Sparking Interest: An Experience with Machine Learning and micro:bit on Girls in ICT Day

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Abstract

The participation of women in Science, Technology, Engineering, and Mathematics (STEM) fields —and particularly in Information and Communication Technologies (ICT)— continues to be affected by structural and cultural factors that limit their persistence and advancement in these disciplines. From an early age, many girls are exposed to messages that discourage their interest in science and technology. Upper secondary education represents a key stage to intervene, spark interest, and provide positive role models. In this context, educational initiatives specifically designed for teenagers gain particular relevance as tools to reduce gender gaps. This article presents an initiative carried out by the School of Engineering at the Universidad de la República (Uruguay) as part of the International Girls in ICT Day. During this event, several hands-on workshops are offered, led by women instructors from the Institutes of Mathematics, Computer Science, and Electrical Engineering. This paper describes two relatively recent workshops implemented in the 2024 and 2025 editions: one focused on the fundamentals of machine learning through playful and collaborative activities, and another aimed at exploring electronic circuits using micro:bit boards. The objectives, content, and methodologies of each workshop are presented, along with preliminary results from their implementation, with the goal of supporting potential adaptation in other educational settings. The article also includes a variant of one of the workshops developed at another institution as a replicable experience, enabling reflection on the scope and challenges of these initiatives in diverse contexts.

Keywords

ICT careers, hands-on workshops, women in engineering, Uruguay

1. Introduction

Over the past decades, researchers across Latin America have developed a variety of interventions to address the gender gap in computing and engineering more broadly, sharing their experiences in specialized venues. In Brazil, the *Sociedade Brasileira de Computação* created the event *Women in Information Technology* ((WIT) in 2007, with this purpose. Two years later, the *Latin American Women in Computing Congress* (LAWCC) began to bring together educational and professional initiatives from the region [1, 2, 3].

Uruguay is no exception: since 2017, the School of Engineering at the Universidad de la República has organized activities as part of the International Girls in ICT Day, a date promoted by the International Telecommunication Union to raise visibility and encourage the participation of girls and adolescents in technology-related careers. These initiatives have been documented in various publications over the years, describing both in-person experiences [4, 5, 6] and online workshops developed during the

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2021 public health emergency [7]. All of them share an active learning approach based on "learning by doing," a methodology in which the School of Engineering has a long-standing track record at multiple levels of its degree programs [8, 9].

The 2025 edition brought together over 200 lower- and upper-secondary students from a wide range of educational institutions, both public and private. In particular, girls from eight public institutions and five private ones attended. A variety of interactive thematic workshops were offered, designed to spark curiosity, promote experimentation, and strengthen computational and scientific thinking. Among them was a mathematics workshop in which the participants rotated through different stations featuring playful challenges such as the infinite puzzle, the Towers of Hanoi, a treasure hunt, and the Monty Hall problem. Other activities involved programming [10], the Butiá educational robotics platform [4], as well as activities integrating mathematics and computing [11]. In addition, instructors from the Institute of Electrical Engineering (IIE) organized two workshops: one focused on machine learning and another one on electronic circuits using micro:bit boards. This article focuses on both of these workshops, which were offered for the second time this year (2024 and 2025) and are among the most recently incorporated into the program.

The *Electrizante* workshop aims to introduce basic electronics and programming concepts through the construction of an intelligent traffic light using micro:bit boards (widely used in Uruguay thanks to Ceibal). The workshop seeks to foster hands-on work, algorithmic logic, and an understanding of sensors and actuators. Meanwhile, the How Do Machines Learn? workshop introduces students to basic machine learning concepts through playful, classification-centered activities.

The overall session lasts approximately two hours. It begins with a welcome delivered by the Dean of the School and by the organizing faculty team. The students are then distributed among the different workshops, ensuring that participants from the same institution can experience different activities, which facilitates a collective discussion afterward. The workshops then take place. Most of them include a short introductory talk about the degree programs offered by the School and about the issue of low female participation in STEM fields. At the end, the girls gather again in a shared space for a snack.

The remainder of the article is structured as follows: Section 2 describes the How Do Machines Learn? workshop, presenting its methodology and some of the results obtained. Section 3 discusses the Electrizante workshop, detailing the materials and equipment used. Both sections include the results of opinion surveys administered to the participants of each workshop. Section 4 presents a modified version of the machine-learning workshop, carried out at a U.S. university by one of the authors. Finally, Section 5 offers overall conclusions about the activity and some final reflections.

2. Workshop: How do machines learn?

This section describes one of the most recent workshops incorporated into the event, focused on introducing basic concepts of machine learning. The following subsections outline the objectives and contents addressed, the activities carried out during the session, and the results obtained from the interaction with the students.

2.1. Aim and content

The aim of the workshop was to introduce students to the field of machine learning, with a particular focus on decision trees and their application to data classification. The motivation for creating this new workshop lies in offering an accessible introduction to machine learning techniques, considering the growing popularity of artificial intelligence (AI) tools in recent years with which students are already broadly familiar. For this purpose, we proposed a playful and collaborative approach to help students understand how machines learn from examples. Decision trees were chosen because they are an intuitive model that allows for the introduction of fundamental machine learning concepts in an accessible and visual way. The workshop was offered in two formats: in-person and online.

In addition to an introductory talk on the School of Engineering, its academic programs, and a reflection on the low participation of women in STEM fields (Science, Technology, Engineering, and

Mathematics), the workshop addressed the following key concepts:

- A general definition of machine learning and its applications.
- An introduction to labeled data and its partition into training, validation, and test sets.
- Presentation of decision trees as a model for classification tasks.
- A discussion on overfitting and the role of the validation set in evaluation.

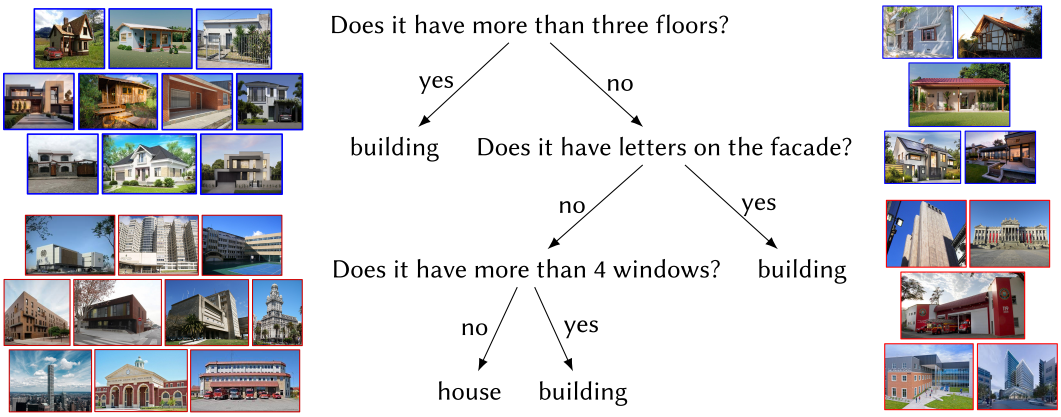
At the end of the workshop, one of the facilitators presented the most relevant findings from her undergraduate thesis, which explored the use of data science in education from an equity and intersectional perspective, considering dimensions such as gender, race, and class [12].

2.2. Description of the activity

The students worked in teams of five or six participants. Each group was given a set of labeled images serving as a training set, corresponding to one of the following binary classification categories:

- sandwiches vs. general food,
- dogs vs. other animals,
- apples vs. other fruits,
- soccer vs. other sports,
- houses vs. buildings,
- cars vs. other vehicles.

Using this dataset, each team constructed a decision tree on paper, defining a sequence of questions that would allow them to correctly classify the images. Figure 1 illustrates one of the trees generated: on the left, the images from the training set are shown with colored borders according to their labels (blue for houses and red for buildings); in the center, the decision tree built by the participants appears in its digital version, recreated from the original paper version.



(a) Training set (b) Decision tree (c) Test set

Figure 1: On the left, the images from the training set are shown, labeled as *house* (blue border) or *building* (red border). In the center, the decision tree constructed by the participants based on those images. On the right, the test set. The tree correctly classifies all examples in the training set but makes errors when generalizing to the test data, illustrating a case of overfitting.

Once the model was designed, it was exchanged with another team, which evaluated its performance using a test set. In Figure 1, these test images are shown on the right, allowing participants to visualize the cases in which the tree successfully generalizes and those in which it fails. During a final group discussion, the correct classifications and errors were reviewed, prompting reflection on the limitations of overfitted models and on strategies to improve their generalization ability.
Figure 2 shows a moment during the workshop in which the students worked in teams to design their own models, as well as one of the decision trees constructed during the activity.

Figure 2: Students working as a team during the workshop, building decision trees on paper.

2.3. Results

At the end of the workshop, participants were invited to complete a brief evaluation questionnaire. In addition to questions aimed at contextualizing the sample (e.g., type of institution, parents' education level, etc.), the survey included the following multiple choice questions:

- Would you be interested in studying a degree related to the topics covered in the workshops?
- What did you think of the introductory talk?
- What do you think about the topics and activities carried out during the workshop?
- Did you learn new things?
- Were you able to complete all the workshop activities?
- How difficult did you find the activities?
- What is your overall opinion of the event?
- Would you recommend that your friends and classmates participate in this event next year?

As shown in Figure 3, the participants' overall evaluation of the workshop was highly positive. A total of 91.6% rated the event as "good" or "very good," while 8.3% rated it as "excellent." Regarding the contents and activities, 79.2% considered them "interesting," and 8.3% described them as "very interesting." Only a minority (12.5%) indicated that they found them "slightly interesting." These results suggest that the workshop successfully captured the interest of most students, both in its format and in the topics addressed.

3. *Taller Electrizante*

The second workshop carried out was called *Taller Electrizante*, this section describes it in detail. As mentioned before, this workshop was supported on micro:bit boards, which are programmable boards developed by Micro:bit Foundation of the BBC (see Figure 4).

For several years now, thanks to Ceibal and with the support of the School of Engineering, public educative institutions have kits of micro:bit boards, tutorials, projects and a community where experiences are shared. This is taken as an advantage since many of the participants had experience with the tool already.

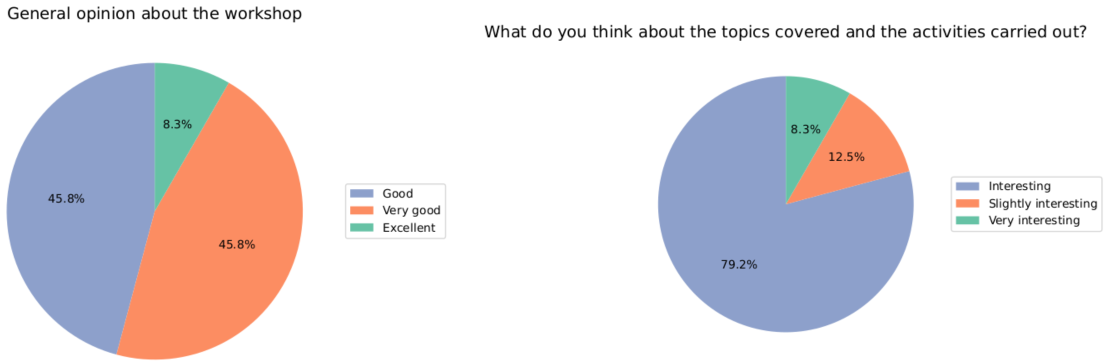


Figure 3: Results of the satisfaction survey answered by the participants at the end of the workshop. On the left, the general assessment of the day. On the right, the opinion on the topics addressed and the activities carried out. In both cases, the majority of responses reflect a positive perception of the experience.

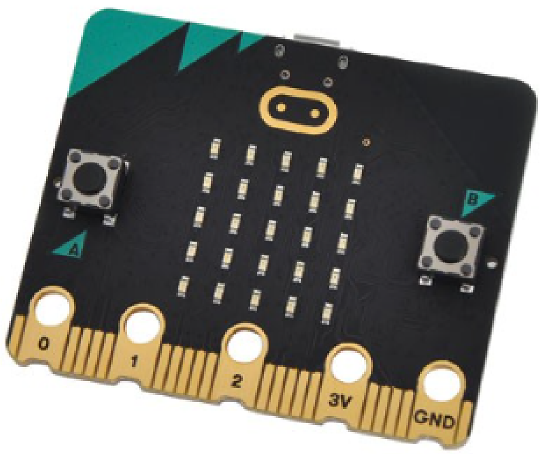


Figure 4: Micro:bit board.

3.1. Aim and content

The aim of the workshop is for the participants to approach electronics and programming by assembling simple circuits and writing short pieces of code to be used in micro:bit boards. Since the final product is a transmitter-receiver system, aspects of communications are considered indirectly, such as the radioelectric spectrum, among others.

Each group of participants had two boards: one to be used with the transmitter system and the other one to be used with the receiving system. The former was in charge of measuring the distance to the most near object, whereas the latter had to simulate traffic lights by turning on red, yellow or green LEDs, depending on the distance of the object. In order to achieve this purpose the boards had to communicate by radio, so that one can send the value of the measured distance to the other.

Concepts developed in the workshop included:

- Basic functioning of a micro:bit board.
- Use of ultrasound sensors for distance measure.
- Radio communication between boards.
- LEDs turn on and off control through programming.
- Basic assembly of circuits, getting familiar with components (resistors, buttons, cables, pins).

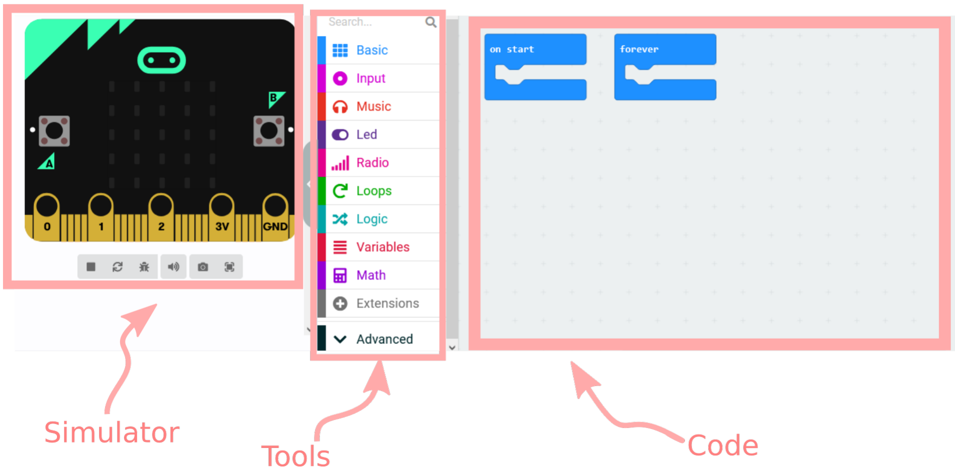


Figure 5: MakeCode workspace. The area on the left is where the user develops the code by arranging blocks. The blocks are selected within the "Tools" menu, where they are grouped according to their functionality. The simulator on the left shows the behavior of the board with the implemented code.

3.2. Description of the activity

Besides the two micro:bit boards, the students —organized in small groups— received a kit with a distance sensor, LEDs, resistors, a button, cables and a board with sockets where to insert the components.

At the beginning of the workshop, a short presentation was made to describe the activity and explain the function of the components delivered, since most of them were probably unknown to most of the students. In addition, a written guide of the tasks to be carried out was provided in order to organize the process. The aim was to build a traffic lights system that reacted to the distance of an object by changing the color of the LEDs: green for large distances, yellow for intermediate ones and red for short ones.

Communication between boards was performed by using the radiofrequency module incorporated in micro:bit; in this way, one of the boards sent the data of the sensor and the other turned on the LEDs. The participants had to connect the components in the board with sockets in the right places, paying special attention to the connections between them. Also, the workshop involved the programming of one of the micro:bit boards using the MakeCode environment. This allows to create code in block format, not being necessary to have previous programming knowledge. The MakeCode workspace is shown in Figure 5.

3.2.1. Receiving system

The micro:bit board of the receiving system is in charge of turning on the LEDs, depending on the value of the distance. This is done by turning on and off the pins P0, P1 and P2: if no objects are near, the green light should be on (1 in P0); if there are objects at a distance between 20 cm and 40 cm the yellow light is on (1 in P1); finally, if there are objects at a distance nearer than 20 cm, the red light (P2) turns on.

Figure 6 shows the circuit to be assembled by the participants (on the right) together with the guide diagram (on the left), where the connections to the micro:bit board can be observed. One of the most challenging tasks for the participants was to examine and understand the soldering on the other side of the board that connected the different sockets, so that they could assemble the circuit correctly.

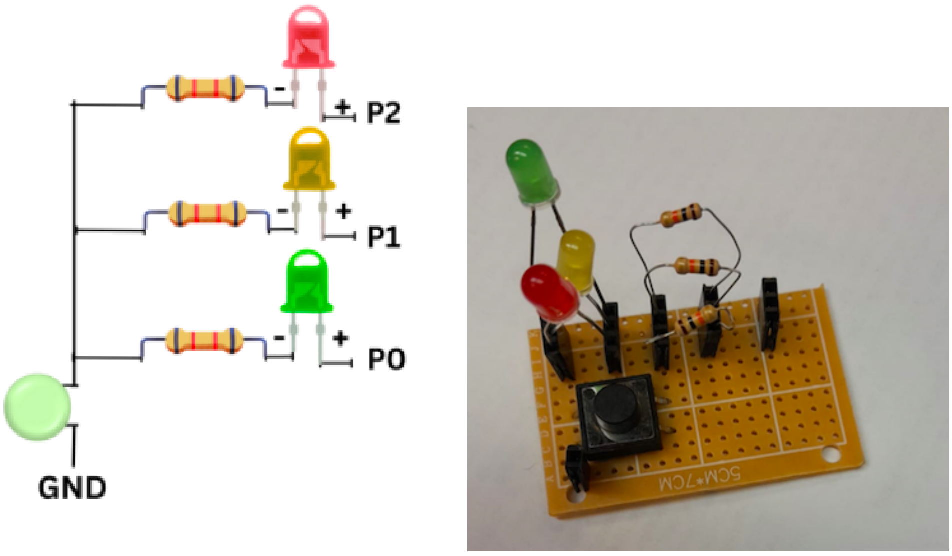


Figure 6: Receiving system circuit. The red, yellow and green leds must be connected to pins P2, P1 and P0 of micro:bit. GND is the ground reference. On the left the basic schematic is shown whereas on the right you can see the circuit that has to be assembled by the students.

The guide suggested that, once the receiver circuit was ready, groups should check every connection before starting to work on the transmitter. To do this, the participants connected pins P0, P1 and P2 directly to the 3 V output. In this way, they could observe that the LEDs turned when pressing the button. During this stage the students were introduced to concepts like ground reference, supply voltage and open or closed circuit.

Regarding the code of the receiving board, it comes pre-loaded in it. The complete code is shown in the guide and the participants are encouraged to analyze its functioning.

3.2.2. Transmitter system

The transmitter system is constituted by another micro:bit board connected to an ultrasound sensor, as pictured in Figure 7. In this case, besides connecting the sensor to the board, the participants had to program the corresponding code. To be able to work with the sensor, they had to use blocks from the category Ultrasonic, and, in order to send the information, the blocks from the category Radio. It was important that each group used a different radio channel so that each micro:bit “listened” only to the other board of the group.

The guide and the initial presentation indicated which blocks had to be used, but the participants had to decide how to use them. During this stage, the groups needed to differentiate between blocks *on start* and *forever* in MakeCode, developing basic concepts of programming such as initialization an infinite loops. They also had to deduce, from physical connections, which pins had to be assigned in the code as channels ECHO and TRIG from the ultrasound sensor.

3.2.3. Integration of both systems

Once both circuits were assembled an micro:bit boards programmed, the systems were combined to observe the functioning of the whole system. To do this, the participants moved objects closer or further from the sensor and verified the changes on the states of the LEDs.

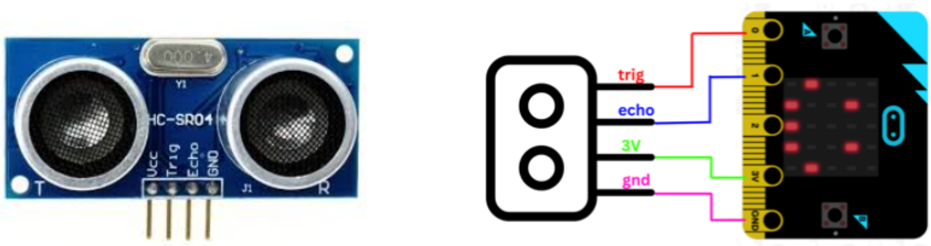


Figure 7: Distance sensor and its connection to the receiver micro:bit. Pin TRIG of the sensor is connected to pin 0 of micro:bit to indicate that a new measurement is required. Pin ECHO is connected to pin 1 of micro:bit to announce that a new result is available. Other pins have the purpose of supply and provide ground reference.

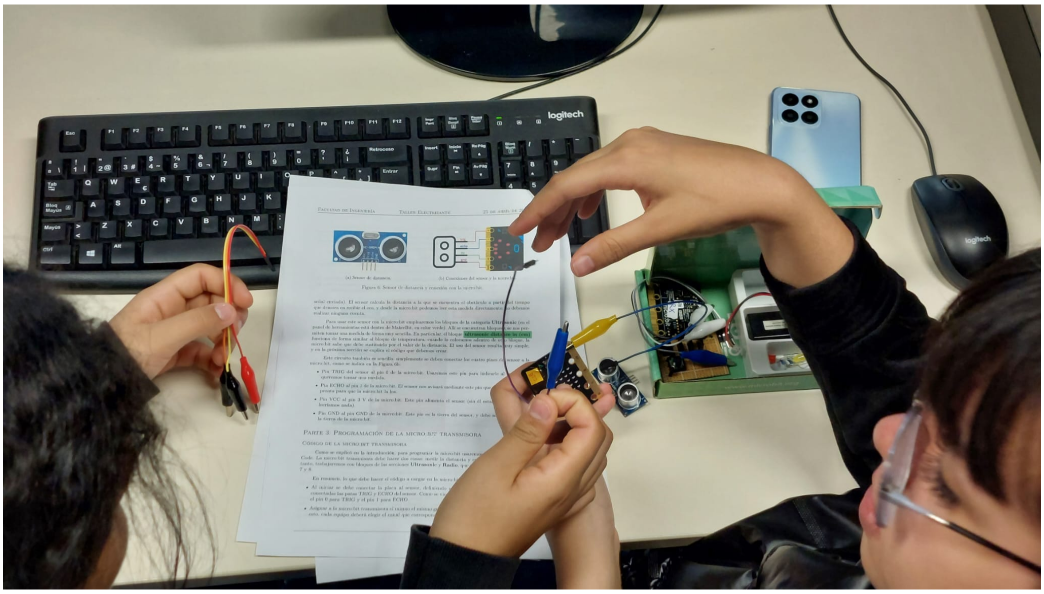


Figure 8: Students working in teams following the instructions of the guide that was delivered. In this case the students are assembling the circuit of the transmitter.

3.3. Results

Figure 8 shows a group of girls assembling the systems. Every group was able to finish the different tasks and to prove the communication system successfully. A strong point of the workshop, even for those students who were not particularly proactive or interested during the activity, was the surprise and satisfaction when they saw the correct functioning of a circuit built by them. This is confirmed by the additional comments that were made in the survey later on, were most of them indicated that seeing the traffic lights functioning was the most interesting part of the workshop.

The survey carried out after the activity was identical to the one mentioned in the previous section. As an example, the results of the same questions are shown in Figure 8. As well as in the other workshop, the feedback of the participants is highly positive.

4. Multiplying the Impact: Replication and Recommendations

The experience developed for the original workshop generated a positive impact on its participants. The survey results motivated the delivery of the workshop (or a variant of the machine learning workshop) at the PennGEMS event at the University of Pennsylvania, in the United States. This section briefly presents that experience, highlighting key elements that facilitated its implementation, as well as a set of recommendations for future initiatives.

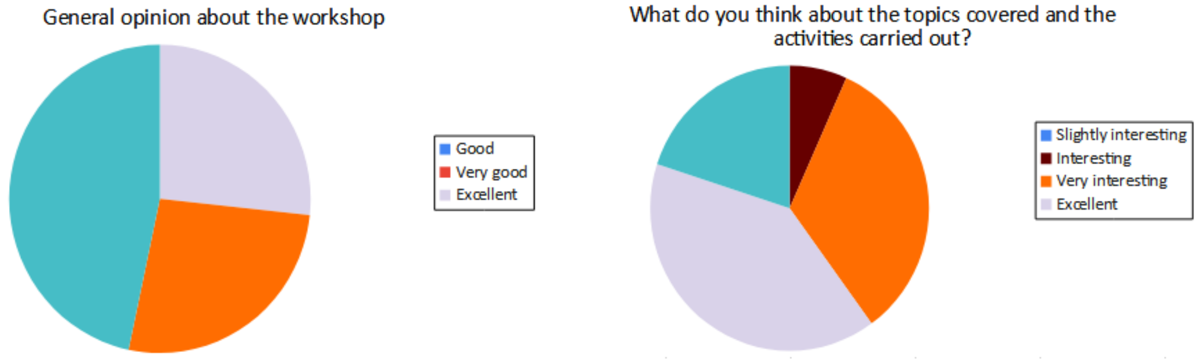


Figure 9: Results of the satisfaction survey answered by the participants at the end of the workshop. On the left, the general assessment of the day is shown. On the right, the opinion of the approached themes and carried out activities is presented. In both cases, the majority of answers reflects a positive perception of the experience.

PennGEMS is a one-week summer camp in which teenagers attend various workshops in STEM areas. A workshop titled "The Magic of AI: How do machines learn?" was proposed, offered twice on consecutive days, with an attendance of 24 teenagers aged 12 to 16 each day. The workshop format consisted of a slide presentation with planned pauses for activities. At the beginning, participants received a handout with exercises, which were referenced at appropriate moments during the workshop and could be solved in teams.

Although the workshop was strongly inspired by the version presented in Section 2 of this article, instead of asking participants to create a decision tree, they were given one that they needed to modify to fit new data (illustrating model instability), as well as another tree on which they had to evaluate performance with test data (to observe overfitting). This resulted in a better understanding on the part of the teenagers and streamlined the activity, making it possible to incorporate additional content. For example, the handout included basic descriptions of more complex architectures (Convolutional Neural Networks, Graph Neural Networks, Transformers, K-Means, and Principal Component Analysis (PCA)), which were read and discussed during the workshop. This constituted a significant enhancement to the technical content. Both the new architectures and the previous activities were then assessed through a live quiz, whose interactive nature allowed students to demonstrate a deeper command of the subjects. At the end of the session, participants engaged in reflections regarding the biases embedded in machine learning models.

The inclusion of additional activities resulted in a more participatory workshop with richer content. It is worth noting the advantage of delivering the workshop twice with enough time in between to apply adjustments. Moreover, the activity benefited from the fact that all participants were already interested in STEM fields—something that does not always occur in activities offered at the School of Engineering, where teachers often register girls without considering their personal interests.

5. Conclusions

The proposed activities achieved the aim of bringing technology closer to women teenagers in an environment that was both challenging and amicable. The two experiences presented in this article allow to confirm that, with good planning, it is possible to introduce complex concepts in ways that are reachable and motivational.

The active participation of the students, their enthusiasm and the quality of the final products obtained at the workshops reinforce the importance of fostering these initiatives from the university sphere, promoting inclusion and equality in key areas for future development. The final survey carried out after each workshop showed that the participants valued the whole experience as very positive, remarking the participative and distended environment, as well as the interest of the contents.

It should be emphasize that the workshops are led by women —students, graduated engineers, and teachers— with different trajectories, which provides the girls with a broad and enriching spectrum of possibilities to consider in their future choices.

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Declaration on Generative AI

The authors have not employed any Generative AI tools.

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