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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 uncertain future and permanent change, teachers must be trained to respond to the challenges posed by today's society, 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. The main purpose of this goal is the elimination of gender disparity in primary and secondary education, and the promotion of ICTs to improve the competences of women and vulnerable groups to ensure that no one is left behind, which are priority areas to achieve SDG4 (Sustainable Development Goal 4) and Education 2030.

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

1. Introduction

In countries such as United States, South Korea and Nigeria, among many others, the education of girls in 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 breach in these areas of knowledge? [1,2,3,4]. 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 breach. The real situation of such breach 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. The latter was the focus of the present study, since the school can help to modify the current patterns and introduce gender inclusion criteria [9].

During the academic year 2016-17, 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]. The aim of this innovation was to initiate university students in the use of different robotic kits that are being commercialised 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. The results, more perceptive and visible at that time, concluded that the students had been motivated and had a very positive reaction to the introduction of educational robotics in the academic curriculum (Figure 1).



Figure 1. Practical sessions with the robotic kit Robot Mouse Activity Set.

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), and then we analysed 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].

The conclusion of the study is that the workshop with the robotic kits was successful among 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 female teacher training programme (Figure 2).



Figure 2. Practical sessions with the robotic kit mBot.

2. 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, mBlock, Makey-Makey and Ozobot) and after completing the teaching practical sessions.

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

A total of three academic years were analysed (2016-17, 2017-18 and 2018-19). The participants completed 667 and 620 pre-test and post-test questionnaires, respectively (Table 1).

Table 1. Academic years analysed (pre-test / post-test).

	Frequency (Pre/Post)	Percentage (Pre/Post)	Valid percentage (Pre/Post)	Accumulated percentage (Pre/Post)
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 2).

Table 2. 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 /

19 years	115 / 97	17.2 / 15.6	17.2 / 15.6	44.7 /
20 years	63 / 63	9.4 / 10.2	9.4 / 10.2	54.1 /
21 years	104 / 93	15.6 / 15.0	15.6 / 15.0	69.7 /
22 years	56 / 54	8.4 / 8.7	8.4 / 8.7	78.1 /
23 years	45 / 56	6.7 / 9.0	6.7 / 9.0	84.9 /
24 years	22 / 38	3.3 / 6.1	3.3 / 6.1	88.2 /
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 3) of the Faculty of Education Science of the University of Seville (Spain).

Table 3. 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)
Degree in early childhood education	220 / 214	33.0 / 34.5	33.0 / 34.5	33.0 / 34.5
Valid 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	

3. Results

Once the questionnaires were collected, the average scores obtained in each of the items were analysed. 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 ($\bar{X}=1.88$), and that they understood the meaning of educational robotics after completing the experience ($\bar{X}=3.40$).

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, and that after this experience they had greater knowledge about this specific area.

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

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; this predisposition showed a remarkable increase after the experience.

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 ($\bar{X}=3.84$). After the experience, such curiosity increased even further ($\bar{X}=4.28$).

With respect to 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. After the practical sessions, their interest for those subjects was considerably higher.

When asked whether the interaction with educational robotics in the classroom could promote new teaching-learning methodologies, the students gave a positive answer ($\bar{X}=4.22$). This perception increased to almost the highest score possible ($\bar{X}=4.46$) 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. After the experience, this perception was significantly higher.

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 ($\bar{X}=3.75$), which was confirmed after the practical sessions ($\bar{X}=3.96$).

Before interacting with the robotic kits, the participants thought that such interaction would allow them to socialise with their peers, which would help them to understand concepts, procedures and attitudes, which was corroborated after the experience, although the obtained scores were not significantly higher.

In another item, the students believed that using educational robotics in the subjects that allowed so would favour the development of self-learning skills; the post-test scores for this item were high ($\bar{X}=3.96$), although not as high as expected.

The participants stated in the pre-test that the use of educational robotics would favour their critical thinking, since such practice would raise interesting questions to be debated with both teachers and students. This perception was not significantly higher in the post-test.

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 ($\bar{X}=3.72$). After the practical sessions, their positive opinion was even higher ($\bar{X}=4.00$).

Similarly, before and after 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 and after the experience.

According to the results of the pre-test, the participants believed that using educational robotics would favour the technological skills related to the use and application of ICT ($\bar{X}=4.30$). These results were higher after the experience with the robotic kits ($\bar{X}=4.40$).

The pre-test and post-test 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 ($\bar{X}=1.71$), which was confirmed with even better results in the post-test ($\bar{X}=1.36$).

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

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 ($\bar{X}=4.00$). After the practical sessions, this perception was even higher ($\bar{X}=4.55$).

Before the experience, the students already stated that they would like to use educational robotics in other subjects, whenever possible. This perception remained unaltered after interacting with the robotic kits.

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 ($\bar{X}=1.44$). After the experience, they were even more strongly convinced that this methodology would not be a waste of time ($\bar{X}=1.16$).

In another item related to motivation, the students stated that educational robotics would indeed catch their attention.

At the beginning of the study, the participants disagreed with the statement “Educational robotics is not necessary in the classrooms” ($\bar{X}=1.70$). After the experience, they still believed that such practice is necessary in the classrooms ($\bar{X}=1.44$).

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. 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.

When asked at the beginning of the study whether they knew about the Scratch programming software, only a few participants answered positively ($\bar{X}=1.54$). After the experience, the number of students who knew about this software was more than double ($\bar{X}=3.49$). This also occurred when they were asked whether they knew about the mBlock programming software: they barely knew it. After the study, almost all participants identified it.

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). No significant differences were observed.

4. Conclusions

This section presents the conclusions drawn after the results of the pre-test and post-test questionnaires were analysed. 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”, and “Value your degree of knowledge about educational robotics”.

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 favours the

development of technological 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 favours the development of technological 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 favours the development of technological skills associated with the use and application of ICT in education".

The conclusion of this study is 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. 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 programme (Figure 3).



Figure 3. Practical sessions with the robotic kit MakeyMakey.

We totally agree with Achiam & 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 breach in terms of accessing STEAM careers [2, 3, 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 toward educational robotics, which can bring important benefits to this respect.

Current university institutions must establish the proper conditions to foster a more student-centred learning using innovative teaching methods and critical training, with the aim of developing 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 [18, 19], the positive interaction with these resources will stimulate their use when these women carry out their work as teachers.

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