

The Influence of Project-Based Learning (PjBL) on Students' Skills and Creativity in Drawing Network Installation Layouts at PTI UNDIKMA, Indonesia

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Abstract. This study aims to explore the influence of Project-Based Learning (PjBL) on the material of drawing network installation layouts in the PTI Study Program at Mandalika University of Education (UNDIKMA). The research method employed was a one-group pretest-posttest design. The research subjects consisted of 30 PTI students. Data analysis techniques included descriptive data analysis for mean measurement and inferential statistics for testing the significance of the t-test values. The pretest scores for skills and creativity before using PjBL-based Learning were 45.33 and 43, respectively. Post-test scores for skills and creativity after using PjBL-based Learning in drawing network installation layouts were 85 and 85.83, respectively. The difference between pretest and post-test scores, referred to as the gain scores, for skills and creativity were 39 and 41, respectively, with N-gain indices of 0.7, categorised as high. Hypothesis testing using a paired sample t-test for skills and creativity resulted in a two-tailed t-value of 0.000, which is smaller than the alpha value of 0.05, indicating that H_a is accepted. This shows that Project-Based Learning (PjBL) can enhance students' skills and creativity in drawing layouts for the network installation course.

Keywords: PjBL; t-test; Drawing Layouts.

INTRODUCTION

In higher education, particularly in information technology, the importance of practical skills and the ability to apply knowledge in real-world situations is increasingly recognised. Project-Based Learning (PjBL) offers an approach that allows students to actively engage in learning, develop critical skills, and apply theory in practice [1, 4].

Project-based learning has been proven effective in enhancing student learning outcomes across various educational levels. Research indicates that implementing the PjBL model can increase student motivation and engagement, improving learning outcomes [5, 7]. In the context of drawing layouts, PjBL enables students to work in groups, design relevant projects, and produce final products that can be assessed. This aligns with educational objectives, emphasising developing collaborative and critical thinking abilities [8].

In today's digital era, skills in drawing layouts and network installations are becoming increasingly important, especially given the growing demand for skilled professionals in information technology. Through the PjBL approach, students learn how to draw layouts and gain a deeper understanding of the underlying concepts of network installation. This gives them highly valuable practical experience relevant to industry demands [3].

Furthermore, research on PjBL shows that this method can enhance students' critical thinking and problem-solving skills. In the context of drawing layouts, students are expected to analyse the problems encountered in their projects and design effective solutions. This is particularly crucial in the field of information technology, where critical thinking and problem-solving abilities are highly sought-after skills by employers [2].

Thus, this study aims to explore the influence of Project-Based Learning on students' skills in drawing layouts in the network installation course at UNDIKMA. It is hoped that the results will provide valuable insights for curriculum development and teaching methods in the PTI Study Program and contribute positively to improving the quality of education in information technology [6].

Literature review

Definition of PjBL and Steps. Project-based learning (PjBL) is an educational approach emphasising learning through engaging projects, allowing students to explore real-world problems and challenges. Implementing PjBL involves several structured steps that guide educators and students through learning. This synthesis outlines the key steps involved in PjBL and is supported by various scientific references.

The initial step in PjBL is identifying and formulating a project question or problem relevant to the student's interests and curriculum. This step is crucial as it sets the foundation for the entire project and engages students from the beginning [9, 10].

Following this, students are encouraged to conduct preliminary research to gather information related to the project topic, helping them understand the context and scope of the problem they are addressing [10, 11]. Once the problem is defined, the next step involves planning and designing the project. This includes creating a detailed project plan that outlines objectives, schedules, and resources required for successful completion [12, 13].

Educators play a vital role during this phase as facilitators who guide students in developing their project plans and staying focused on the learning objectives [13, 14]. The implementation phase involves students actively working on their projects, including conducting experiments, building prototypes, or preparing presentations. During this phase, ongoing monitoring and support from educators are crucial to keep students on track and address any challenges that may arise [10, 15]. This hands-on approach enhances student engagement and fosters critical thinking and problem-solving skills [16, 17].

Once the project is completed, students present their findings or products to peers, teachers, or the community. This presentation stage is essen-

tial as it allows students to articulate their learning and receive feedback [12, 13]. Finally, the last step involves reflection and evaluation, where students assess their learning experiences and the effectiveness of their projects. This reflective practice is critical for reinforcing the skills and knowledge acquired during the project [13, 17].

In summary, Project-Based Learning involves identifying a project question, conducting preliminary research, planning and designing the project, implementing the project, presenting project results, and reflecting on the learning process. Each step is supported by a robust framework that encourages active learning and critical engagement with real-world issues, ultimately preparing students for future challenges.

PjBL in Drawing Layouts for Network Installation Courses. Project-based learning (PjBL) has emerged as a significant pedagogical approach in various educational contexts, particularly enhancing students' critical thinking, creativity, and collaboration skills. This method is especially relevant in network installation courses, where practical skills and theoretical knowledge must be effectively integrated. Recent studies have highlighted the effectiveness of PjBL in fostering these competencies across educational levels, from primary to higher education.

Integrating PjBL with STEM (Science, Technology, Engineering, and Mathematics) education has enhanced students' critical thinking and problem-solving abilities. For example, Fatimah's research emphasises that PjBL-STEM empowers students' critical thinking skills while engaging them in real-world challenges [18]. Similarly, Anindayati and Wahyudi discuss how the STEM approach, combined with PjBL, prepares students for 21st-century demands by sharpening their mathematical thinking skills [19]. These findings indicate that PjBL facilitates the acquisition of technical skills and nurtures essential cognitive abilities needed for future careers in technology and engineering.

Furthermore, applying PjBL in teaching network installation significantly enhances students' practical skills. Habibi et al. highlight that online project-based learning can produce better outcomes, particularly in specialised fields such as English for Specific Purposes (ESP), which aligns with the technical language needed in network installation courses [20]. This demonstrates that PjBL effectively bridges the gap between theoretical knowledge and practical application, making it

an ideal model for courses requiring hands-on experience.

In addition to improving cognitive skills, PjBL promotes a collaborative learning environment. Yanti's meta-analysis reveals that PjBL has a strong positive effect on students' mathematical abilities, which are crucial in technical fields like network installation, where teamwork is often essential [22]. The collaborative nature of PjBL encourages students to work together on projects, enhancing their communication skills and fostering a sense of community within the classroom.

Moreover, implementing PjBL is beneficial in developing students' metacognitive skills, which are crucial for self-directed learning and problem-solving in technical disciplines. Payoungkiattikun et al. note that PjBL is highly effective in improving the metacognitive skills of pre-service teachers, which can be applied to other fields, including network installation [21]. This indicates that students learn the technical aspects of their field and develop the ability to reflect on their learning processes, a vital skill in any technical career.

In conclusion, substantial evidence supports integrating Project-Based Learning into courses related to network installation. This approach enhances critical thinking, collaboration, and practical skills. As educational institutions continue to adapt to the demands of the 21st century, PjBL stands out as a powerful framework that prepares students for real-world challenges, particularly in technical fields.

METHODOLOGY

Research Approach. This study aims to explore the impact of Project-Based Learning (PjBL) on layout drawing skills in the Network Installation course within the Information Technology Education (PTI) program at the Universitas Pendidikan Mandalika (UNDIKMA). The research method used is a one-group pretest-posttest design, which involves only one group of participants in the study.

The research procedure consisted of several stages. The first stage was the preparation stage, in which the researcher prepared learning materials, including modules on layout drawing and network installation. In addition, research instruments were developed, including a layout drawing skills test used as both a pretest and a post-test. Implementation stage: Pretest: Before

the intervention, all students were given a pre-test to measure their initial skills in layout drawing. Intervention: Students were taught using the PjBL method, where they worked in groups to design and draw a network installation layout based on a real-world project for PTI Room 1, measuring 10.85 x 7.3 meters. Post-test: After the intervention, all students took the same post-test to measure improvements in their skills in drawing the network installation layout for PTI Room 1 with the same dimensions.

Data collected in this study included Pretest and Post-test Scores from the layout drawing skills test conducted before and after the intervention.

Population and Sample. This research's population comprises all Faculty of Science and Technology Education (FSTT) students at UNDIKMA, specifically those enrolled in the Information Technology Education program. The research sample comprises 30 students taking the course Network Installation and Administration.

Research Instruments. This study used instruments to measure the impact of Project-Based Learning (PjBL) on students' skills and creativity in drawing network installation layouts in the PTI program at UNDIKMA. The instruments were tested for validity and reliability beforehand. To ensure the validity and reliability of the instruments, validity and reliability tests were conducted before their application.

Content validity was ensured by involving experts in education and instrument design, while reliability was tested using Cronbach's Alpha method. Previous research emphasises the importance of validity and reliability in developing research instruments to obtain accurate and accountable results [26].

Quantitative Instrument (Questionnaire): The instruments consisted of several main components, namely:

Section I: The drawing skills test was conducted to assess students' ability to draw network installation layouts. This test was administered before and after implementing the PjBL method to measure improvements in students' drawing skills. Previous research shows that the PjBL method can improve students' learning outcomes, including practical skills such as drawing [23]. The test was designed with clear assessment criteria, encompassing technical and aesthetic aspects of drawing. The instrument's blueprint for layout drawing skills used in this research includes:

Table 1 – Blueprint of the Instrument Grid for Diagram Drawing Skills

No	Aspect Assessed	Success Indicators	Score Weight, %
1	Conformity with Technical Specifications	a. The network diagram aligns with the technical specifications (e.g., device positioning, cable length, and proper connectors) b. Correct selection of network symbols and devices (such as switches, routers, and cables)	20
2	Accuracy in Scale Usage	a. Use a scale appropriate to the room dimensions and desired network installation. b. The spacing between devices in the diagram corresponds to the actual dimensions	15
3	Neatness and Precision	a. Lines in the diagram are neat, non-overlapping, and follow a clear path b. Devices and labels are arranged systematically and are easy to read	20
4	Completeness of Information	a. The diagram includes all necessary devices for network installation (such as computers, switches, routers, and cables) b. Clear labelling or markings on devices and connection paths	25
5	Creativity and Innovation	a. Presence of innovative ideas in arranging the network layout for efficiency or ease of maintenance b. Use of symbols or colour codes to facilitate interpretation	10
6	Timeliness	Ability to complete the network diagram within the given timeframe	10

Section II: The creativity instrument evaluates various aspects of students' creativity, including divergent thinking skills, innovation ability, and the capacity to connect different ideas. Research indicates that Project-Based Learning (PjBL) can enhance students' creativity by providing opportunities for exploration and the application of

new ideas in the projects they work on [24, 25]. This instrument also includes questions about students' motivation and self-confidence in completing creative tasks, which are crucial to developing creativity [27]. Below is the blueprint of the creativity instrument for drawing network installation diagrams, which includes:

Table 2 – Blueprint of Creative Thinking Instrument in Drawing Network Installation Layouts

No	Indicator Assessed	Aspect Assessed	Success Indicator	Score Weight, %
1	Flexibility	The ability to use various approaches and techniques in drawing network installation diagrams	Demonstrates variation in ideas, diagram structures, or network layouts	20
2	Originality	The ability to create unique and uncommon network diagram designs	Emergence of unique and novel ideas in the diagram, differing from standard designs	15
3	Adaptability (Flexibility of Thought)	The ability to modify and adjust diagrams according to changing network needs	Ability to adapt the diagram when specifications or requirements change	15
4	Detail and Accuracy	Accuracy in depicting network components (switches, routers, cables, etc.) and their connections	Detailed representation of network elements and their interconnections	20
5	Fluency (Idea Flow)	Smoothness in developing network ideas systematically	A wealth of ideas and components is displayed in the diagram without compromising readability	15
6	Critical Evaluation	The ability to reassess installation designs to ensure efficiency and effectiveness	Displays critical thinking in improving or clarifying inefficient parts	15

Data Collection Techniques. In this study, data collection techniques are carried out through tests of two main types: skills tests and creativity tests for drawing network installations. The skills test measures students' technical abilities in drawing network installation diagrams according to the specifications. Through this test, the researcher can assess how accurately students can represent network elements, such as devices, cables, and connections between devices, in compliance with the established technical standards. These skills are crucial to ensure the network installation is done correctly and efficiently. In addition, the creativity test for drawing network installations is designed to evaluate students' ability to generate new and unique ideas in designing network layouts. This test assesses technical aspects and students' ability to think innovatively when creating a network design that is efficient and easy to maintain. The creativity test includes evaluating flexibility, originality, and adaptability in designing networks that can be adjusted to changing or evolving needs. Both tests provide a comprehensive picture of students' technical skills and creativity in designing and drawing network installations.

Data Analysis. The data analysis technique used in this study combines descriptive data analysis for measuring averages and inferential statistics for testing the significance of the t-test values. The significance of the N-gain value (categorised according to Table 3) is tested using a paired samples t-test with an alpha of 0.05, and the results are used to interpret the extent of students' skills in drawing network installation layouts in PTI.

The N-gain score criteria are a measurement tool used to assess the effectiveness of Learning by comparing students' pretest and post-test results. N-gain provides an overview of how much students' abilities have improved after following a particular learning method. In this context, N-gain is calculated using a standard formula commonly used in educational research, and the results are grouped into three criteria: low, medium, and high. First, to calculate N-gain, the formula used is:

$$g = \frac{(\text{posttest} - \text{pretest})}{(\text{maximumscore} - \text{pretest})} \quad (1)$$

The N-gain formula represents the N-gain value, which indicates improving students' abilities

after participating in the learning process. The post-test refers to the score obtained by students after the learning intervention, reflecting their knowledge or skills after the instructional method has been applied. The pretest indicates the score achieved before the learning begins, serving as a baseline measurement of the student's initial abilities. The maximum score is the highest that can be achieved [28, 29]. The results of the N-gain calculation are then classified as follows:

Table 3 – Criteria for N-gain Score Acquisition

N-gain	Criteria
$0.0 < g < 0.3$	Low
$0.3 \leq g < 0.7$	Medium
$0.7 \leq g \leq 1.0$	High

These criteria clearly show how effectively a learning method improves students' abilities. For example, a study conducted by Wahab et al. found that using N-gain in statistics learning showed that the average N-gain of students was in the medium category, indicating a significant improvement in their understanding of the material [30]. Additionally, other studies indicate that N-gain can be used to evaluate various learning methods, such as project-based learning and problem-based learning, which have been proven effective in enhancing students' critical thinking skills [31, 32]. In this context, N-gain is an evaluation tool that indicates success in achieving established learning objectives. Overall, N-gain scoring criteria are a highly useful tool in education for assessing learning effectiveness and providing constructive feedback for developing better teaching methods in the future.

Based on prerequisite tests, using the paired sample t-test, the significance of gaining skills in drawing network installation layouts can be determined through hypothesis testing, which can be calculated using Microsoft Office Excel for Windows. The hypothesis test is stated as follows:

H0: Project-based learning cannot improve skills and creativity in drawing layouts in the network installation course.

H1: Project-based learning can improve skills and creativity in drawing layouts in the network installation course. H_a is accepted if the two-tailed (t) value is smaller than the alpha value 0.05.

RESULTS AND DISCUSSION

The pretest scores for skills and creativity before using PjBL were 45.33 and 43, respectively. The post-test scores for skills and creativity, obtained after implementing PjBL in drawing network installation layouts, were 85 and 85.83, respectively. The difference between the pretest and post-test scores, the gain score, was 39 and 41 for skills and creativity, respectively. The gain index (N-gain) for both skills and creativity resulted in an identical score of 0.7, which falls into the high category. This indicates that PjBL significantly impacts the skills required for drawing network installation layouts, as illustrated in Figure 1 below.

In hypothesis testing, using the t-test (paired sample t-test) with the help of Microsoft Office Excel for Windows, the t-values for skills and creativity were found to be 0.000 and 0.000, respectively, smaller than the alpha value of 0.05, as shown in Table 4 below. This indicates that the

alternative hypothesis (H_a) is accepted, meaning that PjBL can improve skills and creativity in drawing network layout plans in the network installation course.

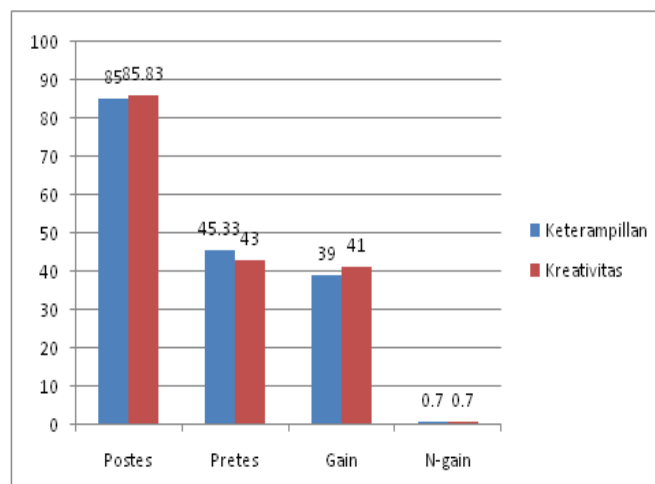


Figure 1 – Analysis Results of Skills and Creativity

Table 4 – T-Test: Paired Two Sample for Means

	Postes	Pretes	Postes	Pretes
Mean	8.433333333	4.533333	8.4	4.3
Variance	0.667816092	0.878161	0.731034483	0.975862
Observations	30	30	30	30
Pearson Correlation	0.273172289		0.628723325	
Hypothesised Mean Difference	0		0	
Df	29		29	
t Stat	20.11640437		27.96550587	
P(T<=t) one-tail	0.00000000		0.00000000	
t Critical one-tail	1.699126996		1.699126996	
P(T<=t) two-tail	0.000000000		0.00000000	
t Critical two-tail	2.045229611		2.045229611	

Project-based learning (PjBL) has become one of the most effective methods for enhancing students' skills, especially in information technology education. In the network installation course, particularly in drawing layout plans, PjBL provides students with opportunities to apply their theoretical knowledge in practical situations. This is crucial, considering that the ability to draw layout plans and perform network installations are key competencies required in the professional world.

Project-Based Learning (PjBL) encourages students to actively learn by designing, implementing, and evaluating relevant projects. In the context of drawing layout plans, students can be assigned tasks to design network installation layouts for specific rooms or buildings. This project

involves technical drawing skills and requires an understanding of network concepts, such as hardware selection, network topology, and user requirements. Research indicates that PjBL can increase student motivation and engagement, improving learning outcomes [33, 34].

One of the main advantages of PjBL is its ability to enhance students' practical skills. A study conducted by Kaharudin found that project-based learning significantly improved students' critical thinking abilities [33]. In this regard, students learn to draw layout plans and understand how these layouts function in network installation. This aligns with studies showing that project-based learning can improve student learning outcomes and practical skills [34].

In addition to technical skills, PjBL also contributes to developing students' creativity. Group-based projects encourage students to think creatively and produce innovative solutions to problems encountered during their projects. Research shows that PjBL can enhance students' creativity through activities requiring critical and innovative thinking [35, 37]. In drawing network installation layouts, students are encouraged to design functional and aesthetically pleasing solutions, improving their ability to create unique and attractive work.

PjBL also promotes collaboration among students. In layout drawing projects, students must collaborate, share ideas, and solve problems collectively. Research indicates that collaborative skills are crucial in the workplace, where many projects require teamwork. Therefore, PjBL enhances students' technical, social and communication skills needed for success in professional environments [39, 40].

Evaluation in PjBL is often formative, where students receive feedback throughout the learning process. This allows them to make improvements and adjustments before completing their final project. Constructive feedback can enhance students' understanding of the material and help them identify areas for improvement. In drawing layouts, feedback from lecturers or peers can assist students in recognising mistakes and refining their skills [41, 42].

Despite the many benefits of PjBL, some challenges need to be addressed. One major challenge is the time required to complete the projects. Students often feel pressured by tight deadlines, especially when projects involve many

technical details. Therefore, lecturers must plan projects carefully, provide clear guidance, and ensure students have sufficient resources to complete their tasks (36)(38).

CONCLUSIONS

This study aims to explore the impact of Project-Based Learning (PjBL) on layout drawing skills in the Network Installation course within the Information Technology Education (PTI) Study Program at Universitas Pendidikan Mandalika (UNDIKMA). Based on the analysis and discussion conducted, it can be concluded that the alternative hypothesis (H_a) is accepted, indicating that Project-Based Learning can improve layout drawing skills in the Network Installation course.

PjBL encourages students to actively engage in the learning process, which contributes to increased motivation and involvement. This aligns with research showing that project-based learning models can enhance students' learning motivation. Students feel more motivated to learn and contribute to group projects by assigning relevant and real-world tasks.

PjBL has also proven effective in improving students' practical skills. Through layout drawing projects, students learn and apply theory in real-world contexts. Research indicates that project-based learning can enhance critical thinking abilities and problem-solving skills, which are crucial in information technology. Thus, students can develop more holistic skills and be better prepared to face challenges in the professional world.

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