Applying Problem Based Learning in Electronic Engineering Project Design

Mohd Amir Hamzah Bin Ab Ghani*, Mohamad Iman Syahmi Bin Mohd Safarin, Nur Idawati Binti Md Enzai, Norhayati Binti Ahmad

Faculty of Electrical Engineering, Universiti Teknologi MARA Terengganu Branch Dungun Campus

***Corresponding Author**

DOI: https://dx.doi.org/10.47772/IJRISS.2025.924ILEIID0075

Received: 23 September 2025; Accepted: 30 September 2025; Published: 01 November 2025

ABSTRACT

This paper discussed the design and development through Problem-Based Learning (PBL) framework for Electrical Engineering student's Final Year Project (FYP) titled Buzz Wire Arduino Arcade Game. The aim was to apply the theoretical concept learned in class into actual practice by way of PBL. The project began with problem identification, recognizing the lack of arcade games that combine entertainment with therapeutic benefits. Knowledge acquisition involved reviewing related technologies and psychomotor training methods to establish design requirements. During solution development, the system was prototyped using related software and hardware components to deliver engaging gameplay while monitoring biometric signals such as heart rate. Testing and evaluation were conducted through iterative experiments, leading to refinements such as vibration feedback and wireless data visualization. Finally, reflection enabled the designer to assess outcomes, demonstrating that the developed game achieves the desired objectives. The study highlights how applying the PBL cycle encourage problem-solving, critical thinking, and innovation in electronic engineering design.

Keywords: (Problem-Based Learning, Electronic, Engineering Education, Game, Arduino)

INTRODUCTION

In today's fast-paced world, people rarely train their mental and physical coordination, and many recreational activities do not enhance these abilities. This project addresses this gap by employing a problem-based learning (PBL) approach, wherein learners engage in hands-on challenges designed to improve psychomotor skills, specifically hand-eye coordination and motor control. Drawing inspiration from traditional buzz wire games, this adaptation uses currently available technology such as Arduino microcontroller systems and real-time data monitoring helps create an interactive learning environment.

The core problem-solving task involves guiding a metal ring along a wire course without making physical contact, with immediate feedback provided via LEDs, a buzzer, and a timer. This setup encourages iterative learning and self-assessment, key principles in PBL. The integration of a MAX30102 sensor allows real-time monitoring and display of biometric data like heart rate or SpO2 levels, adding a health-monitoring aspect. The use of OLED displays, and wireless data communication further enhances the project's educational value by visualizing data and enable remote monitoring.

The project exemplifies problem-based learning by challenging students to design, build, and refine a system that combine fun and functionality. The Buzz Wire Arduino Arcade Game not only offers entertainment but also serves as a tool for psychomotor therapy and precise movement training, making it applicable in therapeutic, educational, and recreational. This interdisciplinary approach promotes critical thinking, collaboration, and technical skills that is important for engineering education and real-world problem solving.

LITERATURE REVIEW

This literature review will combine current research generally on the use of Project-Based Learning (PBL) approach in multiple studies that is focuses on higher education and engineering students.

Husin et al. (2025) researched on Project-Based Problem Learning (PBPL) in higher education engineering found that PBPL improves problem-solving skills, critical thinking, and teamwork among engineering students while stating that the method actively engages students in collaborative, real-world problem scenarios that enhance their ability to analyze, design, and execute engineering solutions. All the mentioned traits are important for student to get ready for professional world. Students reported increased motivation and appreciation for the hands-on learning experience.

Chen, Kolmos, and Du (2025) compared engineering students' perceptions of a Problem and Project-Based Learning (PBL) module delivered via face-to-face and online. The study found that while teamwork satisfaction and collaboration were high in both methods, online delivery had unique factors impacting the learning experience. The study highlights the growing need for flexible, active, student-centered learning strategies in engineering education. It will prepare students for working industry that requires problem-solving and design competencies.

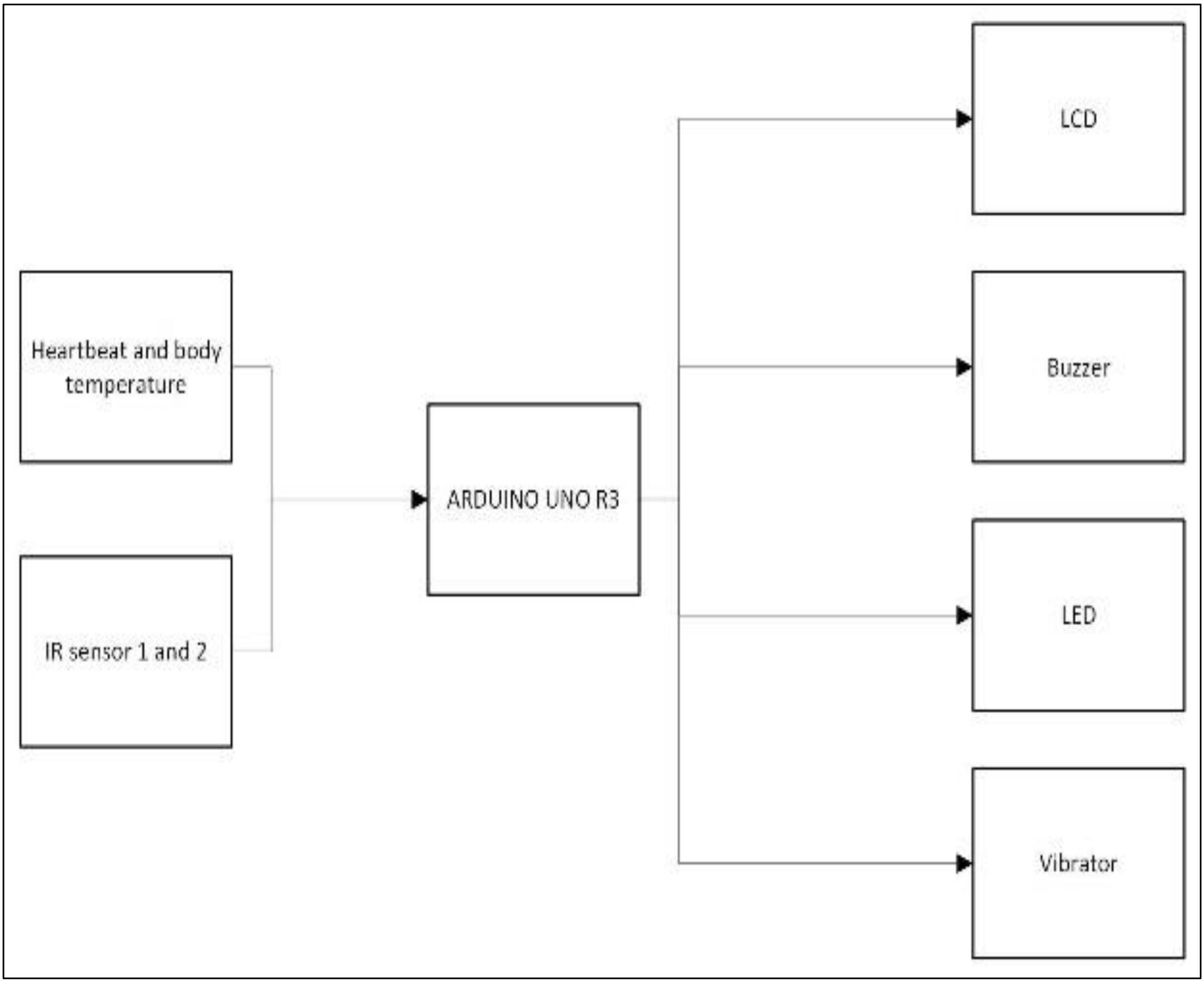

Figure 1 Block diagram of the system.

Rahim and Mahmud (2025) reviewed the integration of the Engineering Design Process (EDP) into STEM classrooms and in doing so revealed that embedding EDP improves critical engineering competencies such as creativity, design thinking, and real-world problem solving. Wei (2023) investigated Design-Based Engineering Learning (DBEL), in which engineering students engage in design activities. It helps by promoting conceptual understanding and skill development. The research highlights DBEL's effectiveness to mirror real engineering tasks, cultivate creativity in designing, problem-solving ability, and teamwork, which all are critical for preparing students that's aiming for engineering careers.

Colmenares-Quintero (2023) studied the use of problem-based learning combined with design thinking to develop renewable energy engineering skills. The study demonstrates that PBL enhances students' practical and analytical skills tailored to engineering fields and increase their readiness for industry in renewable energy sectors through collaborative and innovative problem solving.

Each paper focuses on active learning techniques that exposed engineering students in real-world problem solving, design processes while including collaborative teamwork. The results reflect a positive outcome that can helps contribute to a healthy engineering practice.

METHODOLOGY

The project development can be separated into two sections, hardware and software. The initial development usually starts from design and simulation testing. Figure 1 illustrate the overall visualization of the system showing the flow of two inputs and four outputs with microcontroller ARDUINO UNO R3 act as the main data processor. The block diagram was created based on the design of the overall system that requires heartbeat sensor and movement sensors as its input. The input used is the value of the recorded heartbeat and body temperature in addition to IR sensors that detects starting and ending of the buzz game. Modification was made during hardware testing phase to the starting and finishing point detection system, whereby the PIR sensors were replaced with IR sensors, as the latter provide faster detection and greater practicality.

The Buzz Wire Arduino Arcade Game operates by integrating many electronic components to create a functional and interactive gaming experience. Figure 2 shows the simulation flowchart of the gameplay where the sensors detection triggers other components such as the LED, LCD and buzzer to operate accordingly. The heartbeat sensor is continuously recording data and constantly giving the information in desired parameters which is BPM, AVG BPM and TEMP. It should be noted that the sensors shown in Figure 2 are the IR sensors implemented in the final hardware prototype.

This interactive game begins with a system initialization where all components are activated and ready. Then, the player is prompted to place their finger on the heartbeat sensor. The challenge officially starts when the player's metal ring triggers the first IR sensor, which simultaneously begins the timer and enable the real-time monitoring of the player's heartbeat (BPM), average BPM and temperature.

The main gameplay requires the player to carefully guide the ring along the wire course without making contact; a single touch before finishing the game course immediately triggers a failure sequence which is activating the buzzer, red LED, and vibration motor. It will force players to restart the game.

Successful navigation of the entire course is confirmed when the ring triggers the second IR sensor at the finish line, which stops the timer, concludes the game, and displays the final time recorded, heart rate data, and a success message displayed on the LCD. A pushbutton is available to allows the system to be fully reset for the next player.

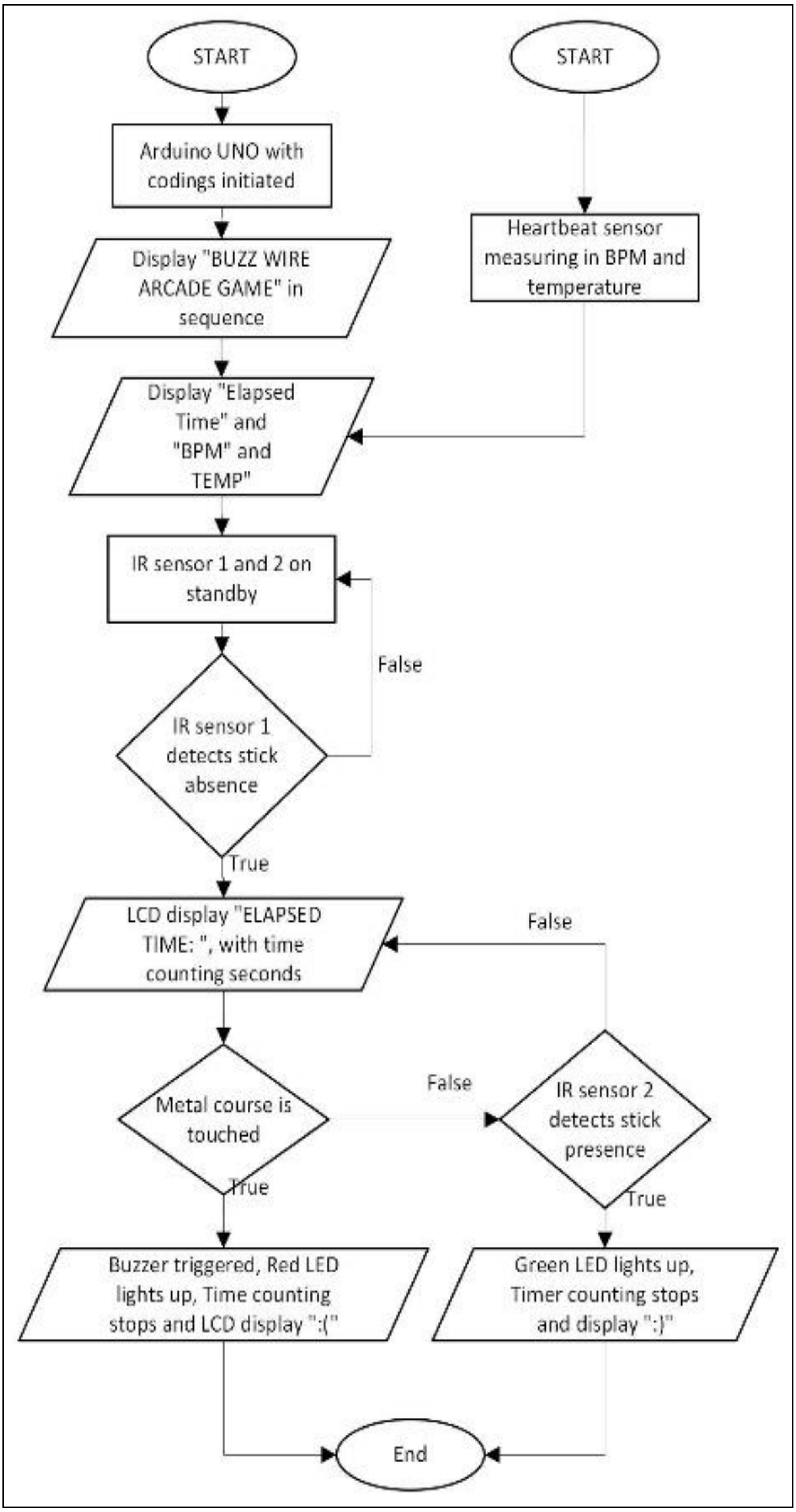

Figure 2 Flowchart of the system

RESULTS AND DISCUSSION

Simulation Result

Figure 3 shows the components are all connected and function accordingly in the simulation software. When the power is turned ON, the Arduino Uno R3 is initiated and all sensor is on standby, with LCD displaying "TIMER". The potentiometer is used to control the backlights of the LCD since non I2C integrated LCD is used here. Few of the resistor is also connected series with components like LEDs to avoid damaging the components.

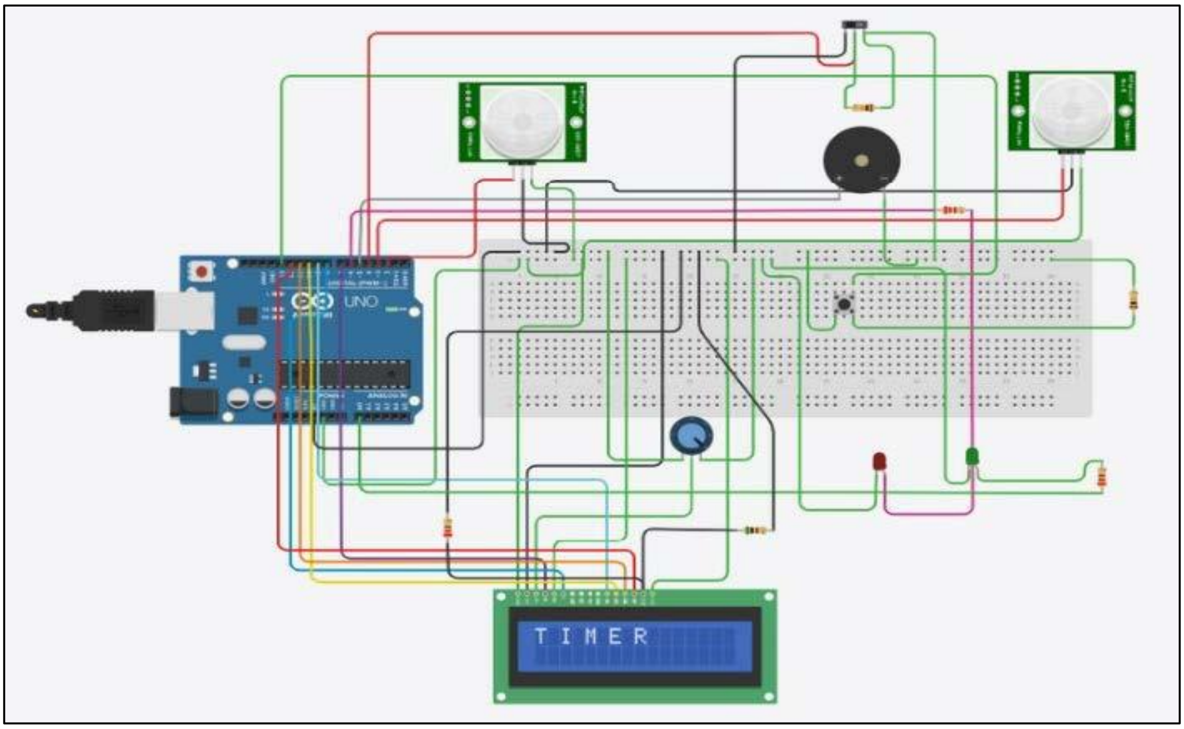

Figure 3 Simulation circuit turned ON

It should be noted that the shown simulation circuit in Figure 3 utilized PIR sensor; however, in the final hardware implementation, it was replaced with IR sensor as discussed in the methodology section of this paper. A pushbutton was used to reset the timer, but triggering the first starting PIR sensor again will also automatically reset the timer. During this early development, the heartbeat data implementation was not applied.

Hardware Result

The prototype design is made from different materials such as plywood, cooper wire, aluminium rod, PVC pipe with supporting components to suits the idea of the projects. Additional power button and mute button is also added for the purpose of practical arcade centre functionality. The power supply is using 12V power adapter, attained from the AC outlet through the input jack of the Arduino Uno R3. Since the power only need 5V voltage operation, the Arduino itself has already integrated with voltage regulator.

Figure 4 shows the final prototype of the system. Heartbeat monitoring system was an improvement made when reaching the prototype phase, as to enhance its practical value and provide real-time physiological feedback to players. By integrating the MAX30102 heartbeat sensor, the game not only offers a fun and engaging experience but also serves as a tool for monitoring and improving the player's physical and mental well-being by making aware of the current state of the body. The system allows players to track their heart rate (BPM), average BPM, and temperature during gameplay, making it particularly useful for rehabilitation or motor skills therapy sessions. This feature helps players understand how their stress or concentration levels affect their physiological state in which encouraging relaxation and focus. In addition, it introduced players to the concept of biofeedback in a practical and interactive manner.

Figure 4 The final prototype of Buzz Wire Arduino Arcade Game

Optimum grip of the clipping force that holds the MAX30102 sensor allows a good data result of BPM, Average BPM, and temperature. The data can be obtained accurately with slight of noise detected. Average human beats per minutes is ranged between value 60-120, depending on the stress experienced. For this project, it is implemented where the buzzer will also make sound corresponding to how high the BPM value is, the higher the BPM value, the faster and higher the frequencies of the buzzer sound will be produced.

CONCLUSION

In conclusion, the Buzz Wire Arduino Arcade Game project serves as an example of Problem-Based Learning (PBL) in action. The project was initialized by a complex problem: the need for an engaging system that could at the same time improve psychomotor skills whilst providing entertainment and it also offers basic physiological monitoring. To solve this problem, the process required the integration of electronic sensors and microcontroller programming. The development starts from theoretical knowledge to practical application. The MAX30102 sensor, for instance, was not just studied but implemented to provide real-time feedback. Furthermore, the hands-on challenge of interfacing and coding components like the Arduino Uno R3, IR sensors, and LCD display encourage critical problem-solving skills as issues like timing accuracy and system reliability were debugged and solved.

Overall, this project demonstrates how a problem-based approach drives meaningful learning that has resulted in a practical output. The need to develop a functional prototype from the ground up required research, design thinking, and testing, which are the core elements of PBL. While the current finished product meets its initial goals, the process of its development identifies future challenges, such as implementing wireless communication or multiple gameplay modes. This PBL helps creates a foundation for innovation and practical skill development which is relevant in real-world settings.

ACKNOWLEDGEMENTS

I would like to express my gratitude and appreciation to all those who have supported and help throughout the process of completing this paper. Many thanks to all writers and colleagues.

REFERENCES

1. Chen, J., Kolmos, A., & Du, X. (2025). Engineering students' perceptions of problem and project-based learning (PBL) in online and face-to-face environments. Journal of Engineering Education, Advance online publication.
2. Colmenares-Quintero, R. F. (2023). Problem based learning and design thinking to develop renewable energy engineers' skills. Cogent Engineering, 10(1).
3. Husin, M., Usmeldi, U., Masdi, H., Simatupang, W., Fadhilah, F., & Hendriyani, Y. (2025). Project-based problem learning: Improving problem-solving skills in higher education engineering students. International Journal of Sociology of Education, 14(1), 62–84.
4. Rahim, R. A., & Mahmud, S. N. D. (2025). Integrating the engineering design process (EDP) in STEM classroom: A systematic literature review of impacts and challenges. STEM Education Journal, 12(3).
5. Wei, L. (2023). The study of the effectiveness of design-based engineering learning (DBEL). Frontiers in Psychology, 14, Article 1151610.