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Hands-on Learning: Assessing the Impact of a Mobile Robot Platform in Engineering Learning Environments

Adrian Suarez [1,*], Daniel García-Costa [2,*], Joaquin Perez [1], Emilia López-Iñesta [3], Francisco Grimaldo [2] and Jose Torres [1]

[1] Department of Electronic Engineering, Universitat de València, Av. de la Universitat s/n, 46100 Burjassot, Spain; jose.torres@uv.es (J.T.)
[2] Computer Science Department, Universitat de València, Av. de la Universitat s/n, 46100 Burjassot, Spain
[3] Department of Didactics of Mathematics, Universitat de València, Av. Tarongers 4, 46022 Valencia, Spain
* Correspondence: adrian.suarez@uv.es (A.S.); daniel.garcia@uv.es (D.G.-C.)

Abstract: As the world continues to change and evolve, students must acquire a diverse set of competencies and skills that focus on sustainability. This term extends beyond environmental matters, encompassing educational aspects, such as critical thinking, communication, creativity, collaboration, and problem solving, all of which are crucial components. In order to promote these aspects in an engineering learning environment, using educational tools that emulate real-life tasks related to students' future careers can significantly boost their motivation. It could be worth considering the integration of teaching techniques that align more closely with the professional work of engineering. By embracing this pedagogical approach, educators can empower students, contributing to the advancement of science and technology. The field of programming embedded or integrated systems presents numerous professional opportunities for students of Telecommunications and Electronics Engineering degrees. An embedded systems engineer is a specialized professional responsible for co-designing electronic devices based on a processor. This contribution analyzes the impact of introducing a mobile robot platform as a cutting-edge teaching approach that merges problem-based learning (PBL) with hands-on learning. The platform's main features include robustness in reducing interconnection problems and the possibility of co-designing projects with multiple integrated sensors and actuators. This learning tool makes it possible for students to work with a professional embedded system that they can find in their future careers. Hence, assessing the impact of this learning strategy using the robot and how students perceive it to enhance their professional skills is fundamental. This evaluation compares students' experiences in previous subjects with the learning approach proposed in this research that intends to support students to prepare them more effectively for transitioning to professional life. The evaluation involves a previous and post-questionnaire that examines three dimensions: energy, absorption, and dedication. Based on the findings, it can be concluded that the general satisfaction item showed the highest growth rate (1.05 out of 5.00) and the best score in the post-questionnaire. This indicates that, overall, the students evaluated the impact of using the learning strategy described positively. After completing the learning experience, the dimension of dedication showed the highest increase (0.73 out of 5.00) among all three dimensions.

Keywords: hands-on learning; learning by doing; engineering learning environments; problem-based learning (PBL); professional skills; embedded systems; sustainable education

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1. Introduction

Experiential learning has long been recognized as a powerful pedagogical approach that promotes active engagement and knowledge construction among students [1–3]. Learning by doing, as a prominent subset of experiential learning, emphasizes the value of practical, hands-on experiences in the learning process. This approach fosters deeper understanding and critical thinking skills by actively engaging students in real-world tasks and problem-solving scenarios, encouraging students to connect theoretical knowledge with practical application [4]. The concept of learning by doing is rooted in the works of influential educational theorists. John Dewey's experiential learning theory highlights the importance of learning through direct experiences, where students actively participate in their education, construct knowledge, and develop skills through reflection [1]. Jean Piaget's constructivist theory underscores the significance of hands-on experiences in cognitive development, where learners actively construct their understanding through interactions with their environment [2]. According to David Kolb's theory of experiential learning, there are four stages in the learning cycle. These stages are focused on concrete experience, reflective observation, abstract conceptualization, and active experimentation [3].

Numerous recent studies have provided empirical evidence supporting the effectiveness of learning by doing in STEM education. Research findings indicate that students engaged in experiential learning activities exhibit higher levels of motivation, problem-solving abilities, and knowledge retention than those taught using traditional instructional methods [5–7]. In a global and changing environment, students are required to develop different competencies and skills related to sustainability. This term goes beyond environmental considerations, including educational dimensions, where critical thinking, communication, creativity, collaboration, and problem-solving competence are essential aspects [7]. In this sense, project-based learning initiatives, internships, and apprenticeship programs are exemplary embodiments of learning by doing, enabling students to apply theoretical concepts in real-world contexts, leading to enhanced learning outcomes [8–11] in a long-term and sustainable way.

Implementing learning-by-doing strategies within the curricula presents both challenges and opportunities for professors. Thereby, it is possible to integrate hands-on activities, lab experiments, and interactive projects to create an immersive learning environment that fosters curiosity and creativity among students [12]. Furthermore, incorporating industry collaborations and practical experiences can help students reduce the gap between academia and the professional environment, preparing them for successful careers in STEM fields [13]. At all levels of education, including universities, there has been an increase over the past few years in the promotion of innovative STEM programs [7,14]. However, considerations regarding resource allocation, assessment methods, and curricular alignment should be carefully addressed to maximize the impact of experiential learning experiences [14,15].

The widespread use of technological devices has caused a change in how modern society functions, introducing a brand-new social paradigm in which smart systems are integrated into domestic and other types of devices [16]. In order to provide more effective learning experiences in the classroom, it is important to use real-life scenarios, educational technology resources, and tools that students are already familiar with. By doing this, students are more likely to be motivated and prepared for the skills and knowledge that companies are looking for [14,17]. Using robotics in learning [18] is a crucial tool to develop sustainable goals regarding quality education and ensure sustainable consumption and production patterns [19] by providing everyone with the chance to receive a high-quality education and personalized vocational training tailored to their individual needs [20].

To promote effective learning in the classroom, it is helpful to create learning scenarios that involve real-life experiences and utilize educational technology tools and resources that students are already familiar with [21,22]. Educational robotics is an interesting technological resource that uses robots as tools to solve specific problems. Rather than being a singular subject, it is a teaching approach that prioritizes creativity and innovation to challenge students in problem solving based on programming for robots. Apart from enabling the development and programming of behaviors, educational robotics offers several benefits as a teaching aid. It fosters knowledge acquisition through interactive play, enhances student motivation, and encourages collaborative teamwork [23]. By utilizing robotic platforms, students can efficiently develop skills like learning new technologies and adapting to new challenges and situations. In this research, we have combined learning-by-doing strategies to emphasize practical experiences and hands-on activities to enhance learning with problem-based learning (PBL). PBL extends the concept of learning by doing since this methodology revolves around students working on challenging and open-ended problems in a structured manner. When a challenge is presented to a workgroup, it empowers students to lead in finding a solution. They can decide which sensors to use for a robot to perform a desired behavior and determine the most efficient method to accomplish the task [24]. Consequently, the benefits of learning by doing include improved retention of knowledge, enhanced problem-solving skills, increased motivation, and better preparation for real-world challenges. It also helps students develop soft skills, like communication, teamwork, adaptability, and critical thinking, which are highly valued by employers [25,26]. Overall, incorporating hands-on practices at higher-education universities can lead to more engaged and competent graduates better prepared to succeed in their careers and make meaningful contributions to society [27,28]. It is essential to utilize the PBL approach in conjunction with these practices to acquire skills in the field of engineering [29,30].

In engineering education, students are now expected to practice on platforms that emulate tasks they will encounter in their future careers. Programming and designing embedded or integrated systems is a common job opportunity for graduates with telecommunications or electronics engineering degrees. An embedded systems engineer is a specialized professional responsible for co-designing electronic devices. These engineers possess a unique combination of hardware and software (referred to as firmware due to its low-level programming nature) skills as they work on integrating computing capabilities into electronic devices to perform specific functions efficiently [31].

The teaching innovation discussed in this contribution is primarily intended for university students. We evaluated the impact of this didactic strategy to encourage the students' interest, motivation, proactivity, perseverance, and skill development through hands-on activities and a final project (the PBL approach) involving a mobile robot platform. This learning tool allows students to work with a professional embedded system that they can find in their future careers carrying out co-design tasks by designing hardware and firmware programming.

Nevertheless, the efforts of the teaching team to bring innovation into the classroom may be wasted if students do not understand how they can benefit their learning experience. The evaluation process involves a pre- and post-questionnaire that assesses three dimensions: energy, absorption, and dedication. The aim of this research is to assess students' engagement by combining hands-on learning and PBL strategies to develop a robot that solves specific problems. This will allow them to emulate tasks they might encounter in their future occupations [31]. Specifically, this innovation was introduced in the Integrated Telecommunication Systems (SIT) subject of the last academic year of the degree in Telecommunications Electronic Engineering.

The proposed questionnaire aimed to determine important insights on the effectiveness of the learning strategy applied, identify areas that require improvement, and assess the overall impact of innovation on the learning experience. The evaluation of innovation activity happened in two stages: during the first session of the subject in the second semester's first week and during the last project session in the second semester's final week. The pre-questionnaire was administered before introducing the innovative learning approach proposed in the SIT subject. After implementing the innovative learning approach, a post-questionnaire was used with the same questions for the students to answer based on their learning experience while carrying out the SIT subject. The questions assessed three dimensions pertaining to various aspects of academic involvement: energy, absorption, and dedication. Energy indicates the student's capacity to tackle and overcome challenges. The concept of absorption pertains to a student's ability to maintain focus on their current tasks. The dedication dimension is connected to how significantly students view the activities they engage in. Consequently, with the analysis obtained from these dimensions, we could consider both the strengths and areas for improvement to enhance the learning experience.

The correlation between dimensions and proposed questions for students was used to verify question selection consistency, revealing strong dependencies (higher than 70%).

The main conclusion obtained in this research is that all the questions received higher scores in the post-questionnaire, suggesting that students positively perceive the use of hands-on learning and a PBL approach through an open project. Moreover, the question that asked about general satisfaction showed the highest growth rate (1.05 out of 5.00) and received the best score in the post-questionnaire (4.17 out of 5.00). In terms of dimensions, all three dimensions displayed an increase in the post-questionnaire, indicating an overall positive perception of the proposed dynamics by the students. The dimension of dedication showed the highest difference (0.73 out of 5.00). This indicates that the learning strategy used in the SIT subject engaged the students and motivated them to solve the challenge proposed: to develop a project with the mobile robot platform. As they work with the robot to create their project, students may start to notice how similar the tasks they are performing are to those they might encounter in a real workplace once they complete their degree program in a few months. This realization can enhance their understanding of the project's importance.

The manuscript is divided into different sections. Section 2 explains how hands-on learning and PBL strategies were implemented in the SIT subject and describes the mobile robot platform used to carry out these strategies. Section 2 also showcases the questionnaire utilized to assess the influence of innovation, along with a detailed description of the studied dimensions. Section 3 presents and discusses the results obtained from the analysis of the questionaries. Lastly, Section 4 summarizes the main conclusions drawn from the research.

2. Materials and Methods

2.1. Engineering Learning Environment

2.1.1. Educational Context: SIT Subject

An embedded system is a specialized processing system that is designed to perform specific functions or tasks within a larger electronic system. It is a computer system that is integrated into other devices and is responsible for controlling and managing the device's functions. These systems are used in a wide range of applications, including automotive, medical, and industrial systems, where they provide reliable and efficient control of complex systems. Unlike general-purpose computers, which can run a wide range of applications, embedded systems are generally tailored to specific applications. They are optimized for efficiency, reliability, and real-time performance. Embedded systems can be found in a variety of electronic devices, such as smartphones, medical devices, portable devices, automotive control systems, industrial automation, and home appliances. Two key aspects that have made embedded systems a crucial element of electronic devices are their low power consumption and long life cycle [32–35]. Many embedded systems are powered by batteries or need to operate within strict power constraints. As a result, they are engineered to be energy efficient and conserve power whenever possible. On the other hand, embedded systems tend to have longer lifecycles than consumer electronics because they might continue to serve their purpose once integrated into a product for many years. The prevalence of embedded systems has increased with the rise of the Internet of Things (IoT), as they are the foundation of interconnected smart devices and systems. Their importance will continue to grow as technology advances, enabling more innovative and sophisticated applications across various industries [36].

For these reasons, electronics and telecommunications engineering students have the opportunity to acquire a highly sought-after skill: the capacity to co-design embedded devices. This involves the redesigning of hardware and/or the reprogramming of firmware, which allows for creating specialized processing systems that perform specific functions or tasks within a larger electronic system. This skill is essential in a variety of industries, including automotive, medical, and industrial systems, where it is used to develop reliable and efficient control systems for complex devices. Thus, an embedded systems engineer, when facing a new electronic design, applies their expertise in this subject along with other transversal skills acquired throughout higher education. This enables the engineer to consider the specific requirements of the problem, the available resources, and constraints related to cost, power, and performance. Specifically, this research focuses on students' learning environment in the degree in Telecommunications Electronic Engineering program at the School of Engineering of the University of Valencia (ETSE-UV) [37,38]. This degree program comprises four academic years, each containing 60 European Credit Transfer and Accumulation System (ECTS) points. During this degree program's first and second years, students begin programming embedded systems through the subject of Digital Electronic Systems (SED-I and SED-II) [39]. Specifically, SED-II is dedicated to acquiring fundamental skills in analyzing and synthesizing techniques for digital systems. The concepts presented in this subject provide a solid foundation for exploring more complex designs in future subjects. The focus of this subject is on the fundamental concepts of digital electronic systems commonly used in the market, with an emphasis on microcontroller-based systems. The subject includes theoretical and practical sessions, allowing students to work on the basics of microcontrollers. In this case, we use a well-established single-chip Harvard microcontroller architecture based on the 8051 to perform the practical sessions.

The subject in which learning innovation is implemented is Integrated Telecommunication Systems (SIT) [40]. It is an optative subject that students can take in their fourth (last) year of the degree program. This subject covers 6 ECTSs and entails 60 h of presential classes. SIT offers students the chance to enhance their expertise in embedded systems. It builds upon previous topics covered in Digital Electronic Systems and is thematically linked. The main goal of the subject is to introduce new methodologies and tools to assist in the hardware/firmware co-design process for embedded systems. By utilizing analysis and synthesis techniques, students can effectively develop a final product. This subject aims to help students develop the following abilities:

- Analyze and design product specifications.
- Follow a proper methodology for successful address-based system design microcontrollers (firmware and hardware), paying particular attention to developing real embedded applications.
- Plan an architecture carefully while considering any design restrictions and the interrelation between various elements and analyze and design modules, subsystems, circuits, libraries, and platforms based on microprocessors and/or reconfigurable devices.
- Select appropriate project design, synthesis, and debugging tools to ensure the accurate development of an electronic product.
- Provide the technical specifications for a project that involves digital electronic systems.
- Make appropriate design decisions as a professional designer does.

In order to enable students to achieve these objectives through hands-on learning and PBL strategies, the teaching team decided to provide a professional embedded evaluation kit in the first class to all students who are taking this subject. This evaluation kit is based on a Programmable System on Chip (PSoC), which will be extensively explained in the next subsection. The PSoC is a chip that combines analog and digital peripherals, memory, and a microcontroller on one single circuit. This chip can be reconfigured and is integrated into an evaluation kit board. This board assists users in comprehending the various elements and modules present within the PSoC.

2.1.2. Learning Strategy

For the development of the SIT subject in terms of vertical integration considering the degree program, it is necessary to use the fundamental concepts in previous subjects, such as SED-I and SED-II. These two subjects define the basis of digital electronics and basic microcontrollers. Other fundamental works in subjects such as Instrumentation, Circuit Analysis, and Analog Electronics are also needed to integrate an embedded device into a whole electronic system. Finally, the Project Management subject is also important to organize the development of the project with the robot platform. During the second term of the final year of their academic degree, students take the SIT subject at the same time as other elective subjects, like CAD design. CAD design helps SIT students comprehend the schematics of the evaluation kit and robot platform utilized.

Over the past three academic years, the development of the SIT subject has been horizontally organized by following a two-stage methodology. During the initial stage, students undergo five hands-on training sessions, each lasting five hours. These sessions align with the five didactic units of the subject and are preceded by a brief explanation from the teacher. Theoretical lectures are integrated with experimental laboratory sessions, with no segregation of contents. The aim is to work on concepts through transversal activities that involve guided tasks to facilitate the co-design of an embedded system. The activities worked on in each of the hands-on sessions are organized as follows:

- Introduction to a co-design project: students are introduced to the features of the PSoC device and its programming tool (PSoC Creator) by implementing a guided project to control the RGB LED.
- General-purpose input–output ports: students develop several short PSoC projects to learn how to control some output and input pins, exploring the advanced functions, such as interruptions and hardware configurations.
- Timers, counters, and PWM modules: students follow short tutorials to learn how to configure these modules and, finally, they implement PSoC projects to control several external modules, such as a DC motor and an ultrasonic sensor.
- Communications: students follow short tutorials to learn how to configure UART, I2C, SPI, and BLE communications modules. Finally, they implement PSoC projects to control several external modules, such as the LED matrix driver.
- Analog peripherals: students follow short tutorials to learn how to configure ADCs, operational amplifiers, and DAC modules. Finally, they implement PSoC projects to control several external modules, such as LDR and IR (line detector) sensors.

The essential principles of the practices are explained by demonstrating a practical example using PSoC technology, highlighting specific functions and concepts. After becoming familiar with the content, the students work independently on the challenges presented during the hands-on session, using the co-design environment and the PSoC evaluation kit. The challenges become progressively more complicated and begin with a basic project that requires additional features to address the given problem. During the initial training phase, students acquire the skills to operate the co-design environment and gain proficiency in using the PSoC device. They also learn to use the components integrated into the evaluation kit (such as an LED and a user button) and external modules, like analog and digital sensors, motors, drivers, and displays. In this first part of the subject, the teaching team emphasizes active engagement and direct experience as the primary means of acquiring knowledge and skills. Instead of passively receiving information through lectures or reading, hands-on learning encourages students to participate actively in the learning process by interacting with real-world materials and experiments using the PSoC evaluation kit and external elements, like sensor and actuator modules. Consequently, the objectives we want to achieve with this strategy during the initial stage are the following:

- Active participation: students are actively involved in the learning process, taking an active role in exploring and understanding the PSoC device and how to co-design it to interact with external modules.
- Real-world context: learning activities are designed to emulate real-world scenarios, such as communicating an embedded device with external modules, making the knowledge and skills more relevant and applicable.
- Experiments: all the exercises involve using the PSoC evaluation kit, designing the hardware and programming the behavior to solve the proposed problem. This allows students to explore concepts, solve problems, and see the results of their actions.
- Critical thinking: through verifying the behavior upload to the PSoC evaluation kit, students are encouraged to think critically, analyze information, and make decisions

based on their observations and understanding. They receive immediate feedback on their performance, enabling them to make corrections and improvements quickly.
- Enhanced retention: the progressive levels of experimental activities proposed with the PSoC evaluation kit improve knowledge retention as students form strong connections between theory and practice.
- Motivation and engagement: active learning with the PSoC evaluation kit can increase motivation and engagement, leading to a deeper interest in the subject.

In the second stage of the subject, the teaching team proposes that the students create and execute a project utilizing the mobile robot platform that implements a PSoC device. Our objective in this second part is to maximize the use of the PBL approach by presenting a significant challenge (project) for the student groups. This PSoC device is the same one that is included in the evaluation kit used during the first stage of the subject. The students have the freedom to choose the project they wish to develop. The teaching team has established some minimum specifications that the project must meet to ensure that the students use minimal platform resources. The students have 30 h of in-person sessions to work on their projects. Afterward, they organize themselves into groups of three people and define a preliminary project to solve the challenge or problem they propose. The students must identify a real-life problem in either an industrial or domestic application that can be addressed using the mobile robot platform.

While the project's complexity is determined by the specifications defined by the subject teaching guide, workgroups have complete freedom to go beyond these specifications and carry out a more advanced co-design. This allows students to explore their creativity and develop innovative solutions to the challenges they face. The project's difficulty level is determined by the guidelines set by the teaching team: using at least two sensors, two actuators, and a new function or non-worked module. Therefore, the teams have the option to exceed these specifications and engage in more advanced design, including new modules, such as other sensors or actuators or wireless communication.

The robot platform includes the hardware elements and modules that have been used in the hands-on session during the training phase: RGB LEDs, a push button, a LED matrix, DC motors, LDR, IR, and an ultrasonic sensor. Consequently, this allows the students to be able to identify previous concepts and integrate them into their projects to control the robot platform. This enables them to integrate previous projects to manage the entire platform. Moreover, it is possible to connect to the standard platform additional modules through the free RJ25 connector.

Consequently, the student teams have to carry out a complete engineering project that includes the main stages: identifying the real-life problem to be solved with the robot platform; dividing it into smaller and easier problems; solving each of these smaller problems; integrating them into the preliminary prototype; testing and validation of the system; final design optimization; and documentation and reporting. These two last stages are carried out by working groups by preparing a technical report for the teaching team and presenting their projects to the rest of the class. Thereby, the objectives we want to achieve with the strategy used during the second stage to complement those achieved in the first stage are the following:

- Creativity: the project proposed by the teaching team is an open-ended problem, since they only provide minimal requirements. Hence, student teams have to think about a need in the industry or a problem in a domestic application that can be solved with the mobile robot platform provided. This problem does not have a single correct answer, allowing students to explore various possibilities and think outside the box to find creative solutions.
- Problem analysis: students analyze the problem they want to solve with the robot mobile platform, identifying what they already know and what they need to learn to address the issue effectively.
- Application of knowledge: students must use the expertise gained in the first stage of the subject, encouraging the application of previous knowledge to real-world situations.

- Collaboration: students learn to work effectively in teams and appreciate diverse perspectives.
- Skill development: the development of the project with the mobile robot platform based on the PSoC promotes enhancing various skills, such as problem solving, communication, teamwork, creativity, and adaptability.
- Presentation and reflection: groups present their projects that were implemented on the robot mobile platform based on the PSoC to the class, fostering further discussion and reflection on the problem-solving process.

2.1.3. Qualification in the SIT Subject

The evaluation of the subject is divided into three aspects:

- Verification of completing the first stage, the hands-on sessions, which accounts for 35% of the final grade.
- Defense of the project based on the mobile robot platform during the second stage, through a presentation, which accounts for 35% of the final grade.
- An exam consisting of practical test questions based on the hands-on sessions and the project developed with the PSoC device, which accounts for 30% of the final grade.

This grading rubric has been applied in the SIT subject for the last three academic years. The only modification has been made to the defense presentation, since, in the last two academic years, the evaluation of the projects presented by the different workgroups has been conducted by the rest of the class, rather than the teaching team. The teaching team only scores the hardware/firmware co-design part, which accounts for 40% of the mark. The remaining 60% is evaluated by the students using a rubric that assesses project risk and creativity (20%), functionality and demonstration (20%), and communication and presentation quality (20%). Over the past two academic years, peer assessment has been implemented as a means of encouraging self-regulated learning and critical thinking. This approach also helps students learn to receive constructive criticism and express themselves positively [41,42]. The teaching team plays a supervisory role in the peer assessment process, since they may monitor the quality of feedback provided, ensure fairness, and step in if any issues arise.

2.2. Description of the Mobile Robot Platform

2.2.1. Embedded Device: PSoC

A System on Chip (SoC) is an integrated circuit that combines multiple electronic components and functionalities of a complete embedded system onto a single chip. It is a highly integrated and compact solution that can include a central processing unit (CPU), memory, input/output interfaces, and various other specialized components required for a specific application. The CPU is the core component responsible for executing instructions and performing calculations. In an SoC, the CPU is typically a microprocessor or microcontroller. SoCs include various types of memory, such as random-access memory (RAM) for temporary data storage and read-only memory (ROM) for firmware and boot code. These integrated circuits generally also integrate various peripherals, such as timers, analog-to-digital converters (ADCs), digital-to-analog converters (DACs), and serial communication interfaces (e.g., UART, SPI, and I2C). This architectural design offers numerous advantages, including decreased manufacturing costs and reduced power consumption for the device. In this sense, SoCs may include power management units to regulate and optimize power consumption to extend battery life in portable devices. An SoC is crucial for smartphones and wearable devices, as they have limited size and weight, which affects their battery life. Integrating all components in an SoC also means that they are nearby, resulting in faster communication and better performance. This setup also reduces issues related to signal integrity and electromagnetic interference.

Specifically, the students use an evaluation kit controlled by a Programmable System on Chip (PSoC) made by Infineon. One major benefit of using a PSoC over a traditional microcontroller is the ability to customize it dynamically, reconfiguring and reprogramming it for specific applications. This allows designers to tailor a chip's features and capabilities to meet the particular needs of their target devices, as shown in Figure 1. Thereby, using a PSoC can significantly reduce development time, resulting in a faster time to market compared to other solutions.

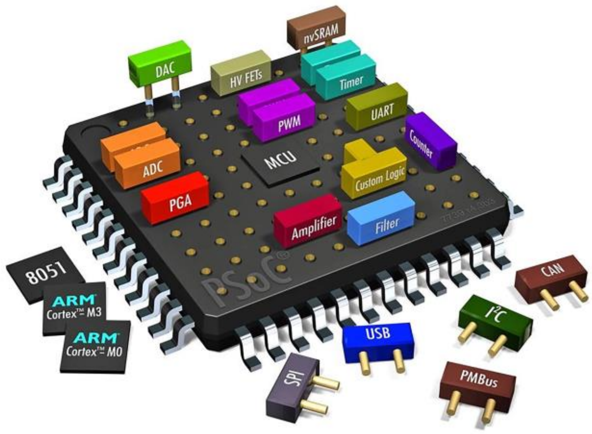


Figure 1. PSoC architecture.

In the initial stage, students utilize the Pioneer CY8CKIT-042-BLE evaluation kit, including the CY8C4248LQI-BL583 device from the PSoC 4 family [43,44]. The device is equipped with an ARM Cortex M0 microprocessor, as well as multiple analog and digital peripheral blocks. These blocks include four operational amplifiers, a 4-channel analog/digital successive approximation converter, and a Bluetooth Low Energy (BLE) module. Figure 2 displays the specific components of the evaluation kit that was utilized.

Figure 2. CY8CKIT-042-BLE evaluation kit.

2.2.2. Mobile Robot Platform Based on PSoC

Before introducing the mobile robot platform provided to students for the last three academic years, students mounted the PSoC evaluation kit onto the platform. They linked with wires different sensors and actuators to the PSoC through a prototyping board. The students had a good perception of this activity when it was proposed. However, when the robot did not perform the desired behavior, it was very difficult to find out the origin of the problem. This led to the student's rejection and distrust of using the robot due to its poor robustness. They usually pointed to the robot platform as the origin of the problem instead of revising the co-design project implemented in the PSoC. Thereby, the final objective of introducing a mobile robot base as a motivating element was blurred. Figure 3 shows a photograph of the first prototype version of the mobile robot platform.

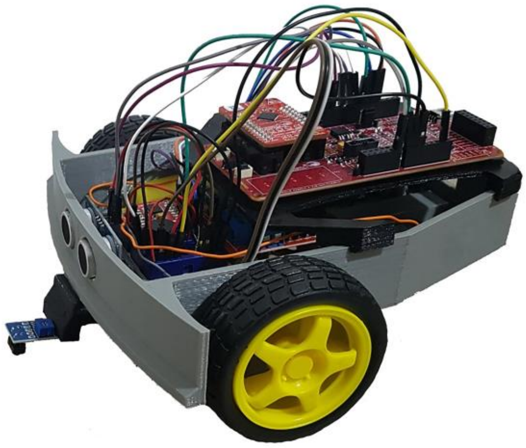


Figure 3. The first prototype version of the PSoC mobile robot platform.

To ensure that students remain focused on solving the co-design challenge, rather than dealing with issues related to project implementation on the mobile robot platform, the teaching team has developed a new prototype of the platform. The latest edition of the robot is a low-cost solution that utilizes a 3D-printed framework to house all its components, as illustrated in Figure 4. This new structure has been designed with three specifications in mind: robustness, reduced dimensions, and ease of printing for manufacture with a conventional 3D printer. This new robot mobile platform has been used during the second stage of the subject to implement the project for the last three academic years studied in this research.

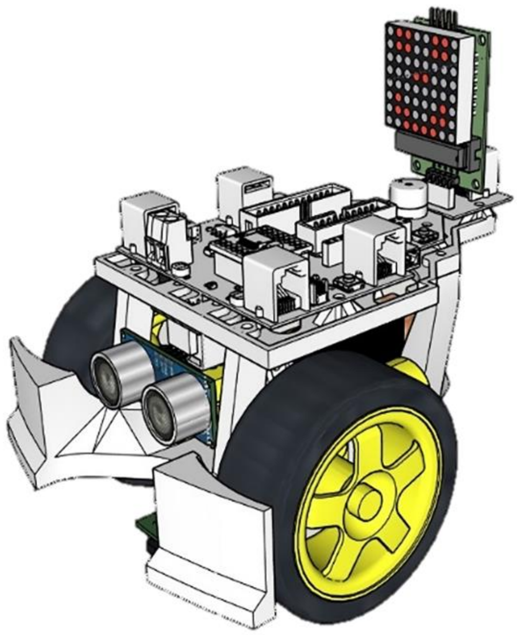


Figure 4. New mobile robot platform 3D structure design.

The main component of this new robot is a control printed circuit board (PCB) that has been specifically designed to include all the necessary hardware elements for connecting a PSoC module. The PSoC 4 module is plugged into this PCB to manage the available modules and program the desired behavior, as shown in Figure 5. The control PCB holds two light-dependent resistors (LDRs), enabling students to experiment with analog signals and various interface components, like two RGB LEDs and user buttons. It also integrates the motor driver that manages the two DC motors connected to the engine wheels. This PCB has been designed by using a four-layer stack-up. The components are placed only on the top layer; the signal traces are routed through the top and bottom layers. The two internal layers are based on a ground and power (5 V) plane.

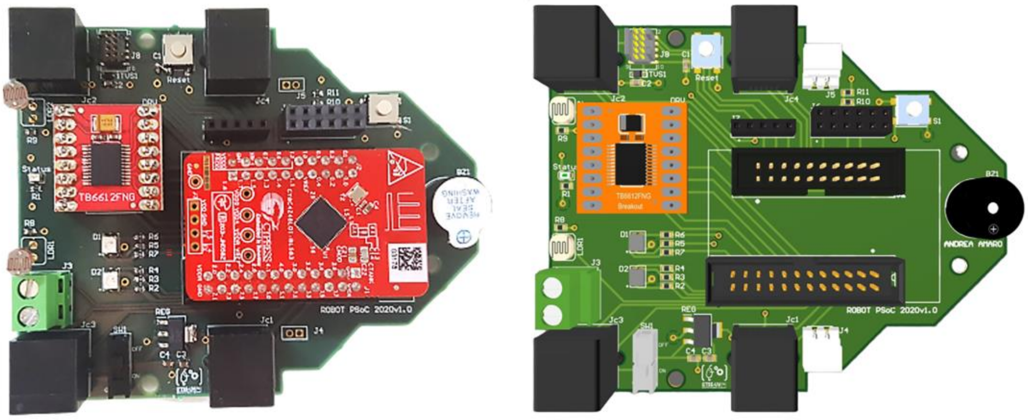


Figure 5. Control PCB that integrates the PSoC device.

The control PCB can be connected to the external modules that integrate the rest of the sensors and actuators via standard RJ25 connections. The connections practically suppress the problems related to cable interconnection and improve the robustness when compared to the previous version of the platform. In the current robotic platform design, the external modules consist of an ultrasonic sensor, an infrared (IR) module that can detect black lines, and an LED matrix for displaying messages. The other RJ25 connector can be used to add an extra module. Regarding the power of the mobile robot, it is based on a rechargeable 9 V battery that is connected to a regulator device that provides 5 V to power all the modules of the system. Figure 6 shows the block diagram of the electronic elements integrated into the mobile robot.

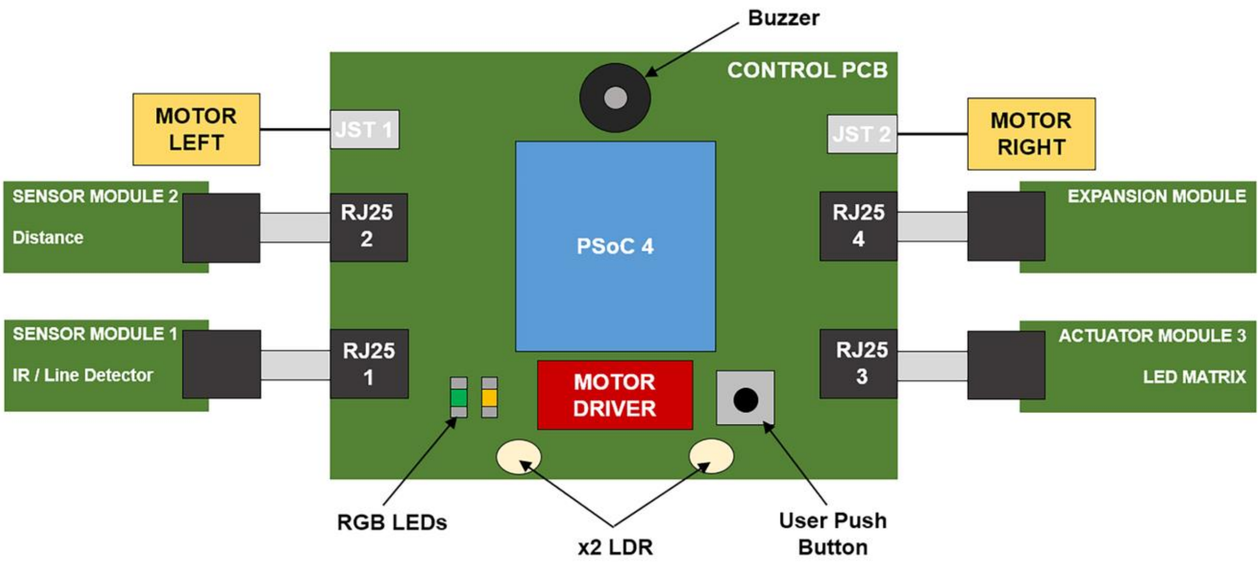


Figure 6. Diagram of the main elements integrated into the mobile robot.

Figure 7 shows the final result of the robot mobile platform based on the PSoC, including the external sensor and the actuator modules. The figure also displays the four RJ25 connectors that interconnect the control PCB with various external modules.

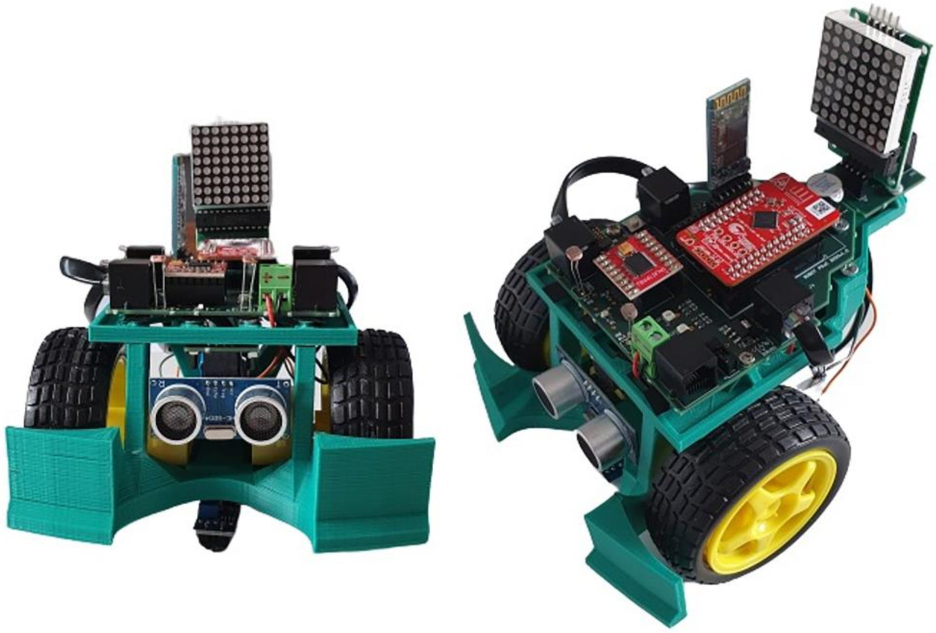


Figure 7. New robot mobile platform based on the PSoC. This is the version used during the last three academic years studied in this research.

Table 1 shows the specific elements that include the robot platform and their cost.

Table 1. Cost of the elements needed to implement the robot.

Element	Units	Cost per Unit (EUR)	Cost (EUR)
PSoC 4 (CY8CKIT-142)	1	9.09	9.09
PCBs (control unit, sensors, and actuators)	1	10.40	10.40
Ultrasonic sensor	1	1.59	1.59
IR sensor	1	1.85	1.85
LDR sensor	2	0.15	0.30
LED matrix	1	2.95	2.95
Wheels (×2)	1	1.49	1.49
DC motor	2	1.49	3.98
Freewheel	1	1.39	1.39
Components, connectors, and structure	1	10.50	10.50
Motor driver	1	2.45	2.45
		Total:	45.99 €

2.3. *Assessing the Impact of the Learning Innovation*

The impact of the learning innovation introduced in the SIT subject by combining hands-on learning and PBL strategies has been evaluated using questionnaires that capture student feedback. The purpose of these questionnaires is to gather valuable insights on how well innovative teaching methods work, identify areas that need improvement, and assess the overall impact of the innovation on the learning experience. Previous (pre-) and post-questionnaires are valuable tools to evaluate the effectiveness of innovation in learning. By proposing these questionnaires before and after implementing the innovative approach, the teaching team can measure changes in students' perceptions, attitudes, and knowledge, providing insights into the impact of the innovation on the learning experience.

With the results obtained, we can gain valuable feedback on the effects of the innovative learning methods proposed, allowing us to improve and refine our approach to better meet the needs of the students.

Thereby, the evaluation of innovation activity occurs in two stages: during the first session of the subject in the second semester's first week and during the last project session in the second semester's final week. The pre-questionnaire for the SIT subject aims to gather information on students' past experiences in other degree program subjects. Hence, the pre-questionnaire is administered before introducing the innovative learning approach proposed in the SIT subject. It serves as a baseline measurement and helps understand the students' initial perspectives and perceptions. The post-questionnaire is administered after the innovative learning approach has been implemented. It aims to measure changes in students' attitudes, knowledge, and experiences following the intervention. Subsequently, the second (post-) questionnaire features the same questions. However, the students answer this time based on their learning experience while carrying out the SIT subject.

In order to evaluate the effectiveness of the hands-on learning approach proposed in this study, a questionnaire designed to measure engagement with a particular task was modified accordingly [45,46]. The students considered ten questions using a Likert scale [47] between 1 (never/almost never) and 5 (almost always/always). The objective was to determine if engaging in hands-on activities and creating a project with a mobile robot platform enhances students' commitment and motivation to the SIT subject more than their previous subjects:

- Q1. I feel very energized in class.
- Q2. I think the practice activities are relevant and meaningful.
- Q3. It seems like time passes quickly when I am engaged in practice activities.
- Q4. During practice activities, I feel extremely empowered and motivated.
- Q5. I am enthusiastic about the proposed activities.
- Q6. When I engage in activities, I tend to forget about my surroundings and everything happening around me.
- Q7. I find working in class to be quite exciting.
- Q8. I feel like going to class when I am in university.
- Q9. I find great satisfaction in working intensely during class.
- Q10. In general, I feel very satisfied with the activities that are proposed to us in class.

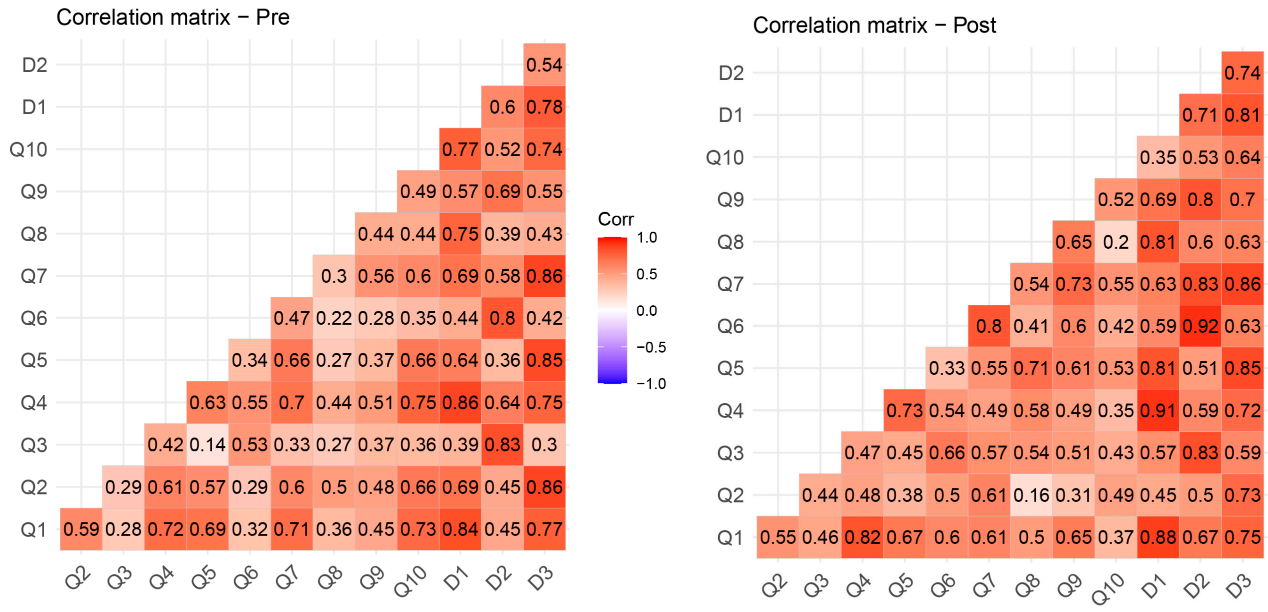
After collecting responses from both the previous and post-questionnaires, the goal was to analyze the data to identify patterns, trends, and changes in students' attitudes and experiences. The initial nine questions assess three dimensions pertaining to various aspects of academic involvement: energy, absorption, and dedication. Energy measures a student's ability to face and resolve problems (Q1, Q4, and Q8). Absorption evaluates the student's ability to concentrate on the tasks (Q3, Q6, and Q9). Dedication is linked to the student's perception of the importance of the activities they undertake (Q2, Q5, and Q7). Question Q10 examines the overall satisfaction level of the student. Consequently, with the analysis obtained from these dimensions, we used the insights gained from the questionnaires to make data-driven decisions about innovation, considering both the strengths and areas for improvement to enhance the learning experience further.

3. Results and Discussion

This section analyzes the results obtained from the previous and post-questionnaire data. First, we will verify the correlation between the questionnaire questions and the three dimensions. Next, we will analyze the scores of the ten questions. Finally, we will study the results of determining the dimension scores.

Figure 8 shows the correlation matrix for the previous and post-questionnaires related to the three dimensions defined: energy, absorption, and dedication (D1, D2, and D3, respectively). A correlation matrix is a valuable tool for verifying a model and examining the relationships between variables in a dataset. The matrix used here helped to identify the strength and direction of associations between the questions included in the questionnaire and the three dimensions. Thereby, it was possible to verify that there were strong dependencies, and the analysis was validated:

- D1: Q1 (pre-: 0.84, post-: 0.88); Q4 (pre-: 0.86, post-: 0.91), and Q8 (pre-: 0.75, post-: 0.81).
- D2: Q3 (pre-: 0.83, post-: 0.83); Q6 (pre-: 0.80, post-: 0.92), and Q9 (pre-: 0.69, post-: 0.80).
- D3: Q2 (pre-: 0.86, post-: 0.73); Q5 (pre-: 0.85, post-: 0.85), and Q7 (pre-: 0.86, post-: 0.86).



(**a**) (**b**)

Figure 8. Correlation matrix between questions and dimensions: (**a**) pre-questionnaire; (**b**) post-questionnaire.

Regarding the previous and post-sampling, the average scores and standard deviations (in parentheses) for each question are presented in Table 2 and Figure 9. Additionally, the difference between the scores obtained at both time instants (pre- and post-) is also included. We collected a sample of 60 students who have taken the SIT subject in the last three academic years. This innovation has been implemented for all students who have taken the SIT subject. The learning method explained in this contribution can be found in the information document that students read when selecting their three optional subjects for the fourth year. Therefore, the teaching team did not select the students enrolled in the SIT subject; rather, the students themselves chose to take it. Based on the results obtained, it was observed that all the questions received higher scores in the post-questionnaire. The assessment performed suggests that students prefer a subject that promotes hands-on learning and a PBL approach through an open project when compared to their accumulated experience with previously studied subjects.

However, Q6 had a minimal evolution from the previous to post-questionnaire (0.07), which shows that the proposed learning strategies improve students' motivation to overcome the proposed challenge or problem. However, this alone was not enough to enhance the abstraction of the rest of the problems surrounding them when compared to the previous questionnaire.

If we focus on the first nine questions, it is evident that Q8 had the most significant increase compared to the previous questionnaire (0.92). This indicates an increase in student engagement when facing the hands-on activities and the project using the mobile robot platform. Q2 received the highest scores in both the pre- and post-questionnaires, with students recognizing the importance and relevance of the learning-by-doing strategy. Q10, which asked about general satisfaction, showed the highest growth rate (1.05) and received the best post-questionnaire score. This indicates that, overall, the students evaluated the impact of using hands-on experiences and developing the project with the mobile robot platform very positively.

Table 2. Variation in the mean values and standard deviations (in parentheses) found for each questionnaire item.

Group	Q1	Q2	Q3	Q4	Q5
Pre-	3.24 (1.05)	3.81 (1.16)	3.09 (1.14)	2.90 (0.97)	2.98 (1.00)
Post-	3.83 (0.97)	4.52 (0.50)	3.83 (0.82)	3.39 (0.97)	3.74 (0.95)
Diff.	0.58	0.71	0.74	0.49	0.76
Group	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
Pre-	2.97 (1.17)	3.21 (0.97)	2.26 (1.13)	3.45 (1.03)	3.12 (0.86)
Post-	3.04 (1.31)	3.91 (0.72)	3.17 (1.06)	4.00 (0.84)	4.17 (0.71)
Diff.	0.078	0.71	0.92	0.55	1.05

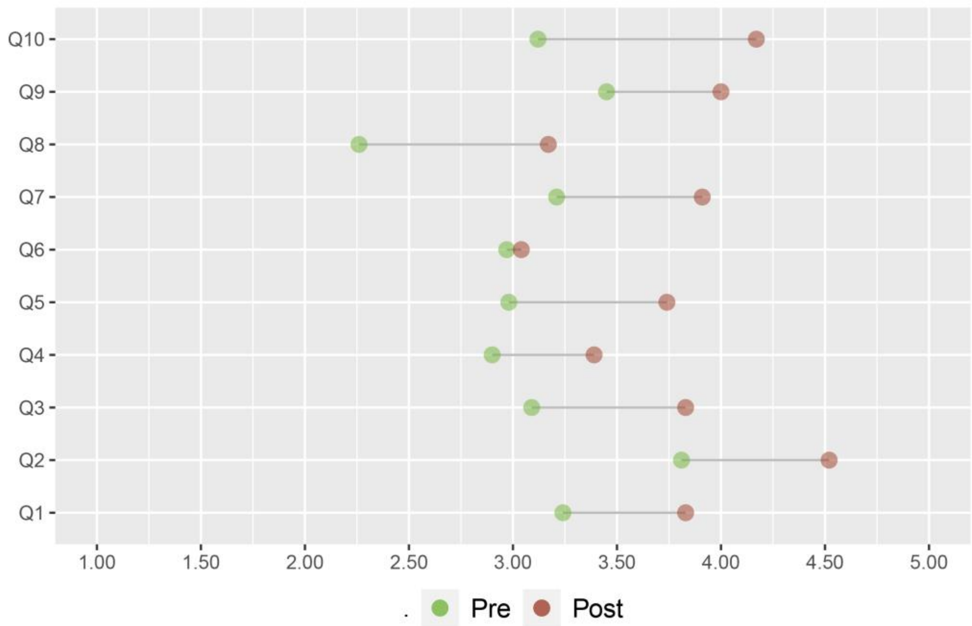


Figure 9. Differences between average values obtained in the questions included in the previous and post-questionnaire.

When analyzing the results obtained from questionnaires, it is essential to consider the dispersion of responses based on each question, as shown in Figure 10. By analyzing the figure, it becomes evident that there was a shift in Q2 from the three lower categories of the Likert scale in the pre-questionnaire to the categories of Agree and Strongly Agree in the post-questionnaire. This shift in the responses suggests that the participants believed the practice activities to be relevant and meaningful. Additionally, the standard deviation of the answers decreased from 1.16 in the pre-questionnaire to 0.50 in the post-questionnaire. In contrast, Q6 had the highest standard deviation in both the previous and post-questionnaires, indicating that this question caused notable uncertainty among the students. It is important to highlight that the students did not select the two lower categories for Q7 in the post-questionnaire. This suggests that they generally agreed with the statement that they felt motivated during the SIT subject classes.

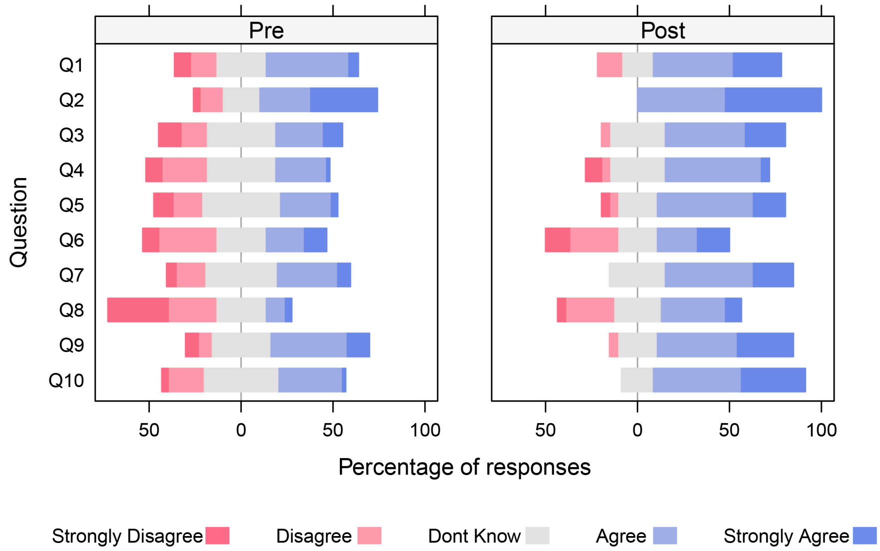


Figure 10. Percentage of responses per question in the previous and post-questionnaires.

Based on the data presented in Table 3 and Figure 11, it can be concluded that the participants had a positive response toward the proposed activities. The results were obtained by analyzing the answers to questions based on three dimensions: energy, absorption, and dedication (D1, D2, and D3, respectively). It was noticed that all three dimensions displayed an increase in the post-questionnaire, indicating an overall positive perception of the proposed dynamics by the students.

Table 3. Variation in the dimensions of energy, absorption, and dedication average values.

Group	Energy (D1)	Absorption (D2)	Dedication (D3)
Pre-	2.80 (0.86)	3.17 (0.86)	3.33 (0.90)
Post-	3.46 (0.87)	3.62 (0.85)	4.06 (0.60)
Diff.	0.66	0.45	0.73

According to the students' evaluations, the absorption dimension showed the smallest increase (0.45) compared to the previous assessment. This could be because, while using a robot platform based on PSoC to complete a project increases motivation compared to traditional classes, it may not result in a significant improvement in concentration toward the task at hand. One factor that influences this dimension is the time constraint the students are subject to in developing the project. They can only work with the mobile robot platform during the in-person sessions, which last for 30 h. They often request an extension of time to the teaching team in order to improve the project. It is possible that working under pressure could lower their level of concentration. However, as a teaching team, we believe that this skill is crucial for future engineers. It is essential that they can efficiently complete projects within a given timeframe.

Based on the pre-questionnaire, the energy dimension also increased (0.66), indicating that the students improved their problem-solving skills. This is an important skill for future engineers, and we believe that the increase in this dimension was due to the students gaining confidence in the first stage of the subject and applying it to the project in the second stage. In this case, adapting previously worked PSoC projects can provide students with the necessary tools to ensure that the robot behaves as desired, which can help them feel more secure. The dimension of dedication shows the most significant difference (0.73). This is noteworthy because the teaching team aims to help students see the project's development as a challenge they may encounter in their future careers. They learn to use limited and real resources to create a specific function. This fact can help students see the importance of working on the project with a mobile robot platform. They can see that the tasks they are performing while creating the project with the robot are similar to those they might perform in a company three months later when they finish the subject and the degree program. This can increase their perception of the project's relevance.

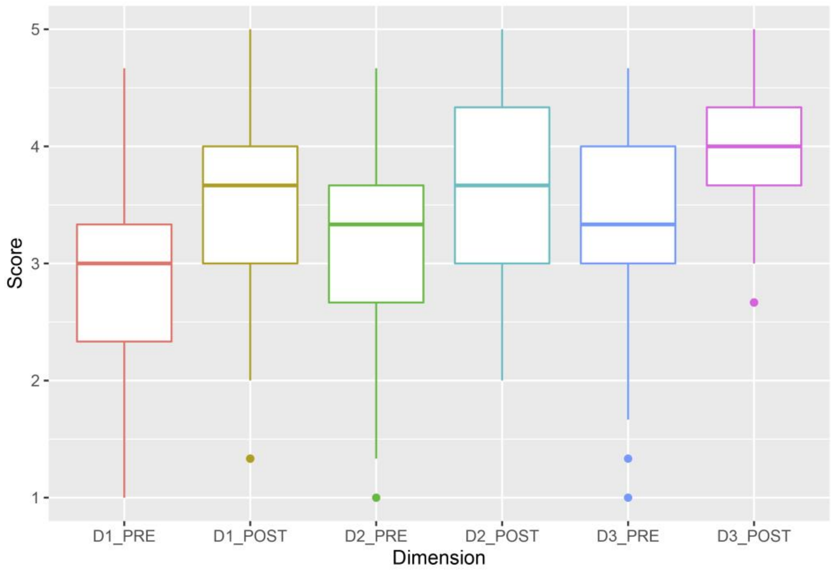


Figure 11. Dimension distribution comparison between the previous and post-questionnaire.

4. Conclusions

The study demonstrated that incorporating hands-on learning and a PBL approach through an open project positively impacted student engagement, motivation, and overall satisfaction with the subject. The students recognized the importance of practical experience and preferred this approach to conventional teaching methods to prepare them for transitioning to professional life.

The effectiveness of hands-on learning and the importance of incorporating active methods in education have been verified by the students of an engineering degree. The proposed activities were well-received by the participants, as the students had a positive perception of the dynamics implemented in the study. The analysis of the answers based on energy, absorption, and dedication showed an increase in all three dimensions in the post-questionnaire. This shows that the students' perception of the proposed activities improved after participating in the SIT subject, which involved designing embedded systems for a mobile robot platform based on PSoC.

Consequently, the students showed improvements in problem-solving skills, perception of the proposed activities' relevance, and the ability to work with limited resources. The findings support the effectiveness of the learning innovation approach and the potential benefits of integrating hands-on, practical projects into the learning process for future engineers. Thereby, future works can focus on adapting the learning environment to other educational levels or countries.

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References

1. Dewey, J. Experience and Education. *Educ. Forum* **1986**, *50*, 241–252. [CrossRef]
2. Piaget, J. *The Construction of Reality in the Child*; Ballantine: New York, NY, USA, 1954. [CrossRef]
3. Kolb, D.A. *Experiential Learning: Experience as the Source of Learning and Development*; FT Press: Upper Saddle River, NJ, USA, 2014.
4. Lewin, K. Action research and minority problems. *J. Soc. Issues* **1946**, *2*, 34–46. [CrossRef]
5. Winsett, C.; Foster, C.; Dearing, J.; Burch, G. The Impact of Group Experiential Learning on Student Engagement. *Acad. Bus. Res. J.* **2016**, *3*, 7–17.
6. Hall, A.; Miro, D. A study of student engagement in project-based learning across multiple approaches to STEM education programs. *Sch. Sci. Math.* **2016**, *116*, 310–319. [CrossRef]
7. Benavent, X.; de Ves, E.; Forte, A.; Botella-Mascarell, C.; López-Iñesta, E.; Rueda, S.; Roger, S.; Perez, J.; Portalés, C.; Dura, E.; et al. Girls4STEM: Gender Diversity in STEM for a Sustainable Future. *Sustainability* **2020**, *12*, 6051. [CrossRef]
8. Barak, M.; Dori, Y. Enhancing undergraduate students' chemistry understanding through project-based learning in an IT environment. *Sci. Educ.* **2005**, *89*, 117–139. [CrossRef]
9. Miller, E.C.; Krajcik, J. Promoting deep learning through project-based learning: A design problem. *Discip. Interdiscip. Sci. Educ. Res.* **2019**, *1*, 7. [CrossRef]
10. Potvin, A.S.; Miller, E.A.; Kuck, R.; Berland, L.K.; Boardman, A.G.; Kavanagh, S.S.; Clark, T.L.; Cheng, B.H. Mapping Enabling Conditions for High-Quality PBL: A Collaboratory Approach. *Educ. Sci.* **2022**, *12*, 222. [CrossRef]
11. Bradberry, L.; De Maio, J. Learning by Doing: The Long-Term Impact of Experiential Learning Programs on Student Success. *J. Political Sci. Educ.* **2019**, *15*, 94–111. [CrossRef]
12. Cui, Y.; Hong, J.C.; Tsai, C.R.; Ye, J.H. How Does Hands-On Making Attitude Predict Epistemic Curiosity and Science, Technology, Engineering, and Mathematics Career Interests? Evidence from an International Exhibition of Young Inventors. *Front. Psychol.* **2022**, *13*, 859179. [CrossRef] [PubMed]
13. Márquez-Ramos, L. Does digitalization in higher education help to bridge the gap between academia and industry? An application to COVID-19. *Ind. High. Educ.* **2021**, *35*, 630–637. [CrossRef]
14. Queiruga-Dios, M.-Á.; López-Iñesta, E.; Diez-Ojeda, M.; Sáiz-Manzanares, M.-C.; Vázquez-Dorrío, J.-B. Implementation of a STEAM Project in Compulsory Secondary Education That Creates Connections with the Environment (Implementación de Un Proyecto STEAM En Educación Secundaria Generando Conexiones Con El Entorno). *J. Study Educ. Dev.* **2021**, *44*, 871–908. [CrossRef]
15. Rosicka, C. *Translating STEM Education into Practice*; Australian Council for Educational Research: Camberwell, Australia, 2016. Available online: https://research.acer.edu.au/cgi/viewcontent.cgi?article=1010&context=professional_dev (accessed on 30 June 2023).
16. Suarez, A.; Garcia-Costa, D.; Martinez, P.A.; Fayos, R.; Amaro, A.; Martos, J. A transversal educational robotic platform for teaching in different education levels. In Proceedings of the INTED2020, Valencia, Spain, 2–4 March 2020; pp. 6032–6040. [CrossRef]
17. Lombardi, M.M.; Oblinger, D.G. Authentic Learning for the 21st Century: An Overview. *Educ. Learn. Initiat.* **2007**, *1*, 1–12. Available online: http://alicechristie.org/classes/530/EduCause.pdf (accessed on 30 June 2023).
18. Belpaeme, T.; Kennedy, J.; Ramachandrran, A.; Scassellati, B.; Tanaka, F. Social robots for education: A review. *Sci. Robot.* **2018**, *3*, eaa5954. [CrossRef]
19. Resolution, A. *RES/70/1. Transforming Our World: The 2030 Agenda for Sustainable Development*; Seventieth United Nations General Assembly: New York, NY, USA, 2015. Available online: https://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_70_1_E.pdf (accessed on 30 June 2023).
20. Guenat, S.; Purnell, P.; Davies, Z.G.; Nawrath, M.; Stringer, L.C.; Babu, G.R.; Balasubramanian, M.; Ballantyne, E.E.F.; Bylappa, B.K.; Chen, B.; et al. Meeting sustainable development goals via robotics and autonomous systems. *Nat. Commun.* **2022**, *13*, 3559. [CrossRef]
21. Sotelo, D.; Sotelo, C.; Ramirez-Mendoza, R.A.; López-Guajardo, E.A.; Navarro-Duran, D.; Niño-Juárez, E.; Vargas-Martinez, A. Lab-Tec@Home: A Cost-Effective Kit for Online Control Engineering Education. *Electronics* **2022**, *11*, 907. [CrossRef]
22. Tran, L.Q.; Radcliffe, P.J.; Wang, L. A low budget take-home control engineering laboratory for undergraduate. *Int. J. Electr. Eng. Educ.* **2019**, *59*, 158–175. [CrossRef]

23. Eguchi, A. What is Educational Robotics? Theories behind it and practical implementation. In Proceedings of the Society for Information Technology & Teacher Education International Conference 2010, San Diego, CA, USA, 29 March–2 April 2010; pp. 4006–4014. Available online: https://www.learntechlib.org/primary/p/34007 (accessed on 30 June 2023).
24. Penmetcha, M.R. Exploring the Effectiveness of Robotics as a Vehicle for Computational Thinking. Master's Thesis, Purdue University, West Lafayette, IN, USA, 2012. Available online: https://docs.lib.purdue.edu/dissertations/AAI1529729/ (accessed on 30 June 2023).
25. Tobón, S.; Luna-Nemecio, J. Complex thinking and sustainable social development: Validity and reliability of the complex-21 scale. *Sustainability* **2021**, *13*, 6591. [CrossRef]
26. Sotelo, D.; Vázquez-Parra, J.C.; Cruz-Sandoval, M.; Sotelo, C. Lab-Tec@Home: Technological Innovation in Control Engineering Education with Impact on Complex Thinking Competency. *Sustainability* **2023**, *15*, 7598. [CrossRef]
27. Benitti, F.B.V. Exploring the educational potential of robotics in schools: A systematic review. *Comput. Educ.* **2012**, *58*, 978–988. [CrossRef]
28. Kandlhofer, M.; Steinbauer, G. Evaluating the impact of educational robotics on pupils' technical- and social-skills and science related attitudes. *Robot. Auton. Syst.* **2016**, *75*, 679–685. [CrossRef]
29. Chen, J.; Kolmos, A.; Du, X. Forms of implementation and challenges of PBL in engineering education: A review of literature. *Eur. J. Eng. Educ.* **2020**, *46*, 90–115. [CrossRef]
30. Sanger, P.A.; Ziyatdinova, J. Project based learning: Real world experiential projects creating the 21st century engineer. In Proceedings of the 2014 International Conference on Interactive Collaborative Learning (ICL), Dubai, United Arab Emirates, 3–6 December 2014; pp. 541–544. [CrossRef]
31. Piaget, J.; Piaget, J. *To Understand is to Invent: The Future of Education*; Viking Press: New York, NY, USA, 1974; ISBN 0670005770.
32. Heath, S. *Embedded Systems Design*; Elsevier: Amsterdam, The Netherlands, 2002.
33. Abdelfatah, W.F.; Georgy, J.; Iqbal, U.; Noureldin, A. FPGA-Based Real-Time Embedded System for RISS/GPS Integrated Navigation. *Sensors* **2012**, *12*, 115–147. [CrossRef]
34. Lucca, A.V.; Sborz, G.A.M.; Leithardt, V.R.Q.; Beko, M.; Zeferino, C.A.; Parreira, W.D. A Review of Techniques for Implementing Elliptic Curve Point Multiplication on Hardware. *J. Sens. Actuator Netw.* **2021**, *10*, 3. [CrossRef]
35. Alam, T. Blockchain-Based Internet of Things: Review, Current Trends, Applications, and Future Challenges. *Computers* **2023**, *12*, 6. [CrossRef]
36. Samie, F.; Bauer, L.; Henkel, J. IoT technologies for embedded computing: A survey. In Proceedings of the 2016 International Conference on Hardware/Software Codesign and System Synthesis (CODES+ISSS), Pittsburgh, PA, USA, 2–7 October 2016. [CrossRef]
37. School of Engineering—University of Valencia (ETSE-UV). Available online: https://www.uv.es/uvweb/engineering/en/school-engineering-1285845344131.html (accessed on 30 June 2023).
38. Degree in Telecommunications Electronic Engineering—University of Valencia. Available online: https://www.uv.es/degree/telecommunications-electronic-engineering (accessed on 30 June 2023).
39. Digital Electronic Systems (SED-II) Subject—University of Valencia. Available online: https://go.uv.es/HXup974 (accessed on 30 June 2023).
40. Integrated Telecommunication Systems (SIT) Subject—University of Valencia. Available online: https://go.uv.es/7QC0s2N (accessed on 30 June 2023).
41. Ibarra-Sáiz, M.S.; Rodríguez-Gómez, G.; Boud, D. Developing student competence through peer assessment: The role of feedback, self-regulation and evaluative judgement. *High. Educ.* **2020**, *80*, 137–156. [CrossRef]
42. Loureiro, P.; Gomes, M.J. Online Peer Assessment for Learning: Findings from Higher Education Students. *Educ. Sci.* **2023**, *13*, 253. [CrossRef]
43. PSoC 4: 4200_BLE Family Datasheet—Infineon. Available online: https://www.cypress.com/file/416486/ (accessed on 30 June 2023).
44. Getting Started with PSoC 4—Infineon. Available online: https://www.cypress.com/file/46106/ (accessed on 30 June 2023).
45. García-Ros, R.; Pérez-González, F.; Tomás, J.M.; Fernández, I. The schoolwork engagement inventory: Factorial structure, measurement invariance by gender and educational level, and convergent validity in secondary education (12–18 Years). *J. Psychoeduc. Assess* **2018**, *36*, 588–603. [CrossRef]
46. Botella, C.; Soriano-Asensi, A.; Segura-Garcia, J.; Pérez, J.; Felici-Castell, S.; Navarro-Camba, E.A.; Montagud, M. Incorporando dispositivos de radio definida por software en la materia de Comunicaciones Digitales: Del grupo piloto a la gran clase. In Proceedings of the IN-RED 2020: VI Congreso de Innovación Educativa y Docencia en Red, Valencia, Spain, 16–17 July 2020; pp. 95–103. [CrossRef]
47. Robinson, J.P.; Shaver, P.R.; Wrightsman, L.S. *Criteria for Scale Selection and Evaluation, in Measures of Personality and Social Psychological Attitude*; Academic Press: San Diego, CA, USA, 1991. [CrossRef]