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# Perceptions about the Use of Educational Robotics in the Initial Training of Future Teachers: A Study on STEAM Sustainability among Female Teachers

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**Abstract:** In these moments of future uncertainty and change, teachers must be trained to respond to the challenges posed by today's society, and the challenges that are closely related to the economy. We are going through the first steps of the Fourth Industrial Revolution, and changes are already taking place in our daily lives, in our way of learning, working, and interacting with each other. According to the data of the World Economic Forum (WEF), the future of teacher professional development is disfigured—most technological profiles play a strong role, and this affects the skills and abilities of teachers, especially in the fields of Science, Technology, Engineering, Arts, and Mathematics (STEAM). The goal is to achieve the Millennium Goal number three proposed by the United Nations: All countries must promote gender equality and the empowerment of women. This objective aims to eliminate gender disparity in primary and secondary education, and the promotion of ICT (Information and Communication Technology) to improve the competences of women and vulnerable groups to ensure that no one is left behind. These are priority areas to consider regarding SDG4 (Sustainable Development Goal 4) and Education 2030.

**Keywords:** STEAM; higher education; robotics; students' perceptions

## 1. Introduction

In countries, such as the United States, South Korea and Nigeria, among many others, the education of girls in Science, Technology, Engineering, Arts, and Mathematics (STEAM) areas is considered as a crucial element for national economic development. The scientific community currently faces the following question: Why is there a gender gap in these areas of knowledge? [1–4]. All over the world, researchers have published experiences in which the research questions were focused on identifying gender barriers in scientific disciplines [5].

The academic literature shows that at a global level, women are still insufficiently represented in STEAM—not only as students, but also as teachers, faculty members, researchers and workers, which generates an important gender gap. The reality this gap is documented by the international observatories and reports on this topic [6,7], and the European Institute for Gender Equality [8].

The factors that mark these differences are numerous and of different scopes, including personal, familiar, social, and especially school factors (many educational centers do not have the necessary infrastructure, or their teachers are not technologically or pedagogically prepared). The latter was the

focus of the present study, since the school can help to modify current patterns and introduce gender inclusion criteria [9].

## 2. The Intervention with Robotic Kits

During the academic year 2016–2017, we carried out an activity of educational innovation, which consisted in the training of students of the Faculty of Education Science of the University of Seville in educational robotics and computational thinking [10]. This innovation aimed to initiate university students in the use of different robotic kits that are being commercialized in Spain for early childhood and primary education, as well as to show them the importance of such practice in these educational stages. The participants were students of the subject “Information and communication technologies applied to education (ICT)”, from the degree in early childhood education and the degree in primary education of the Faculty of Education Science of the University of Seville (Spain).

In both degree programs, there is a subject related to information and communication technologies applied to early childhood education, in the first of the programs, and Information technologies and of communication applied to education, in the second of the degree programs.

Both subjects are compulsory and have six ECTS credits (European Credit Transfer and Accumulation System), in the first of the degree programs it is taught during the first semester (from September to January) and in the second of the degrees it is taught during the second semester (from February to June).

In the degree in early childhood education, the subject is taught in the last year of its formation (fourth), while in the degree in primary education it is taught in the first year. In both degree programs, a lesson related to educational robotics is included, and it explains the origins of robotics and computational thinking and how these types of technologies can help train properly trained students for their performance and professional future.

As background, we explain that currently the number of female programmers is much lower than that of male programmers, and we explain that this situation occurs because many women do not feel empowered to carry out this work in the future, although are excited about learning about it.

The reason for choosing these two degrees is because they are the only ones that would be able to transform and modify the digital divide related to programming, where it is considered that is almost exclusively a matter of males. It is in these degree programs where the educational foundations of the future of society are established—and where we can intervene so that the girls of the future become empowered, and decide to study careers related to programming and engineering.

The results, more perceptible and visible, concluded that the students had been motivated and had a very positive reaction to the introduction of educational robotics in the academic curriculum.

One of the priority objectives of this study was to attract more women to technical and scientific careers, especially those related to programming. One only has to see a classroom in Spain for software engineering or computer engineering to verify the small number of women who are studying them. Increasing this number of female students can be achieved by making future female teachers wake up their future student girls the idea of studying this type of university studies and that they can do it just like men.

The first robot that we have used in the experience was Mouse Robot Colby (Figure 1), from the American manufacturer Learning Resources, very similar to the famous Beebot (<https://www.terrapiologo.com/beebot.html>), and very appropriate for early childhood education and the first years of primary education.



**Figure 1.** Mouse Robot Colby, by learning resources (<http://bit.ly/mouse-robot>).

The Mouse Robot promotes problem-solving, critical thinking, basic programming skills, motivation, curiosity, respect for peers and educational materials, participation, collaborative work, self-learning, the shared construction of knowledge, access to new channels of information and knowledge, application knowledge, creativity, imagination, learning to learn, skills in and with ICT, and especially tolerance to stress and frustration. Students choose an activity card (a circuit of the 20 provided by the cards that come with the mouse) and plan their route using the code cards with arrows forward, backward, turn left and right, to guide the mouse to the target. When the movement sequence is already programmed, the student presses the upper green mouse button.

The second one was mBot (Figure 2), from the Chinese manufacturer Makeblock, specially designed for primary and secondary education.



**Figure 2.** mBot by Makeblock (<http://bit.ly/mbot-makeblock>).

mBot Bluetooth/WiFi is an ideal educational robotics STEAM kit for kids to get started in robotics, programming and electronics based on Arduino and the Scratch programming language. It can be controlled and programmed from a mobile phone, a tablet or with a computer via a USB cable. It is compatible with mobile devices with Bluetooth 4.0 and with Apple iOS 7 and up (excluding iPad1, iPad2, iPhone 4 and below).

Our mBot kits were purchased with the bluetooth adapter and WiFi adapter. The advantage of this type of educational robotic kits is that, like the robot mouse, no external wiring is needed, it has RJ25 connectors that allow you to plug in any sensor or external Arduino device. They also include a programmable infrared remote control, and it comes initially pre-programmed so that it can be used from the first moment with the infrared remote control or the App of your mobile or Tablet. This is very interesting because it allows you to use it as if it were a remote control for a television. The mBot robot is powered either by a USB cable, by four AA batteries or by a 3.7V lithium battery. Our kit did not have this last option.

We also worked with the Makey-Makey (Figure 3) board, from Joylabz, a young spin-off created by two students of the MIT Media Lab of Massachusetts, USA.

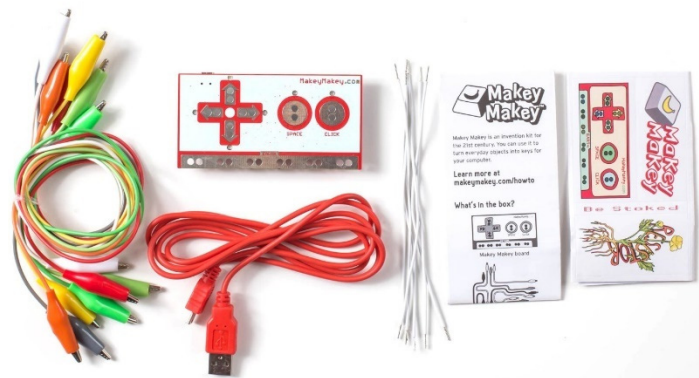


Figure 3. Makey-Makey board by Joylabz (<http://bit.ly/placa-makey-makey>).

Makey-Makey is a board similar to the command of a game console, the computer (PC or Macintosh) detects it as if it were a keyboard or mouse, which allows sending commands to the computer to which it is connected. Instead of pressing the buttons on the keyboard, what we do is close the circuit using contacts or crocodile clips, and this simulates having pressed a button. In this way, it allows us to convert any object of daily life into a keyboard, remote control, or a mouse.

This kit consists of an Arduino-based electronics board with a USB cable that connects to the computer as one more peripheral, so that it gives its users the opportunity to search and find new ways to interact with their computers, enhancing creativity, imagination and design.

In our case, in the practical class, we used a paper where four dates were drawn (up, down, right and left) and then filled in with the graphite of a pencil. Then they connected the cables from the board to those arrows and simulated the controllers of a game console. We also used modeling clay to make arrows, a special type of modeling clay that was electrically conductive, as not all brands are conductive.

To learn the Scratch programming language, a simple template provided by the non-profit association programamos.es (<https://programamos.es>) was used, which consisted of programming a video game related to healthy eating, in where the famous cat had to position himself with the buttons created with Makey-Makey under the fruits that went down the screen and discarded the bowls full of knick-knacks.

Lastly, we also worked with Ozobot, (Figure 4), (a small intelligent robot for children, for learning the STEM (Science, Technology, Engineering and Mathematics) language, which is capable of reading colored lines drawn on paper. It has the shape of a sphere about two and a half centimeters in diameter that is moved by very small wheels that are located at its base, where it also has color sensors that will allow it to read the color codes drawn.

Ozobot is a line-following robot, since it can perfectly follow a color line and interpret line crossings, and it can also read color codes (a combination of several color strokes) that we put on a line.

With this robot you can make racing circuits, puzzles, mazes, loops, obstacles and much more. These games are intended to foster and develop in students such important skills as creativity, autonomy, logic, and programming.

Ozobot not only can be programmed using colored lines, but it can also be programmed on a tablet through the block application called OzoBlockly, very similar to Scratch, in which students will be able to carry out more complex programming, as they progress in their learning.

Table 1 shows the different competences and abilities that each of the educational robotic kits develops.



Figure 4. Ozobot (<http://bit.ly/placa-makey-makey>).

Table 1. Comparative table of the robots used in the study. Competences/abilities they develop.

	Robot Mouse Colby	mBot	Makey-Makey	Ozobot
Manufacturer's recommended age.	Since four years	Since eight years	Since eight years	Since five years
Problem-solving	X	X	X	X
Critical thinking	X	X	X	X
Motivation	X	X	X	X
Curiosity	X	X	X	X
Creativity	X	X	X	X
Imagination	X	X	X	X
Participation	X	X	X	X
Stress tolerance and frustration	X	X	X	X
Respect for peers	X	X	X	X
Respect for educational materials	X	X	X	X
Collaborative work	X	X	X	X
Self-learning	X	X	X	X
Shared construction of knowledge	X	X	X	X
Access to new channels of information and knowledge	X	X	X	X
Application of knowledge	X	X	X	X
Learning to learn	X	X	X	X
Skills in and with ICT	X	X	X	X
Basic and initial programming skills	X	X	X	X
Scratch programming		X	X	

The kits used are complementary and develop almost the same skills, three of them are considered “ground robots” (Robot Mouse Colby, mBot, and Ozobot), and one of them is a programmable board (Makey-Makey).

After introducing educational robotics consecutively in the following two academic years (2017–18 and 2018–19), also in both university degrees, we studied the perceptions of the female students toward robotics before using the robotic kits (pre-test) and after using them (post-test). Then, we analyzed the possible significant differences.

The research methodology was quasi-experimental and longitudinal, since the practical lectures of the subject were compulsory, and thus, it would not be possible to accurately establish the initial equivalence of the groups, as is the case of experimental designs [11].

### 3. Materials and Methods

During this study, an ad hoc information gathering instrument was designed to collect the perceptions of the participants before interacting with the selected kits (Mouse Robot, mBot, Makey-Makey, and Ozobot) and after completing the practical teaching sessions with them.

We did not know if they believed that educational robotics could develop the ability to solve problems, the critical thinking, basic programming skills, the motivation, curiosity, the respect for peers and educational materials, participation, the collaborative work, self-learning, the shared construction of knowledge, access to new channels of information and knowledge, the application of knowledge, the creativity, the imagination, learning to learn, skills in and with ICT, the tolerance to stress and frustration, and learn to program with the Scratch programming language, and if, after interacting with robotic kits, they would continue to think in the same way.

This instrument consisted of 42 items (five identification items and 37 items about educational robotics) and a Likert-type scale from 1 (totally inappropriate, totally irrelevant, and not valid) to 5 (very appropriate, very relevant, and very valid).

The following table shows the complete list of questions and what they develop—they are all related to digital competence (Table 2).

**Table 2.** Questionnaire items and what they measure.

Items	What Develops
Score your degree of knowledge about what is educational robotics.	General knowledge
Evaluate your degree of interaction with experiences where you have used educational robotics.	Interaction
Estimate your degree of willingness to use educational robotics in your teaching practice when you are a graduate or are practicing professionally.	Predisposition
Using educational robotics, in classes where possible, I would increase my motivation for the monitoring and study of these subjects.	Motivation
Participating in academic activities where educational robotics is used would increase my interest in the subject.	Interest
Interaction in the classroom with educational robotics experiences could promote new teaching-learning methodologies.	New teaching and learning methodologies
If I used educational robotics I would increase my level of participation in the subjects that use it.	Participation
Participating in activities where I interact with educational robotics experiences could increase my skills related to teamwork.	Teamwork
Interaction with educational robotics would allow me to interact with other colleagues or colleagues helping me to understand concepts, procedures and attitudes (control with item 37).	Social relationships
Using educational robotics in classes where possible, it could favor the development of competence related to self-learning.	Self-learning
The use of educational robotics would favor my critical thinking when asking questions and questions during its use that can generate interesting debates with teachers and other students.	Critical thinking
The use of educational robotics would develop the shared construction of knowledge among all the members who participate in this teaching-learning process.	Teamwork
Participation in activities where educational robotics was used would facilitate the expansion of information through extra documentary resources and different from those provided by the teachers of the subjects since there is a lot of information online related to this topic.	Information expansion
Participation in activities using educational robotics would facilitate the ability to apply theoretical knowledge to practice.	Applicability
Using educational robotics, technological skills related to the use and application of ICT are promoted.	ICT skills
It would be appropriate and pertinent to use educational robotics to support traditional didactic materials in the subjects of the degree in which it could be used.	Complementarity
I will get bored while I use educational robotics during the development of the subjects.	Entertainment
I will attend class enthusiastically when doing activities with educational robotics.	Enjoyment



Table 2. Cont.

Items	What Develops
I will enjoy the classes in which educational robotics activities are carried out.	Extrapolation
I would like to use educational robotics in other subjects than this one, as long as it can be adapted.	Exploitation
Performing activities with educational robotics in the classes will be a waste of time.	Attention
Educational robotics will no longer attract my attention in the subjects in which it is used.	Need
There will be no need to use educational robotics in class.	Motivation
In general, I think that the use of educational robotics denotes an interest on the part of the teacher towards the teaching of his subject, and that it is very innovative.	Social relationships
Do you know the Scratch programming software?	Programming training
Do you know the Mblock programming software?	Programming training

A total of three academic years were analyzed (2016–2017, 2017–2018 and 2018–2019). The participants completed 667 and 620 pre-test and post-test questionnaires, respectively (Table 3).

Table 3. Sample size (pre-test/post-test).

		Frequency (Pre/Post)	Percentage (Pre/Post)	Valid Percentage (Pre/Post)	Accumulated Percentage (Pre/Post)
Valid	2016–2017	115/116	17.2/18.7	17.2/18.7	17.2/17.2
	2017–2018	300/299	45.0/48.2	45.0/48.2	62.2/66.9
	2018–2019	252/205	37.8/33.1	37.8/33.1	100.0/100.0
	Total	667/620	100.0/100.0	100.0/100.0	

The age of the participants ranged between 18 and 25+ years (Table 4).

Table 4. Age of the participants (pre-test/post-test).

		Frequency (Pre/Post)	Percentage (Pre/Post)	Valid Percentage (Pre/Post)	Accumulated Percentage (Pre/Post)
Valid	18 years	183/143	27.4/23.1	27.4/23.1	27.4/23.1
	19 years	115/97	17.2/15.6	17.2/15.6	44.7/38.7
	20 years	63/63	9.4/10.2	9.4/10.2	54.1/48.9
	21 years	104/93	15.6/15.0	15.6/15.0	69.7/63.9
	22 years	56/54	8.4/8.7	8.4/8.7	78.1/72.6
	23 years	45/56	6.7/9.0	6.7/9.0	84.9/81.6
	24 years	22/38	3.3/6.1	3.3/6.1	88.2/87.7
	25 or more years	79/76	11.8/12.3	11.8/12.3	100.0/100.0
	Total	667/620	100.0/100.0	100.0/100.0	

The participants were students of the degrees of early childhood education (over 200 participants) and primary education (over 400 participants) (Table 5) of the Faculty of Education Science of the University of Seville (Spain).

Table 5. Degree in which the participants were registered (pre-test/post-test).

		Frequency (Pre/Post)	Percentage (Pre/Post)	Valid Percentage (Pre/Post)	Accumulated Percentage (Pre/Post)
Valid	Degree in early childhood education	220/214	33.0/34.5	33.0/34.5	33.0/34.5
	Degree in primary education	447/406	67.0/65.5	67.0/65.5	100.0/100.0
	Total	667/620	100.0/100.0	100.0/100.0	

#### 4. Results

Once the questionnaires were collected, the average scores obtained in each of the items were analyzed. Regarding the item “Mark your degree of knowledge about educational robotics”, the participants asserted that they had a very low level of knowledge at the beginning of the study

( $\bar{x} = 1.88$ ;  $\sigma = 0.859$ ;  $\sigma^2 = 0.738$ ), and that they understood the meaning of educational robotics after completing the experience ( $\bar{x} = 3.40$ ;  $\sigma = 0.924$ ;  $\sigma^2 = 0.854$ ).

When they were asked about their degree of interaction with experiences in which they used educational robotics, the students stated that they had had very little interaction with educational robotics in secondary education and/or baccalaureate ( $\bar{x} = 1.67$ ;  $\sigma = 0.906$ ;  $\sigma^2 = 0.820$ ), and that after this experience they had greater knowledge about this specific area ( $\bar{x} = 3.59$ ;  $\sigma = 1.015$ ;  $\sigma^2 = 1.031$ ).

During the study, it was observed that the participants were initially eager to use robotics in their teaching practice when they became teachers ( $\bar{x} = 3.61$ ;  $\sigma = 0.989$ ;  $\sigma^2 = 0.979$ ); such predisposition increased considerably after the experience ( $\bar{x} = 4.07$ ;  $\sigma = 0.875$ ;  $\sigma^2 = 0.766$ ).

Regarding the item "Using educational robotics, in the subjects that allow so, would increase my motivation to follow-up and study those subjects", before carrying out the practical sessions, the students already stated that such practice would increase their motivation for the subjects that would include it ( $\bar{x} = 3.81$ ;  $\sigma = 0.880$ ;  $\sigma^2 = 0.774$ ); this predisposition showed a remarkable increase after the experience ( $\bar{x} = 4.25$ ;  $\sigma = 0.866$ ;  $\sigma^2 = 0.750$ ).

When asked whether using educational robotics would increase their motivation for the subjects in which this practice would be implemented, we observed that, prior to the practical sessions conducted in this study, the participants already showed high curiosity toward the subjects that used educational robotics ( $\bar{x} = 3.81$ ;  $\sigma = 0.880$ ;  $\sigma^2 = 0.774$ ). After the experience, such curiosity increased even further ( $\bar{x} = 4.25$ ;  $\sigma = 0.866$ ;  $\sigma^2 = 0.750$ ).

Concerning the item "Participating in academic activities that use educational robotics would increase my interest for the subject", the students stated that they would be interested in the subjects that used educational robotics ( $\bar{x} = 3.84$ ;  $\sigma = 0.849$ ;  $\sigma^2 = 0.721$ ). After the practical sessions, their interest for those subjects was considerably higher ( $\bar{x} = 4.24$ ;  $\sigma = 0.830$ ;  $\sigma^2 = 0.690$ ).

When asked whether the interaction with educational robotics in the classroom could promote new teaching-learning methodologies, the students gave a positive answer ( $\bar{x} = 4.22$ ;  $\sigma = 0.755$ ;  $\sigma^2 = 0.571$ ). This perception increased to almost the highest score possible ( $\bar{x} = 4.46$ ;  $\sigma = 0.702$ ;  $\sigma^2 = 0.492$ ) after interacting with the educational robotic kits.

Regarding the item "Using educational robotics would increase my participation in the subjects that included such practice", before interacting with these kits, the participants asserted that they would participate more in the subjects that implemented this teaching methodology ( $\bar{x} = 3.63$ ;  $\sigma = 0.881$ ;  $\sigma^2 = 0.777$ ). After the experience, this perception was significantly higher ( $\bar{x} = 4.33$ ;  $\sigma = 0.780$ ;  $\sigma^2 = 0.608$ ).

When asked whether participating in activities where they interacted with educational robotic kits would increase their team-work skills, the students already believed, before the experience, that such interaction would improve the mentioned skills ( $\bar{x} = 3.75$ ;  $\sigma = 0.844$ ;  $\sigma^2 = 0.712$ ), which was confirmed after the practical sessions ( $\bar{x} = 3.96$ ;  $\sigma = 0.883$ ;  $\sigma^2 = 0.780$ ).

Before interacting with the robotic kits, the participants thought that such interaction would allow them to socialize with their peers, which would help them to understand concepts, procedures and attitudes ( $\bar{x} = 3.85$ ;  $\sigma = 0.839$ ;  $\sigma^2 = 0.703$ ), which was corroborated after the experience, although the obtained scores were not significantly higher ( $\bar{x} = 4.03$ ;  $\sigma = 0.938$ ;  $\sigma^2 = 0.880$ ).

In another item, the students believed that using educational robotics in the subjects that allowed so would favor the development of self-learning skills ( $\bar{x} = 3.81$ ;  $\sigma = 0.829$ ;  $\sigma^2 = 0.687$ ); the post-test scores for this item were high ( $\bar{x} = 3.96$ ;  $\sigma = 0.873$ ;  $\sigma^2 = 0.762$ ), although not as high as expected.

The participants stated in the pre-test that the use of educational robotics would favor their critical thinking, since such practice would raise interesting questions to be debated with both teachers and students ( $\bar{x} = 3.57$ ;  $\sigma = 0.864$ ;  $\sigma^2 = 0.747$ ). This perception was not significantly higher in the post-test ( $\bar{x} = 3.74$ ;  $\sigma = 0.919$ ;  $\sigma^2 = 0.845$ ).

When asked in the pre-test whether the use of educational robotics would develop the shared construction of knowledge among those who participate in this teaching-learning process, the students



agreed with a high score ( $\bar{x} = 3.72$ ;  $\sigma = 0.831$ ;  $\sigma^2 = 0.691$ ). After the practical sessions, their positive opinion was even higher ( $\bar{x} = 4.00$ ;  $\sigma = 0.852$ ;  $\sigma^2 = 0.725$ ).

Similarly, before ( $\bar{x} = 3.71$ ;  $\sigma = 0.840$ ;  $\sigma^2 = 0.705$ ) and after ( $\bar{x} = 4.32$ ;  $\sigma = 0.748$ ;  $\sigma^2 = 0.560$ ) the experience, the participants stated that their participation in activities that implemented the use of educational robotics would facilitate the expansion of information through additional documentary resources different from the ones provided by the teachers of the subjects.

With regard to the item “Participating in activities that use educational robotics would improve the capacity to apply theoretical knowledge in the practice”, the students responded positively, both before ( $\bar{x} = 3.98$ ;  $\sigma = 0.812$ ;  $\sigma^2 = 0.659$ ) and after the experience ( $\bar{x} = 3.76$ ;  $\sigma = 0.936$ ;  $\sigma^2 = 0.953$ ).

According to the results of the pre-test, the participants believed that using educational robotics would favor the technical skills related to the use and application of ICT ( $\bar{x} = 4.30$ ;  $\sigma = 0.799$ ;  $\sigma^2 = 0.638$ ). These results were higher after the experience with the robotic kits ( $\bar{x} = 4.40$ ;  $\sigma = 0.708$ ;  $\sigma^2 = 0.502$ ).

The pre-test ( $\bar{x} = 3.88$ ;  $\sigma = 0.858$ ;  $\sigma^2 = 0.737$ ) and post-test ( $\bar{x} = 4.29$ ;  $\sigma = 0.783$ ;  $\sigma^2 = 0.613$ ) results confirm that it would be appropriate and relevant to use educational robotics as a complement to the traditional didactic materials in the subjects of the degree in which such practice could be implemented.

When asked whether they would get bored while using educational robotics in the subjects, the results were excellent. The participants stated that they would get less bored in the subjects that use robotic kits ( $\bar{x} = 1.71$ ;  $\sigma = 0.917$ ;  $\sigma^2 = 0.841$ ), which was confirmed with even better results in the post-test ( $\bar{x} = 1.36$ ;  $\sigma = 0.849$ ;  $\sigma^2 = 0.721$ ).

In the pre-test, the students asserted that they would attend the lectures with excitement when activities with educational robotics were carried out ( $\bar{x} = 3.97$ ;  $\sigma = 0.857$ ;  $\sigma^2 = 0.735$ ). After the experience, the students reinforced such perception up to 4.49 out of the maximum 5.00 points possible ( $\sigma = 0.764$ ;  $\sigma^2 = 0.584$ ).

The perception of the participants toward their enjoyment when attending lectures in which robotic kits were used was very high, even before interacting with these devices ( $\bar{x} = 4.00$ ;  $\sigma = 0.852$ ;  $\sigma^2 = 0.727$ ). After the practical sessions, this perception was even higher ( $\bar{x} = 4.55$ ;  $\sigma = 0.751$ ;  $\sigma^2 = 0.563$ ).

Before the experience, the students already stated that they would like to use educational robotics in other subjects ( $\bar{x} = 3.91$ ;  $\sigma = 0.925$ ;  $\sigma^2 = 0.856$ ), whenever possible. This perception remained unaltered after interacting with the robotic kits ( $\bar{x} = 4.39$ ;  $\sigma = 0.771$ ;  $\sigma^2 = 0.595$ ).

When asked whether it would be a waste of time to implement activities with educational robotics in the classroom, the participants answered that this was not true ( $\bar{x} = 1.44$ ;  $\sigma = 0.787$ ;  $\sigma^2 = 0.619$ ). After the experience, they were even more strongly convinced that this methodology would not be a waste of time ( $\bar{x} = 1.16$ ;  $\sigma = 0.551$ ;  $\sigma^2 = 0.304$ ). This means that students do want to receive training in educational robotics—they are interested and perceive that it is important for their comprehensive training as teachers.

In another item related to motivation, the students stated that educational robotics would indeed catch their attention. And this was manifested both before the experience ( $\bar{x} = 1.68$ ;  $\sigma = 0.896$ ;  $\sigma^2 = 0.802$ ) and after the experience ( $\bar{x} = 1.23$ ;  $\sigma = 0.729$ ;  $\sigma^2 = 0.531$ ).

At the beginning of the study, the participants disagreed with the statement “Educational robotics is not necessary in the classrooms” ( $\bar{x} = 1.70$ ;  $\sigma = 0.856$ ;  $\sigma^2 = 0.733$ ). After the experience, they still believed that such practice is necessary for the classrooms ( $\bar{x} = 1.44$ ;  $\sigma = 0.788$ ;  $\sigma^2 = 0.621$ ).

In the pre-test, the students stated that the use of educational robotics shows the interest of the teachers toward the teaching of their subjects and makes them highly innovative ( $\bar{x} = 4.12$ ;  $\sigma = 0.851$ ;  $\sigma^2 = 0.724$ ). The results of the post-test show that this perception was reinforced after interacting with the robotic kits and that, therefore, the use of this type of new technologies increases the innovative capacity of teachers ( $\bar{x} = 4.39$ ;  $\sigma = 0.830$ ;  $\sigma^2 = 0.690$ ).

When asked at the beginning of the study, whether they knew about the Scratch programming software, only a few participants answered positively ( $\bar{x} = 1.54$ ;  $\sigma = 1.085$ ;  $\sigma^2 = 1.176$ ). After the

experience, the number of students who knew about this software was more than double ( $\bar{x} = 3.49$ ;  $\sigma = 1.399$ ;  $\sigma^2 = 1.958$ ).

This also occurred when they were asked whether they knew about the mBlock programming software: they barely knew it ( $\bar{x} = 1.33$ ;  $\sigma = 0.779$ ;  $\sigma^2 = 0.607$ ). After the study, almost all participants identified it ( $\bar{x} = 3.61$ ;  $\sigma = 1.361$ ;  $\sigma^2 = 1.852$ ).

Correlational tests were carried out to determine the existence of differences in the obtained answers by age group and by academic degree (early childhood education and primary education) and nonsignificant differences were observed.

When analyzing the standard deviations obtained in each of the items, it is observed that the opinions of the students are grouped, and that these opinions do not differ much from the average score obtained, both in pre-test and post-test measurements.

Only the last two items, which refer to the degree of knowledge of programming languages (Scratch and mBlock), it is observed that there are opinions that differ from those of the rest of the participants, but high scores compensate low scores. We believe that the students could have been distracted when we have been explaining in the class that this programming language was called Scratch (for the Makey-Makey kit) and mBlock (for the mBot kit), programming with this language was fundamental to both move the mBot kit and to interact with the Makey-Makey board. The reason for these low scores can also be explained because these students did not attend any of those two practical seminars that we organized with them and only attended the sessions of the other two educational robotic kits. We do not believe that there are any specific personal, institutional or cultural factors, because Scratch is a programming language used by eight year old children, it is not difficult to learn.

For the variance calculated for each item, the result was similar, there is no variability in the dispersion of the answers, except for the same items referred to above, which refer to students' knowledge of the Scratch and mBlock programming languages.

This means that although the mean score in the post-test has risen considerably in relation to the score obtained in the pre-test, some results are grouped around lower scores and others around higher scores, with no uniformity in the results. This result has surprised us because, during the practices, the students had to program with both types of languages, so the post-test results should have been more grouped, and similar to the previous items.

Summarizing, the following table shows (Table 6) the results obtained in each of the questions, indicating the average scores, the standard deviations and the variances obtained, which measure the level of perception that female students have about the convenience of the use of educational robotics in schools.

**Table 6.** Mean scores, standard deviations and variances obtained (pre-test/post-test).

	Pre-Test-Post-Test	N	Mean	Standard Deviation	Average Error Deviation
Score your degree of knowledge about what is educational robotics.	Pre-test	667	1.88	0.859	0.033
	Post-test	620	<b>3.40</b>	0.924	0.044
Evaluate your degree of interaction with experiences where you have used educational robotics.	Pre-test	667	1.67	0.906	0.035
	Post-test	620	<b>3.59</b>	1.015	0.048
Estimate your degree of willingness to use educational robotics in your teaching practice when you are a graduate or are practicing professionally.	Pre-test	667	3.61	0.989	0.038
	Post-test	620	<b>4.07</b>	0.875	0.041
Using educational robotics, in classes where possible, I would increase my motivation for the monitoring and study of these subjects.	Pre-test	667	3.81	0.880	0.034
	Post-test	620	<b>4.25</b>	0.866	0.041
Participating in academic activities where educational robotics is used would increase my interest in the subject.	Pre-test	667	3.84	0.849	0.033
	Post-test	620	<b>4.24</b>	0.830	0.039
Interaction in the classroom with educational robotics experiences could promote new teaching-learning methodologies.	Pre-test	667	4.22	0.755	0.029
	Post-test	620	<b>4.46</b>	0.702	0.033
If I used educational robotics I would increase my level of participation in the subjects that use it.	Pre-test	667	3.63	0.881	0.034
	Post-test	620	<b>4.33</b>	0.780	0.037
Participating in activities where I interact with educational robotics experiences could increase my skills related to teamwork.	Pre-test	667	3.75	0.844	0.033
	Post-test	620	<b>3.96</b>	0.883	0.042
Interaction with educational robotics would allow me to interact with other colleagues or colleagues helping me to understand concepts, procedures and attitudes.	Pre-test	667	3.85	0.839	0.032
	Post-test	620	<b>4.03</b>	0.938	0.044
Using educational robotics in classes where possible, it could favor the development of competence related to self-learning.	Pre-test	667	3.81	0.829	0.032
	Post-test	620	<b>3.96</b>	0.873	0.041
The use of educational robotics would favor my critical thinking when asking questions and questions during its use that can generate interesting debates with teachers and other students.	Pre-test	667	3.57	0.864	0.033
	Post-test	620	<b>3.74</b>	0.919	0.044
The use of educational robotics would develop the shared construction of knowledge among all the members who participate in this teaching-learning process.	Pre-test	667	3.72	0.831	0.032
	Post-test	620	<b>4.00</b>	0.852	0.040
Participation in activities where educational robotics was used would facilitate the expansion of information through extra documentary resources and different from those provided by the teachers of the subjects since there is a lot of information online related to this topic.	Pre-test	667	3.71	0.840	0.033
	Post-test	620	<b>4.32</b>	0.748	0.035
Participation in activities using educational robotics would facilitate the ability to apply theoretical knowledge to practice.	Pre-test	667	3.98	0.812	0.031
	Post-test	620	<b>3.76</b>	0.976	0.046
Using educational robotics, technological skills related to the use and application of ICT are promoted.	Pre-test	667	4.30	0.799	0.031
	Post-test	620	<b>4.40</b>	0.708	0.034
It would be appropriate and pertinent to use educational robotics to support traditional didactic materials in the subjects of the degree in which it could be used.	Pre-test	667	3.88	0.858	0.033
	Post-test	620	<b>4.29</b>	0.783	0.037
I will get bored while I use educational robotics during the development of the subjects.	Pre-test	667	1.71	0.917	0.036
	Post-test	620	<b>1.36</b>	0.849	0.040
I will attend class enthusiastically when doing activities with educational robotics.	Pre-test	667	3.97	0.857	0.033
	Post-test	620	<b>4.49</b>	0.764	0.036
I will enjoy the classes in which educational robotics activities are carried out.	Pre-test	667	4.00	0.852	0.033
	Post-test	620	<b>4.55</b>	0.751	0.036
I would like to use educational robotics in other subjects than this one, as long as it can be adapted.	Pre-test	667	3.91	0.925	0.036
	Post-test	620	<b>4.39</b>	0.771	0.037
Performing activities with educational robotics in the classes will be a waste of time.	Pre-test	667	1.44	0.787	0.030
	Post-test	620	<b>1.16</b>	0.551	0.026
Educational robotics will no longer attract my attention in the subjects in which it is used.	Pre-test	667	1.68	0.896	0.035
	Post-test	620	<b>1.23</b>	0.729	0.035
There will be no need to use educational robotics in class.	Pre-test	667	1.70	0.856	0.033
	Post-test	620	<b>1.44</b>	0.788	0.037
In general, I think that the use of educational robotics denotes an interest on the part of the teacher towards the teaching of his subject, and that it is very innovative.	Pre-test	667	4.12	0.851	0.033
	Post-test	620	<b>4.39</b>	0.830	0.039
Do you know the Scratch programming software?	Pre-test	667	1.54	1.085	0.042
	Post-test	620	<b>3.49</b>	1.399	0.066
Do you know the Mblock programming software?	Pre-test	667	1.33	0.779	0.030
	Post-test	620	<b>3.61</b>	1.361	0.065

Graphically, we present in the following illustration (Figure 5) those questions whose average post-test score has exceeded 4.00 points (maximum of five points). Pre-test scores are also represented to know the evolution of perceptions, standard deviations and variances.

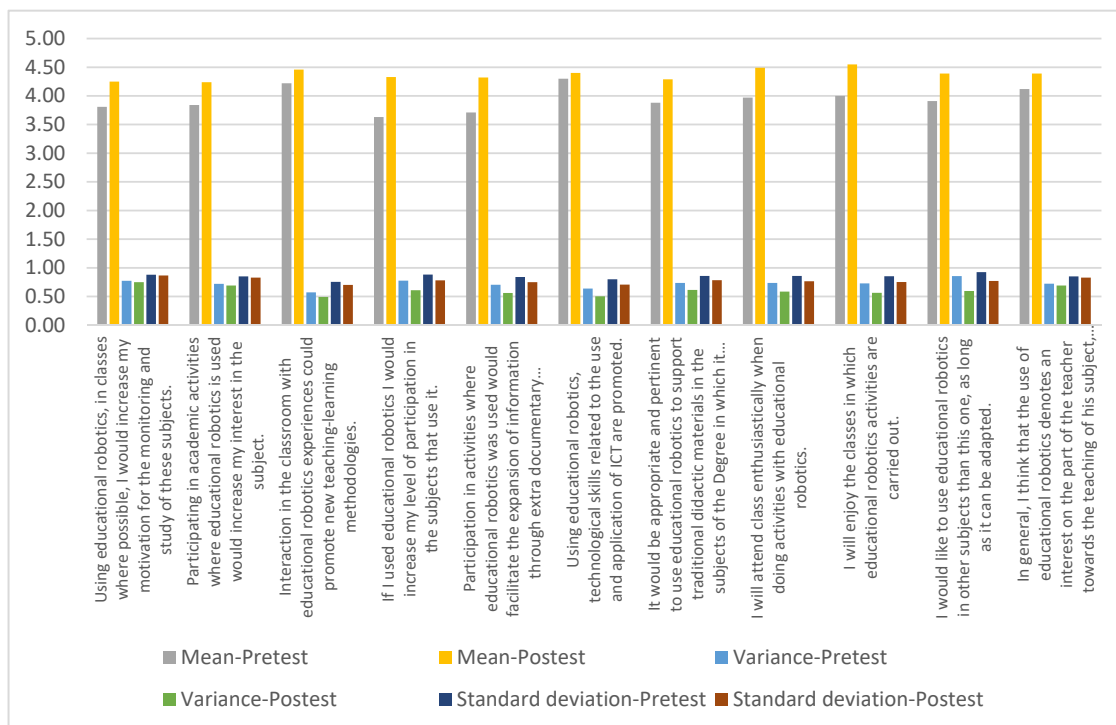


Figure 5. Questions with the best average post-test score, their standard deviations and variances.

To compare the mean values obtained in the pre-test and in the post-test, the *t*-test has been applied. This comparison provides an inferential statistic to assess whether the difference between the two means obtained in the pre-test and in the post-test is statistically significant. In our case we have applied the independent samples *t*-test.

But to perform the *t*-Tests, the data must be distributed in a normal way. To know if they are, we must first apply the Kolmogorov–Smirnov (Ks) test. We check the significance level—if it is less than 0.05, the distribution is not normal; if it is greater than 0.05, the distribution is normal. In our case the distribution is normal (significance level 0.060) (Table 7).

Table 7. Kolmogorov–Smirnov (Ks) test.

Test Statistics		Average
Maximum extreme differences	Absolute	0.263
	Positive	0.223
	Negative	−0.043
Z de Kolmogorov–Smirnov		4.294
Asymptotic Sig (bilateral)		0.060

Grouping variable: Pre-test-Post-test

Once we know that the distribution is normal, we have applied the *t*-test for samples, and this is the result we have obtained (Table 8).

**Table 8.** T-test for independent samples.

		Levene's Test for Equality of Variances		T-Test for Equality of Means						
		F	Sig.	<i>t</i>	df	Sig. (bil.)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper	
Pre-test Items	Equal variances assumed	27.95	0.052	-28.053	1285.000	0.000	-1.521	0.054	-1.627	-1.414
	Equal variances not assumed			-27.649	903.618	0.000	-1.521	0.055	-1.629	-1.413
Post-test Items	Equal variances assumed	30.45	0.063	-33.033	1285.000	0.000	-1.923	0.058	-2.037	-1.809
	Equal variances not assumed			-32.291	876.023	0.000	-1.923	0.060	-2.040	-1.806

Levene's test for equality of variances tells us whether or not we can assume equal variances. Thus, if the probability associated with the Levene statistic is  $>0.05$ , we assume equal variances, and if it is  $<0.05$ , we assume different variances. In our case, once the data has been analyzed, we assume the same variances as it is greater than 0.05.

After assuming equal variances, we observe the *t* statistic with its level of bilateral significance, this value informs us about the degree of compatibility between the hypothesis of equality of means and the difference between observed population means; in our case, it is less than 0.05.

The conclusion is that there is no compatibility between the hypothesis of equality of population means and the differences between the means of represented groups, those made before the interaction with the robotic kits and after having used them.

The confidence interval limits indicate that for the pre-test items, the limits for perceptions of educational robotics are between  $-1.627$  and  $-1.414$  points, and the limits for perceptions of educational robotics after interaction with the robotic kits are between  $-2.037$  and  $-1.809$  points.

The fact that the value 0 is not included within the confidence interval limits also indicates that we can reject the equality of means hypothesis.

The results of the study showed that the workshop with the robotic kits was success with the female students, who showed very positive perceptions before and after carrying out the practical sessions. In some of the comments they made after the experience, they stated that a larger number of hours should be dedicated to this type of practices, and they wished that these competences were included in the teacher training program.

## 5. Conclusions

This section presents the conclusions drawn after the results of the pre-test and post-test questionnaires were analyzed. The results conclude that the scores obtained in the pre-test and post-test are quite grouped, as demonstrated by the standard deviations obtained and their calculated variances. The mean of the global standard deviations was 0.863, and that of the post-test was 0.864, measures that confirm the grouping of the responses.

The same happens with the global variance—which was 0.749 in the pre-test and 0.759 in the post-test. There is no variability in the dispersion of the answers, only in the items that asked about the degree of knowledge they had about the languages of Scratch and mBlock programming.

The reason for these low scores can be explained because these students did not attend any of those two practical seminars that we organized with them (mBot kit and Makey-Makey kit) and only attended the sessions of the other two educational robotic kits (Robot Mouse Colby and Ozobot). It may also be because the students were distracted when we have been explaining in class that this programming language was called Scratch (for the Makey-Makey kit) and mBlock (for the mBot kit), programming with this language was essential to be able to move the mBot kit and to interact with the Makey-Makey board.

The items with the lowest scores before carrying out the practical sessions with the robotic kits (ordered from lower to higher score, up to a maximum of 2.00 points), were those related to having basic knowledge about robotics, robots and programming language, as well as the items that were enunciated negatively to prevent the participants from answering randomly:

- "Do you know the mBlock programming software?"
- "Carrying out activities with educational robotics in the classroom will be a waste of time",
- "Do you know the Scratch programming software?",
- "Value your degree of interaction with experiences in which you had used educational robotics",
- "Educational robotics would not especially catch my attention in the subjects in which it is used",
- "It will not be necessary to use educational robotics in the classrooms",
- "I will get bored using educational robotics in the classroom",
- "Value your degree of knowledge about educational robotics".

This is logical because in Spain the training in programming and robotics that students who enter the University have is very little or nil. Currently, the only training in educational robotics and precomputational thinking is being developed in the last years of secondary education (about 15 and 16 years old). We believe that training in educational robotics should start from the age of four and extend to all secondary education.

The items with the lowest scores after carrying out the experience with the robotic kits (ordered from lower to higher score up to a maximum of 2.00 points) were precisely the ones enunciated negatively: "Carrying out activities with educational robotics will be a waste of time", "Educational robotics would not especially catch my attention in the subjects in which it is used", "I will get bored using educational robotics in the classroom", and "It will not be necessary to use educational robotics in the classrooms". Therefore, we can conclude that carrying out activities with educational robotics in the classrooms will not be a waste of time, will improve the attention of the students in the subjects that implement this practice and it will be entertaining and very useful in different subjects.

The items with the highest scores (ordered from higher to lower score) before carrying out the experience with the robotic kits were the following: "Using educational robotics favors the development of technical skills associated with the use and application of ICT", "Interacting with experiences of educational robotics could promote new teaching-learning methodologies", "The use of educational robotics shows the interest of the teachers toward the teaching of their subjects and makes them highly innovative", "Students will greatly enjoy the subjects that implement activities of educational robotics", "Participating in activities that use educational robotics would improve the capacity to apply theoretical knowledge in the practice", "Students will attend the lectures with excitement when activities with educational robotics are carried out", and "The use of educational robotics helps to develop aspects such as creativity and imagination when programming robots".

The items with the highest scores (ordered from higher to lower score) after the experience were the following: "Students will enjoy the classes in which activities of educational robotic are conducted", "Students will attend the lectures with excitement when activities with educational robotics are carried out", "Interacting with experiences of educational robotics could promote new teaching-learning methodologies", and "Using educational robotics favors the development of technical skills associated with the use and application of ICT.

The items with the most significant changes after carrying out the experience (those with pre-post test score differences between 1.50 and 2.30 points) were, as was expected, those related to the degree of knowledge about robots, educational robotics and the programming languages used for their management (Scratch and mBlock), as well as the degree of interaction with experiences of educational robotics, since practically none of the participants had had any previous contact with this methodology.

Lastly, the items whose average scores remained practically unaltered after the experience were: "Carrying out activities of educational robotics would help to develop other cognitive skills (analysis,



synthesis, criticism...)", and "Using educational robotics favors the development of technological skills associated with the use and application of ICT in education".

This study concludes that working with the robotic kits was a great success among these female students, who showed very positive perceptions toward educational robotics before and after carrying out the experience. We knew about their previous motivation before interacting with the robotic kits, but we did not know if, once they worked with them, they would maintain that level of perceptions. Furthermore, no significant differences were obtained in the answers by age group or academic degree in which the participants were registered (early childhood education and primary education).

In some of the comments they made after the experience, they stated that a larger number of hours should be dedicated to this type of practices, and they wished that these competences were included in the female teacher training program.

We totally agree with Achiam and Holmegaard [9], who stated that it is the schools which can help to modify the current patterns and introduce gender inclusion criteria, since very few female students enter STEAM degrees, due to their general lack of interaction with educational robotics [5,12]. This would greatly contribute to reducing the gender gap in terms of accessing STEAM careers [2–4].

Although the number of women in these areas of knowledge (science and technology) is growing, the male representation is still higher [13,14] in terms of the highest education levels of these careers. The results obtained in the present study show that women have very positive perceptions of educational robotics, which can bring important benefits to this respect.

Current university institutions must establish the proper conditions to foster a more student-centered learning, using innovative teaching methods and critical training, to develop active citizens who are eager to share their knowledge for social service [15]. Therefore, universities must play a new role as promoters of competences that future graduates will have to use in their academic, personal and professional development [16,17].

Obviously, from Education Science Faculties, our duty is to train men and especially women to be competent in the use of robotic kits, since, according to references [18,19], the positive interaction with these resources will stimulate their use when these women carry out their work as teachers.

We believe that, with this type of activities at the University, we are helping to reduce the digital divide on the basis of gender, as is currently happening, where you only think of the male gender when talking about robotics, programming, and technical profiles related to these disciplines, and where different studies show that girls are less exposed and have less prior coding experience than boys [20]. It is a digital divide that also tends to widen as one progresses through the stages of the educational systems, and where secondary school girls are more easily discouraged in these learning because they think they are not prepared for it [21]. However, the vast majority of students surveyed hold the idea that computer programming is a relevant skill for their personal and professional future [20], and as has also been demonstrated with this investigation.

The underestimation by girls, studied by various authors [22], establishes how among boys, believing or not being able to make their own games has no influence when evaluating the importance of computing as a profession. In the case of girls, this perception is highly conditioned by their feeling of capacity; women often believe that they are not prepared to program, even without trying. During the practical sessions, they stated that they found it very easy to program and believed that it was much more difficult.

Following recent research [20], it has been detected that the students, without distinction of gender, declare that they would like to know how to make a computer or mobile game and they are attracted by the possibility of creating their own programs, although later their abilities to creating such a program are quite different. Thus, the data shows that while there is a large majority of boys who believe that they will be able to play a computer or mobile game, only 60% of girls consider it this way [20].

The choice of studies and professional profile is often influenced by gender and especially social stereotypes—for example, the belief that there is an innate talent in people entering any field of STEM or STEAM [23,24]. In order to explain and raise awareness about why these stereotypes must be

stopped when talking about STEAM, it is crucial not to consider that STEAM careers are aimed at certain social groups—especially to men of European origin, because women and social groups from other races may feel left out [12,25].

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