

Article

Effectiveness of the Flipped Project-Based Learning Model Based on Moodle LMS to Improve Student Communication and Problem-Solving Skills in Learning Programming

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Abstract: The acquisition of programming skills is often complex and poses challenges that impede students' progress and understanding. This study aimed to assess the effectiveness of the flipped project-based learning (FPBL) model, implemented via Moodle LMS, in enhancing students' communication and problem-solving abilities in programming education. The study employed a quasi-experimental design with a control group following a blended learning approach and an experimental group utilizing the FPBL model. Purposive sampling was used. Data collection involved pre- and post-tests assessing communication and problem-solving skills, analyzed through paired and independent sample *t*-tests to evaluate the significance of the observed improvements. These findings demonstrated significantly positive outcomes in the experimental group. For problem-solving skills, the paired sample *t*-test showed a mean difference of 16.000, a *t*-value of 5.852, and a significance level of 0.000. Communication skills analysis revealed a mean difference of 7.400, a *t*-value of 10.418, and a significance level of 0.000. Independent sample *t*-tests corroborated these results, indicating notable enhancements in both skills in the experimental group compared to the control group. The FPBL model based on the Moodle LMS markedly improved students' communication and problem-solving skills in programming education. Future research should investigate the long-term retention of these skills and the applicability of the model across different disciplines and educational levels.

Keywords: flipped project-based learning; Moodle LMS; communication skills; problem-solving skills; programming education



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1. Introduction

Programming can present significant challenges for students, impacting their educational journeys and outcomes. The process of acquiring programming skills often involves complexities that can hinder students' progress and understanding. Students, especially beginners, can face various difficulties when learning a programming language, especially beginners [1]. In addition, students may experience difficulties in transitioning from theoretical knowledge to practical applications, especially when tasked with coding and troubleshooting in an inadequate learning environment [2,3].

The acquisition of problem-solving and communication abilities is critical in programming education. These skills are crucial for identifying, analyzing, and resolving problems effectively [4]. Well-structured problems with clearly defined goals and paths to solutions play an essential role in building foundational problem-solving skills. These problems allow learners to apply established rules and principles systematically, reinforcing their ability to tackle more complex problems in the future [5]. Problem-solving abilities involve

not only technical proficiency but also traits such as determination, responsibility, and the capacity to analyze and find solutions to various problems [6]. These skills are crucial for addressing challenges in diverse fields, including engineering, natural resources, and software development [7,8]. Furthermore, the development of problem-solving skills has been linked to enhanced communication, teamwork, and self-management abilities [9]. Effective communication skills facilitate the exchange of ideas, collaboration, task completion, and presentation of solutions [10,11].

Moreover, problem-solving skills help programmers approach tasks systematically, break down problems, and implement logical solutions. Critical thinking and problem solving are essential for navigating the intricacies of programming and developing efficient solutions [12,13]. The integration of these two skills helps students approach tasks confidently, tackle complex problems, and develop innovative solutions [14,15]. To address these challenges, a holistic approach that provides support, resources, and guidance to help students overcome difficulties and develop proficiency in programming languages is required.

One effective approach to address this challenge is the project-based learning (PjBL) model, which guides students through tasks, fosters teamwork, and enhances collaboration [16,17]. In this model, students apply problem-solving skills in real-world scenarios, communicate strategies, and work towards project goals [18–20]. To maximize the benefits of PjBL, engaging the concept of flipped classroom learning is appropriate, as it offers a modern educational approach that leverages technology, such as e-learning, gamification, and active learning strategies, to engage students in interactive and self-directed learning. This model allows students to access foundational knowledge outside the classroom, freeing up in-class time for collaborative activities, discussions, and problem-solving exercises [21–24].

The transition from traditional teaching methods to a student-centered approach makes the flipped classroom model encourage active learning and student engagement with self-reliance and motivation to learn, which is essential for mastering complex courses such as programming [25,26]. In addition, the flipped classroom model has been associated with benefits such as increased teacher-student interaction, increased independence in accessing courses, and a student-centered structure that increases motivation [26]. By offering opportunities for self-directed learning and active participation, the flipped classroom model creates an environment conducive to problem-solving skills and programming language acquisition [27]. By shifting focus from passive to active learning, the flipped classroom model empowers students to take charge of their learning processes, resulting in improved knowledge acquisition and retention [28].

Despite the recognized benefits of project-based learning (PjBL) and the flipped classroom model, there is an important gap in empirical research investigating the combined impact of these pedagogical strategies, specifically in the context of programming education [29]. While PjBL can enhance teamwork and problem-solving skills, and flipped learning can facilitate interactive and self-directed learning, there are limitations on how these approaches can be effectively integrated using a learning management system (LMS) such as Moodle to enhance communication and problem-solving skills among programming students. In addition, the challenge of transitioning from theoretical knowledge to practical applications in programming remains significant, and it is unclear how a combined FPBL model can address this issue within an LMS framework.

The novelty of this study lies in its integrative approach, which combines the strengths of project-based learning and flipped classroom methodologies within the Moodle LMS to create a comprehensive educational model aimed at improving student communication and problem-solving skills. This research is unique in that it focuses on the synergistic effects of these pedagogical strategies when implemented together rather than separately. By utilizing the technological capabilities of Moodle, such as e-learning tools and gamification features, this study provides a modern and innovative solution to the challenges faced by programming students. An empirical evaluation of this combined model will provide

new insights into its effectiveness, potentially setting precedents for future programming education.

The research objective of this study was to evaluate the effectiveness of the Moodle LMS-based flipped project-based learning (FPBL) model in improving communication and problem-solving skills among programming students. This study aimed to determine whether the integration of PjBL and flipped classroom strategies within a Moodle framework can significantly improve these important skills, facilitating the transition from theoretical knowledge to practical application in programming education. This study aims to provide evidence-based recommendations for educational institutions seeking to adopt innovative teaching methodologies to equip their students to face future professional challenges.

Research Questions

- a. Is there an effect of using the flipped project-based learning (FPBL) model based on the LMS Moodle on communication and problem-solving skills?
- b. What are the differences between students who follow the FPBL model and those who follow the blended learning model in improving their communication and problem-solving skills?

2. Materials and Methods

2.1. Design

This study employs a quantitative research approach, utilizing a quasi-experimental design as described by Creswell and Clark [30], to evaluate the efficacy of the flipped project-based learning (FPBL) model implemented through LMS Moodle in enhancing students' communication and problem-solving skills. The research design included pre- and post-test assessments to gauge changes in these skills. The study comprised two groups: an experimental group engaging with the FPBL model and a control group following a blended learning model. The design involved comparing pre- and post-test outcomes to ascertain the impact of the intervention.

2.2. Participants, Survey Instruments, and Data Collection

This study involved informatics and computer engineering education students who were prospective Vocational High School (SMK) teachers studying web programming courses. A total of 69 students were assigned to the experimental or control group, with 35 and 34 students assigned to the experimental and control groups, respectively. Purposive sampling was used in this study to select participants based on the average score of learning outcomes in the Algorithms and Programming course. The experimental group was chosen because it had a lower average score than the control group. This selection was made with the aim of testing whether the Moodle LMS-based flipped project-based learning (FPBL) model can significantly improve problem-solving and communication skills in students who tend to experience difficulties in programming.

The problem-solving ability was obtained from the results of a complex multiple-choice test designed to measure problem-solving ability defined as well-structured problem solving [5,31]. This test was administered to both groups at the beginning (pre-test) and end (post-test) of the semester. The problem solving multiple choice test instrument shown on Table 1.

Table 1. Problem solving multiple choice test instrument.

No	Variable	Statement
1	Understanding the Problem	1–6
2	Planning to solve the problem	7–12
3	Carrying Out the Plan	13–19
4	Evaluation	20–25

The communication skills questionnaire was used to assess communication skills. This questionnaire was also administered as a pre-test and post-test to measure improvements in communication skills. The questionnaire in this study adopted research from [32–35] with the instrument grid, which can be seen in Table 2 below:

Table 2. Communication skills questionnaire, non-test instrument.

No	Variable	Statement	Reference
1	Impact of Moodle-Based Flipped Learning	1–3	[32]
2	Perception of Moodle-based LMS	4–6	[33]
3	Attitudes towards Inclusive Education	7–9	[34]
4	Educational Environment and Student Experiences	10–12	[35]

To ensure that the research data were of good quality, the product moment validity test and validity test with cronbach alpha on the SPSS version 27 application can be seen in Table 3.

Table 3. Validity and reliability test results.

No	Class	Variable	Validity Value	Reliability Value
1	Experimental	Pre-Test Problem Solving	Pearson Correlation value (r-count) > 0.339 (r-table)	0.901
		Post-Test Problem Solving		0.857
		Pre-Test Communication Skills		0.882
		Post-Test Communication Skills		0.879
2	Control	Pre-Test Problem Solving	Pearson Correlation value (r-count) > 0.339 (r-table)	0.892
		Post-Test Problem Solving		0.882
		Pre-Test Communication Skills		0.850
		Post-Test Communication Skills		0.832

The validity and reliability test results showed that all the instruments used in this study were valid and reliable. The Pearson correlation (r-count) values for all variables exceeded the r-table value (0.339), indicating that the instruments precisely measured the intended constructs. The reliability values for all variables in both the experimental and control groups were above 0.8, indicating excellent consistency. This means that the measurements of problem-solving and communication skill variables in the pre-test and post-test were consistent and reliable.

With its high validity and reliability, this instrument can be used to measure the effectiveness of the intervention in both groups. The experimental group showed excellent reliability values for problem solving (pre-test, 0.901; post-test, 0.857) and communication skills (pre-test, 0.882; post-test, 0.879). The control group also showed excellent reliability values for problem solving (pre-test, 0.892; post-test, 0.882) and communication skills (pre-test, 0.850; post-test, 0.832). Therefore, this instrument can be used in future research to evaluate the interventions used in this study.

Furthermore, data collection involved the following steps, which can be seen in Figure 1 and in the narrative.

Figure 1 illustrates the main stages in the flipped project-based learning (FPBL) model applied in this study. The model is divided into three main phases: Pre-Class Preparation, In-Class Activities, and Post-Class Reflection.

- (1) **Pre-Class Preparation:** The pre-test was conducted at the beginning of the first meeting before the learning intervention was applied. The purpose of this pre-test was to measure the initial level of students' communication and problem-solving skills in the context of the web programming course in both the experimental and control groups. At this stage, all students from both groups were given a series of tests specifically designed to evaluate their basic abilities in two important aspects.

- a. Problem solving: The test consisted of 25 multiple-choice questions designed to assess students' ability to identify, analyze, and solve problems related to web programming. The questions covered programming scenarios commonly encountered in web application development.
 - b. Communication skills: The communication skills questionnaire consisted of 12 questions on a 5-point Likert scale that evaluated students' ability to convey ideas, collaborate with peers, and articulate web programming solutions. The questionnaire assessed various aspects of communication that are important in web project development.
- (2) **In-class activities:** After the administration of the pre-test, the experimental group began to engage in activities facilitated by the flipped project-based learning (FPBL) model organized through the Moodle LMS. The control group continued learning using the traditional blended learning method. The FPBL intervention lasted for seven meetings, where each meeting focused on implementing web programming projects that required team collaboration, effective communication, and the application of problem-solving skills in a real context.
 - a. Sessions 1–2: Introduction to HTML
 - Session 1: Introduction to basic HTML tags such as <html>, <head>, and <body>, and the creation of a simple webpage structure. The students built a basic webpage and discussed their results.
 - Session 2: Development of more complex webpage structures using elements such as <table>, <form>, and <div>. Each group created a more structured layout and received feedback.
 - b. Sessions 3–5: Applying CSS
 - Session 3: Introduction to basic CSS, including the use of selectors and properties such as color, margin, and padding for styling the webpage.
 - Session 4: Use of Flexbox and Grid to create responsive webpage layouts. Groups design responsive layouts and discuss their designs.
 - Session 5: Implementation of animations and media queries to make webpages more dynamic and responsive across different devices.
 - c. Sessions 6–7: Implementing JavaScript
 - Session 6: Introduction to basic JavaScript concepts, including variables, functions, and event handling to add interactivity to the webpage.
 - Session 7: Development of advanced functionality using JavaScript, such as DOM manipulation and API integration, culminating in the completion of group projects.
- (3) **Post-Class Reflection:** The post-test was conducted at the end of the last meeting after all intervention sessions were completed in both the experimental and control groups. This post-test was designed to evaluate the improvement in skills in the context of web programming after the learning process.
 - a. Problem solving: The post-test for problem-solving skills maintained the same format as the pre-test, consisting of 25 multiple-choice questions. These questions aimed to measure the extent to which students developed their problem-solving skills in the context of web programming after following the FPBL or blended learning model. The post-test results were analyzed to compare the improvement between the experimental and control groups.
 - b. Communication skills: The post-test for communication skills used the same questionnaire as the pre-test, consisting of 12 questions. It aimed to assess the changes that occurred in students' ability to communicate effectively during web programming projects, in the delivery of ideas, team collaboration, and presentation of project results.

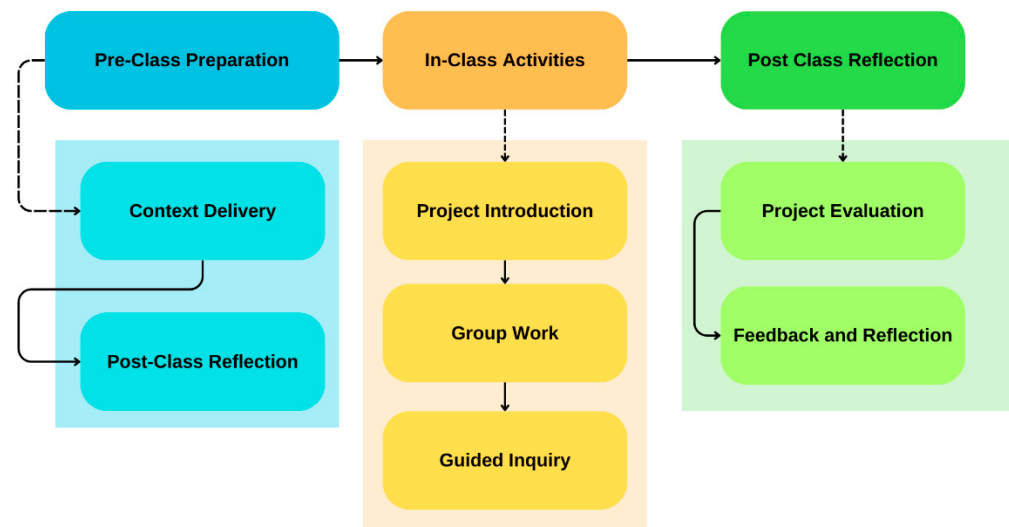


Figure 1. FPBL stages.

2.3. Hypothesis

Based on the research described, there are 4 (four) hypotheses proposed in this study:

H1. *The application of the flipped project-based learning model leads to a significant improvement in problem-solving skills.*

H2. *The application of the flipped project-based learning model results in significant enhancement of communication skills.*

H3. *There is a significant difference in problem-solving abilities between the experimental group that used the flipped project-based learning model and the control group that used a blended learning model.*

H4. *There is a significant difference in communication skills between the experimental group that used the flipped project-based learning model, and the control group that used the blended learning model.*

2.4. Data Analysis

Descriptive statistical analysis was used to summarize the pre- and post-test scores of both groups. This initial analysis provides an overview of the data distribution and highlights notable trends. Before proceeding to the *t*-tests, the normality of the data was assessed using the Kolmogorov–Smirnov test, while the homogeneity of variances was evaluated using Levene’s test. For both tests, a significance value greater than 0.05 was considered acceptable, ensuring that the assumptions for conducting parametric tests were met.

Following these preliminary checks, a paired sample *t*-test was conducted to compare pre-test and post-test scores within the experimental group that participated in the flipped project-based learning model. This test aimed to determine whether the intervention had a significant impact on students’ communication and problem-solving skills. Additionally, an independent sample *t*-test was used to compare the changes in scores between the experimental and control groups, which followed the blended learning model. This comparison helped identify any significant differences in the effectiveness of the two instructional approaches.

3. Results and Analysis

3.1. Results

Inferential statistical analysis can be conducted after meeting the criteria of classical assumption tests, specifically tests for normality and homogeneity. The results of the normality test for the data on student problem-solving skills in both the experimental and control groups are shown in Table 4.

Table 4. Data normality of problem solving.

Tests of Normality				
Class		Statistic	Df	Sig.
Pre-test	Experiment Class	0.113	35	0.200 *
	Control Class	0.134	34	0.130
Post-test	Experiment Class	0.145	35	0.059
	Control Class	0.139	34	0.094

* This is a lower bound of the true significance. Source: Output SPSS.

Table 4 indicates that the significance value for problem-solving skills in both the pre- and post-tests for the experimental group was greater than 0.05, suggesting that the data for the experimental group were normally distributed. Similarly, the significance value for problem-solving skills in the control group's pre-test and post-test exceeded 0.05, indicating that the data for the control group were also normally distributed. The normality test results for the data concerning the students' communication skills in both the experimental and control groups are presented in Table 5.

Table 5. Data normality of communication skills.

Tests of Normality				
Class		Statistic	Df	Sig.
Pre-test	Experiment Class	0.074	35	0.200 *
	Control Class	0.073	34	0.200 *
Post-test	Experiment Class	0.106	35	0.200 *
	Control Class	0.090	34	0.200 *

* This is a lower bound of the true significance. Source: Output SPSS.

Table 5 demonstrates that the significance value for student communication skills in both the pre- and post-tests for the experimental group exceeded 0.05, indicating that the data for the experimental group were normally distributed. Similarly, the significance value for the communication skills scores in the control group's pre-test and post-test also surpassed 0.05, suggesting that the data for the control group were normally distributed. The subsequent assumptions were based on the homogeneity test. Table 4 presents the homogeneity test results for problem-solving skills data.

According to Table 6, the significance values for the pre- and post-test were 0.737 and 0.107, respectively. Both values are greater than 0.05, indicating that the data fall within the homogeneous category and that the variations in problem-solving skills data have the same variance. The results of the homogeneity test for the learning motivation data are presented in Table 7.

Table 6. Problem solving homogeneity data.

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Pre-test	Based on Mean	0.114	1	67	0.737
Post-test	Based on Mean	2.676	1	67	0.107

Source: Output SPSS.

Table 7. Communication skills homogeneity data.

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Early	Based on Mean	0.104	1	67	0.748
End	Based on Mean	0.237	1	67	0.628

Source: Output SPSS.

As shown in Table 7, the pre- and post-test significance values were 0.748 and 0.628, respectively, both of which were greater than 0.05. This indicates that the data are homogeneous, implying that variations in the communication skills data have the same variance. With the classic assumption test requirements met, a paired-sample *t*-test was conducted to measure the effectiveness of the flipped project-based learning model based on the Moodle LMS in problem-solving and communication skills. Additionally, an independent sample *t*-test was used to determine differences in problem-solving and communication skills between students in the flipped project-based learning model and those in the blended learning model.

3.1.1. The Application of the Flipped Project-Based Learning Model Leads to a Significant Improvement in Problem-Solving and Communication Skills

The results of the descriptive statistical analysis demonstrated an enhancement in the problem-solving skills of students in the experimental group following the implementation of flipped learning (FPBL). This improvement was reflected in the mean scores before and after the implementation of the FPBL, as shown in Table 8.

Table 8. Data descriptive analysis of problem solving experiment group.

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Post-test	74.5143	35	20.44414	3.45569
	Pre-test	58.5143	35	27.06134	4.57420

Source: Output SPSS.

Table 8 illustrates that the post-test average of 74.51 is higher than the pre-test average of 58.51, indicating an improvement in the problem-solving skills of students in the experimental group. To determine the significance of this improvement and the effectiveness of the flipped project-based learning model, a paired-sample *t*-test was conducted (Table 9).

Table 9. Data results paired sample *t*-test problem solving.

Paired Samples Test							
Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	<i>t</i>	df	Sig. (2-Tailed)
Pair 1	Post-test – Pre-test	16.00000	16.17551	2.73416	5.852	34	0.000

Source: Output SPSS.

Table 9 presents the results of a paired sample *t*-test evaluating the impact of an intervention on problem-solving skills, comparing pre- and post-intervention scores. The data indicated that the mean difference between the post-test and pre-test scores was 16.0000, reflecting a notable improvement. The standard deviation of this difference was 16.17551, with a mean standard error of 2.73416. The *t*-value was 5.852 with 34 degrees of freedom, and the significance level (Sig. 2-tailed) is 0.000, suggesting that the result is statistically significant.

The significant improvement in problem-solving skills post-intervention ($p < 0.05$) underscores the effectiveness of the intervention program. The substantial mean increase indicated that participants' problem-solving abilities were positively affected by the program, highlighting the program's success in enhancing these skills. As for the communication skills of student learning, after the implementation of the flipped project-based learning model, the communication skills of students in the experimental group increased from the previous one. The results are presented in Table 10.

Table 10. Descriptive analysis data communication skills experiment group.

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	End	42.0000	35	3.87298	0.65465
	Early	34.6000	35	4.33318	0.73244

Source: Output SPSS.

Table 10 shows that the average final communication skills were 42.00 higher than the average early communication skills of 34.60. This means that there was an increase in students' communication skills in the experimental group. To determine the significance of improving student communication skills and the effectiveness of the flipped project-based learning model, we used a paired-sample *t*-test, as shown in Table 11.

Table 11. Data results paired sample *t*-test communication skills.

Paired Samples Test							
Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	<i>t</i>	df	Sig. (2-Tailed)
Pair 1	End-Early	7.40000	4.20224	0.71031	10.418	34	0.000

Table 9 shows the results of a paired sample *t*-test assessing the effect of an intervention on communication skills, comparing the scores from the beginning to the end of the study. The data revealed that the mean difference from the end to the early assessment was 7.40000, demonstrating an improvement. The standard deviation was 4.20224, with a standard error mean of 0.71031. The *t*-value was 10.418 with 34 degrees of freedom, and the significance level (Sig. 2-tailed) is 0.000, confirming that the result is statistically significant.

The significant enhancement in communication skills ($p < 0.05$) highlights the efficacy of the intervention. The marked mean increase suggests that participants experienced considerable gains in their communication abilities owing to the program, emphasizing its success in developing these skills. An overview of improving communication skills and problem-solving of the experimental group students is shown in Figure 2.

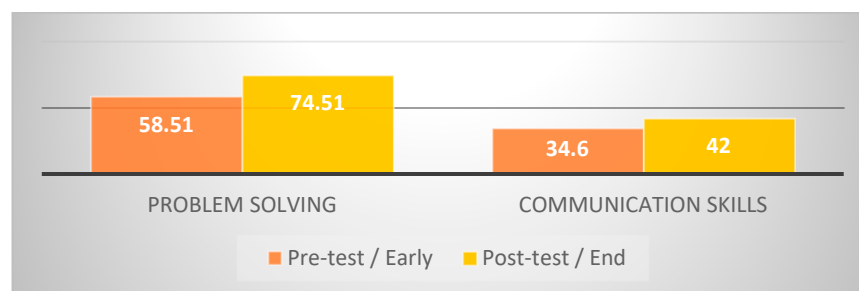


Figure 2. Average problem-solving and communication skills of experimental group students.

Figure 2 illustrates the pre-test (early) and post-test (end) scores for problem-solving and communication skills, showing the impact of an educational intervention on these two key competencies. For problem solving, the pre-test score was 58.51, while the post-test score was 74.51. This increase of 16 points demonstrates a substantial improvement in problem-solving skills following the intervention. For communication skills, the pre-test score is 34.6, and the post-test score is 42, indicating an improvement of 7.4 points. This suggests that the participants' communication abilities were also significantly enhanced by the intervention.

The figure clearly depicts significant gains in both problem-solving and communication skills, highlighting the effectiveness of the educational intervention. Notable improvements in these areas suggest that the intervention successfully enhanced participants' abilities, providing evidence of its efficacy in fostering essential skills. These results underscore the value of interventions in educational settings and contribute to better outcomes for learners.

3.1.2. Differences in Problem-Solving Abilities and Communication Skills between the Experimental Group Employing the Flipped Project-Based Learning Model and the Control Group Using Blended Learning

The difference in problem-solving skills between the experimental and control groups was identified using independent sample *t*-tests. Table 12 presents the data for the *t*-tests regarding problem-solving skills.

Table 12. Independent Sample *t*-test Problem Solving Data.

		Independent Samples Test			
		<i>t</i> -Test for Equality of Means			
		<i>t</i>	df	Sig. (2-Tailed)	Mean Difference
Pre-test	Equal variances assumed	−0.456	67	0.650	−2.89748
Post-test	Equal variances assumed	2.107	67	0.039	11.45546

Source: Output SPSS.

Table 12 presents the results of an independent sample *t*-test comparing problem-solving skills between the control and intervention groups both before and after the intervention. The pre-test results showed no significant difference ($t = -0.456$, $df = 67$, $p = 0.650$), with a mean difference of -2.89748 . In contrast, the post-test results indicated a significant difference ($t = 2.107$, $df = 67$, $p = 0.039$), with a mean difference of 11.45546 .

The post-test findings revealed a statistically significant improvement in problem-solving skills in the intervention group compared to the control group. This demonstrates the effectiveness of the intervention in enhancing problem-solving abilities among participants, providing evidence of its successful implementation. Furthermore, an independent sample *t*-test was conducted to determine whether there was a difference in communication skills between the experimental and control groups, as shown in Table 13.

Table 13. Data results independent sample *t*-test communication skills.

		Independent Samples Test			
		<i>t</i> -Test for Equality of Means			
		<i>t</i>	df	Sig. (2-Tailed)	Mean Difference
Pre-test	Equal variances assumed	−1.493	67	0.140	−1.54706
Post-test	Equal variances assumed	4.039	67	0.000	3.67647

Source: Output SPSS.

Table 13 presents the results of an independent sample *t*-test comparing communication skills between the control and intervention groups in both the pre-test and post-test stages. The pre-test results revealed no significant difference ($t = -1.493$, $df = 67$, $p = 0.140$), with a mean difference of -1.54706 . Conversely, the post-test results indicated a significant difference ($t = 4.039$, $df = 67$, $p = 0.000$), with a mean difference of 3.67647 .

The post-test data demonstrated a significant improvement in communication skills in the intervention group compared to the control group, confirming the positive impact of the intervention on enhancing communication abilities. This validates the conclusion that the intervention successfully fostered better communication skills among the participants. The independent sample *t*-test results for problem-solving and communication skills showed that students in the experimental group, using the flipped project-based learning model, exhibited better problem-solving and communication skills than those in the control group using blended learning.

3.1.3. Addressing the Research Questions

- *Is there an effect of using the flipped project-based learning (FPBL) model based on the LMS Moodle on communication and problem-solving skills?*

The results of this study indicate a significant positive effect of the flipped project-based learning (FPBL) model, as implemented via the Moodle LMS, on both communication and problem-solving skills among programming students. The paired sample *t*-test results showed a mean difference of 16.000 in problem-solving skills ($t = 5.852$, $p = 0.000$) and a mean difference of 7.400 in communication skills ($t = 10.418$, $p = 0.000$), demonstrating statistically significant improvements in both areas. These findings confirm that the FPBL model effectively enhances students' communication and problem-solving abilities, validating its efficacy in a programming-education context.

- *What are the differences between students who follow the FPBL model and those who follow the blended learning model in improving their communication and problem-solving skills?*

The independent sample *t*-test results revealed significant differences between the experimental group (using the FPBL model) and the control group (using the blended learning model) in terms of improvements in communication and problem-solving skills. For problem-solving skills, the post-test results showed a mean difference of 11.45546 ($t = 2.107$, $p = 0.039$) in favor of the experimental group. Similarly, for communication skills, the post-test results indicated a mean difference of 3.67647 ($t = 4.039$, $p = 0.000$), also favoring the experimental group. These results suggest that the FPBL model is more effective than the traditional blended-learning model in enhancing students' essential skills.

4. Discussion

The analysis of the effectiveness of the flipped project-based learning (FPBL) model based on the Moodle LMS in improving student communication and problem-solving skills revealed substantial positive outcomes. The paired sample *t*-test for problem-solving skills (Table 7) indicated a mean difference of 16.000 , with a *t*-value of 5.852 and a significance level of 0.000 , demonstrating a significant enhancement in students' problem-solving abilities post-intervention. Similarly, for communication skills (Table 9), the paired sample

t-test showed a mean difference of 7.400, a *t*-value of 10.418, and a significance level of 0.000, indicating a significant improvement in communication skills.

Moreover, independent sample *t*-tests (Tables 10 and 11) confirmed these results. For problem-solving skills, the post-test results indicated a mean difference of 11.45546, with a *t*-value of 2.107 and a significance level of 0.039, signifying a notable improvement compared with the control group using blended learning. For communication skills, the post-test results revealed a mean difference of 3.67647, with a *t*-value of 4.039 and a significance level of 0.000, affirming a positive impact on students' communication abilities.

The results of this study are in accordance with existing research on the effectiveness of project-based learning (PBL) models, especially those integrated with the flipped classroom approach, in developing learners' skills. Research such as that conducted by [36] on the implementation of a project-based learning model based on the flipped classroom and research by Agustiniingsih et al. and Fadhilatunisa et al. [37,38] on modified flip-based argumentation learning recommended that the use of the flipped classroom is a valuable pedagogical approach. In addition, Karyadi et al. [39] emphasized the positive impact of the flipped classroom model on student learning outcomes, especially when combined with project-based learning and cooperative learning strategies.

Several other studies have also demonstrated the benefits of integrating project-based learning into a flipped classroom model. Research from Paristiowati et al. and Ramadhani and Fitri [40,41] emphasized that this combined approach can improve learner achievement by encouraging active, communicative, and collaborative learning experiences. In addition, Chua and Islam [42] showed that learners in a project-based learning-Flipped Classroom environment tend to be more engaged and active in their learning process, which supports the positive outcomes observed in this study.

Furthermore, research on the flipped classroom model extends its benefits to include a range of competencies beyond problem-solving and communication skills. Priyaadharshini and Sundaram [43] discussed how the flipped classroom model can enhance higher-order thinking skills and metacognitive processes. Similarly, Zhou et al. [44] explored the cognitive skills and emotional states of vocational students, illustrating the multifaceted benefits of the flipped classroom approach. Statistical analyses from this study showed significant improvements in problem-solving and communication skills, in line with research by Harmini et al. [45], who also found significant differences in favor of the flipped classroom model in improving student learning outcomes. The consistency of these results across different studies emphasizes the robustness and effectiveness of the FPBL model in developing students' skills.

The positive impact of the FPBL model on students' communication and problem-solving skills is consistent with the findings of Ramadhani and Fitri [41], who highlighted the positive impact of the Project-Flipped Classroom model on students' statistical thinking skills. This study's emphasis on the significant improvement in these skills after the intervention further strengthens the existing literature that supports the integration of innovative teaching methodologies to improve student competencies. In contrast, while this study focuses on the specific outcomes of the FPBL model on communication and problem-solving skills, other studies, such as those conducted by Isma et al., Aufi and Naidu, Fakhri et al., and Prasetya [46–49], explore broader aspects of learning management systems (LMS) and the challenges and opportunities associated with technology-enhanced pedagogy. These studies provide a more comprehensive view of the implications of using LMS platforms, such as Moodle, in educational settings, offering insights into the design of effective learning materials and understanding students' perceptions of technology-mediated learning experiences.

Overall, the results of this study reinforce existing evidence on the effectiveness of the project-based learning model coupled with the flipped classroom approach in developing important skills such as problem solving and communication in students. The existing literature supports these findings, demonstrating the significant benefits of this innovative teaching approach in the modern educational context. The significant improvement in

students' problem-solving and communication skills underscores the practical value of adopting an FPBL model based on Moodle's LMS in programming education. These skills are essential for students' success in both academic and professional settings, where problem-solving and effective communication are highly valued. These findings suggest that educational institutions can enhance their programming curricula by incorporating FPBL models, thereby preparing students for real-world challenges.

Moreover, the study's results have broader implications for educational practices, advocating for a shift towards more interactive and student-centered learning approaches. Educators can create more engaging and effective learning environments by leveraging technology and innovative teaching methods. Future research should explore the long-term effects of FPBL on student outcomes and investigate its applicability across different subjects and educational levels. Significant improvements in students' problem-solving and communication skills have important scientific and practical implications. Scientifically, this study contributes to the growing body of evidence supporting the effectiveness of blended learning approaches in higher education. Practically, the findings suggest that educational institutions should consider adopting the FPBL model to prepare students to meet the demands of the modern workforce. The model's emphasis on active learning and collaboration aligns well with the skills required in contemporary professional environments, thereby enhancing students' employability and readiness for real-world challenges.

This study addresses several gaps in the literature. Previous studies have primarily focused on either flipped or project-based learning. By integrating these approaches and utilizing the Moodle LMS, this study provides new insights into the synergistic effects of combining multiple innovative teaching methods. Furthermore, this study extends the application of the FPBL to programming education, a context that has received relatively less attention in the existing literature. Future research should explore the long-term impact of the FPBL model on student outcomes, including the retention of problem-solving and communication skills over time. Additionally, it would be beneficial to investigate the applicability of this model across different disciplines and educational levels to determine its generalizability. Research can also examine the potential challenges and barriers to implementing FPBL models in various educational contexts, providing insights for educators on how to effectively integrate these approaches into their teaching practices.

5. Conclusions

This study effectively answered the two primary research questions posed at the outset. First, it confirms that the flipped project-based learning (FPBL) model based on the Moodle LMS significantly enhances communication and problem-solving skills among programming students. The paired sample *t*-tests indicated substantial improvements in these skills, with a mean difference of 16.000 for problem-solving skills ($t = 5.852, p = 0.000$) and a mean difference of 7.400 for communication skills ($t = 10.418, p = 0.000$). These results validate the hypothesis that this innovative pedagogical approach fosters better learning outcomes by developing essential skills that are crucial for students' academic and professional success.

Second, the study identified significant differences between students who participated in the FPBL model and those who engaged in a blended learning approach. Independent sample *t*-tests revealed that the experimental group using the FPBL model showed more significant improvements in both communication and problem-solving skills than the control group, with a mean difference of 11.45546 for problem-solving skills ($t = 2.107, p = 0.039$) and 3.67647 for communication skills ($t = 4.039, p = 0.000$). These findings underscore the superiority of the FPBL model over the traditional blended learning model in enhancing essential competencies. The integration of flipped learning and project-based methodologies, supported by the Moodle LMS, provides a synergistic effect that maximizes student engagement, critical thinking, and practical application of knowledge. These improvements are vital for preparing students to meet the demands of the modern

workforce, where effective communication and robust problem-solving abilities are highly valued.

This study contributes to the growing body of evidence supporting blended learning approaches in higher education and highlights the practical implications of adopting the FPBL model in programming curricula. Educational institutions should consider implementing this model to enhance students' readiness for real-world challenges. Future research should explore the long-term retention of these skills and investigate the applicability of the FPBL model across disciplines and educational levels. Additionally, examining the potential barriers and challenges to the implementation of FPBL models will provide valuable insights for educators seeking to enhance their teaching practices. Overall, the FPBL model based on the Moodle LMS represents a promising approach for advancing educational outcomes in the 21st century.

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