Crumble Day to introduce robotics

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***Abstract*—Crumble is an easy-to-use programmable controller. Its programming interface uses a block programming language that makes it easy for children above 10 to use. In addition, the hardware elements associated with Crumble are very intuitive and easy to connect. For this reason, educational robotics can be easily implemented thanks to the card connectors. The motors and servos can be managed by Crumble. Different sensors such as the ultrasonic distance sensor, infrared distance sensor and line sensor can also be connected. In addition, Crumble can handle up to 32 RGB (Red, Green and Blue) LEDs (Light Emitter Diodes) independently and with 24-bit color resolution. Robotics and computational thinking are ideal tools for developing science, technology, engineering and mathematics (STEM) pedagogy. Today, robotics training tools are raised with the aim of promoting innovation and motivation of students during the learning process. Robots are becoming more and more common in our daily lives; therefore, it is important to integrate robots into all levels of our society. This document presents a workshop that focuses on two main objectives. The first is to make an event to promote Crumble locally. On the other hand, the aim of this event is to present a robotic teaching tool so that people can take their first steps in the world of robotics. This workshop is aimed at those children and adults who want to discover the possibilities that Crumble brings in the introduction to robotics. An introduction to Crumble in the context of educational robotics is developed throughout this workshop.**

Keywords—education; programming; robotics; STEM

I. Introduction

Throughout the last few years, a multitude of events have been promoted with the aim of making technological learning activities available to people. Examples of such events are Scratch Day, Arduino Day, European Robotics Week and more.

Due to the successful participation of the Scratch Day workshop for the celebration of Scratch's tenth birthday, a new proposal has been made with the aim of providing another educational robotics tool to facilitate the process of introducing robotics into a science, technology, engineering and mathematics (STEM) related education environment.

Robotics is one of the main drivers of modernization and continuous improvement for most processes [1]. Considering also the great ease of access to robotics that exists, it is a good opportunity to start integrating robots as part of education, as there are tools that facilitate people's access to technological knowledge.

Reference [2] provides learning experiences using Scratch as a prelude to the introduction of robotics using LEGO NXT units. Scratch is widely used to introduce students to programming, as shown in [3], [4] and [5].

As the authors mention in [6], the motivation of young students increases with the use of visual programming languages, while when children use textual programming languages, there is no increase in motivation.

Robotics and computational thinking are ideal tools for developing STEM pedagogy: science, technology, engineering and mathematics. The main objective of this workshop is to present a simple and economic tool for educational robotics. Reference [7] demonstrates how Crumble tool can be used as STEM educational tool. Crumble tool has been developed by Redfern Electronics [8]. Redfern Electronics also maintain the software to program the hardware.

For early stages of the robotics introduction process, educational robotics tools based on textual programming languages such as Arduino and Raspberry Pi combined with Python can be used. The references [9], [10] and [11] are clear examples of such educational applications.

II. Crumble Day workshop

This workshop promotes Crumble locally. Additionally, Crumble is used as a robotic educational tool for people as the first step to get into robotics world.

A. *Workshop location*

The workshop was held in the El Circulo shopping center [12], located in the city of Torrejón de Ardoz. Torrejón de Ardoz is in the eastern area of the Community of Madrid. Additionally, Incomaz was providing advertising and logistic support to this workshop [13]. Furthermore, Plaza Robotica

[14], IEEE UNED Student Branch, the Engineering Industrial School of UNED (Spanish University for Distance Education), the Electrical, Computer Engineering Department (DIEEC) and the Doctorate School of UNED were supporting and collaborating with educational materials used along the workshop.

B. Student's profiles

The students group was formed by 5 students. Three students were between the ages of 10 and 15. A student was between the ages of 26 and 45 years old. Finally, one student with an age over 45 years attended the workshop. The group consisted of two women / girls and three men / boys.

Before starting the workshop, a pre-test was conducted to obtain the concerns about their attendance at the workshop. They were also asked about their previous knowledge about programming, robotics and the use of the Crumble tool.

The first question was: What do you want to achieve in this workshop? The responses were the following:

- Learn about programming and have fun.
- Not to get frustrated with the LEDs, my pending subject.
- Learn how to program Crumble.
- Know the robot programming methods.
- Improve my knowledge.

On the other hand, students were asked to get feedback about questions related to previous knowledge about programming, electronic, electricity, mechanic, robotics and the use of the Crumble tool. Most of the students had programming experience. On the other hand, most of the students showed in their answers that they lacked a high degree of knowledge in electronics, electricity, mechanics, robotics and the use of the Crumble tool.

C. Workshop structure

The workshop duration was 4 hours in one day. The workshop was divided into three parts. The first part was used to introduce robotics, present the workshop objectives and provide information about Crumble resources such as the development environment, the Crumble controller and some hardware elements used along the workshop. The second part was focused on getting basic knowledge about the Crumble. This was done through simple activities aimed at familiarizing attendees with the tool and the components they were going to use. Finally, the content of the workshop was oriented to the construction of applications based on problem solving. In this way, the participants were able to use the knowledge acquired during the second part to solve the problems raised during the last part of the workshop. All the content of the workshop was given for four hours, although there was a break in the middle of the workshop.

Figure 1 shows a Crumble-based robot like the ones used during the workshop. This robot consists of a Crumble controller. The robot also includes a battery holder. It also has two engines and wheels. At the bottom you can see a Sparkle, and below it an ultrasonic sensor. Although not shown in the Figure, the bottom of the robot has been fitted with a line follower sensor, which consists of a pair of on/off infrared sensors.

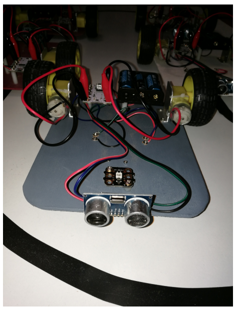

Fig 1. Example of a Crumble robotic kit.

The methodology used was a combination of theory and practice. At the beginning of the workshop the balance between the two was mostly theoretical and not practical. To try to keep the attention of the attendees, they were asked about the theoretical contents. In this way, the attendees became more involved and their attention was greater. From the middle of the workshop, the instructor hardly provided theoretical content and it was the participants who had to put into practice all the knowledge they had received.

The objectives for the second part are: know about Crumble, obtain notions of electricity, obtain notions of electronics and programming a robot.

The objectives for the third part are: go deep into Crumble, use Crumble, know about sensors and perform activities using Crumble.

Not all attendees had previous experience using Crumble. In addition, the programming experience of the attendees was not very extensive. As the attendees worked through the activities they were asked to do, the instructor was able to observe a change in the questions asked by the attendees. At first, attendees were shyly asking questions or showing a slight assimilation of the contents. As the workshop progressed, participants asked the questions with greater confidence, and in some cases, they answered the questions themselves. In some cases, questions from one attendee were answered by another attendee.

D. Workshop results

As exposed in the activity's contents, different kind of activities can be carried out with the aim of providing how STEM education can be covered using simple tasks and project-oriented activities.

In the second part, most of the attendees had their first contact with Crumble. This part is eminently theoretical but combined with the participation promoted by the instructor. As the instructor explained the theoretical concepts, the participants were able to experiment to a greater or lesser extent. For example, in the activity related to Crumble hardware, attendees had the Crumble controller at their disposal so that they could visually identify each item as the instructor listed and explained its purpose. All participants completed the first four activities. The rest of the activities required additional clarification and assistance from the instructor. This is due to the fact that in this type of activity the participation of the participants was greater, and they needed to start solving problems on their own. The activity that took the most effort to complete was that related to the Sparkles. After completing the knowledge deployment tasks and the first troubleshooting activities, all attendees completed the last activity without assistance. This activity combined knowledge from the previous two. Table I summarizes information regarding the activities that were completed by the attendees. On the one hand, if the participants were able to complete the activities without any help. On the other hand, if the attendees needed some kind of help to complete the activity.

TABLE I. SECOND PART ACTIVITIES AND STUDENTS WHICH COMPLETED

Activity title	Completed without help	Completed with some help
Crumble hardware	5 (100 %)	0 (0 %)
Crumble environment	5 (100 %)	0 (0 %)
Power systems	5 (100 %)	0 (0 %)
Motors	5 (100 %)	0 (0 %)
LED lights	5 (100 %)	0 (0 %)
First program with Crumble	4 (80 %)	1 (20 %)
Describing paths	3 (60 %)	2 (40 %)
Using Sparkles	1 (20 %)	4 (80 %)
Programming a robot	5 (100 %)	0 (0 %)

Upon arrival at the third part of the workshop, the students were engaged in different project-oriented activities using Crumble. Through the proposed activities, the instructor led the students first of all to set the objectives of the project. On the other hand, the surrounding theory of the corresponding activity was attached.

Throughout the last part of the workshop, three types of challenges were proposed. In the first challenge, the assistants tried to solve it independently or by asking the instructor for help. While trying to solve the second challenge, attendees teamed up and asked for less help from the instructor while helping each other. In the last challenge, the attendees solved the problem autonomously and collaborated with each other to achieve the proposed goal. Table II summarizes the results obtained during the third part of the workshop. This table displays both the number of students and the percent of the group total. It also presents two types of data: attendees who completed each of these activities without assistance and those who completed it with some form of assistance or supervision.

TABLE II. THIRD PART ACTIVITIES AND STUDENTS WHICH COMPLETED

Activity title	Completed without help	Completed with some help
Controlling the motors	1 (20 %)	4 (80 %)
Line follower	3 (60 %)	2 (40 %)
Avoiding obstacles	5 (100 %)	0 (0 %)

Additionally, at the end of workshop, a post-test was conducted to obtain the opinion about the student's outcomes from the workshop. In addition, some questions were asked to verify that the students had acquired the knowledge that was intended to be transmitted throughout the workshop. They were also asked in relation to acquired knowledge about programming, robotics and the use of the Crumble tool.

Firstly, a battery of question was asked with aim of getting the students' opinion about the workshop. Table III compiles the students' opinion about the workshop. The questions are:

TABLE III. STUDENTS' OPINION ABOUT THE WORKSHOP

Workshop topic	Number of students			
	Most liked	Less liked	Easiest	Hardest
Programming	1	0	2	1
Turn on lights	0	2	0	3
Moving motors	0	0	3	0
Use sensors	4	0	0	1
Nothing	0	3	0	0

All questions related to verify that the students had acquired the knowledge that was intended to be transmitted throughout the workshop were answered correctly by all students.

On the other hand, students were asked to get feedback about questions related to acquired knowledge about programming, robotics and the use of the Crumble tool. Most of students increased their perception about programming knowledge. Half of attendees increased their perception about robotics knowledge, the other half had not the same perception. Furthermore, most of students Most students showed an increase in their curiosity about robotics. Finally, most students increased their perception about Crumble knowledge.

Finally, the participants were asked a series of general knowledge questions to gather information about the knowledge acquired during the workshop. Most of the attendees were clear about what the Crumble controller can do. Also, they improve their knowledge about robotics related elements.

At the end of the workshop we could see how all the students increased their motivation to program and create simple projects. At the beginning of the workshop, all the students had knowledge of new technologies such as computers, tablets and smartphones. Despite this, the use they made of it was a basic user use, that is to say, this knowledge was limited to Internet queries, games or basic functionalities. During the course, they scaled up their skills such as systems thinking, programming mentality, active learning, math, science, judgment and decision making, good communication, technological design, complex problem solving and persistence.

III. CONCLUSIONS

Despite not having a large number of attendees, the experience provided results that may be useful for other teachers to promote a workshop with similar or equal content to obtain more results. For this reason, the operational details, materials used, and the reflection of each activity are also presented with the expectation that all teachers or instructors can adapt these activities in their classes. Collaborative student work, teacher reflection and industry inspiration are also used to help students understand better. The results of this work show that it is important to combine theory and practice in order to include fun tasks intertwined with the challenges of applying theory to problem solving.

In conclusion, Crumble has proven to be a good choice when it comes to introducing robotics in a cost-effective, simple and convenient way for people to develop scalable concepts. As has been noted through the experience described throughout this paper, In addition, the reference [7] also shows Crumble as a tool that can be used to deploy STEM knowledge in the home by bringing adults and children together.

Finally, the results will be integrated in an open hardware platform which promotes innovation and motivation for students during the learning process [15]. The platform which is being developed presents wirelessly connections such as Bluetooth and WiFi as enhancements [16]. This research continues the development described in [17]. The doctoral thesis is being carried out in the Engineering Industrial School of UNED (Spanish University for Distance Education) and the Electrical and Computer Engineering Department (DIEEC).

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