

Technology Courses for Non-STEM Degrees: A Project-Based Learning Case Study

Mihaela I. Chidean¹, Ana Arboleya², Maria Cerezo-Magaña³, Antonio J. Caamaño⁴, Eduardo del Arco⁵,
and David Cortés-Polo⁶

Abstract—Actual and future society requires more and more technology-related knowledge. One of the goals of the educational system is to prepare current students and future workers for the different challenges and jobs that they might encounter, even if most future jobs are largely unknown. Although administrations gradually modify education policies that will affect future generations, nowadays, there are students enrolled in non-STEM degrees who require the same opportunities. There are multiple approaches to this issue, such as double major art-engineering degrees or specific technological courses offered for students enrolled in non-STEM degrees. In this work, we present a case study conducted in a mandatory course for an undergraduate design degree in the art and humanities field. The course objective is to teach students basic electronic design and programming with the Arduino platform. To evaluate the previous knowledge and attitude of the students with regard to technology, initial tests were conducted. To evaluate their acquired knowledge, the students' final projects developed during the course were assessed. The present study analyzes the benefits for this student profile, showing that besides acquiring new expertise they have also broadened their options and opportunities in the labour market.

Index Terms—Education, educational technology, education courses, engineering education, learning.

I. INTRODUCTION

IN TODAY'S society the only constant is the constant change. This situation makes it difficult to predict the jobs of the future or to know what skills would be more appropriate to promote to current students [1]. The trend of the last decades indicates that we are moving towards an even more technological society. Therefore, it is prudent to affirm that the education in technology-related academic disciplines is highly recommendable. In recent years, the

STEM —academic disciplines of Science, Technology, Engineering and Mathematics— field has been increasingly encouraged, and a variety of new subjects/syllabus has been introduced into school systems since early ages [2], [3], [4], [5], [6]. It is even possible to find studies that try to predict students' selections in higher education [7].

While administrations try to encourage students towards the STEM field [8], it is also interesting to provide STEM-related knowledge (although obviously, not in the same depth) to students from other fields. For this purpose, a new current called STEAM, where the term “art” also comes into consideration, was defined claiming that society should not ignore creativity. This current has already found the support of industry, and it is possible to find specific development boards in the market proposed to attract artists and designers, such as the Arduino LilyPad [9], [10] or the Teensy boards [11]. The STEAM education model has also been introduced in several Universities worldwide, where double major programs of art and engineering are offered [12], [13], [14].

Nevertheless, the STEAM approach also has detractors that state that STEM education has difficulties in attracting students and the migration to STEAM would aggravate this problem [15], [16]. However, we must not forget one of the possible approaches of STEAM education: teaching STEM concepts to students who have already chosen the artistic branch and have discarded any STEM degree. The STEAM approach would expand the possibilities of these students by expanding their work domain. One possible implementation of STEAM consists of offering specific subjects within the curriculum or workshops for participants without previous knowledge [17], [18], [19].

Multiple methodologies can be considered for this purpose, each with its own advantages and challenges, and the choice usually depends on the course objectives or students background [20], [21]. For example, direct instruction-based learning provides structured lectures and exercises, ensuring a strong theoretical foundation but limiting creative exploration. Flipped learning allows students to study theoretical content beforehand and focus on practical application during class, fostering engagement but requiring self-discipline [22]. Experiential learning, through internships or workshops, immerses students in real-world scenarios, though opportunities may be limited. Among these, Project-Based Learning (PrBL) stands out for its ability to merge technical skills with creativity [23], [24]. By working on real-world projects, students develop

Received 12 December 2024; revised 11 March 2025, 12 May 2025, and 29 August 2025; accepted 30 August 2025. Date of publication 8 September 2025; date of current version 15 September 2025. (Corresponding author: Mihaela I. Chidean.)

Mihaela I. Chidean, Ana Arboleya, Antonio J. Caamaño, and Eduardo del Arco are with the Department of Signal Theory and Communications, Universidad Rey Juan Carlos, 28942 Fuenlabrada, Spain (e-mail: mihaela.chidean@urjc.es; ana.arboleya@urjc.es; antonio.caamano@urjc.es; eduardo.delarco@urjc.es).

Maria Cerezo-Magaña is with the Department of Aerospace Engineering, Universidad Carlos III de Madrid, 28911 Leganés, Spain (e-mail: mcerezo@ing.uc3m.es).

David Cortés-Polo is with the Department of Computing and Telematics Engineering, Universidad de Extremadura, 10003 Cáceres, Spain (e-mail: dcortpol@unex.es).

A Spanish version of this article is available as supplementary material at <https://doi.org/10.1109/RITA.2025.3607479>.

Digital Object Identifier 10.1109/RITA.2025.3607479

problem-solving abilities, collaboration skills, and technical expertise while maintaining artistic freedom. In a STEAM environment, PrBL can enhance interdisciplinary learning and encourage students to integrate artistic expression with technology [25], [26].

The present work presents a case study for the Equipment and Device Design mandatory course within the third year of the Bachelor's Degree of Integral Design and Image Management at Universidad Rey Juan Carlos. The degree is organized by the Faculty of Arts and Humanities and its curriculum provides comprehensive training in areas related to design and its practical applications. Therefore, students also receive instruction in several courses within STEM fields, such as IT and Electronics. The previous editions of this course involved some independent practices with microcontrollers addressing the design of simple prototypes without any interconnection between projects nor direct application. In the course edition examined in this work, a PrBL methodology is employed to teach students fundamental concepts of electronics and programming using the Arduino platform [27]. Arduino is an open-source development board that facilitates the easy and rapid design and implementation of projects involving electronic components. It is one of the best options for the PrBL approach in the Equipment and Device Design course, as even individuals with limited knowledge of both electronics and programming, as in the case of the students subject of this study, can achieve good results with it. For this reason, we hypothesize that incorporating a PrBL methodology using the Arduino platform can significantly enhance the technological understanding and creative application skills of students in non-STEM design disciplines.

The rest of this paper is organized as follows: Section II describes the participants and the course planning. Section III presents the results obtained during this study and several projects developed by the students. Section IV includes the result discussion and Section V concludes this work.

II. METHODS

A. Participants

This case study includes the results from the last two editions of the Equipment and Device Design course. This course is mandatory in the degree curriculum, and a total of 156 students were enrolled across the two editions, 74 in the first and 82 in the second, respectively. There were 116 females (74.4%) and 40 males (25.6%), percentages similar to the ones reported by the University authorities for all the students enrolled in the entire degree in the corresponding annual reports.

Detailed information regarding age or specific background for each student is unavailable for the faculty members due to the Spanish law on protection of personal data. Given the demographic data of the university students, the average age of the participants in this case study is between 20 and 21 years old. Moreover, given the broad scope approach of the Degree of Integral Design and Image Management, all students and therefore all participants in this study had a heterogeneous background and a diverse interest in technology.

For this reason, maybe the unique common characteristic of the participants is their little technology vocation.

B. Previous Knowledge Assessment

In order to achieve a better understanding of the students' background, a previous knowledge test was performed during the first session of each course edition.¹ This survey included several general questions, intended to establish the interest in technology of the students, such as: (i) What is your long-term goal in your career? What is your dream job? (ii) Have you ever considered working as a designer in the technology field? (iii) Have you ever heard of the Arduino Platform? If so, where? What do you think Arduino is?

The test also included specific questions which intended to assess their previous knowledge in technology subjects, such as: (i) Which electronic component has color bands to identify its value? (correct answer: the resistor) (ii) Which electronic component is used to measure the light intensity? (correct answer: photoresistor or light-dependent resistor) (iii) What do you understand by computer programming? (correct answer: the designing and writing of a computer program which performs a specific computer task).

C. Course Planning

The main assumption for the course planning was that students have little or no knowledge about electronics and programming, in general, and about Arduino, in particular. The course started with three class sessions of two hours each planned as theory-classes to introduce electronics, the Arduino Platform and programming. The remaining sessions, 12 in total, adopted a PrBL approach, where students worked on progressively complex Arduino projects. All sessions were conducted in classrooms equipped with computers and electronic components. Students, working in pairs, begun with guided lab exercises using basic electronic components like resistors, buttons, and photoresistors. These exercises were supported by detailed instructions provided by the instructors.

During these lab sessions, students were also introduced to essential programming concepts such as instructions, loops, and functions while learning to use the Arduino IDE (Integrated Development Environment). The primary objective of these initial labs was to build a foundational understanding of electronics and programming, enabling students to undertake a final project. Consequently, the lab activities were designed to gradually increase in complexity and difficulty. Fig. 1 shows several projects developed during these initial lab classes.

D. Final Project

The final project aimed to challenge students by requiring each pair to propose and develop their own Arduino-based project. Creativity and complexity were strongly encouraged and positively reflected in the project grading. Students were motivated to explore electronic components not introduced during the initial lab sessions, such as LCD (Liquid-Crystal

¹Course materials, planning documents, and the surveys used are available upon request.

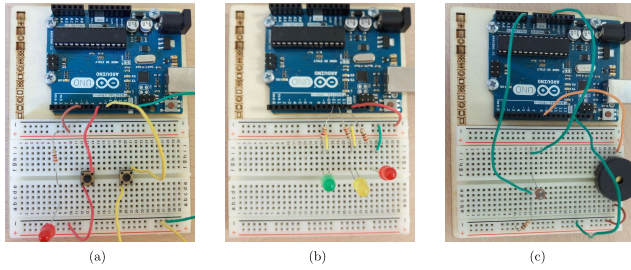


Fig. 1. Projects developed during the guided teaching activities: (a) “Push buttons” – introduction to conditionals; (b) “Basic semaphore” – introduction to loops; (c) “Pseudo-Theremin” – reading data from an analogical sensor.

Display) screens, DC Direct Current motors, and temperature sensors.

To ensure that projects are neither overly simplistic nor excessively complex, each student pair presented their project concept to the faculty members prior to commencement. In the event that the initial idea was excessively simplistic, the faculty members provided guidance to the students, suggesting a gradual increase in the project’s complexity. Conversely, students who presented overly complex (and even impractical) ideas were advised by the faculty members on potential variations that could be employed to reduce the project’s complexity. Throughout the project development process, the professors provided ongoing support to students, particularly in addressing advanced programming challenges and integrating complex electronic components.

To pass the course each project had to work properly, either according to the initial idea, either in a more simplified version of the initial idea. Simplified versions were accepted when students insisted in a complex project but lacked time to complete their idea.

Students were also required to submit a written report describing their project. This report also had to include additional sections with self-evaluation and with comments regarding the course planning and the class organization.

E. Data Collection and Analysis

Students’ previous knowledge was assessed at the beginning of the first class day. During the course the classes were developed as planned and once the final project was finished, each group submitted a final report. The students’ answers to the survey and comments from the final project report were collected and analyzed using a categorical grouping technique. Comments were systematically reviewed and grouped into predefined categories based on their recurrence and relevance to the course objectives. This approach allowed us to identify common patterns and insights aligned with the research questions considered in this work.

III. RESULTS

A. Previous Knowledge Assessment

The wide variety of answers obtained in the previous knowledge tests confirms that students enrolled in this mandatory course, and therefore in the Degree of Integral Design

TABLE I
RESULTS OBTAINED FROM THE QUESTIONNAIRE FOR THE GENERAL QUESTION “WHAT IS YOUR LONG-TERM GOAL IN YOUR CAREER? WHAT IS YOUR DREAM JOB?”

	What is your long-term goal in your career? What is your dream job?
I don’t know	21 13.46%
Graphic design	29 18.59%
Architecture	17 10.90%
Interior design	13 8.33%
Advertising	10 6.41%
Animation	8 5.13%
Photography	7 4.49%
3D design	6 3.85%
Furniture design	6 3.85%
Management of corporate image	4 2.56%
Product design	4 2.56%
Fashion	4 2.56%
Event organizer	4 2.56%
Editorial design	3 1.92%
Content creator for TV	2 1.28%
Scenography	2 1.28%
Car design	2 1.28%
Other: Shoe design; Commercial space design; Web page design	9 5.77%
No answer	5 3.21%
TOTAL	156 100%

TABLE II
RESULTS WITH HIGHER % OBTAINED FROM THE QUESTIONNAIRE FOR THE GENERALIST QUESTION “HAVE YOU EVER CONSIDERED WORKING AS A DESIGNER IN THE TECHNOLOGY FIELD? WHY?”

Have you ever considered working as a designer in the technology field?	YES	NO
	39.7%	60.3%
“Why?” among participants that answered YES:		
“technology is necessary as a designing tool”	56.5%	
“salaries are higher”	17.4%	
“wider range of future possibilities”	13.0%	
other reasons	13.1%	
“Why?” among participants that answered NO:		
“never considered it”		34.9%
“not interested or do not like the subject”		11.7%
“don’t have any technological knowledge”		9.3%
other reasons		44.1%

and Image Management, had a heterogeneous background. Below are presented the results from both general and specific questions are presented and analyzed, in order to show this fact.

Among the general questions, one of the questions with the greatest disparity in answers is “What is your long-term goal in your career? What is your dream job?”. Table I includes the complete list of answers, displaying the number of participants and the corresponding percentage for each response category. The responses encompassed occupations that belong to all design disciplines, from graphic design (18.91%) to fashion (2.56%), going through architecture (10.90%), interior design (8.33%), advertising (6.41%), animation (5.13%), etc. It should be noted that 13.46% of participants said they still do not know what their “dream job” is.

Table II includes the results obtained from the questionnaire for the generalist question “Have you ever considered working as a designer in the technology field? Why?” Even given the previous list of dream jobs, 39.7% of participants answered

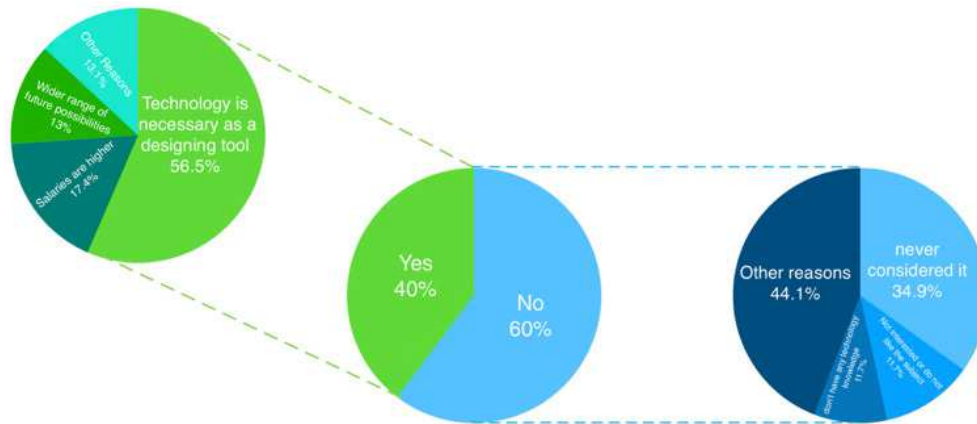


Fig. 2. Graphical analysis for the generalist question: “Have you ever considered working as a designer in the technology field?”. Students who responded “yes” are represented in green tones, while those who answered “no” are shown in blue tones.

“yes” when asked whether they have ever considered working as a designer in the technology field. Among the reasons, they highlighted that technology is necessary as a designing tool (56.5% of the ones that answer “yes”), that salaries are higher – particularly for web designers – (17.4%) and 13% believed that this option would open a wider range of future possibilities. On the other hand, among those who answered “no” (60.3% of participants), 34.9% had never considered it, 11.7% were not interested or do not like the subject and 9.3% dismissed the idea because they lack of technological knowledge. It is worth noting that only 4.3% stated that the technology field has always been a preferred option and that they have already worked within the field. Figure 2 shows the graphical distribution of the students’ responses.

The previous results surprisingly contrast with the fact that most students ignore what “Arduino” is. Only 28.3% indicated that they have heard something about this platform.

Within the more specific questions, the results show that of the 55 students who answered this question, 43 provided a correct definition of “computer programming,” while 12 gave an incorrect one, and the remaining students chose to leave the question unanswered. On the one hand, some of the best definitions are: (i) *Writing functions which compose a code that applied to some hardware do the programmed tasks;* (ii) *Coding in a specific language able to transform that code in actions or elements;* (iii) *Set of computer orders which result in a series of results perceptible by the senses. They tend to be dynamic, for design programs (video games), etc.;* (iv) *Giving a series of parameters to an element so that it works in a certain way;* (v) *Sequencing of a series of commands written in a specific language.* On the other hand, some of the less accurate definitions are: (i) *Set of complex numbers for certain things to work;* (ii) *Determining the purpose or purposes of a device;* (iii) *A way of proceeding by means of commands that give an order;* (iv) *Study the way in which an electrical device can be controlled mathematically or mechanically;* (v) *What is prepared previously for a purpose. Everything related to electricity.*

Finally, in order to provide a more accurate idea of the previous technological knowledge, the answers to two very basic

TABLE III
RESULTS TO OBTAINED IN THE QUESTIONNAIRE TO THE QUESTIONS “WHICH ELECTRONIC COMPONENT HAS COLOR BANDS TO IDENTIFY ITS VALUE?” AND “WHICH ELECTRONIC COMPONENT IS USED TO MEASURE THE LIGHT INTENSITY?”

	Which electronic component ...			
	has color bands to identify its value?		is used to measure the light intensity?	
I don't know	46	71.88%	41	67.21%
I don't remember	2		2	
Resistence	10	15.63%		
Wires	4			
Light bulb	1	9.37%		
Television	1			
Photometer or light sensor			11	18.03%
Amperimeter			4	
Voltimeter			1	11.48%
Potenciometer			1	
Lights panel			1	
Total answers:	64	100%	61	100%

electronic-related questions are given next: “Which electronic component has color bands to identify its value?” and “Which electronic component is used to measure light intensity?” – results are detailed in Table III. In the first case, 71.88% of participants did not know the answer, while only 15.63% gave the correct answer; among other answers are: *wires*, *light bulbs*, or *television*. In the second case, 67.21% didn’t know the answer and 18.03% were able to guess the answer, while some participants indicated one of the following options: *amperimeter*, *voltimeter*, *potentiometer*, or *light panel*. The remaining students, up to the total enrolled in each edition, did not provide an answer to these questions.

Implications regarding this heterogeneous background and the little technological knowledge are discussed in Section IV.

B. Final Project

Projects developed by the students are very diverse, from classical Arduino projects inspired by the Internet and with custom modifications to some quite ingenious projects. In the following, a selection of the developed final projects are listed and classified by their difficulty.

As just mentioned, classical Arduino projects inspired from the Internet were selected by some students. Motivations for choosing these projects were diverse: (i) difficulties found during the course and choice of an easy-to-approach project to secure the grade; or (ii) pass the course dedicating the least effort on the project. Examples of these types of projects are:

- “Thermometer” – get the temperature value from a sensor and show it on the computer screen.
- “Simon says game” – random LED sequence that the player has to reproduce by pressing push-buttons.

Other students started with simple projects – like the ones in the previous list – and included additional electronic elements or additional programming tasks in the project. In this project category, motivations were also diverse: (i) the easier project was finished, they still had enough time and aimed for a higher grade; (ii) from the very beginning the idea was to add something different and customized to an existing project. Some examples of these types of projects are:

- “Thermometer with screen” – improvement of “Thermometer” where temperature is displayed on a LCD screen.
- “Thermostat and air-conditioning system” – improvement of “Thermometer with screen”. Additional elements were included, such as LED turned on/off depending on the temperature or DC motors simulating heating and air-conditioning systems.
- “Modified Simon says” – improvement of “Simon says game” where different elements were added. For example, some students added a DC motor that was turned on and waved a flag when the player lost the game.

Some students also selected more complex projects that were already developed and published in the Internet. In this case, the approach aimed for a complex and difficult project in order to learn more programming – the final project report had to include a detailed description of the code – and implement their artistic skills to create the props or the encapsulation. Some examples of these types of projects are:

- “The arcade game” – a famous arcade game was replicated and a custom made cover box was fabricated. Although almost all of the code was downloaded from the Internet, students were encouraged to modify it and add some customization. See Fig. 3(a).
- “The game console” – multiple games were replicated; screen and game controller were manufactured. See Fig. 3(b).
- “The LED matrix” – one of the most popular projects as it is very colourful and at first sight seems quite easy to implement. However, most students encountered difficulties when trying to change the light pattern. See Fig. 3(c).

Innovation along with props and encapsulation were the main motivations for the following type of projects. In this case, the technological part was less complex, but the authenticity and customization came from the artistic part and from the integration of both into a meaningful project. The projects from this category are much more diverse, proof of the great creativity of design students:

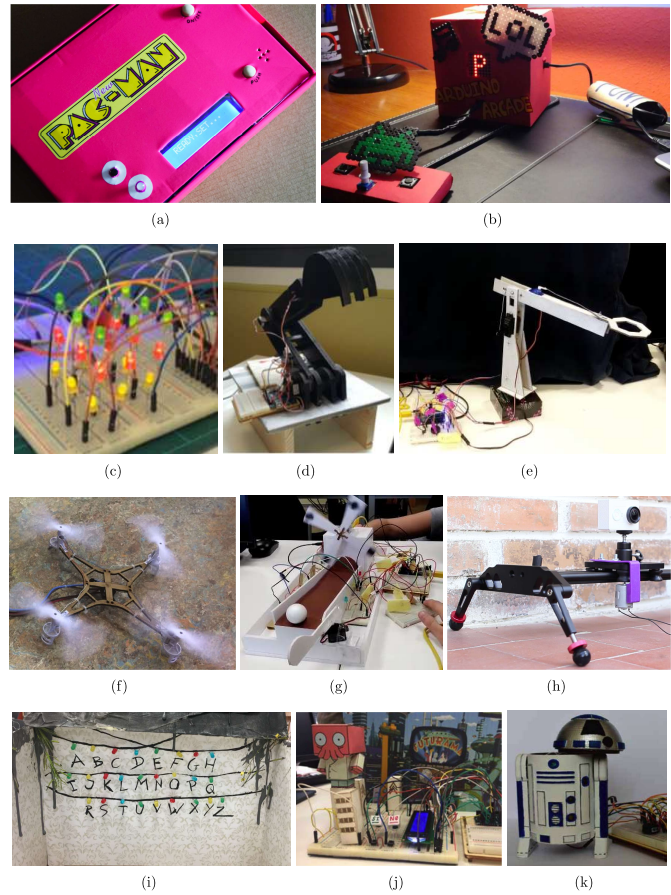


Fig. 3. (a)-(k) Samples of the final projects developed by the students. Each sample is described in the body of Section III-B.

- “The excavator” – the electronic block included three servo-motors with three potentiometers and the programming block was only in charge of the control of these motors. However, students shown their design background to elaborate the actual miniature excavator with three axes of rotation. See Fig. 3(d).
- “The perfect tea machine” – also including three servo-motors, but with the addition of a timer and a more complex programming. The idea in this project was to control the tea preparation process in such a way that the bag of tea is submerged in hot water the precise time and automatically taken out afterwards. See Fig. 3(e).
- “The drone” – four DC motors and a laser-cut structure were employed to create a drone. In this project, students had to deal with aerodynamics issues, e.g. they did not know beforehand that drone motors rotate in opposite directions. They also had to deal with physics (mainly gravity), as their initial structure design was much more artistic, but heavier than the final prototype. This project is a clear example of what happens when a designer has to adapt its ideas to real-life solutions. See Fig. 3(f).
- “The miniature golf” – one DC motor for the wheel along with a large number of other different electronic components such as a motion detector, a servo-motor, LEDs or buzzers have been used for this project. It is

worth mentioning the ingenious of the students solution to reduce the wheel's speed: instead of modifying the code, they added weights to the blades. See Fig. 3(g).

- “The camera slider” – motivated by the high price of motorized camera sliders, students aimed for the customization of a manual slider with a DC motor controlled by Arduino. They also 3D printed several elements to attach the motor to the manual slider. See Fig. 3(h).
- “The movie-set” – a TV series was the inspiration for this project. Students prepared the set and programmed Arduino to reproduce a well known scene of the show. See Fig. 3(i).
- The Q&A game” – an animated sitcom was the central part of a project that included several electronic components such LEDs, buzzers and a LCD screen. The game plot was quite simple and straightforward, but the challenging part for the students was the programming. See Fig. 3(j).
- The movie star” – LEDs, buzzers and motors were included in this project which replicated a famous movie saga robot. The structure was 3D printed and although only the head was prepared to spin, its famous sounds and beeps were programmed. See Fig. 3(k).

As previously mentioned, all the students were encouraged to use electronic components that were not used during the initial lab sessions. The goal of this approach was twofold: to challenge them and to let them see they already had enough knowledge to understand and modify online published schematics and the Arduino programs. As seen from the previous projects descriptions, most students accepted this challenge and developed very diverse projects with a great amount of different components. It is also worth mentioning that in some cases students were completely independent. The following list includes some of the electronic components that students learn how to use and included in their projects: (i) LCD screen (with or without an I2C bus), dot matrix displays (e.g. MAX7219) or seven-segment displays used as interface for some projects. (ii) DC motor and servo-motor used in projects that seek some kind of movement. (iii) Temperature sensor. (iv) Ultrasonic Sensor used for movement detection and distance measurement. (v) Passive Infrared Sensor for presence detection. (vi) Push-buttons matrix used as a keyboard in multiple projects. (vii) Bluetooth modules to establish communication with mobile phones. (viii) Diodes, transistors and many other auxiliary electronic components required for the implementation.

C. Students' Comments Included in the Final Report

Once the final project was finished, the students had to submit a report describing their work. Additionally, they were encouraged to include comments about the course, the organization and the learning process. The idea behind requesting these comments was to identify the course strengths and weaknesses in order to improve it in the following editions. These comments would also support this study and give insight regarding the initial hypothesis. Not all student pairs included comments in their report, and among those who

did, many provided similar feedback. This section includes the most relevant comments, i.e. a selection of both positive and negative comments gathering the main concerns of the students.

Some of the positive comments were:

(P1) *Learning (something that most of us started from scratch) is progressive and the weekly projects with small milestones helped us to notice a great improvement. In general, the impressions with the course have been very positive, it was a very interesting subject and we have learned a great amount of new things.*

(P2) *The practical part of this course has been the most interesting one. We have learned many new things and we got the motivation to learn more about this field.*

(P3) *For us, the final project was a great success. We never thought that we would be able to write an entire code from scratch and get it to work. We certainly believe that this project has helped us a lot to realize what we have learned during the course and to be able to carry it out has been very rewarding.*

(P4) *We have learned how Arduino and programming work and we understand this field a little more. It is a field that has little relation with our degree but where we could collaborate in the future.*

(P5) *We would like to thank for the freedom that we had for the final project, where we could do whatever we wanted. It is much more motivating and few professors allow it.*

(P6) *This has been our first contact with programming and within a semester we have acquired basic knowledge that can help us in the future. Although we have not finished our initial idea for the final project, we are proud of the result and of what we have learn during this course*

The following list includes the negative comments:

(N1) *We consider that more theory-classes to explain more basic Arduino programming commands are necessary.*

(N2) *We would have preferred something more guided and explained and not to depend so much on Internet searching.*

(N3) *Students who started from scratch in the programming or who find electronic devices especially difficult to understand would have needed a little more support, although we are aware that the high number of students in the class is a limitation.*

A total of 78 projects were completed across both editions, yielding 31 comments (17 and 14, respectively). The feedback was predominantly positive (25 comments), underscoring the value of hands-on learning from scratch, practical motivation, and exploration of new tools. Recurring themes included instructors dedication, the hands-on approach, and programming progress. Only six comments conveyed mixed or negative impressions, primarily concerning project complexity and initial difficulties. Overall, comments affirmed the course's practical orientation as its key strength.

IV. DISCUSSION

For this section, all the possible inputs such as the previous knowledge test, the resulting final projects and the student's comments were taken into account. The University's course quality evaluation surveys and the professors' experiences during both considered editions were also considered.

First, the heterogeneous background of the enrolled students was very beneficial for this study. One might think that this fact could be directly translated into more difficulties for the professors and uneven opportunities for the students. There were no differentiated requirements for the students depending on their previous knowledge, and the course results were very positive for all students. Therefore, the fact that enrolled students have different backgrounds regarding technology enriched this course by offering very different perspectives that benefited the entire group. This conclusion is also validated by the students' comments, such as comments (P1), (P2) or (P3) where they state their satisfaction with the course, the syllabus, and the learning process.

Also related with the students' previous knowledge, it should be noted that most of the students provided a quite correct definition of the "computer programming" concept in the performed test. This is clear evidence of the fact that actual society is a highly technological one and even people with non-STEM background or interest are totally immersed in it. Therefore, this fact supports the hypothesis of this work that students enrolled in non-STEM related degrees should also study some STEM courses in order to prepare them for the future society. Through the comments included in the final report, students also validated this hypothesis, e.g. students that wrote comment (P4) are even aware that they could work as designers collaborating with a technology company. In addition, the final assessment of the subject was carried out through the evaluation of the developed project, which included both an in-person demonstration and the submission of a final report. All the projects were successfully passed in the first examination session, which demonstrates students' ability to apply the acquired skills in a practical context and confirms the adequacy of the proposed learning approach.

Another relevant aspect of the students enrolled in this degree is their great imagination. As can be seen from the great variety of projects, this skill was very useful for the course, but was also a challenge from the teaching point of view. Most project proposals were reasonable from the very beginning considering their knowledge, project complexity and the available time. There have been even unfeasible project proposals, both in terms of complexity and technological limitations points of view, such as a "self-drawing robot with own genuine ideas" or a "voice recognition system". In these cases, students were advised to consider a shorter or a less complex project. However, from the presented results, such as comment (P5), it can be observed that students appreciated the freedom to propose and to carry out the project.

In order to help students and avoid dropouts caused by frustration, they were not completely by themselves during the final project development. On one hand, frustration was one of the predominant feelings during the final project, mainly due to their recent introduction to programming and electronics. Instructors were always willing to help students, especially considering that they were encouraged and challenged to use electronic components not considered covered in the preparatory lab sessions. On the other hand, other feelings during the final project development included pride and satisfaction, as they were achieving their goals. It can be seen, thanks to

comments like (P6), that students were satisfied with their achievements even if they did not complete their initial project idea.

It is worth mentioning that students had to deal with different implementation related issues that were caused by their own design. The best example of this kind of project is "the drone" project, where the students first discovered that the propellers had to spin in different directions. They also had to change their artistic and too heavy drone chassis in order to reduce the weight and allow the drone to actually fly. Although some of these issues were foreseen by the professors during the project proposals, the "let them discover the technology related problems that are design consequences" approach was considered. With this approach, students learned that the designer-engineer relation is not always straightforward and that engineers cannot always fulfil a designer's wish. In these projects, students were designers and engineers at the same time. This approach is very instructive for design students and will help them throughout their careers.

Positive comments were very useful from the professors' motivation point of view, as they reaffirmed our initial hypothesis that this course is truly beneficial for design students. However, from a practical point of view, negative comments were also useful, as they reflected the weak points of the course that could be improved in future editions. For example, comment (N1) was taken into consideration and future course editions will include additional theory-classes to explain a bit more electronic and programming basics. On the other hand, comments like (N2) were not taken into consideration, as one of the goals of the first lab sessions was to develop students' self-sufficiency in order to start the final project in the most appropriate way.

It is worth mentioning that there were also contradictory comments, like (N3) and (P1), where two different groups stating lack of previous knowledge reveal different opinions about the course planning. In this regard, both predisposition of the students when studying a new topic and their response to the given encouragement were the main reasons for these different outcomes. Thanks to these types of comments, in future course editions, more emphasis will be put on student motivation. Final reports also included comments regarding the number of students per group. Many of them suggested to reduce student/professor ratio by creating more groups or to assign more professors to the laboratory sessions. From the professors' point of view, this situation is beyond control due to the university's policy. However, the groups always had fewer than 40 students (20 pairs), which is a reasonable number for a university-level degree. Moreover, thanks to the experience gained in the past editions, course organization improves with each edition.

The University's quality program gives an external and independent perspective of the students' opinion. At the end of each edition students fill out an anonymous survey where they rate different course aspects. Results from these surveys are included in Table IV and indicate that students are satisfied with this course – assigning scores of 4.2 and 4.1 out of a maximum of 5 – and that the course and lecture planning allow for adequate follow-up and learning – assigning scores

TABLE IV

RESULTS FROM THE ANONYMOUS SURVEYS CONDUCTED AT THE END OF EACH EDITION AS PART OF THE UNIVERSITY'S QUALITY PROGRAM. THE RESULTS FOR THIS COURSE AND THE DEGREE ARE PRESENTED BELOW. (RATING FROM 1 TO 5)

	This course		The degree	
	Edition 1	Edition 2	Edition 1	Edition 2
Overall Assessment of the course.	4.2	4.1	-	-
Course and lecture planning allow them an adequate follow-up and learning.	4.1	4.0	3.6	3.7
Instructors adequately clarify doubts about the different proposed activities in the course.	4.3	4.0	3.8	3.7
Teaching activities align with the syllabus objectives, contents, and methodology.	4.3	4.2	3.8	3.8
I am satisfied with the work carried out by the faculty members.	4.2	4.1	3.6	3.7
Number and percentage of students who have completed the survey.	40 (54.5%)	75 (91.5%)		

of 4.1 and 4.0 out of a maximum of 5. Based on this survey, we can infer that students were able to appreciate this new knowledge, integrate it into their context, and value its relevance. Additionally, the results indicate that this course is rated more highly than other courses within the same degree program. These surveys are highly relevant for this study as they reaffirm our own results.

Based on the outcomes of this research, the initial hypothesis posited, namely that incorporating technology courses into non-STEM curricula is advantageous for students, can be substantiated. Students acquired technology-related knowledge that, in certain instances, was entirely novel to them. Notably, some individuals underwent a shift in their career aspirations, considering design roles within technology companies. This conclusion was reached through our experience during the course editions under investigation, as well as the insights gleaned from previous knowledge assessments, the outcomes of the final project, and the invaluable feedback provided by students. Consequently, based on the lessons learned, we strongly advocate for including technology courses in non-STEM degrees.

This study has some limitations that should be acknowledged in order to properly interpret the results. First, it is still a recent study, and long-term results and their impact on students' employability and job opportunities will require multiple editions require multiple editions of this course with the same methodological approach, as well as long-term data collection from graduates of this degree. Additionally, while we believe this approach could be implemented at different study fields and educational levels, our work is focused solely on bachelor's degree students, meaning the results may not be generalizable to other disciplines or educational levels. Addressing these limitations is the focus of both our current and future work.

V. CONCLUSION

One of the goals of education is to prepare students for the future and for their potential careers. In the society towards which we are evolving, it is increasingly likely that we will all need technology-based knowledge. Moreover, this knowledge can become a differentiating element in jobs that do not purely belong to the STEM field. Teaching technology-based courses in non-STEM degree programs is one of the ways to bring this knowledge to non-STEM students.

In this work this approach is addressed in the subject Equipment and Device Design of the Degree of Integral Design

and Image Management organized by the Faculty of Art and Humanities at Universidad Rey Juan Carlos. The methodology followed and the lesson plans as well as the results of the initial evaluation of the students in terms of technical knowledge are presented. Likewise, several of the projects that the students created by the students, demonstrating their great evolution in technical knowledge, acquired within a very limited time-frame, and how this knowledge is used to enhance their creativity in new areas.

Future work will focus on consolidating the current PrBL methodology in this course across additional editions, while also assessing the long-term benefits of this approach from a longitudinal perspective. In parallel, we plan to replicate the study in non-STEM degree programs by applying the same methodology in diverse fields such as business and the humanities, as well as at different educational levels, including master's programs. These future analyses will both provide valuable comparative insights with the results presented in this paper and help identify the specific adaptations needed for different student profiles and curricula to enhance knowledge acquisition.

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