Code Huntresses: promoting gender equity in ICTs

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Abstract

Multiple metaphors are used to describe the gender gap in areas of knowledge linked to careers in science, technology, engineering and mathematics. One of them is the existence of a "glass ceiling" that prevents women from reaching higher levels in their professional development. There is also talk of the "leaky pipeline" to describe when women begin an educational or professional path, but gradually leave it, either for personal reasons or because of institutional barriers, stereotypes and other forms of discrimination. Many of these "leaks" are encountered from their passage through secondary education. Working with adolescent girls at the secondary school level, seeking to provide them with key knowledge of these disciplines and encouraging them to choose careers in this area, has been a strategy chosen by several organizations around the world. In this sense, and taking advantage of the celebration of the International Day of Girls in Information and Communication Technologies (ICTs), the Faculty of Engineering of the University of the Republic has been giving technological workshops for several years to adolescents between 12 and 16 years of age as a way of promoting ICT careers in Uruguay. This article presents in detail the "Code Huntresses" workshop so that it can be replicated and/or adapted by other institutions, and also presents the results obtained from the first edition of the workshop.

Keywords

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

1. Introduction

For some time now, the low participation of women as students, researchers and professionals in the areas of knowledge related to science, technology, engineering and mathematics (STEM) careers has emerged as a problem on the agenda of different public and private institutions. This is a concern not only in our country, but also in several countries in Latin America and the world. Seeking to reach adolescent girls who have not yet defined their vocational future, which is a strategy followed by several countries around the world [1, 2, 3], resulted in the beginning in 2016 of the project "Promoting ICT careers in female adolescents in secondary education in Uruguay" (see the project's WebPage, FRIDA Award 2018 winner project). This initiative is carried out by female teachers, articulating their extension and teaching functions, mainly belonging to the Institutes of Electrical Engineering and Computer Science of the School of Engineering, University of the Republic. The main objective of the project is to bring aspects of

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Information and Communication Technologies (ICTs) closer to adolescent female high school students in order to promote their training and professional future in this area. It also seeks to generate spaces for reflection for the general public in order to break down stereotypes about women and technology. To date, more than 1,500 adolescents from public and private institutions in the country have participated in different activities (talks, visits, workshops, etc.).

A key activity of the project is the celebration of the International Day of Girls in ICTs on the fourth Thursday of April each year, promoted by the International Telecommunication Union (ITU) of the United Nations. Its main objective is to open the doors of educational institutions, companies and scientific-technological spaces to groups of primary and secondary school girls, so that they can make contact with the area of ICTs. Under the slogan of "doing instead of seeing", and under a *role-model* approach, since 2017, we celebrate this day in our Faculty by offering workshops on programming, robotics, databases, telecommunications, electronics, etc. A summary and description of the different workshops can be found in our WebPage and in the articles [4, 5, 6] (particularly the latter describes the adaptation made of the workshops to the distance modality, as a consequence of the Covid-19 pandemic, carried out in the 2021 edition). In this year's edition (see diffusion material in Figure 1), which was attended by a total of 230 adolescents and in which to the traditional workshops the new workshop called "Code Huntresses" was added.

The new workshop was designed and executed by a group of four professors from the Telecommunications and Signal Processing Departments of the Institute of Electrical Engineering. The workshop involved different disciplines of the ICT area; in particular, aspects of wireless networks, software defined radio, coding and decoding, radio spectrum, etc. The workshop was conducted as a treasure hunt, allowing the teenage girls, in small groups, to walk around and get to know different parts of the Faculty building while doing the workshop. In addition, in order to make the role of women in areas related to ICTs more visible, the dynamics of the workshop was used to allow the teenagers to meet different women leaders and teachers of the Institute of Electrical Engineering, some of them with relevant careers in different areas at national and international level (As an example, some of the women the teenagers met are: Eng. María Simón (former Dean of the Faculty, former Minister of Education and Culture and President of the state-owned telecommunications company); Eng. Fiorella Haim General Manager of Plan Ceibal [7], Eng. Alicia Fernández reference in the development of Artificial Intelligence in Uruguay, etc).

The rest of the article is structured as follows. In section 2 the "Code Huntresses" workshop is described, detailing the materials and equipment used. This section mentions different important aspects to take into account in order to replicate the workshop and details of its implementation. In section 3 some results obtained from the first edition of the workshop are summarized. In particular, we present some graphs of a survey done by the participants of the workshop. Finally, in section 4 we draw some conclusions, reflections and lessons learned.

2. "Code Huntresses" workshop

As mentioned in the previous section, this workshop consisted of a treasure hunt throughout the Faculty building, where participants received (using software define radio devices) images of

Figure 1: Part of the diffusion material of the activity developed in 2023 within the framework of the International Day of Girls in ICTs. Dissemination was carried out via social networks and e-mail.

prominent women from the Institute of Electrical Engineering. The transition between different checkpoints (detailed in Section 2.2) was done through clues with encoded information. High school students participating in the event were divided into groups of five members who faced the challenges. Each group was accompanied by a professor from the institute who took the opportunity to provide information about the courses, the faculty, the University, etc.

The activity followed a workshop structure, in which participants were first provided with a concise theoretical overview, followed by a hands-on approach with a strong emphasis on practical exercises. This designed workshop aimed to acquaint the young participants with concepts including the radio spectrum, the utilization of software tools like SDR++ [8] and software-defined radio (SDR) devices, in addition to introducing them to the basics of encoding and decoding.

2.1. Workshop Preparation

The workshop's preparation involved the study and adaptation of hardware and software materials. Transmission and reception systems were implemented using various technologies. The objective was to centralize difficulties primarily in the transmitting aspects, with the intention of making the reception process more straightforward (to be performed by high school students). The entire workshop was conducted using laptops donated to the faculty by Ceibal of the *Wezen* model (2022). Ceibal is Uruguay's digital technology center for education innovation at the service of public education policies. Ceibal promotes the integration of technology to improve learning and foster innovation, inclusion and personal growth. For more information see [7]. An example of these laptops is shown in Figure 4. In addition to the laptops, the workshop's hardware was supplemented with SDR equipment, which will be detailed further in this document.

2.1.1. Signal transmission

During the workshop, images of women of the Institute of Electrical Engineering, focusing on the ICT field, were transmitted. This transmission occurred directly within the radio spectrum using an out-of-tree module of the GNU Radio software known as *gr-paint*.

GNU Radio [9] is a free and open-source software development toolkit that provides signal processing blocks to implement software radios. An example of a GNU Radio scheme is shown in Figure 2. It can be used with readily-available low-cost external RF hardware to create software-defined radios, or without hardware in a simulation-like environment. The tool is implemented using the programming languages Python and C++. It is widely used in research, industry, academia, government, and hobbyist environments to support both wireless communications research and real-world radio systems. This fact results in the development of out-of-tree modules. These modules are available on platforms like GitHub, but they are not included in the default GNU Radio application. Some modules are added to the main application as they gain popularity and demonstrate their utility for the general public. Out-of-tree modules can be easily downloaded and added to GNU Radio. In particular, the *gr-paint* module was used in the workshop.

The *gr-paint* module [10] is a tool for GNU Radio developed by Ron Economos and improved thanks to contributions from users around the world. The goal of this project is to build a software-defined OFDM (Orthogonal Frequency-Division Multiplexing) transmitter that "paints" monochrome images into the waterfall of a receiver.

In the workshop, a GNU Radio setup was created employing *gr-paint* blocks for transmissions. Preconverted images in TGA format were used. The signals were transmitted around a central frequency of 500 MHz, with a transmission sampling rate of 1.024 MHz. The transmission equipment included Ettus USRP B100 and Great Scott Gadgets HackRF One. Tools utilized for signal transmission during the workshop's development are accessible in our github repository.

2.1.2. Signal Reception

High school student groups were provided with Plan Ceibal laptops and a RTL-SDR dongle kit. Figure 3 illustrates the kit given to the participants, which includes various antennas and

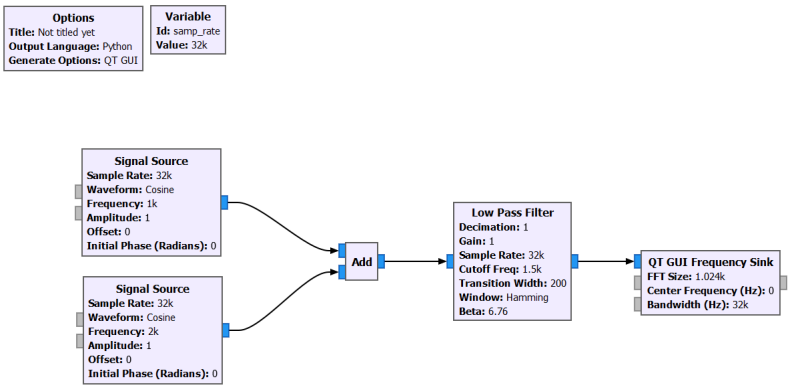

Figure 2: EGNU Radio *flowgraph* example. This example shows two blocks that generate sinusoidal signals; a block that performs the sum of the first and then a low-pass filter. The last block allows to obtain and display the frequency representation of the signal resulting from the previous operation.

corresponding connectors, along with the SDR dongle. This device allows for the capture of analog signal samples received by an antenna, with a USB connection to the computer.

Figure 3: RTL-SDR dongle kit. The SDR dongle, the antennas to be used, and various types of connectors and brackets for the antennas are shown from top to bottom. The RTL-SDR device in the figure allows receiving signals with frequencies between 500 kHz and 1.7 GHz. Image retrieved from Amazon.

SDR++ application [8] was utilized for processing the received samples through the SDR dongle. This application enables the selection of different modulation schemes and the definition of parameters like the central reception frequency and the sampling frequency. Participants configured both of these settings and also they adjusted the gain value during reception to enhance image clarity and contrast. Figure 4 illustrates an image reception.

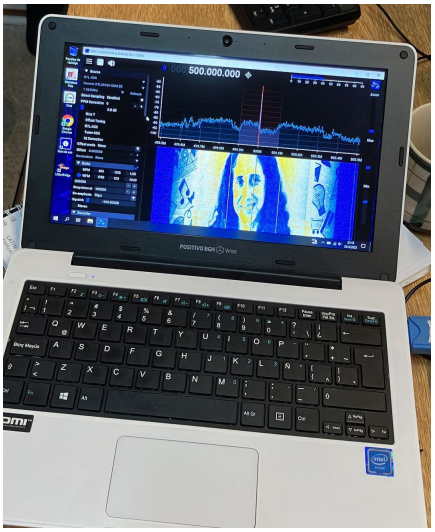

Figure 4: Example of reception of one of the transmitted images. The image was taken during the preparation process of the workshop. In particular in this image the woman shown is Eng. Fiorella Haim.

2.1.3. Coded clues given to students

For the passage between bases, clues were given to the students. These hints referred to some location within the Engineering Faculty building, with the challenge that the information was coded. The mechanisms used for coding are listed below:

- **Morse Code:** Developed by Samuel Morse and Alfred Vail around 1840, it was widely used for the first long-distance communications using the telegraph [11]. This coding system assigns to each letter of the alphabet a sequence of dots and/or dashes. The same mechanism is applied for the ten digits.
- **Emojis:** These are small drawings that seek to represent gestures or elements of everyday life (food, animals, sports). They originated in Japan at the end of the last century and have become more popular over the years. It is common to see games of guessing the names of movies or places in the world based on a certain combination of symbols.
- **Caesar Cipher:** Used by Julius Caesar in his correspondence, it is considered a simple encryption mechanism[12]. As a first step, a number N is defined, agreed upon between those who must be able to encode and decode the messages. Encoding consists of changing each letter of the message to the letter that is N places further down the alphabet. For decoding, the process is simply reversed.
- **ASCII Code:** The ASCII code allows encoding letters and numbers with seven-bit binary words.
- **Código QR:** This is a mechanism from which links can be obtained by making use of the camera of a device such as a cell phone. *QR* stands for *quick-response* [13].

Table 1 presents the clues used and the corresponding decoding. A brief discussion on these and other mechanisms of coding information was conducted as an introduction to the workshop.

The students searched the Internet for reference tables or images that allowed them to decode the information.

Table 1
Delivered clues and corresponding decoding.

Clue	Decoding
1010000 1001001 1010011 1001111 110111	7th floor
	Canteen
	Library
	Institute of Electrical Engineering
2 KOKEKQ	Starting Point

2.2. Workshop development

The workshop lasted an hour and a half (not counting the initial presentation on the career offerings at the Faculty). It began with a brief discussion on coding mechanisms and a general explanation of the working materials. Then, the group was divided into four subgroups, each of which was given a kit for signal reception in the different bases, and they were shown how to assemble it. Once each group had their reception equipment ready, the first clue to be decoded was handed out. All the groups followed a different path, passing through all the stations and ending at the starting point of the activity. Each group was accompanied by a workshop teacher. The trajectory of one of the groups will be described below. The map with the location of the tracks along the Faculty is shown in Figure 5.

- On the first floor (where the workshop began) they were given a clue in ASCII code whose decoding leads to the seventh floor.
- On the seventh floor, the image of the first featured woman is received. After the participants search for information about her on the Internet, they are given the next clue, in this case, coded with emojis that leads to the canteen.
- In the canteen, the second image is decoded. A new search is made on the same image and the next clue, encoded in Morse, is given to them, which leads to the library.
- In the library, they go through the facilities and find the transmitter to receive the third image. Again, information about it is sought and they are given the next clue, in this case, coded in QR, which leads to the Institute of Electrical Engineering.
- In the Institute of Electrical Engineering they walk through the facilities and find the last transmitter from which they receive the fourth image. After a brief discussion about who that woman is, they are given the Caesar coded clue leading to the start (first floor).

- Once at the place of departure, the kit is put away, the participants are asked to complete the evaluation surveys, they are given commemorative stickers of the event and a snack is shared (while they meet again with their classmates who participated in other workshops of the day).

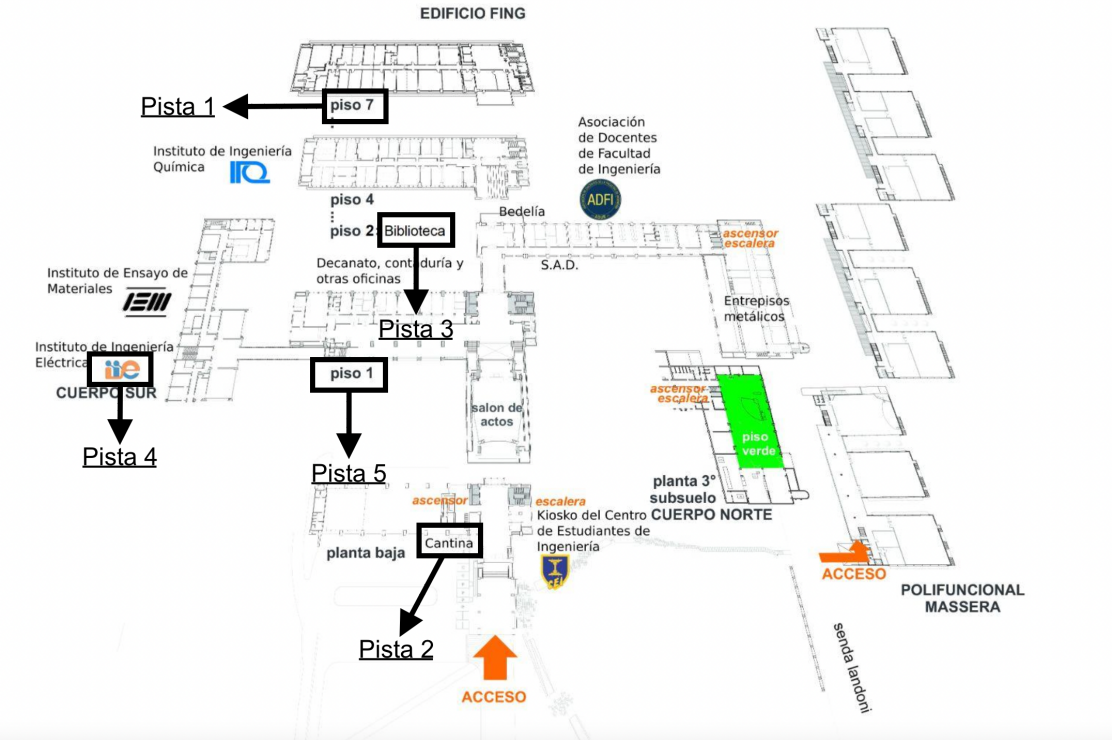

Figure 5: Map of the Faculty of Engineering with the location of the bases and their corresponding tracks. It can be seen that during the workshop a good part of the building was toured.

The main results of the first edition of the workshop that took place in April 2023 are summarised in the following section.

3. Results and Assessment

Over 230 students from 7th to 9th grade and 1st year of high school participated in this activity, all of them belonging to different economic and social contexts, from both public and private high schools in Montevideo and the rest of the country. Thanks to the FRIDA Award won in 2018, funding has been provided to cover transportation costs for institutions located far from the capital. This has been ongoing since 2019, except during the pandemic, when activities were conducted remotely.

In particular, 40 students participated in the “Code Huntresses” workshop. Figure 6 shows a series of photographs that were taken during the development of the activity. Moreover, Figure

7 shows a group of teenagers benefiting from the tour to take photos of places that caught their attention.

Figure 6: Development of the activity. The picture on the top left shows the girls attending the introductory exhibition. The pictures on the right depict the groups testing the kits according to the instructions given by the workshop facilitators. The bottom left picture features one of the teenage girls trying to decode one of the clues by looking up the code information on her mobile phone.

After the workshops were concluded, attendees were invited to participate in a Google Forms survey to gather feedback and improve future editions of the activity. The survey featured personal questions, such as the grade they were in and the characteristics of the high school they attended. In addition, there were questions about the event in general and specifically about our workshop. Furthermore, the adults who accompanied the teenagers, such as teachers or school counsellors, were also asked to complete a similar survey.

The survey was optional and was completed by 19 out of the 40 students who attended our workshop. It is noteworthy that all the participants found the introductory talk about the different career options offered by our faculty to be of interest. They also rated the activities they participated in, as well as the topics introduced in them, positively. In addition, they all expressed that they had learned something new. The results obtained for these questions are

Figure 7: A group of teenagers taking pictures of the beautiful views that can be seen from the faculty building, especially from the seventh floor, which is one of the bases visited during the workshop.

presented in the circle graphs shown in Figure 8.

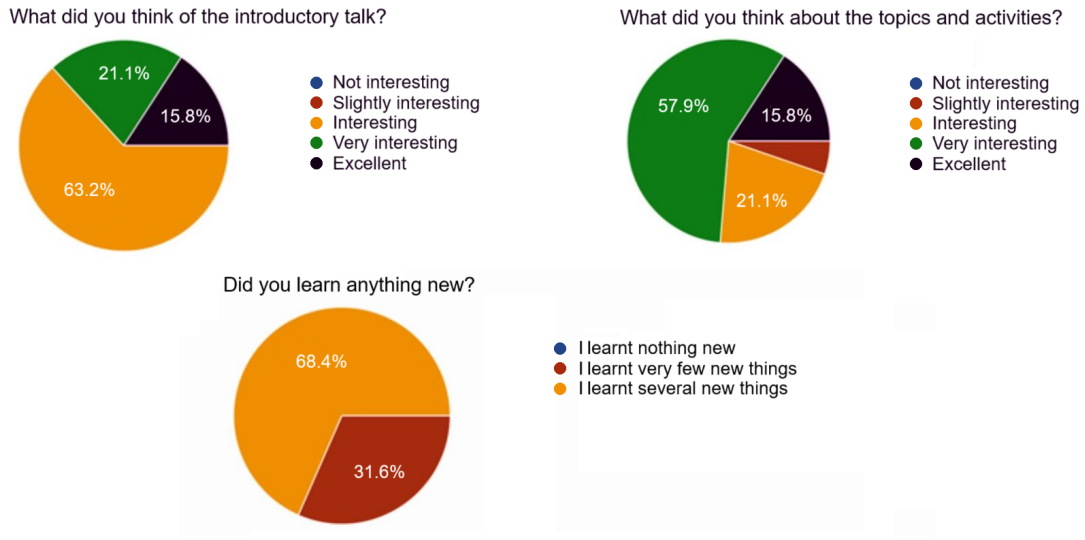

Figure 8: Circle graphs depicting the results obtained for certain questions in the questionnaire.

Over 80% out of the surveyed teenagers said that neither of their parents had attended university. Out of these teenagers, 75% were enrolled in the public education system. This fact should not be overlooked when it comes to conveying to teenage girls the possibilities of study and career development to which they can have access.

Finally, it is noteworthy that 90.5% out of attendees expressed their interest in participating in the event again next year and 97.7% would recommend the activity to their friends and colleagues.

4. Conclusions

Year after year, participants have expressed their desire to participate in activities such as the one we proposed. Most of the girls are delighted to have the opportunity to learn in an environment different from their school, through experiences with topics that are new and interesting to them. The impact of the activities, which have been taking place since 2016, is already being noticed in the new generations that join our Faculty. For instance, two of the instructors who conducted the workshop in 2023 had participated in the activities proposed in 2017, when they were still high school students.

The methods of evaluation make it possible to identify areas for improvement for the following year. Our goal for 2024 is to improve the registration process, with the aim of reaching more educational institutions and providing opportunities for girls who have never participated in the activity. Online registration forms will be included and sent along with the event invitation to encourage the participation of all potential interested girls. In particular, emphasis will be placed in those who are interested in STEM fields or those who are not sure about what they would like to study at the tertiary level. Furthermore, some parts of the event, such as the introductory talk and concluding workshops, will be formalised by reserving special rooms for them.

Specifically, regarding the "Code Huntresses" workshop, the conclusion of this first edition is that it is here to stay. However, some areas for improvement were identified, such as the need to change some of the bases for the treasure hunt. There will be a particular focus on the discovery of new locations within the faculty, which will have a positive impact on the tour of the building during the activity.

This instance of dissemination and motivation are highly valuable for both the participating teenage girls and the teachers and students who plan the activity. The representatives of the different educational institutions have expressed their gratitude to the organisation and have expressed their enjoyment in accompanying their students during this activity.

Seeing the excitement of the girls when they arrive at Faculty and their eagerness to learn makes each year's work worthwhile. We will continue to break down gender stereotypes, seeking to have more women in engineering and ICT careers.

To facilitate the replication of the workshop, a comprehensive repository is accessible at the following link.

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