

Project-Based Learning in Microprocessor Systems Courses to Improve the Competencies of Computer Technology Students

Sururi¹, Muhamad Hilmansyah Susanta²

¹Politeknik Pajajaran ICB Bandung; sururi@poljan.ac.id

² Politeknik Pajajaran ICB Bandung; muhamad.hilmansyah@poljan.ac.id

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ABSTRACT

This study aimed to describe the implementation of Project-Based Learning (PjBL) in the Microprocessor Systems course to enhance the competencies of Computer Technology students through the development of an Arduino Uno-based traffic light project. The study employed a descriptive approach by implementing PjBL activities involving project planning, circuit design, programming, testing, and project presentation. The participants were Computer Technology students enrolled in the Microprocessor Systems course. The project utilized Arduino Uno as the main controller integrated with light-emitting diodes (LEDs), resistors, breadboards, and jumper wires to simulate a traffic light system. Data were collected through observation, project assessment, and documentation of learning activities. The assessment focused on students' abilities in circuit assembly, programming, system functionality, teamwork, and presentation skills. The findings indicated that students actively participated throughout the learning process and successfully completed the assigned projects. The implementation of PjBL not only improved students' understanding of microprocessor concepts and applications but also fostered technical competencies, problem-solving skills, collaboration, communication, and critical thinking. Therefore, Project-Based Learning using Arduino Uno can be considered an effective instructional strategy for supporting competency-based learning and preparing Computer Technology students to meet the demands of current technological developments and industry needs.

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Corresponding Author:

sururi

Politeknik Pajajaran ICB Bandung, sururi@poljan.ac.id

INTRODUCTION

The rapid advancement of technology in the era of the Industrial Revolution 4.0 requires higher education institutions to produce graduates who not only possess strong theoretical knowledge but also demonstrate 21st-century skills, including critical thinking, creativity, communication, collaboration, and problem-solving abilities. Therefore, the learning process in higher education should be directed toward a student-centered learning approach to develop competencies that align with the demands of the workforce and ongoing technological advancements (Fatimah et al., 2024).

One of the core courses in the Computer Technology Study Program that plays a significant role in developing these competencies is the Microprocessor Systems course. This course equips students with the ability to understand microprocessor architecture, programming techniques, input-output interfacing, and the implementation of embedded systems in various applications. However, the teaching of Microprocessor Systems is often still dominated by conventional lecture-based methods, resulting in passive student participation and difficulties in connecting theoretical concepts with practical applications. Consequently, the development of more contextual learning media and instructional tools is essential to help students understand the integration of microprocessor technology with real-world needs and applications (Isnaini et al., 2025).

One alternative instructional model that can be implemented to address these challenges is Project-Based Learning (PjBL). This model places projects at the center of the learning process, enabling students to gain meaningful learning experiences through the stages of planning, implementation, testing, and evaluation of the products they develop. Research conducted by Lesmana and Jaedun (2015) demonstrated that the implementation of PjBL effectively improves student learning outcomes because students actively engage in completing project-based tasks related to their field of expertise.

The effectiveness of Project-Based Learning has also been demonstrated in electronics education. Najamuddin and Wahrini (2024) reported that the implementation of the PjBL model in the Microprocessor Systems course within the Electronics Engineering Study Program, Faculty of Engineering, Universitas Negeri Makassar, had a positive impact on students' learning outcomes. Students became more actively involved in the learning process, found it easier to understand microprocessor concepts through hands-on practice, and were able to complete assigned projects more independently and systematically.

In addition to improving academic achievement, the implementation of PjBL can also foster the development of students' non-technical competencies. Fatimah et al. (2024) stated that integrating Project-Based Learning into instructional activities enhances students' competencies by promoting teamwork, communication skills,

responsibility, and decision-making abilities. These competencies are essential skills required of Computer Technology graduates to successfully face the increasingly dynamic challenges of the industrial sector.

Based on the discussion above, the implementation of Project-Based Learning in the Microprocessor Systems course is considered a promising instructional strategy for enhancing the competencies of Computer Technology students. Through active involvement in designing and completing microprocessor-based projects, students are expected not only to understand theoretical concepts but also to be capable of implementing, testing, and evaluating microprocessor-based systems in accordance with industry requirements. Therefore, this article aims to examine the implementation of Project-Based Learning in Microprocessor Systems instruction as an effort to improve the competencies of Computer Technology students.

METHODS

This study employed a descriptive method with an implementation approach to describe the application of the Project-Based Learning (PjBL) model in the Microprocessor Systems course through the development of an Arduino Uno-based project. The descriptive method was used to illustrate the learning process, the stages of project implementation, and the project outcomes produced by Computer Technology students (Arikunto, 2019).

The study was conducted with students of the Computer Technology Study Program who were enrolled in the Microprocessor Systems course during the even semester of the 2025/2026 academic year. The learning activities were carried out in groups, with each group consisting of 3–5 students.

The learning process followed the Project-Based Learning syntax, which included: (1) identifying the problem or project to be completed; (2) planning the project; (3) developing an implementation schedule; (4) carrying out the project; (5) testing and presenting the project outcomes; and (6) evaluating both the learning process and the project results (Kokotsaki et al., 2016).

The project developed in this study was a simple Arduino Uno-based traffic light system. Students designed the circuit using an Arduino Uno board, red, yellow, and green LEDs, resistors, a breadboard, and jumper wires. They then developed the program using the Arduino IDE, uploaded the code to the Arduino Uno board, and conducted testing to ensure that the system functioned according to the intended design.

The research data were collected through classroom observations during the learning process, activity documentation, and assessments of students' project outcomes. The assessment aspects included circuit assembly skills, programming accuracy, functionality of the developed device, teamwork within the group, and the ability to present the project results.

The collected data were analyzed descriptively by describing the implementation of the learning activities and the project outcomes achieved by the students. The results of the analysis were used to provide an overview of the implementation of Project-Based Learning using Arduino Uno in supporting Microprocessor Systems learning among Computer Technology students.

RESULTS AND DISCUSSION

1. Result

The Microprocessor Systems course based on Project-Based Learning (PjBL) was implemented through the development of a simple traffic light project using Arduino Uno. The students were divided into six groups, each consisting of 3–5 members. Each group was responsible for designing the circuit, developing the program using Arduino IDE, conducting system testing, and presenting the completed project.

The developed project consisted of an Arduino Uno as the main controller, red, yellow, and green LEDs as a traffic light simulation, resistors, a breadboard, and jumper wires. The students independently carried out the design and system testing processes under the guidance of the lecturer.

The assessment was conducted based on four aspects: circuit assembly skills, programming skills, device functionality, and project presentation.

Table 1. Project Assessment Results

Group	Circuit Assembly	Programming	Device Functionality	Presentation	Final Score
K1	85	82	90	84	85.25
K2	90	88	92	86	89.00
K3	80	78	85	80	80.75
K4	88	85	88	82	85.75
K5	92	90	94	90	91.50
K6	86	84	89	85	86.00

Based on the assessment results, Group K5 achieved the highest score of 91.50, while Group K3 obtained the lowest score of 80.75. In general, all groups were able to complete the project with good performance.

2. Discussion

The implementation results indicate that the application of Project-Based Learning enhanced student engagement throughout the learning process. Students not only learned microprocessor concepts theoretically but also gained hands-on

experience through designing, programming, and testing Arduino Uno-based systems.

The device functionality aspect obtained the highest average score compared to the other assessment aspects. This finding suggests that most students were able to develop projects that functioned according to their intended designs. However, the programming aspect still requires improvement, as some students experienced difficulties in developing program logic and performing debugging processes.

The project presentation activities also had a positive impact on students' communication and teamwork skills. Students became more confident in explaining the development process of the device, discussing the challenges encountered, and describing the solutions implemented during the project development process.

Overall, the implementation of Project-Based Learning using Arduino Uno can serve as an effective alternative instructional approach in the Microprocessor Systems course, as it is capable of integrating the cognitive, psychomotor, and affective competencies of Computer Technology students.

CONCLUSION

The implementation of Project-Based Learning (PjBL) in the Microprocessor Systems course through the development of an Arduino Uno-based traffic light project provided students with practical learning experiences that integrated theoretical knowledge and hands-on skills. Throughout the project activities, students were actively involved in designing electronic circuits, developing program codes, testing system functionality, and presenting project outcomes. The results indicated that students were able to successfully complete the project and demonstrate a good understanding of microprocessor concepts and applications.

Furthermore, the use of Project-Based Learning contributed to the improvement of both technical and non-technical competencies among Computer Technology students. In addition to enhancing circuit assembly and programming skills, the learning model fostered collaboration, communication, problem-solving, and critical thinking abilities. Therefore, Project-Based Learning using Arduino Uno can be considered an effective instructional approach for supporting competency-based learning and preparing students to meet the demands of modern technology and industry.

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