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Promoting Computational Thinking through Visual Block Programming Tools

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***Abstract*—Computational Thinking is a competence that is developed more in the last few years. This is due to the multitude of benefits it has in the classroom. Throughout this article we show a series of activities that promote the development of Computational Thinking using tools that allow visual block programming. The particularity of these activities is that some of them were performed during the confinement due to the COVID-19 and other activities were performed later, in the period known as the new normality. Throughout the article, details are provided about the different sessions. The different visual programming tools by blocks and the educational scenarios used are also indicated. In addition, the results obtained are shown.**

Keywords— Computational Thinking, Educational Robotics, Learning technology, STEAM

I. Introduction

In March 2006 Jeannette M. Wing published the article Computational Thinking in which she argued that this new competence should be included in the education of all children, since it represents a vital ingredient of learning science, technology, engineering and mathematics [1]. But what is Computational Thinking?

In Wing's own words, "Computational Thinking involves solving problems, designing systems, and understanding human behavior, making use of the fundamental concepts of computer science". In other words, the essence of computer thinking is to think as a computer scientist would when faced with a problem [2].

Other definitions of Computational Thinking have emerged in the scientific literature since then. Among the most accepted are the following: (a) "Computational thinking is the process of formulating problems in such a way that their solutions can be represented as sequences of instructions and algorithms" [3], and (b) "Computational thinking is the process of recognizing aspects of computing in the world around us and applying computing tools and techniques to understand and reason about both natural and artificial systems and processes" [4].

A very interesting initiative in relation to the definition of Computational Thinking is that promoted by the International Society for Technology in Education (ISTE) and the Association of Computer Science Teachers (CSTA), which have collaborated with leaders in the world of research and higher education, industry, and primary and secondary education to develop an operational definition that accurately describes its essential characteristics and provides a framework and common vocabulary for education professionals to work with.

According to this working definition, computer-based thinking is a problem-solving process that includes the following characteristics:

- Formulating problems in a way that allows the use of a computer and other tools to help solve them.
- Organizing and logically analyzing information.
- Representing information through abstractions such as models and simulations
- Automate solutions by using algorithmic thinking (establishing a series of ordered steps to reach the solution)
- Identify, analyze, and implement possible solutions with the aim of achieving the most effective and efficient combination of steps and resources.
- Generalize and transfer this problem-solving process to be able to solve a wide variety of problem families.

That is why certain activities have been carried out focused on developing computer thinking using a variety of tools. Some examples of these activities include the use of Scratch programing environment [5-7], the use of Crumble for [8-11], and the use of Arduino for [12-15]. In addition, several activities have been performed using a combination of these tools. For details on the activities, refer to [16-25].

To facilitate the development of computer thinking, there are currently many tools that allow users of all levels to get started in software development quickly and simply. These tools are based on the philosophy of block programming, through visual programming environments [26].

One of the objectives of the IEEE Student Branch at UNED is precisely to promote the development of Computational Thinking from an early age through video game programming and educational robotics in all school stages, from early childhood education to professional training.

Throughout this paper we describe certain activities carried out during confinement due to COVID-19 and activities carried out during the later stage of the new normal.

II. Purpose

Over the past few years, robotics and mechanical workshops have been provided to schools and foundations. These proposals, extracurricular, include programming and are presented as meetings that invite interest and vocations in children and young people.

Generally, through robotics kits in physical spaces, on a "trial and error" basis, it is possible to learn how circuits, mechanisms, and programming languages work, among other aspects. But what will happen to these kinds of proposals during the COVID-19 pandemic?

Handling objects that are moved from school to school will not be possible. Robotics and electronics workshops, specifically, will also have to be reinvented.

To benefit from robotics and digital education, it is essential that children have access to computers or tablets. The COVID-19 pandemic forced schools around the world to move to digital education.

For this reason, new orientations and materials for teachers, students and families are being developed, which can be implemented virtually. These can be found in the sessions organized with the IEEE Student Branch at the UNED, led by its Vice President of Students and Entrepreneurship, in combination with the IEEE Student Branch at the UNED, a new activity will be developed with the participation of students who belong to the Branch, in collaboration with other UNED Vice-rectorates (Research and Internationalization, Associated Centers), the Associated Center of Madrid at its headquarters in Las Tablas, the Schools of Industrial Engineering, Computer Science and the Faculty of Sciences (Mathematics, Physics, Chemistry and Environment), the Teaching Innovation Project (PID) for Teaching Innovation Groups (GID) of the UNED, GID2016-17 "Laboratorios de STEM y robótica educativa para la mejora de la experiencia del estudiante – STEM-SEC", the Spanish Chapter of the IEEE Education Society and Plaza Robotica (http://www.plazarobotica.es/).

The proposals being implemented at this time are focused on programming, a fundamental aspect of robotics.

III. Approach

The approach has been based on providing a series of sessions on how to use a variety of educational tools and scenarios in online settings.

In addition to the online and free access sessions, attendees were provided with a PDF with the presentation of each session. The sessions were also recorded and posted on the YouTube channel of the IEEE Student Branch at UNED, so that people can access this content in the future.

The following sub-sections detail the content of each of the sessions.

A. *Digital Twin with Arduino and mBlock*

This session was the first visual block programming activity carried out during confinement due to COVID-19.

The theoretical details of the Digital Twin technology are shown at the beginning of this session. Next, the hardware platform, the Arduino tool (https://arduino.cc/), and the software platform, the mBlock tool (https://mblock.makeblock.com/), are presented. Also included is information about the LEDs (Light Emitter Diode) that will be used throughout this session.

The next step is to indicate the components that will be used: (1) Arduino, (2) a USB cable, (3) a protoboard, (4) LEDs, (5) 100 Ohm resistors ¼ W, and (6) DUPONT male-male cables.

This point indicates the electrical connections required for the example to be made: (a) LED cathode (long leg) to digital pin 8 of the Arduino, (b) LED anode (short leg) resistance, and (c) The free leg of the Arduino's 0V port resistor.

The next step is to build the program with the different commands so that the code executed with the Arduino is synchronized with the code executed by the mBlock Sprite: (1) Create two aspects for the default Sprite, (2) Adds commands for the object to change its appearance every second, (3) Add the commands for the Arduino to turn the LED connected to port 8 on for 1 second and off for another second, (4) Connect the USB cable to the Arduino and the PC, (5) Connect the Arduino to mBlock, (6) Upload your program, (7) Install the diffusion complement (extension) for the Arduino, (8) Add the commands for the Arduino to indicate the state of the LED to the object, (9) Install the diffusion plug-in (extension) for the object, (10) Add the commands for the object use the messages received from the Arduino to change the disguise, (11) Connects the junction between the resistor and the LED to the Arduino's A0 analog port, (12) Add the commands for the Arduino to send the measured voltage between the LED and the resistance measured on the analog port 0 to the object, and (13) Add commands for the object indicate when the circuit is open.

Figure 1 shows an example of the hardware connections and operation of the Sprite running in mBlock.

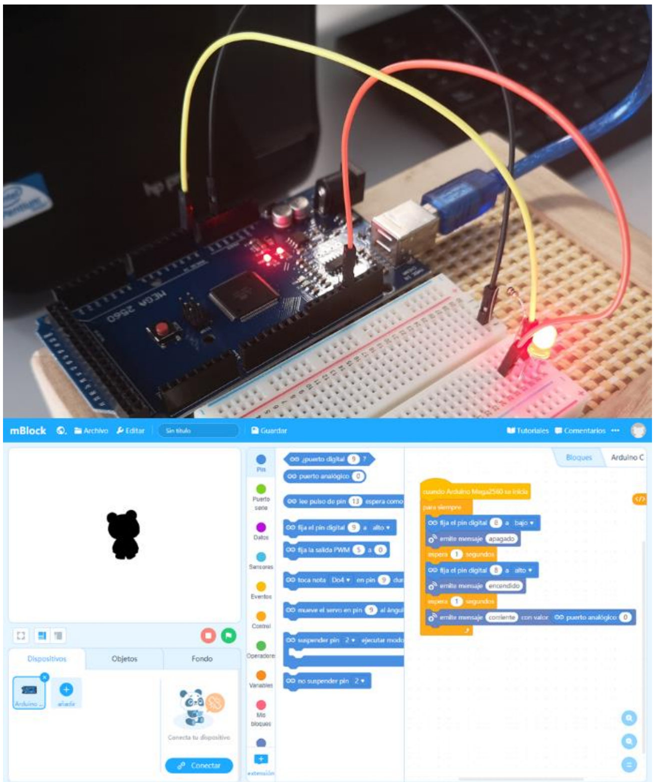

Fig. 1. Digital Twin application using Arduino and mBlock.

At the end of the session, two challenges were proposed to the attendees: (1) Create your own traffic light to behave like a real traffic light: Red ➔ Green ➔ Yellow, and (2) Create your own Digital Twin application using the knowledge you have acquired and the components you have available.

B. *Scratch as the first contact with educational robotics*

This session was the second visual block programming activity performed during confinement due to COVID-19.

The objective of this session is to introduce attendees to the Scratch tool (https://scratch.mit.edu/). First, the origin of the tool and the uses that can be given in learning environments framed in STEAM (Science, Technology, Engineering, Arts and Mathematics) was detailed.

Then, the Scratch panels and command groups were shown. Then, we started with the educational scenario of the traffic light. The traffic lights have lights to regulate the passage of vehicles and lights to regulate the passage of pedestrians. To work on this educational scenario, the following steps were proposed: (1) Select the scenario on the display panel, (2) Edit the background of the stage to start creating your traffic light, (3) Each light of the traffic light will be a character, (4) Each Sprite will have two costumes: an on and an off aspect, and (5) Program your Sprites to be: One time on, one time off.

Figure 2 shows some of the results of the steps followed throughout the session.

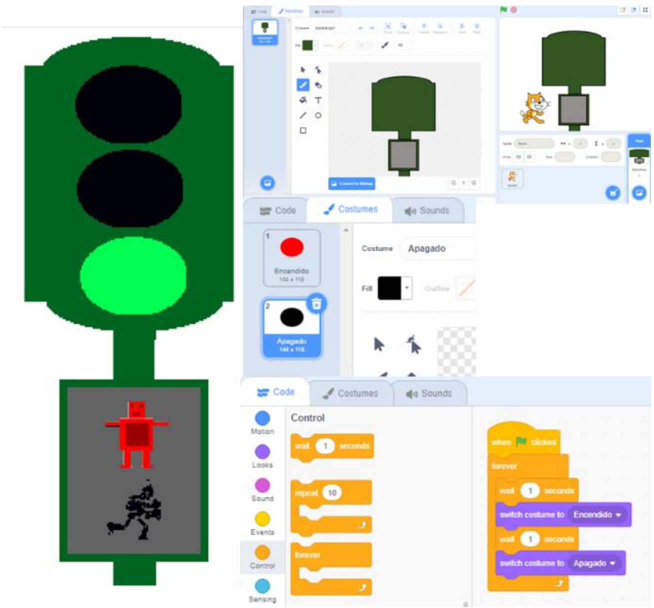

Fig. 2. Traffic light application using Scratch.

At the end of the session the following challenge was proposed to the attendees: Synchronize your character's programs so that your traffic light behaves like one:

- Sequence of vehicles: red, green, and yellow
- Sequence of pedestrians: red, green, and flashing green.
- If a vehicle can pass, the pedestrians must stop and vice versa

C. *Scratch Day 2020 Faculty*

This session was the first visual block programming activity carried out during the new normal stage.

This session started with a networking as presentation part. During this, all attendees and the panelists had a time to connect. After the presentation there was time to discuss ideas in a brainstorming format. From this brainstorming, the following ideas appeared from the use of Scratch in the classroom: (1) It is interesting to link it with real physical systems, (2) Students use Scratch to develop computer thinking., (3) Didactic use: evaluative interventions and integrated into the curriculum, (4) It is natural for children to work with Scratch, (5) Use Scratch with knowledge of Chemistry, (6) Using Scratch with Children with Special Needs, (7) Using Scratch with Seniors, (8) Watch out, Scratch is addictive, (9) Scratch forces you to unlearn, (10) With Scratch you favor/prepare to work with textual languages, (11) Limitation by complexity and hardware, and (12) Scratch forces you to change the concept about learning programming.

After this brainstorming, panelists and attendees were categorizing the ideas. The resulting categories was as follows: (a) Attracting children as a playful environment, (b) First contact, (c) Diversity, (d) Transversality, and (e) Limitations.

The rest of the session was composed of 3 panelists, who provided their experience with Scratch in different areas: (1) Scratch as a tool for use in Compulsory Secondary Education in Spain, (2) Scratch as a tool for use in extracurricular activities in Spain, and (3) Scratch as a tool for use by teachers of Compulsory Secondary Education in Spain.

D. *Scratch Day 2020 Projects*

This session was the second visual block programming activity performed during the new normal stage.

This session was composed of 5 parts: (1) the opening ceremony, (2) Project level 1, (3) Project level 2, (4) Project level 3, and (5) closing ceremony. All attendees connected simultaneously to the first and last part, but parts 2, 3 and 4 were in parallel.

The different projects had in common: maze-type video game, COVID19 theme, and multilevel projects. The level 1 project had the following objectives: (1) familiarize with the interface, (2) image editing, and (3) basic programming. The level 2 project had the following objectives: (1) intermediate programming, (2) character interaction, and (3) character-scene interaction. The level 3 project had the following objectives: (1) advanced programming, (2) mathematical operations, and (3) Scratch resources. Figure 3 shows some images of the results of the different projects.

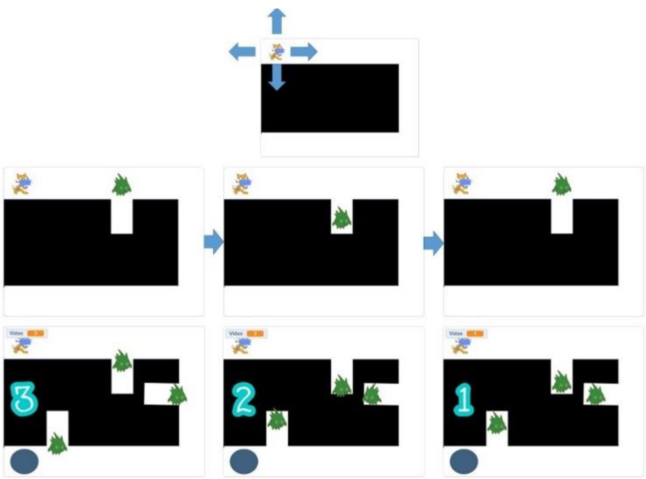

Fig. 1. Examples from the Scratch projects results..

As the attendees were given access to the contents of the different levels, at the end of the session the following challenges were proposed:

- For the attendees who completed the level 1 project:
  - Share images of the result with us
  - Enter the Moodle of Plaza Robotica and complete the level 2 project
- For those attendees who completed the level 2 project:
  - Share images of the result with us
  - Enter the Moodle of Plaza Robotica and complete the level 3 project
- For those attendees who completed the level 3 project:
  - Share images of the result with us
  - Incorporate enhancements you have discovered that allow you to do Scratch

E. *Machine Learning with visual block programming language*

This session was the third visual block programming activity carried out during the new normal stage. In this session, the work and possibilities of machine learning were demonstrated, using the resources of Machine Learning for Kids (https://machinelearningforkids.co.uk/) that are integrated with Scratch, so that there are easily manageable activities for students in elementary education. We worked the "Shy Panda" Project, which is a resource on the aforementioned website and an original idea from Cassie Evans (https://codepen.io/cassie-codes/pen/jKaVqo). In this project you interact with a shy panda bear. If the character does not feel observed, he will be dancing, but if this panda bear detects that you are observing him, he will be ashamed and he will stop dancing.

Fig. 2. Shy Panda, Machine Learning for kids

Through *Machine Learning for kids* the model is trained with numerous images in 2 categories (*I see you; I do not see you*) so that it recognizes if you are staring at the panda, or if you cover your eyes. In short, with this resource we add examples of things that we want the computer to identify automatically, the examples are used to train a computer so that it learns to recognize objects automatically, and the game is created in Scratch that makes use of these conditions with a Visual Block Programming Language.

F. *Introduction to micro:bit*

This session was the fourth visual block programming activity performed during the new normal stage.

At the beginning of this session, the following details were provided about the micro:bit platform (https://microbit.org/):

- Developed by micro:bit Educational Foundation in 2016
- BBC micro: bit is a small programmable card
- Open Source: open hardware and software

The hardware capabilities of this platform were also indicated:

- Bluetooth
- 3-axis accelerometer
- 3-axis magnetic sensor
- 25 LEDs
- Web Development
- 2 Pushbuttons
- 3 inputs/outputs with banana plug (4 mm)
- 23 pins (digital, analog, PWM, serial, I2C, SPI)

Below are some simple examples of how the platform can be used. Some micro:bit applications were also shown. And finally, it was shown an example of STEAM application with this tool.

Figure 5 shows some wheel robot assemblies that can be worked with in educational environments.

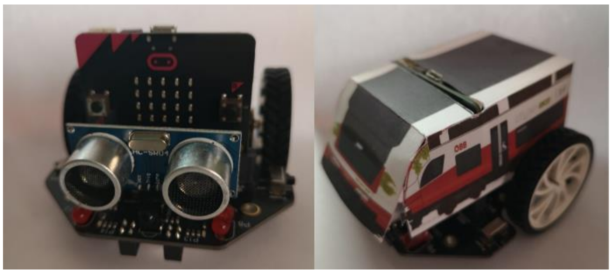

Fig. 3. Hardware setups for micro:bit.

IV. Outcomes

Throughout the paper we present different educational resources to be used in the framework of visual block programming tools to work on Computational Thinking. During our educational experiences, a total of 78 attendees were adhered to the sessions:

- 8 attendees were connected to Digital Twin with Arduino and mBlock
- 15 attendees were connected to Scratch as the first contact with educational robotics
- 13 attendees were connected to Scratch Day 2020 Faculty
- 16 attendees were connected to Scratch Day 2020 Projects
- 16 attendees were connected to Machine Learning with visual block programming language
- 10 attendees were connected to Introduction to micro:bit

All attendees were attending the sessions from their home in different parts of Spain. Figure 6 shows the location for the attendees. The attendees' figure represents an accumulated value in some cases the same person attended to several sessions. Hence, Figure 4 shows the number of attendees per session.

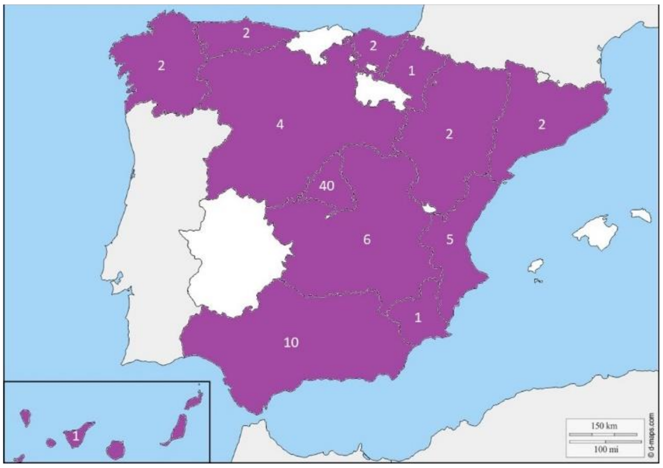

Fig. 4. Attendees location.

In addition, one person from England, two people from Mexico and two people from Peru attended too.

Some of them connected during the session with their parents. What has happened during the quarantine, moreover, is that families have become more involved in the educational process. The time they spend together can be spent doing projects based on the visual block programming tools as a family sharing activity, and then talking about what they learned. Now, not all parents have the same possibilities or knowledge, so it is also very useful to give the children the word. When the children take the word, they tell us what they are learning, their new knowledge. This can result in a moment of shared learning in family.

V. Conclusions

As shown throughout this paper, several activities have been carried out during the confinement caused by COVID-19 and other activities carried out during the new normal. We have described both the topics covered and a series of tools with which you can work on Computational Thinking.

In the different sessions, participants have been able to participate throughout the Spanish geography, and even, some participants were from other countries (England, Mexico, and Peru).

The use of the methodology and the tools used are a good choice for the participants to develop the Computational Thinking in the framework of Educational Robotics and STEAM.

As future lines of work, it is proposed to have a greater number of participants to analyze the effect of this type of activities. In addition, it is proposed to use LabsLand's remote Arduino laboratories that allow working with visual block programming. These labs allow the use of LEDs, servo, LCD screen, buttons, and variable resistors. In addition, LabsLand (https://labsland.com/) provides an Arduino remote laboratory for the control of a wheeled robot.

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