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Flipped Learning Approach in Project Based Learning: Improving Critical and Creative Thinking Skills

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Abstract

The current study investigates the effectiveness of combining the flipped model with project-based learning (PjBL) in an attempt to build critical and creative thinking skills among students within mechanical engineering education. In a quasi-experimental non-equivalent control group design, the study involved two groups of fifth-semester students taking a Learning Program Planning course at Nusa Cendana University. Traditional offline teaching was offered to a control set, while the treatment group was exposed to a flipped classroom combined with PjBL. Pretests, post-tests, and lesson plans were employed to gather the data. Using t-tests and descriptive statistics, it was clear that the flipped-PjBL method had starkly better output in comparison to traditional methods, with higher post-test scores and improved cognitive outcomes. This finding points to the potential in combining flipped learning and project-based designs to create higher-order thinking capabilities. The practice is well-suited for student-centric learning environments that suit the demands of 21st-century learning, particularly in the context of Industry 4.0 and Society 5.0 challenges.

Keywords: *Flipped Learning; Project Based-Learning Approach; Critical and Creative Thinking Skills.*

INTRODUCTION

The demand for analytical and creative abilities increases during the era of Industrial Revolution 4.0 and Society 5.0, especially in the field of education (Amalia, 2022). According to world organizations like the World Economic Forum, these two capabilities should be possessed by the next generations to cope with global shifts and technological progress (Schwab & Zahidi. 2020). However, the best way of acquiring these skills remains a challenge for the education system in Indonesia. Conventional, instructor-based approaches tend to prevent learners from participating actively in the learning process, thereby inhibiting the development of critical and creative thinking abilities (Kusuma et al., 2023).

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Flipped learning is one of several innovative teaching methodologies developed in response to this challenge. By moving knowledge acquisition outside of the classroom and reserving face-to-face time for dialogue and problem-solving, this approach redefines how learning is conducted (A. Bergmann & Sams, 2012). Numerous studies show that flipped learning enhances student motivation, engagement, and conceptual understanding understanding (Lo & Hew, 2017). In parallel, Project-Based Learning (PBL) has been widely recognized for its effectiveness in fostering higher-order thinking skills, as it requires learners to engage with real-world tasks (Hmelo, 2004).

Several studies have explored the individual effectiveness of flipped learning and PBL, but their integration remains under-researched, particularly in the Indonesian education context (Akbar et al., 2023). Combining these models is believed to provide a more holistic approach to developing critical and creative thinking skills (Rosa et al., 2024). Through flipped learning, students come to class already equipped with preliminary knowledge, allowing them to engage in deeper-level discussions and applications (Maheswari & Seth, 2019), while PBL directly involves them in collaborative and problem-solving activities rooted in authentic scenarios (Hujjatusnaini et al., 2022).

Recent literature emphasizes the growing success of integrated flipped learning and PBL models. For example, Listiqowati (2022) demonstrated that the Project-Based Flipped Classroom (PjBFC) model significantly improves students' critical thinking skills. Similarly, Hao (2024) found that students exposed to PjBFL showed enhanced creative problem-solving compared to those taught through conventional PjBL. Köpeczi (2024) also reported that such integration boosts motivation and engagement, particularly at the university level.

In addition, studies by Fitrah et al. (2025) and the International Journal of Learning, Teaching and Educational Research indicate substantial improvement in analytical, abstraction, and communication skills when flipped learning is combined with PBL strategies. These findings point to the potential of this dual approach in addressing the current skill-gap crisis within tertiary education. Moreover, hybrid learning models that incorporate flipped-PBL designs have proven effective in STEM fields, especially engineering education (Listiqowati, 2022 & Köpeczi, 2024).

Even though each model demonstrates effectiveness individually, the scarcity of integrated research calls for further empirical investigation. The study by Ilham Kamaruddin et al (2022) confirms PjBL's positive influence on critical thinking and classroom engagement. Ekayana et al. (2021) also show that flipped classrooms significantly enhance learning outcomes, while Agustina (2021) validate that PjBL in a flipped format cultivates collaborative competencies. Despite these findings, studies that empirically test the synergy between flipped learning and PBL to enhance both critical and creative thinking remain limited.

In the 21st century, fostering critical and creative thinking is essential due to global demands for innovation and adaptability. Traditional teacher-centered models often fail to support the development of these competencies (Putri, 2024). There is an urgent need for instructional designs that not only improve comprehension but also empower students to solve real-world problems through critical analysis and creative application.

Therefore, this study investigates the combination of flipped learning and project-based learning in mechanical engineering education, aiming to bridge the research gap. The expected outcome is to offer an effective pedagogical strategy that supports the development of 21st-century skills. It is hoped that this research will inform policymakers and educators in crafting future-responsive instructional designs tailored to the challenges of Industry 4.0 and Society 5.0.

METHOD

This study employed a quasi-experimental design, specifically the *Nonequivalent Control Group Design (*Tuckman, 1999), which aligns with rigorous methodological standards in educational research (Campbell et al, 2015). The study was conducted in September 2024 and involved two intact groups of fifth-semester students from the Mechanical Engineering Education Program, Faculty of Teacher Training and Education (FKIP), at Nusa Cendana University. The students were enrolled in the *Learning Program Planning* course and were assigned to Class A and Class B through a random draw process. Class A served as the experimental group, which received instruction through a flipped classroom model integrated with Project-Based Learning (PBL)**,** while Class B acted as the control group, receiving traditional offline instruction.

The instructional intervention followed the learner centered flipped classroom procedures described by Van Alten et al., (2019), where students engaged in pre class content learning and active, collaborative project work during face-to-face sessions. The PBL framework emphasized authentic, product-based tasks such as the development of a detailed *lesson plan (RPP)* as a project outcome, allowing for assessment of both learning achievement and 21st-century competencies, particularly critical and creative thinking skills (Facione, 2011 & Mamun, 2020).

The participants of this study were 60 students enrolled in the *Learning Program Planning* course during the fifth semester of the 2024 academic year. Class A consisted of 30 students, and Class B also consisted of 30 students. These classes were assigned as the experimental and control groups respectively, with treatment allocated as previously described. The students were drawn from the Mechanical Engineering Education Study Program, FKIP, Nusa Cendana University.

The preparation phase included designing and developing instructional materials tailored to the flipped learning and project-based learning models. Lecturers were assigned based on their experience

with the respective teaching methods traditional and flipped PBL and were briefed on the learning framework and assessment strategy. Training modules were designed to cover the course's core topics, including both theoretical and applied components. Trial sessions were conducted to refine the instruments and procedures.

Both the control and experimental groups underwent a pre-test to assess baseline learning achievement. The control group received instruction using a traditional offline teaching model, while the experimental group engaged in flipped classroom activities enhanced with PBL. Throughout the instructional period conducted over four full sessions the students in the experimental group worked collaboratively to develop and present their RPP products. After the intervention, both groups completed a post-test and submitted their final RPP products, which were assessed using a rubric measuring critical and creative thinking skills as conceptualized by Facione (2011). The outcomes were disseminated in a national seminar to share findings with the broader academic community

The research utilized two primary instruments: A learning achievement test, designed based on the course syllabus and aligned with the intended learning outcomes. A rubric-based assessment tool for evaluating students' critical and creative thinking skills demonstrated through their lesson plan (RPP) project.

Both instruments underwent expert validation and pilot testing to ensure validity and reliability. The pilot test was conducted with students who had previously completed the course, and statistical analyses were performed using SPSS version 20.0. Item validity, reliability coefficients, and internal consistency were examined before the instruments were applied in the actual study

The data analysis process adhered to rigorous quantitative standards. First, normality testing was performed using the Lilliefors test, and homogeneity testing was done using Levene's test. Upon confirming that the data met the parametric assumptions, independent samples t-tests were conducted to compare the pretest and post-test scores of both groups. Descriptive statistics (means, standard deviations) were used to summarize performance data.

Analysis focused on identifying statistically significant differences in learning achievement and the quality of lesson plan products between the experimental and control groups. The use of SPSS 20.0 for Windows facilitated precise statistical computations. The findings were interpreted in light of instructional design theories Wang et al. (2005) and recent evidence supporting the effectiveness of flipped-PBL models in engineering education (Arslan, 2020s & Van Alten et al., 2019).

RESULTS AND DISCUSSION

Description of Research Subjects

This study was carried out on FKIP Undana Mechanical Engineering Education students who were enrolled in the Learning Program Planning course in 2024. 30 individuals in Class A and 30

individuals in Class B. Class group B employed traditional offline learning, while class group A used a flipped learning model with a project based learning approach. Both groups have undergone learning activities in accordance with the research design. To make it easier to see the distribution of research subjects in this flipped learning, consider the following table.

Description of Pretest Data of Learning Outcomes

Both sets of research participants in the offline conventional learning class and the flipped learning class with project based learning method took a pretest before to the start of the experimental treatment. The pretest data is used to obtain an initial picture or initial input (entry data) about the research subjects, whether the research subjects have different or not different initial abilities, see table 1 below:

Table 1. Detailed Explanation of Initial Trial Result Data

	Learning Model	N	Mean	Std. Deviation	Std. Error Mean
Pretest Data	Flipped Learning Model PjBL approach	30	41.1000	4.88029	.89102
	Conventional Offline	30	42.8333	4.95555	.90476

T-test was conducted to find if there was a significant difference between the two groups of data. Prior to carrying out the t-test, it is required to test the data for homogeneity and normality. The outcome of the Kolmogorov-Smirnov test for normality indicates that the old offline learning model receives a significance value (SIG) of 0.12, and the project-based learning model receives a SIG of 0.200. In view of the fact that both pretest data sets are greater than 0.05, the data sets are regarded as normally distributed. The results of the Levene test provide a mean significance value (SIG) of 0.891, which is higher than 0.05, meaning that the pretest data are homogeneous. With the pretest data guaranteeing normality and homogeneity, t-test analysis between two independent groups can be done, and the results are as follows:

Table 2. t -test Analysis of Independent Sample Pretest Information

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Pretest Data	Equal variances assumed	.006	.940	-1.365	58	.178	-1.7333	1.2698	-4.275	.8085
	Equal variances not assumed			-1.365	57.98	.178	-1.7333	1.2698	-4.275	.8085

According to the t-test outcome of two distinct samples, the result of learning outcome of the pretest in the Learning Program Planning Course showed that there were no significant differences (p>0.05) between the group taught using traditional offline methodology and the group taught using a reverse model learning and a project-based

delivery. The initial competency of both groups is hence identical and shows no differences.

Post-Test Learning Outcomes (MK Learning Program Planning)

According to the data collected from the experimental class using project-based learning approach and switch learning technique, where 30 students were involved in the study, the average student learning outcome was 80.233 with a standard deviation of 5.7934. Below is the distribution of data from the experimental class using both approaches:

Table 3. Learning Outcomes of Experimental Class Learning Program Planning

No	Learning Outcome	Absolute Frequency	Relative Frequency
1	60 - 69	1	3,33 %
2	70 - 79	14	46,67 %
3	80 - 89	13	43,33 %
4	90 - 100	2	6,67 %
Total		30	100 %

The learning outcomes of the control class with the offline conventional model, with 30 students as research subjects, have a mean of 74.366 and a standard deviation of 5.0547. The following is the distribution of learning outcome data for the control class with the offline conventional model:

Table 4. Learning Outcomes of Control Class Learning Program Planning

No	Learning Outcome	Absolute Frequency	Relative Frequency
1	60 - 69	4	13,33 %
2	70 - 79	21	70,00 %
3	80 - 89	5	16,67 %
4	90 - 100	0	0,00 %
Total		**30**	**100 %**

Test of Analysis Requirements

The findings from the analysis requirements evaluation utilizing the Kolmogorov-Smirnov test for the academic performance data of the traditional offline model (GIS) show a value of 0.095, compared to 0.05. In contrast, the learning outcome data using the inverted learning framework based on the project-oriented approach (GIS) presents a result of 0.200, also in relation to 0.05. These outcomes suggest that the learning data exhibits a normal distribution. Since the homogeneity assessment (GIS) yields a value of 369, which is above 0.05, it confirms that the t-test is applicable due to the data being homogenous.

Hypothesis Test

Tables 5 and 6 display the data findings from the hypothesis test:

Table 5. Experimental and Control Class Learning Outcome Data

	Learning	N	Mean	Std. Deviation	Std. Error Mean
Results Learning	Flipped Learning Project Based Learning Approach (Experimental Class)	30	80.2333	5.7934	1.0577
	Conventional offline (Control Class)	30	74.3667	5.0547	.9228

Table 6. Analysis of t Test Data on Learning result of MK Learning Program Planning

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Results Learning	Equal variances assumed	.820	.369	4.179	58	.000	5.86667	1.40374	3.0567	8.6765
	Equal variances not assumed			4.179	56.953	.000	5.86667	1.40374	3.0556	8.6776

Thirty research subjects in the experimental class using the flipped learning-based project learning approach had an average score of 80.23, while 30 students in the offline conventional model class had an average score of 74.37, based on the results of the two-sample independent t-test in table 5.

The t-value for independent samples is 4.179, as shown by Table 6. The p-value (sig 2-tailed) of 0.00 is thus the p-value, and as can be seen, the p-value (sig 2-tailed) of 0.00 is less than α (0.05) for the α = 0.05 level of significance. This shows that there is a significant difference in learning outcomes (post-test) between the flipped learning project and the offline traditional model ($p<0.05$).

Consequently, in contrast to the implementation of conventional offline models in the Control group, the integration of flipped learning combined with a project-based learning method in the experimental group of the Learning Program Planning course shows improvement and can effectively stimulate students' critical and creative thinking skills.

The average value of 80.2 for flipped learning with a project-based learning strategy was greater than 74.3 for regular learning with a common approach, according to the data. The results of t-test analysis revealed a value of significance probability 0.000 and a value of t as 4.179. This significance value indicates that the value of probability 0.000 is less than 0.05. As a result, it can be concluded that the combination of project-based learning and flipped learning offers superior quality and a beneficial impact on the development of critical and creative thinking skills (Baepler et al., 2014 & Thai et al., 2017).

These findings support previous studies that show flipped learning when combined with project activities yields improved metacognitive awareness, retention, and conceptual mastery (Zainuddin et al., 2016 & Sun et al., 2022).

The flipped learning system is instruction that complements class time with flipped learning (Sulaiman, 2018). The flipped learning model is an innovation of learning that reverses all learning processes, whereby students learn course content at home via modules, PPTs, learning videos, and afterwards make summaries, write questions for content not understood, engage in discussion of flipped learning with fellow students, or read content from alternative sources, then complete the product of independent learning at home (Tomas et al., 2019). In class, the students are required to conduct discussions in order to be able to solve problems learned through self-learning at home. During this discussion, there is a practice of giving information to one another by the students (Shih, 2017). Reinforcement or reinforcement of unclear concepts is the responsibility of the teacher (Igirisa, 2017). With such a flipped learning approach, students can learn more actively during class to address problems and work on the Learning Program Planning Course project of crafting RPP products, and at home using flipped learning. This aligns with the concept of reflective thinking as emphasized by J. L. Bishop et al (2013), which shifts the content transmission outside the classroom and utilizes class time for deeper conceptual understanding.

Learner centered is reflected in the Project Based Learning (PjBL) model by Chimbi & Jita (2021). PjBL typically involves learning through discussing actual issues (Anazifa, 2017). Based on the 2013 Curriculum Implementation Module, PjBL is an exercise of learning that utilizes projects or activities as a process to develop attitude, knowledge, and skills (Wahyu, 2016). Behaviors of students that apply research skills, analyze, generate, and present learning products from real experiences are the areas of learning focus (Kasanah, 2022). In line with this, Wanner et al (2015) noted that flipped PjBL improves student autonomy and performance, while Karaca et al. (2017) highlighted its effectiveness in reducing cognitive load and promoting resilience in learning.

Project based flipped learning can acclimatize students to classroom learning (Sjafei, 2022). This is because they already have the knowledge of the subject that will be addressed in class. Information that will be addressed in class, and let the learning process go into problem solving methods or into the process of addressing issues or projects falling into their domain. It is work on their part. Critical and creative thinking of the students will be enhanced by this type of learning method. According to Iman (2017), critical thinking is associated with fluent thinking, in which students produce a high quantity of ideas, answers, problems, or questions; flexible thinking, in which students produce a variety of (alternative) ideas, answers, or questions; and original thinking, in which students create new and

original statements or discover unusual combinations of common components. This view aligns with Albert et al. (2014), who emphasized that flipped PjBL environments foster independent thought and student initiative.

Conversely, creative thinking is the capability to circumvent obstacles by creating a product that addresses the problem at hand (Khalid et al., 2020). It is creating a Learning Program Plan (RPP) in this situation. One of the innovations in learning that incorporates information technology into learning is the flipped learning process using the project-based learning strategy (Hossein et al, 2021). Ding et al. (2021) also highlighted that integrating digital tools into flipped PjBL improves learners' creative expression and engagement with authentic tasks.

Flipped learning project based encourages students to understand, research, and question, giving rise to new problem-solving methods. While doing this, the students are required to learn at home on their own before coming for class teaching learning. By group problem solving, it is possible to examine the concept and inherent principles of the problem. Hence, the moment the material that will be taught to class is learned, students are better positioned to carry out research on all learning materials provided, both in groups and as individuals, in order to find the best ways to overcome problems. Further, integrating flipped learning with a project-based learning strategy allows students to develop their critical and innovative thinking ability (Farah et al., 2022), as the learners recognize all the pertinent data related to the current situation at firsthand, and try to provide solutions that can ultimately develop higher order thinking capability. This is in accordance with Mok (2014), who pointed out that such models enable learners to link theory with real world challenges effectively (Mok, 2014).

Secondly, the project-based learning environment creates conditions that facilitate greater motivation for students to learn, so much so that they are always in good mood and punctual gathering tasks that get converted into project assignments (Dole et al., 2017). Thus, flipped learning based on a project-based learning approach needs proper attention even if it utilizes identical learning resources and facilities since it enhances learning performance of critical and creative thinking skills. The connection between learning motivation and deep learning has also been emphasized by Sunaryati et al. (2023), who found that students in flipped PjBL environments display increased independence and mastery across domains.

The findings are consistent with results Sari et al. (2021) that students' higher order thinking skills, or 6Cs (communication, collaboration, critical thinking, creative thinking, computation skill, and compassion), are considerably enhanced by the Blended Learning model based on Flipped Learning (HOTS). The results of the test on students' critical thinking skills reflect this, ranging from an average of 36.67 to 88.28. In creative thinking skills, the increase is from a mean of 60.77

to 87.18. In communication skills, there is an increase in the mean from 31.28 to 67.69. However, since the mean outcomes were not maximized, a second cycle was also run on this skill and resulted in a mean of 87.38. In team skills, there was an increase from 50.51 to 87.54. In computation skill, the starting mean of 25.90 was boosted to 68.21. Again, since it was not optimal, there was a second cycle done and brought to 90.64. In empathy skill, it rose from 36.28 to 87.56. These improvements validate earlier work by Zainuddin & Attaran (2016), who emphasized how flipped PjBL cultivates motivation, punctuality, and learner responsibility.

In addition, as suggested by research findings Kamaruddin et al. (2022), both the Flipped Learning model and the Project Based Learning (PjBL) approach have a positive impact on students' critical thinking and creative thinking capacities. With the incorporation of both the Flipped Learning model and the PjBL approach, students are able to develop their conceptual development skills as well as their analytical skills. This confirms the importance of using hybrid learning environments to build students' 21st-century competencies (Rahayu et al., 2023).

Moreover, the study results from Sunaryati et al. (2023) indicated that 1) learners instructed using project based flipped learning techniques and traditional teaching methods exhibit varying levels of motivation for English learning and achievement, 2) learners educated through project based flipped learning approaches and conventional instructional strategies possess different motivations for acquiring English skills, and 3) learners who engage with project based flipped learning strategies as opposed to direct teaching demonstrate differing levels of success in English learning, with greater effectiveness noted in project based flipped learning settings. This suggests that flipped PjBL is adaptable and effective across disciplines, including language learning contexts.

The findings of the research indicate that the project based flipped learning approach has a prominent influence on students' willingness to learn English and on their motivation to learn. Therefore, the flipped format combined with project-based instruction methods allows students to become more active while learning at home and in the classroom. This allows them to solve problems and carry out projects utilized to create lesson plans for the Learning Program Planning Course that are essential in instructing campus programs.

It is achievable to increase the process and quality of learning in flipped learning using project-based learning approaches. This practice has the capability of generating a learning context that compels students to utilize all they have learned in order to make choices regarding real world issues the instructor presents. Seven major principles of the contextual model of learning, one being project-based learning as a method, are constructivism, inquiry, questioning, communities of learners, modeling, reflection, and authentic assessment. With this project-based learning technique incorporated

into the flipped learning process, students can apply higher order thinking and integration between disciplines and learn independently and more effectively. By using their own methods of problem solving, expressing ideas, and generating concepts, students are encouraged to participate in class discussions. Lecturers serve as facilitators and learning motivators. Besides, project-based learning coupled with the incorporation of group work approaches can enable students to learn how to initiate, think critically, enhance their social behavior comprehension capacity, and work together while delivering their group work (Ding et al., 2021 & Lo et al., 2017).

CONCLUSION

The findings of the t-test reveal t count = 4.179 and p (Sig = 0.00) ≤ 0.05. This is a demonstration of significant difference in critical and creative thinking skills between students of the flipped learning group who used project-based learning strategies and students of the traditional learning group ($p < 0.05$). Having an average score of 80.2, its application using a project-based learning method fared better than traditional learning using a traditional method that recorded an average score of 74,3.

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