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La robótica en la formación docente universitaria: un análisis comparativo de las percepciones entre España y Portugal

Robotics in university teacher training: A comparative analysis of perceptions between Spain and Portugal

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RESUMEN

La robótica educativa ha ganado relevancia como herramienta para mejorar la enseñanza, especialmente en disciplinas relacionadas con la Ciencia, Tecnología, Ingeniería, Artes y Matemáticas. Este estudio compara las percepciones de estudiantes universitarios en España y Portugal sobre su uso, con el objetivo de identificar el impacto de la robótica en su formación docente. Se empleó un enfoque cuantitativo y descriptivo, utilizando un cuestionario de 42 ítems aplicado a 193 estudiantes de ambas naciones. Se analizaron las percepciones sobre el conocimiento de la robótica, la interacción con ella y su impacto en la motivación y aprendizaje. Los datos se procesaron con el software informático especializado. Los estudiantes de ambos países mostraron una actitud positiva hacia la robótica educativa. Las puntuaciones medias fueron altas en áreas como la motivación y la disposición para implementar robótica en sus prácticas docentes, aunque se identificó un bajo conocimiento en herramientas específicas como Arduino y Scratch. Los resultados reflejan que la robótica educativa es vista como una herramienta efectiva para fomentar habilidades críticas, como el pensamiento crítico y el autoaprendizaje. Sin embargo, es necesario mejorar la formación en tecnologías específicas. La robótica educativa es percibida como beneficiosa tanto en España como en Portugal, especialmente en términos de motivación y metodología pedagógica. No obstante, se requiere una mayor familiarización con las herramientas tecnológicas para maximizar su impacto educativo.

PALABRAS CLAVE

Educación Superior; robótica; STEAM; percepciones de estudiantes.

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ABSTRACT

Educational robotics has gained relevance as a tool to improve teaching, especially in disciplines related to Science, Technology, Engineering, Arts and Mathematics. This study compares the perceptions of university students in Spain and Portugal about its use, with the aim of identifying the impact of robotics on their teacher training. A quantitative and descriptive approach was used, using a questionnaire with 42 items and applied to 193 students from both nations. Perceptions about knowledge of robotics, interaction with it and its impact on motivation and learning were analysed. The data were processed with specialized computer software. Students from both countries showed a positive attitude towards educational robotics. The average scores were high in areas such as motivation and willingness to implement robotics in their teaching practices, although low knowledge was identified in specific tools such as Arduino and Scratch. The results reflect that educational robotics is seen as an effective tool to foster critical skills, such as critical thinking and self-learning. However, training in specific technologies needs to be improved. Educational robotics is perceived as beneficial in both Spain and Portugal, especially in terms of motivation and pedagogical methodology. However, greater familiarity with technological tools is required to maximize its educational impact.

KEYWORDS

Higher Education; robotics; STEAM; students' perceptions.

1. INTRODUCTION

Nowadays, we find technology in all aspects of our lives, such as medicine, industry, household appliances, education, etc. Interest in educational robotics has increased in recent years, and because students are digital natives and use technology easily (Athanasiou et al., 2019; Micó-Amigo & Bernal, 2020; Khushk, 2023). According to these authors, more and more teachers are trying to include robotics activities in the teaching-learning processes, so many educational centers and universities offer elective subjects and through robotics summer camps or introduce educational robotics practices in their curricula (Chavarría & Saldaño Mella, 2010; Morales Pérez et al., 2021; Hervás-Gómez et al., 2019; Román Graván et al., 2019). It appears that robots can help students understand difficult abstract concepts about science, engineering, and technology, and transform these concepts into a real-world understanding. Robots, combined with specific software and curriculum, offer learning opportunities, and although they are expensive for many educational center budgets, the offers and improvements in their costs and their simple use, make it possible for students to participate in these types of practical activities.

Lytridis *et al.* (2020) state that in recent years there have been significant advances in robotics in hardware, software and artificial intelligence capabilities, and these advances have allowed robots to operate more autonomously and perform tasks more effectively. Consequently, robotics is being introduced into areas where traditionally only humans have participated, one of these areas being education, with research being carried out on how robots can be used in the classroom to facilitate, improve, and support the learning process (Benitti, 2012; Chavarría & Saldaño Mella, 2010; Morales Pérez et al., 2021). One of the most sought-after objectives in the educational field today is to integrate robotics and programming into the learning environment, with the aim of promoting the development of STEAM skills and knowledge, as well as problem-solving, creativity, critical thinking, teamwork and communication skills. This educational area uses robots and programming platforms as teaching tools to teach theoretical and practical concepts in an interactive and engaging way.

Relating the SDG to training in educational robotics involves identifying how the latter can contribute to achieving specific goals established in the SDG. Explaining the relationship between educational robotics and the different SDG is as follows:

a) Quality education (SDG 4): Educational robotics can transform the teaching-learning process, making it more interactive, hands-on and stimulating for students. This can improve learning outcomes and foster interest in STEAM disciplines. Robotics also teaches critical skills such as critical thinking, problem-solving, creativity and teamwork, which are essential for success in today's global economy.

b) Gender equality (SDG 5): Educational robotics can be a tool to close the gender gap in STEAM fields, encourage more girls to participate in these areas from an early age and challenge gender stereotypes.

c) Decent work and economic growth (SDG 8): By teaching robotics, students are prepared with technical skills that will be highly in demand in the future labor market, thus contributing to economic growth and decent work.

d) Industry, innovation and infrastructure (SDG 9): Robotics can inspire students to innovate and develop new technologies, which can contribute to the development of resilient infrastructure and promote inclusive and sustainable industrialization.

e) Reducing inequalities (SDG 10): By providing equitable access to robotics education, inequalities can be reduced by ensuring that students from diverse socioeconomic backgrounds and regions have equal opportunities to learn and benefit from these technological skills.

f) Partnerships to achieve the goals (SDG 17): Educational robotics programs often require collaboration between schools, universities, industry, and government. These partnerships can strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development.

By integrating educational robotics into the curriculum and/or extracurricular activities, interest and skills in STEAM are fostered and contribute to the achievement of the SDG, preparing students to face global challenges with innovative, inclusive and sustainable solutions.

1.1. Robotics applied to education: educational robotics

For several years now, there has been talk about educational robotics, what it is, what it is used for, how it is used and with whom, and in that order of ideas, there are also the first investigations on this topic.

For Bravo & Forero (2012), today's society is demanding that the educational system develop new skills and competencies that allow students to respond efficiently to the changing environments of today's world. The use of robotics in the classroom as a learning tool generates multidisciplinary learning environments that allow students to strengthen their learning process while developing different skills that will allow them to face the challenges of today's society.

The implementation of educational robotics projects in the classroom creates the best conditions for knowledge appropriation, which allow students to create their own representations of the phenomena of the world around them, facilitating the acquisition of knowledge about these phenomena and their transfer to different areas of knowledge (Llanos-Ruíz et al., 2023; Morales Pérez et al., 2021; Hervás-Gómez et al., 2019; Román Graván et al., 2019).

Márquez & Ruiz (2014) state that robots can be seen as a pedagogical tool widely used in the academic training of women and men, in such a way that when the student is involved in this type of academic processes, creativity and motivation are being encouraged, which will subsequently allow them to develop cognitive and manual skills.

García Hurtado *et al*. (2012) state that robotics in the classroom allows for enriching learning strategies as support for the comprehensive training of students, and conclude that:

a) Robotics is a very efficient tool to be implemented in educational processes in basic, secondary and higher education.

b) The implemented robot is designed with all ergonomic and safety considerations to guarantee the integrity of the users.

c) A mechanical system, an electrical/electronic system and proprietary software were functionally integrated to develop a mobile robotic platform for education.

d) The developed software allows for easy and quick learning of the programming principles and theories commonly used. The developed system allows the development of basic skills in the student such as teamwork, systematic thinking, openness, individuality, problem identification and solution, project management, and others that are very important in the formation of the human being.

Another reason why it is advisable to introduce educational robotics in educational centers is because as technology and its accelerated development are changing society, its members are required to adapt to this change. In recent years, attention has focused on educational robotics as a platform towards STEAM fields (Milašinčić et al, 2020).

Therefore, in education, and according to Botes & Smit (2019), robotics is applied in various ways and for multiple purposes, relating to education in two ways: robotics in education and robotics for education.

The first approach (*robotics in education*) focuses on teaching about robotics as a subject in itself. It includes learning the principles of designing, building, programming and controlling robots. The goal is to provide students with specific knowledge and skills related to robotics, which could include mechanics, electronics, software and control systems. It is used to prepare students for careers in engineering, computer science, and technology fields, where they can apply this knowledge directly. Robotics in education focuses on integrating robotics as part of the STEAM curriculum (Shin et al., 2016), promoting technological literacy and understanding of complex systems.

In the second approach (*robotics for education*), robotics is used as a pedagogical tool to facilitate learning in various areas, not just robotics or computer science. Robots act as educational mediators to teach concepts that can range from basic mathematics to languages, social sciences, and more. This focus is on how robotics can enhance the learning process, foster critical thinking, problem solving, creativity, and social skills such as teamwork and communication. In robotics for education, robotics is seen as a means to a broader educational end, not necessarily geared toward careers in technology, but to enrich the educational process in general.

Both approaches are complementary and valuable in the educational context. Robotics in education delves into the technical knowledge and application of robotics, while robotics for education uses robotics as an innovative pedagogical tool to enrich the learning experience in a wide range of disciplines.

At the University of Seville, and during the 2016-17 academic year, we started an educational innovation activity consisting of training in educational robotics and computational thinking for students of the Faculty of Education Sciences (Román-Graván et al., 2017).

The general objective of this innovation was to introduce university students (future teachers of Primary or Basic Education) to the use of different robotic kits that are being marketed in our country and that are used in early childhood and primary education, as well as to raise awareness of their importance for education at these educational levels.

The results concluded that, in general terms, the students had been very motivated and reacted very positively to the introduction of educational robotics in their academic curriculum for this subject.

After introducing educational robotics consecutively, during the following two academic years: 2017-18 and 2018-19, also in both University Degrees (Early Childhood Education and Primary Education). The conclusion of this study, after incorporating these two academic years into the sample, was that working with the robotic kits was also a success among students, expressing very positive perceptions (Román Graván et al., 2019). It has been eight years since we started this innovation, and after carrying out a research stay at the Centro de Estudos em Educação e Inovação (Ci&DEI) and at the Escola Superior de Educação, Comunicação e Desporto of the Instituto Politécnico da Guarda (Portugal), we wanted to replicate the work carried out and compare the results obtained in Spain with those obtained in Portugal during the 2023-24 academic year, and check whether there were significant differences in their perceptions about their level of knowledge and use of educational robotics in relation to the country where the questionnaire was applied.

2. MATERIAL AND METHOD

2.1. Methodology

The research methodology has been quantitative, descriptive and correlational.

The study of the study is transversal because the data has been collected in a single moment in time, instead of over time (longitudinal). In addition, the use of random sampling of students from the faculties of education in Spain and Portugal tries to generalize the results to these broader populations.

Therefore, descriptive statistical calculations have been applied to obtain an overview of the results (median, median and fashion), the calculation of the standard deviation, variance, asymmetry and kurtosis: to evaluate the dispersion and deviation of the responses of the responses made, and, finally, the calculation of the correlation between the responses given by the students of Spain and Portugal (Spearman correlation). These statistical analyses have been carried out using SPSS Statistics analysis software.

2.2. Information collection instrument

During this study, the same information collection instrument has been used as the one used during the first study in 2016, and which was created ad hoc to collect students' perceptions before interacting with robotic kits.

This instrument consisted of 42 items (5 identification items and 37 items related to perceptions about educational robotics and robotics) and the measurement scale used was Likert type, where score 1 represented nothing suitable, nothing relevant, invalid; And the 5 was very suitable, very pertinent, very valid.

The information collection instrument is in the following Internet address: *https://bit.ly/robotica-pretest*, it is a Google form.

ESUROBOTIC, as the questionnaire is called, it is a registered trademark, with application code No. M4100289, by the Spanish Patent and Brands Office (*https://bit.ly/esurobotic*).

2.3. Participants

To ensure the relevance and actuality of the data in our study, we have focused on the questionnaires collected during the 2023-2024 academic year. This decision guarantees that the sample is representative of the current conditions of students in Spain and Portugal, although we are aware that the number of students enrolled in the studies of these countries is different. Including data from previous academic years, from 2016-2017 to 2022-2023, could have compromised the proportionality and precision of our findings, given the possibility of significant changes in the educational, social and technological contexts that could influence the responses of the responses of the students.

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The questionnaires completed were 193 students (Table 1), being the percentage of men 10.4% compared to 89.6% of women. Normally, in this type of studies carried out in the field of social sciences, it usually has a more predominant female representation.

Table 1. Gender of the participants.

		Frequency			Percentage		
		T	SP	PT	T	SP	PT
Valid	Female	173	154	19	89,6	79,8	9,8
	Male	20	17	3	10,4	8,8	1,6
	Total	193	171	22	100,0	88,6	11,4

The ages of the participants ranged between 18 and 25 or more years (Table 2).

Table 2. Age of the participants.

		Frequency			Percentage		
		T	SP	PT	T	SP	PT
Valid	18	40	39	1	20,7	20,2	0,5
	19	8	3	5	4,1	1,6	2,6
	20	28	22	6	14,5	11,4	3,1
	21	44	42	2	22,8	21,8	1,0
	22	31	28	3	16,1	14,5	1,6
	23	18	17	1	9,3	8,8	0,5
	24	7	6	1	3,6	3,1	0,5
	25 or more	17	14	3	8,8	7,3	1,6
	Total	193	171	22	100,0	88,6	11,4

The universities that have participated in this study have been (table 3) the University of Seville (Spain) and the Escola Superior de Educação, Comunicação e Desporto, Instituto Politécnico da Guarda (Portugal).

Table 3. Participating universities.

		Frequency	Percentage
Valid	Escola Superior de Educação, Comunicação e Desporto, Instituto Politécnico da Guarda (Portugal)	22	11,4
	University of Seville (Spain)	171	88,6
	Total	193	100,0

The degree where the participants in this study were enrolled (Table 4) have been: Bachelor's degree in Early Childhood Education from the University of Seville (4th course), Bachelor's degree in Primary Education from the University of Seville (1st course) and the Bachelor's degree in Basic Education by the Polytechnic Institute of Guarda, IPG (2nd course).

Table 4. Bachelor's degree where you are enrolled.

		Frequency	Percentage
Valid	Bachelor's degree in Early Childhood Education	107	55,4
	Bachelor's degree in Primary Education from the University of Seville	64	33,2
	Bachelor's degree in Basic Education by the Polytechnic Institute of Guarda, IPG	22	11,4
	Total	193	100,0

3. RESULTS AND DISCUSSION

The results obtained for the mean, median, mode, and standard deviations (Table 5 and Figure 2) from the survey conducted among students in Spain (SP) and Portugal (PT), as well as the combined total (T), have been structured into six major blocks. Below, we present the items co-rresponding to each block:

Dimension 1. Fundamentals and knowledge of Educational Robotics (ER):

- Item 6: Knowledge about what educational robotics is.
- Item 39: Knowledge about Arduino.
- Item 40: Knowledge about the Raspberry plate.
- Item 41: Knowledge about SCRATCH programming software.
- Item 42: Knowledge about MBLOCK programming software.

Dimension 2. Interaction and experience with the ER:

- Item 7: Interaction with experiences where re.
- Item 14: Participation in activities with educational robotics that would increase team skills.
- Item 15: Interaction with educational robotics that helps understand concepts and attitudes.

Dimension 3. Provision and attitude towards the implementation of the ER:

- Item 8: Provision to use educational robotics in teaching practice.
- Item 34: Motivation to work in subjects through ER.

Dimension 4. Motivational impact and curiosity:

- Item 9: Impact of educational robotics on the motivation to study.
- Item 10: How educational robotics would increase curiosity for study.
- Item 11: Impact on the interest in the subject after participating in robotics activities.

Dimension 5. Pedagogical and Methodological Applications:

- Item 12: Promotion of new teaching methodologies.
- Item 13: Increase in participation in classes with the use of robotics.
- Item 16: Driving self -learning.
- Item 17: Promotion of critical thinking.
- Item 18: Development of shared knowledge construction.
- Item 19: Facilitation of access to additional documentary resources.
- Item 20: Application of theoretical knowledge to practice.
- Item 21: Work in quasi-real problems.
- Item 22: Improvement in the ability to learn to learn.
- Item 23: Improvement in technological skills.
- Item 24: Personalization of the learning process.
- Item 25: Support to traditional teaching materials.

Dimension 6. Social and emotional impact:

- Item 26: Boredom experience when using robotics in class.
- Item 28: Class assistance with enthusiasm.
- Item 29: Enjoy classes with robotics.
- Item 30: Use of educational robotics in other subjects.
- Item 31: Perception of loss of time with robotics in class.
- Item 32: Attraction of attention to the subjects with the use of robotics.
- Item 33: Need to use robotics in class.
- Item 35: Improvement of opinion on the content of the subject.
- Item 36: Perception of innovation and teaching interest.
- Item 37: Opportunity to share ideas and visions.
- Item 38: Development of cognitive skills.

The following section presents a detailed report on the results obtained from the calculated statistical measures: mean, median, mode, and standard deviation for each of the six previously defined categories. This analysis aims to provide a clearer understanding of the results obtained.

The mean, also known as the average, is a measure of central tendency calculated by summing all numerical values in a dataset and then dividing this sum by the total number of data points (Freedman, Pisani, & Purves, 2007; Daniel & Cross, 2018). It serves as a useful indicator of the "center" of a dataset and is highly sensitive to extreme values. The median represents the value that divides a dataset into two equal parts when the data are arranged in ascending or descending order. In other words, half of the data points fall below the median, while the other half fall above it. Unlike the mean, the median is less affected by extreme values and is a more appropriate measure of central tendency for highly skewed distributions. The mode refers to the most frequently occurring values in a dataset. A dataset can be unimodal (one mode), bimodal (two modes), or multimodal (multiple modes). The mode is particularly useful for identifying the most common categories or values within a dataset. The standard deviation is a measure of dispersion or variability within a dataset. It indicates how spread out the data points are relative to the mean. A low standard deviation suggests that the data points are closely clustered around the mean, whereas a high standard deviation indicates greater dispersion. Standard deviation is calculated as the square root of the variance, which represents the average of the squared differences between each data point and the mean.

The results of these descriptive statistical analyses are as follows:

1. Dimension 1. Fundamentals and knowledge of the ER (items 6, 39, 40, 41 and 42). The results obtained in the average scores reflect that they are very close to the midpoint, indicating a moderate-low level related to general knowledge about ER and specific hardware (Arduino and Raspberry). The median predominantly has been 1, suggesting that most respondents incline a level of basic or initial knowledge. Fashion has generally been 1, reinforcing the observation that the most common answer is a level of knowledge under the questions answered. Regarding the standard deviation, the resulting scores vary, but it has generally been low, indicating that the answers are not very dispersed and tend to group together near the low average.
2. Dimension 2. Interaction and experience with ER (items 7, 14 and 15). The results obtained in the average scores reflect high values in all groups, reflecting positive and significant interactions with educational robotics. The results obtained after the calculation of the medians have been 4 points for all groups and items, which indicates a generally favorable experience. Fashion has indicated a frequent value of 4 points, indicating that the most common response is positive. Finally, the standard deviation obtained for this dimension has presented a moderate value, suggesting that there is some variability in the answers, but in general, they are positive.
3. Dimension 3. Provision and attitude towards the implementation of the ER (items 8 and 34). In relation to the average scores, these have been very high, indicating a very positive disposition towards the use of educational robotics. The average values obtained from the median have been uniformly high, over 4 points, reflecting a strong inclination towards the active use of robotics in teaching. The average fashion result has been a consistent value of 4 points, reaffirming a positive attitude in relation to the disposition and attitude towards the implementation of the ER. As for the standard deviation for this dimension, it has turned out to be relatively low, showing little variation in the high disposition towards robotics.
4. Dimension 4. Motivational impact and curiosity (items 9, 10 and 11). In relation to the average scores for this dimension, we must comment that they have been quite high for all items, suggesting that educational robotics has a positive impact on motivation and curiosity. The median has remained constant in 4 points, indicating a general agreement on the positive impact. The average fashion score has generally been 4 points for the items that make up this dimension, confirming the uniform perception of the benefit. Finally, in terms of the average standard deviation obtained for this dimension, it has been moderate, indicating a certain diversity on how students perceive the impact of robotics.
5. Dimension 5. Pedagogical and Methodological Applications (Items 12, 13, 16, 17, 19, 20, 21, 22, 23, 24 and 25). The average score achieved by the items that make up this dimension has been very high, highlighting the perception that robotics favours teaching and learning. As for the median, it has remained mostly in 4, aligned with the high half. In relation to fashion, the score for this dimension has turned out to be 4 points, showing a consensus in the positive evaluation. Finally, the average standard deviation obtained has presented a moderate variability, suggesting differences in the perception of methodological impact.

6. Dimension 6. Social and emotional impact (items 26, 28, 29, 30, 31, 32, 33, 35, 36, 37 and 38). The average scores of the items corresponding to this dimension have been varied, with some items showing low socks indicating areas of concern or disinterest. The average score obtained from the medians has also been varied, with tendencies towards middle or low values in some items, particularly in those that evaluate negative aspects such as boredom. In relation to fashion, its score has been diverse, reflecting the variability in emotional and social responses. The standard deviation has presented generally high values in items with low socks, indicating a wide dispersion of opinions.

Table 5. Medium, medium, fashion and typical deviations obtained (shaded the highest average scores and in italic the items that are formulated in negative).

ITEMS	Mean			Median			Mode			Standard deviation		
	T	SP	PT	T	SP	PT	T	SP	PT	T	SP	PT
6. Rate your degree of knowledge about what is educational robotics.	2,36	2,37	2,32	2	2	2	3	2	3	0,975	0,963	1,086
7. Assess your degree of interaction with experiences where you have used educational robotics.	2,37	2,37	2,36	2	2	2	2	2	3	1,097	1,116	0,953
8. Estimate your degree of willingness to use educational robotics in your teaching practice when you graduate or are practicing professionally.	3,8	3,82	3,64	4	4	4	4	4	4	1,023	1,016	1,093
9. Using educational robotics, in classes where possible, would increase my motivation for the monitoring and study of these subjects.	4,05	4,07	3,91	4	4	4	4	4	5	0,876	0,844	1,109
10. Using educational robotics would increase my curiosity for the follow-up and study of the subjects in which it was used.	4,02	4,03	3,91	4	4	4	4	4	4	0,904	0,884	1,065
11. Participating in academic activities where educational robotics is used would increase my interest in the subject.	4,02	4,07	3,59	4	4	4	4	4	4	0,898	0,865	1,054
12. Interaction in the classroom with educational robotics experiences could promote new teaching-learning methodologies.	4,35	4,39	4,05	5	5	4	5	5	4	0,784	0,747	0,999

ITEMS	Mean			Median			Mode			Standard deviation		
	T	SP	PT	T	SP	PT	T	SP	PT	T	SP	PT
13. If I used educational robotics, it would increase my level of participation in the subjects that use it.	3,84	3,85	3,77	4	4	4	4	4	3[a]	0,945	0,925	1,11
14. Participating in activities where I interact with educational robotics experiences could increase my skills related to teamwork.	3,9	3,9	3,91	4	4	4	4	4	4	0,955	0,95	1,019
15. The interaction with educational robotics would allow me to interact with other colleagues or colleagues helping me to understand concepts, procedures and attitudes.	3,88	3,9	3,68	4	4	4	4	4	4	0,971	0,968	0,995
16. Using educational robotics in classes where possible, could favor the development of competence related to self-learning.	4,08	4,11	3,86	4	4	4	4	5	4	0,859	0,848	0,941
17. The use of educational robotics would favor my critical thinking by asking questions and questions during its use that can generate interesting debates with teachers and other students.	3,88	3,91	3,64	4	4	4	4	4	4	0,881	0,883	0,848
18. The use of educational robotics would develop the shared construction of knowledge among all members who participate in this teaching-learning process.	3,9	3,91	3,77	4	4	4	4	4	4	0,924	0,926	0,922
19. Participation in activities where educational robotics were 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 on the network related to this topic.	3,96	3,99	3,73	4	4	4	4	4	4	0,865	0,861	0,883

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ITEMS	Mean			Median			Mode			Standard deviation		
	T	SP	PT	T	SP	PT	T	SP	PT	T	SP	PT
20. Participation in activities using educational robotics would facilitate the ability to apply theoretical knowledge to practice.	4,11	4,12	4	4	4	4	4	4	4	0,838	0,828	0,926
21. Using educational robotics would allow me to work on quasi-real problems developing aspects such as creativity and imagination while programming the robots.	4,02	4,05	3,73	4	4	4	4	4	4	0,875	0,87	0,883
22. Interacting with activities where educational robotics is used would improve my ability to learn to learn.	4,01	4,05	3,73	4	4	4	4	4	4	0,884	0,88	0,883
23. Using educational robotics, technological skills related to the use and application of ICT are favored.	4,36	4,43	3,86	5	5	4	5	5	4	0,812	0,774	0,941
24. Experimentation with educational robotics supposes a personalization of the learning process, making it more adapted and efficient since each student could learn at their own pace.	3,94	3,97	3,73	4	4	4	4	4	4	0,908	0,91	0,883
25. It would be appropriate and pertinent to use educational robotics to support traditional teaching materials in the Bachelor's subjects in which it could be used.	4,18	4,21	3,95	4	4	4	5	5	4	0,874	0,862	0,95
26. I will get bored while using educational robotics in subject activities.	1,93	1,78	3,05	2	1	3	1	1	3	1,092	1,009	1,09
28. I will attend class with enthusiasm when doing activities with educational robotics.	4	4,05	3,59	4	4	3,5	5	5	3	0,979	0,96	1,054
29. I will enjoy the classes in which educational robotics activities are carried out.	4,07	4,08	4	4	4	4	4	4[a]	4	0,916	0,91	0,976

ITEMS	Mean			Median			Mode			Standard deviation		
	T	SP	PT	T	SP	PT	T	SP	PT	T	SP	PT
30. I would like to use educational robotics in other subjects apart from this one, as long as it can be adapted.	4,01	4,04	3,77	4	4	4	4	5	4	0,941	0,923	1,066
31. Doing activities with educational robotics in class will be a waste of time.	1,58	1,49	2,27	1	1	2	1	1	2	1,008	0,935	1,279
32. Educational robotics will no longer attract my attention to the subjects in which it is used.	1,77	1,67	2,55	1	1	2	1	1	2	1,096	1,04	1,224
33. There will be no need to use educational robotics in class.	1,65	1,57	2,23	1	1	2	1	1	1	0,968	0,894	1,307
34. Using educational robotics will motivate me more to work on this subject.	4,02	4,04	3,86	4	4	4	4	4	4	0,895	0,884	0,99
35. The use of educational robotics will improve my opinion about the content of the subject (practical vision).	4	4,04	3,73	4	4	4	4	4	4	0,896	0,894	0,883
36. In general, I think that the use of educational robotics denotes an interest on the part of the teacher towards the teaching of their subject, and that it is very innovative.	4,11	4,15	3,86	4	4	4	5	5	4	0,9	0,879	1,037
37. Working with educational robotics will allow me to share my ideas, answers and visions with my teacher and classmates.	3,87	3,86	3,91	4	4	4	4	4	4	0,874	0,87	0,921
38. Carrying out activities with educational robotics will make me develop other cognitive skills (analysis, synthesis, criticism,...).	4,13	4,15	4	4	4	4	5	5	4	0,868	0,861	0,926
39. Do you know what Arduino is?	1,38	1,35	1,59	1	1	1	1	1	1	0,9	0,857	1,182

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ITEMS	Mean			Median			Mode			Standard deviation		
	T	SP	PT	T	SP	PT	T	SP	PT	T	SP	PT
40. Do you know the Raspberry board?	1,3	1,28	1,45	1	1	1	1	1	1	0,786	0,761	0,963
41. Do you know the Scratch programming software?	2,16	2,13	2,36	1	1	2	1	1	1	1,493	1,495	1,497
42. Do you know the Mblock programming software?	1,47	1,45	1,64	1	1	1	1	1	1	1,021	1,013	1,093

Figure 2. Items with the highest mean score.

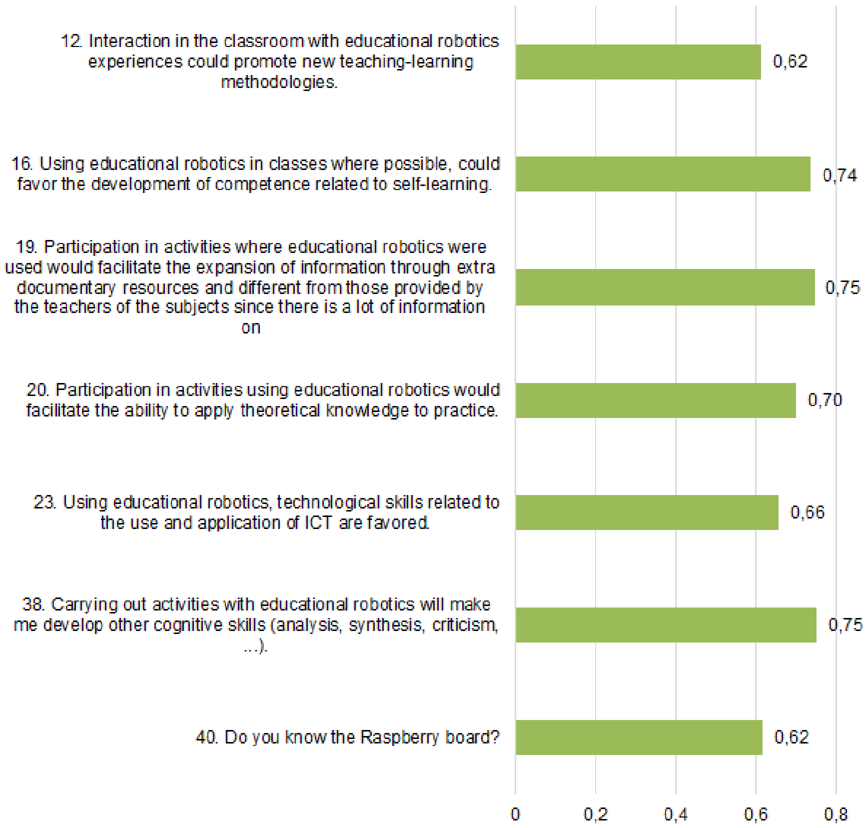
Finally, the variances, skewness, and kurtosis of the responses of students from Spain (SP) and Portugal (PT) on ER, organized into the six key dimensions already defined above, were analyzed. The variance analyses indicate the variability in the responses, while skewness and kurtosis provide insight into the shape of the distribution of the responses (DeCarlo, 1997; Trochim & Donnelly, 2006; Gravetter & Wallnau, 2016).

1. Dimension 1: Fundamentals and knowledge of ER (items 6, 39, 40, 41 and 42). The variance obtained for these items has been moderately low, indicating a consistency in the level of knowledge between students. The asymmetry has been found to be mostly positive, suggesting that many students have limited knowledge with few reaching high levels. The data obtained regarding kurtosis reflect that the responses tend not to be extremely pointed, indicating a relatively moderate distribution without pronounced peaks.

2. Dimension 2: Interaction and experience with ER (items 7, 14 and 15). The variance obtained for this group of items has varied, showing differences in how students have interacted with ER. The skewness obtained for this dimension is generally positive, reflecting that fewer students report high levels of interaction. The results for kurtosis have turned out to be mixed, with some distributions showing higher peaks, which could indicate specific experiences that are either very positive or very negative.
3. Dimension 3: Willingness and attitude towards the implementation of ER (items 8 and 34). The results obtained for the variance in this dimension have been relatively low, suggesting a consistent attitude towards ER. The asymmetry presented by these items has turned out to be negative in many cases, indicating that more students are willing to use ER. The values related to kurtosis have turned out to be generally low, indicating a wide distribution in attitudes without pronounced extremes.
4. Dimension 4: Motivational impact and curiosity (items 9, 10 and 11). The mean scores relative to the variances of the items grouped in this dimension have been moderate, reflecting different levels of motivational impact among students. The values related to asymmetry have been predominantly negative, suggesting that most students are motivated by ER. Finally, the values obtained for kurtosis have been varied, with some responses indicating a tighter clustering around the mean.
5. Dimension 5: Pedagogical and methodological applications (items 12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 24 and 25). The mean values of the variance in these items have been, in general, moderate, indicating a reasonable agreement on the pedagogical benefits of ER. The asymmetry presented by this dimension is mixed, but some items show negative asymmetry, suggesting that many students value these applications. Regarding the kurtosis values of some items, these are high, indicating that there are more concentrated responses around the mean.
6. Dimension 6: Social and emotional impact (items 26, 28, 29, 30, 31, 32, 33, 35, 36, 37 and 38). Regarding the results obtained from the variance, these have been relatively high in some items of this dimension, indicating variability in how students perceive the social impact of ER. The resulting asymmetry has turned out to be predominantly negative, especially in items related to enthusiasm and enjoyment, indicating that most students respond positively. Finally, the kurtosis presented has been varied, with some more pointed distributions suggesting strong concentrated positive or negative reactions.

In Figure 3 we can observe the variances obtained, the results obtained below 0.75 indicate that the responses do not deviate from the mean and, therefore, there is high consistency.

Figure 3. Variances obtained below 0,75 points.



Regarding the items whose correlations have been positive and negative (Spearman correlation coefficient), these have been the following (Table 6).

In general, the results show that perceptions about the adequacy of educational robotics vary between students from Spain and Portugal, although the magnitude of this variation is generally moderate and, in some cases, statistically significant.

In these items, where the correlations are positive, indicating that there is a tendency for positive perceptions to increase according to the country (with some items showing more favourable or positive perceptions in Portugal). However, the strength of these correlations varies significantly between items.

Some items show statistically significant correlations, suggesting that the country of origin may have a real effect on how students perceive the adequacy of educational robotics. For example, items such as: Using educational robotics favours technological skills related to the use and application of ICT, and: I will get bored while using educational robotics in class activities, indicate a moderately strong and significant association, suggesting differences in perception between students from the two countries.

The items that presented significant and stronger correlations tend to be related to technical aspects and motivation towards study, such as the development of technological skills, and the influence on students' interest and motivation to participate in classes that use educational robotics.

These results suggest that while in some respects ER is perceived in a similar way between Spain and Portugal, there are certain elements or contexts where the country of origin significantly influences the perception of its suitability. This could be due to differences in educational implementation, access to technological resources, or cultural differences in the assessment of technological education.

Correlational tests were also carried out to determine whether there were significant differences in the responses obtained by age group and by academic qualification in which the participants were enrolled (Bachelor's Degree in Early Childhood Education and Bachelor's Degree in Primary Education), with no significant differences being found.

Table 6. List of items with positive and negative correlations (items with negative wording in italics).

Nº de ítem	Texto del ítem	Coeficiente de correlación de Spearman	Valor p
11.	Participating in academic activities where educational robotics is used would increase my interest in the subject.	0.1550	0.0314
23.	Using educational robotics, technological skills related to the use and application of ICT are favored.	0.2253	0.0016
26.	*I will get bored while using educational robotics in subject activities.*	−0.3528	0.000000485
28.	I will attend class with enthusiasm when doing activities with educational robotics.	0.1516	0.0353
31.	*Doing activities with educational robotics in class will be a waste of time.*	−0.2714	0.00013
32.	*Educational robotics will no longer attract my attention to the subjects in which it is used.*	−0.294	0.000034
33.	*There will be no need to use educational robotics in class.*	−0.194	0.0069

4. CONCLUSIONS

We can conclude that ER is perceived in multiple facets by students, from knowledge and interaction to its impact on motivation, pedagogical methodology and the social and emotional sphere.

High average scores in many areas indicate a positive perception towards ER.

Average scores higher than 4, on a 5-point Likert scale, indicate a highly positive assessment in several of the items in the questionnaire used. Below, the conclusions are broken down for each of the six defined dimensions. Average scores higher than 4 have not been found in all dimensions in the total (T) of the questionnaires, even in Spanish students (SP) they have been found and in Portuguese (PT) they have not reached 4 points:

Dimension 1 (items 6, 39, 40, 41, and 42) Fundamentals and knowledge of ER: There are no items in this dimension that reach a mean higher than 4. This suggests that, although students are familiar with ER, the level of in-depth knowledge about specific tools such as Arduino, Raspberry Pi, Scratch, or Mblock is not very high. This highlights an opportunity to improve education in both programming tools and related hardware.

Dimension 2 (items 7, 14, and 15) Interaction and experience with ER: This dimension also does not present items with a mean higher than 4, indicating that, although students have interacted with ER, the experiences have not been impactful enough to be rated extremely high. This may point to the need to integrate more meaningful and practical experiences into the curriculum.

Dimension 3 (items 8 and 34) Willingness and attitude towards the implementation of ER: items 8 and 34 show high means, reflecting a positive willingness towards the use of ER and a motivation to integrate it into academic work. This indicates a positive acceptance and assessment of ER as an effective and enriching educational tool.

Dimension 4 (items 9, 10 and 11) Motivational impact and curiosity: items 9, 10 and 11 highlight a significant impact on students' motivation and curiosity. The high scores underline that ER is perceived as a catalyst for increasing interest and participation in learning, suggesting that its use in the classroom could be very beneficial in improving student engagement.

Dimension 5 (items 12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 24 and 25) Pedagogical and methodological applications: some of the items belonging to this dimension, such as 12, 16, 20, 22 and 23, receive high ratings, indicating that students perceive ER as highly beneficial for teaching and learning. These items reflect a strong belief in the power of ER to improve self-learning skills, foster critical thinking and personalize and enrich the educational process.

Dimension 6 (items 26, 28, 29, 30, 31, 32, 33, 35, 36, 37 and 38) Social and emotional impact: Items 28, 29 and 30 show that ER has a positive effect on students' social and emotional dimension. High scores indicate that ER activities are enjoyed and appreciated, suggesting that their inclusion can make classes more engaging and emotionally rewarding.

The general conclusions related to the mean scores obtained by students in Spain and Portugal indicate that they highly value ER, not only as a technological tool but as a means to enhance their overall educational experience. The analysis suggests that while familiarity with specific technological tools may need strengthening (programming languages and related hardware), the disposition towards ER and its motivational and pedagogical impact are clear.

Educational robotics is highly valued by students in both Spain and Portugal, with mean scores reflecting strong approval of key aspects of the educational experience. These include enhancing autonomous learning, increasing motivation and curiosity, facilitating the application of theoretical knowledge, and developing social and emotional skills. The results also suggest that effective implementation of ER can significantly contribute to the modernisation of teaching, making learning more engaging, personalised and efficient.

These results encourage educators and policy makers to consider ER not only as a technological complement but as an integral component of modern pedagogical strategies that can significantly contribute to the development of key competencies and the enrichment of students' educational experience. This is particularly pertinent in an educational environment increasingly focused on technology and innovation.

It is therefore important to consider ER as both an end and a technological means in teaching.

Regarding the conclusions obtained after the analysis of the medians, modes and standard deviations obtained, we conclude the following:

1. Dimension 1: Fundamentals and knowledge of ER: Items in this dimension (6, 39, 40, 41 and 42) show generally low medians and modes, with fundamental knowledge about robotics, programming languages and associated hardware (Arduino, Raspberry, Scratch, Mblock) not exceeding the basic level. This suggests that there is a significant need to improve basic education in emerging technologies such as RE, potentially by incorporating more specific content in curricula.
2. Dimension 2: Interaction and experience with ER: Items in this dimension (7, 14 and 15) reflect that interaction and participation in related activities appear to be moderately positive, with medians and modes frequently reaching 4. However, variability in responses, as indicated by the standard deviation, suggests inconsistent experiences among students. This could imply an uneven implementation of ER in different areas or institutions.

3. Dimension 3: Willingness and attitude towards implementing ER: Items in this dimension (8 and 34) reflecting the willingness to use it as well as the motivation to work with ER in subjects show a high level of acceptance, with solid medians of 4. This reflects a positive attitude towards integrating ER into teaching practice, indicating that students are willing and motivated to include these technologies in their future learning and teaching.
4. Dimension 4: Motivational impact and curiosity: Items assessing the impact of ER on motivation and curiosity (9, 10 and 11) also show high medians and modes of 4. Students perceive it as a powerful motivator that increases their interest and curiosity in learning, underlining the value of it as an educational tool to enhance student engagement.
5. Dimension 5: Pedagogical and methodological applications: This dimension, which encompasses items (12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 24 and 25) ranging from promoting new teaching methodologies to improving technological skills and personalizing learning, shows a consistent recognition of the pedagogical value of ER. Most items in this dimension achieve medians of 4 or 5, indicating that ER is seen as critical to modern and effective educational development.
6. Dimension 6: Social and emotional impact: The responses to the items in this dimension (26, 28, 29, 30, 31, 32, 33, 35, 36, 37 and 38) reflect that there are items in this dimension with varied responses, those related to enthusiasm, enjoyment and improved perception of course content show medians of 4, reflecting a positive perception of the social and emotional impact of ER. This suggests that not only improves cognitive learning but also the social and emotional experience in the classroom.

Moderate standard deviations in some blocks suggest that there is room to improve the cohesion in these perceptions. Analysis of these values reveals a positive perception of ER among students in Spain and Portugal, with a high willingness and motivation to integrate this technology into the educational environment.

Differences between the responses of students in the two countries are minimal, suggesting a uniform valuation of educational technology in the Iberian Peninsula.

Measures of central tendency and dispersion indicate concentrated and consistent responses, reinforcing the validity of the results obtained.

In conclusion, ER is widely valued by students in both Spain and Portugal, with high scores in willingness, motivational impact, and pedagogical applications. However, there is significant room to improve fundamental knowledge about specific technological tools and consistency in the experience of interacting with ER. The results emphasize the need for educational strategies that not only integrate ER effectively, but also ensure a solid basic technological education and consistent, high-quality learning experiences for all students.

The analysis of variance, skewness and kurtosis shows that, in general, students have a positive perception of ER, particularly in terms of motivation, willingness and pedagogical applications. However, there is variability in the interaction experience and knowledge of specific ER tools, suggesting the need for more uniform education and practical experiences. The responses tend to cluster around positive means, but with variability in the intensity of these perceptions.

As a conclusion to the calculation of the correlations between the responses given by students from Spain (SP) and Portugal (PT), we must point out that some items showed significant negative correlations, all of which are related to negative perceptions about ER, such as boredom and the perception of loss of time. These results must be justified by the negative wording of these items:

a) 26. I will get bored while using educational robotics in subject activities.

b) 31. Doing activities with educational robotics in class will be a waste of time.

c) 32. Educational robotics will no longer attract my attention to the subjects in which it is used.

d) 33. There will be no need to use educational robotics in class.

When items are negatively worded, a negative correlation may indicate a positive perception. For example, a negative correlation on these items might suggest that those who rate their agreement with the negative statement low (i.e., disagree that ER is boring or a waste of time) have a positive attitude toward ER.

For these items, a negative correlation with variables such as overall satisfaction with RE or academic performance might indicate that students who agree less with these negative statements have a more positive experience or find greater value in ER.

Negative wording requires careful interpretation of correlation coefficients to understand the true meaning behind the numbers.

5. DISCUSIÓN.

We fully agree with Alimisis (2013) when he states that to achieve full inclusion of ER it is necessary to work not only on technical skills, but also on problem-solving and creativity skills. The effective integration of robotics in STEM (Science, Technology, Engineering & Mathematics) and STEAM (Science, Technology, Engineering, Arts & Mathematics) education can also increase students' interest and motivation, providing richer and more engaging learning contexts.

Authors such as Benitti (2012) conclude that robotics has great educational potential in schools, helping to improve both discipline-specific skills and general competencies such as teamwork and problem-solving. However, he also points out challenges such as the need for adequate training of teachers (current and in training) and curricular integration to maximize the benefits of educational robotics.

Kandlhofer & Steinbauer (2016) found that has a significant positive impact on the development of students' technical and social skills. Furthermore, the use of robotics in education can improve students' attitudes towards science and technology, making these subjects perceived as more accessible and attractive.

This consideration is not something new, Bers (2008) stated that technologies such as robotics can be powerful tools for cognitive and social development in early education. This same author highlights that robotics activities help students understand abstract concepts in a tangible way and promote essential skills such as planning, critical thinking, and collaboration from an early age.

In their study, Hudson *et al*. (2020) found that robotics-based interventions significantly increase students' interest in STEM subjects and their future careers. This result supports the idea that RE can be a catalyst to encourage participation and motivation in technical fields.

We also agree with Jung & Won (2018) when in their study they conclude that robotics education positively influences young people, improving not only technical knowledge but also social and cognitive skills. This issue has several important implications for education and student development: that ER not only improves technical skills, such as programming and technology management, but also fosters social and cognitive skills; this implies that robotics can be a holistic educational resource that contributes to the comprehensive development of the student.

The ability of robotics to impact multiple areas of development underlines its value as an interdisciplinary tool. This may encourage educators to integrate robotics into various aspects of the curriculum, not only in science and mathematics, but also in areas that promote social and cognitive skills Jung & Won (2018).

If robotics improves social and cognitive skills, it could also increase student motivation and engagement. Students may find robotics activities more engaging and rewarding, which may lead to greater enthusiasm for learning in general.

The implications of robotics supporting cognitive and social development suggest that it may be a useful tool for personalized education. Educators could use robotics to tailor learning to individual students' needs, helping those who may need additional support in certain areas. By fostering technical skills alongside social and cognitive skills, robotics education prepares students for the challenges of the future workplace, which will increasingly demand more of these combined competencies.

If robotics proves effective in developing such a wide range of skills, it could be a key resource for educational inclusion, providing equitable learning opportunities for students of diverse backgrounds and abilities.

Robotics activities increase student motivation and interest, suggesting that robotics can be an effective tool for improving disposition and attitude towards learning (Kaloti-Hallak et al., 2015), and for this reason it should be taught more in university training centres that have the mission of training future teachers in a more meaningful and stimulating way.

In fact, project-based robotic applications improve students' computational thinking skills and their perception of basic STEM skills (Karaahmetoğlu & Korkmaz, 2019), their results indicate significant improvements, highlighting the effectiveness of educational robotics in improving critical and technological competencies.

We even agree with Llanos-Ruiz et al. (2023), who went beyond the formal scope of training, their study found that both students and families perceive ER very positively, this suggests that robotics is not only well received in formal educational settings, but is also valued in non-formal contexts, such as extracurricular activities and workshops. They recognize ER as an effective tool to motivate students and maintain their interest, as we have previously stated and as reflected in this study. This is especially relevant in non-formal settings, where voluntary participation underlines the importance of maintaining student engagement.

Today's university institutions must establish the appropriate conditions to foster more student-centered learning, using innovative teaching methods, critical training, and active citizens, who are willing to provide their knowledge for social service (Vázquez-Cano et al., 2020).

Therefore, universities must play a new role as promoters of competencies that future graduates must manage in their academic, personal, and professional development (Fernández-Batanero et al., 2019; Delgado-Vázquez et al., 2019).

Logically, from the Faculties of Education Sciences we have the mission of training male and female students to be competent in computational thinking and in the management of robotic kits (Román Graván et al, 2019), since, as they say (Master et al., 2017; Valverde-Berrocoso et al., 2015), positive interaction with these resources will stimulate their use when these women work as teachers.

AUTHOR CONTRIBUTION

All authors contributed to the conception and design of the study. Material preparation, data collection, and analysis were carried out by [Pedro Román-Graván] and [Pedro-José Arrifano-Tadeu]. The first draft of the manuscript was written by [Pedro Román-Graván] and [Pedro-José Arrifano-Tadeu] and all authors commented on earlier versions of the manuscript. All authors read and approved the final manuscript.

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