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Teachers' perception about the difficulty and use of programming and robotics in the classroom

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ABSTRACT

Programming and robotics are resources that can be used as a learning tool for understanding content. However, some teachers are unmotivated due to preconceptions about their difficulties, which hinder their learning and subsequent application in the classroom. This study aims to determine the perception of 195 teachers teaching different grade levels and areas of knowledge on the learning of programming, robotics, and their possibilities of applying them in the classroom. The results show no differences according to the educational stage to perceive adequate skills to learn programming and robotics, although, by area, the teachers of STEAM are considered more capable than the rest. Regarding the introduction of these resources in the classroom, there are no differences according to educational stage. As for differences by area, STEAM teachers stand out, followed by generalist teachers at lower levels (kindergarten and basic school), while there is greater reluctance among teachers of non-STEM areas at higher levels (high school and university and others). It is concluded that the initial perception is similar for teachers of different stages, and with differences with respect to the area, having interesting repercussions on the design of courses.

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Introduction

Technology has great potential for students to learn actively (Pandolfini, 2016) since it has improved the way of interacting in our society (Baller et al., 2016), offering teachers more options to improve the process of teaching (Segura-Robles et al., 2020; Thai et al., 2017; Yoon et al., 2021). Programming and robotics have a great reception in education (López-Belmonte et al., 2021), which is why many countries are including them as part of the educational curriculum (Miller & Nourbakhsh, 2016).

There are two ways of introducing programming and robotics in education: as a learning object, whose objective is to learn about these resources from early educational stages (Jung & Won, 2018; Sáez-López et al., 2021); and as a learning tool, whose objective is to treat them as yet another resource for learning other disciplines, such as mathematics (Zhong & Xia, 2020) or music and art (Sullivan & Bers, 2018), or even to develop skills and competencies., such as teamwork (González-Fernández et al., 2021) or computational thinking and problem solving (Ortega-Ruipérez & Asensio, 2018).

The opinion of teachers about the use of programming and robotics is positive but carries specific nuances, such as the differences found in terms of previous training related to STEAM careers or gender (Zha et al., 2020). In the case of gender, there is more reluctance regarding the use of

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STEAM resources in women, something that can be mitigated with adequate training (Román-Graván et al., 2020).

Differences have been found in the perception of self-efficacy to implement these resources in the classroom among teachers of different educational stages, although no differences are shown in terms of motivation (Çoban et al., 2020).

In early childhood education, teachers can be reluctant if they do not have references of experiences; however, after receiving training, they see robotics as an ideal resource (Álvarez, 2019). In general, teachers of this stage consider a lot of support necessary through courses and training materials, infrastructure, and technical support (Uğur-Erdoğmuş, 2020), as well as in primary education (Quevedo et al., 2020) and, in general, at any educational stage (Chevalier et al., 2016).

In the case of special education, teachers view educational robotics as a powerful tool for children with Down syndrome, autism spectrum disorders, or dyspraxia (Di Battista et al., 2020).

Training in programming and robotics in courses for teachers, both in training and active, improves their opinion about the use of technology in the classroom (Çakır et al., 2021), their motivation (Aksu & Durak, 2019), in addition to their interest and self-efficacy towards the use of robotics (Mallik et al., 2018) and STEAM projects (Chalmers, 2017; Smyrnova-Trybulska et al., 2017).

In recent years, courses have proliferated to teach programming and robotics to teachers of all educational stages: for early childhood teachers (Alimisis, 2019; Borrull et al., 2020), for primary school (Camilleri, 2017; Kaya et al., 2017; Mason & Rich, 2019; Pina-Calafi, 2017; Sáez-López et al., 2020), from first years of secondary school (Negrini, 2019), from last years of secondary in general (Gülbahar & Kalelioğlu, 2017), or who teach computer science in particular (Kert, 2019; Piedade et al., 2020). Training experiences with remote laboratories have even been designed (Wu & Albion, 2019). The grand reception of these courses has led to the creation of curricular integration proposals for teacher training (Monteiro et al., 2019).

Nevertheless, not only should it be considered that teachers learn programming and robotics in training courses, but they should also be able to integrate this knowledge into their educational practices (Kucuk & Sisman, 2018). Training should include how to integrate these resources into the curriculum and pedagogy (Tang et al., 2020). As several studies show, teachers do not always manage to develop this knowledge during trainings (Guven & Cakir, 2020; Jaipal-Jamani & Angeli, 2017).

In this research, a needs study is carried out to determine how teacher training should be planned according to the educational stage and the area in which they teach. With this knowledge, it will be possible to design courses that cover pedagogical aspects on the inclusion of programming and robotics as educational resources.

Methodology

Research design

This study aims to determine the perception of teachers, teaching different age groups and subjects, about the difficulty of learning programming and robotics and the difficulty of implementing them into the classroom.

For this, three objectives were established, in order to clearly define the purposes of the research in the study's results:

(1) Learn about teachers' perceptions about the difficulties they may encounter in learning the basic elements of programming.
(2) Know the preconceptions about the difficulty in learning about the structure of basic robotics and its main components.
(3) Detect ideas about how they will be able to introduce programming and robotics in their classes.

Therefore, three dependent variables (DV) were used, corresponding to each of the specific objectives. On the other hand, as independent variables (IV), the age group they teach is considered, the subject area, and previous knowledge about programming and robotic educational tools to identify any significant differences between the focus groups.

To achieve these objectives, a non-experimental cross-sectional design with descriptive scope has been chosen, since the intention is to describe a specific reality. The results of this study are intended to serve as a basis for designing future courses for teaching programming and robotics targeted to teachers.

Participants

The study's focus group corresponds to those teachers who are interested in starting courses on programming and robotics to introduce them as resources that can be used in the classroom to work in any subject area with different age groups. The study is made up of 195 students, from a total of 600 teachers who are studying the Master of Educational Technology and Digital Competences of UNIR, which represents 32.5% of the total.

These teachers belong to different school subject areas and have been grouped into three groups: general (in the first stages, they are teachers who teach all the core areas), STEAM (Sciences, Technology, Engineering, Plastic arts, Mathematics), and No STEAM (language, social sciences, physical education).

In addition, these participants teach students of different age groups: from early childhood education to higher education. Four groups have been created to facilitate the analysis of the data four groups have been created: kindergarten, basic school, high school, university, and others (adult training, academies, language schools, etc.). The distribution of the participants is found in Table 1.

The participants come from different nationalities: Spain (77), Colombia (72), Ecuador (31), and Peru (15). To obtain the final sample, the sampling procedure has been non-probabilistic, since students have decided to participate voluntarily in the study.

Instruments

An instrument has been created for the purpose of the research, so that the objectives set out in the study can be fully answered. It is a questionnaire with 28 items in affirmative format, which are distributed around the three research objectives: 8 items per objective (Table 2).

All the items have 10 response options, 10 totally agree with the statement, and 1 totally disagree with the statement. Utilising a more extensive scale will help distinguish the different response levels rather than using a smaller one.

Procedure

The questionnaire was created electronically with *Google Forms* to be administered online through a link. The link was shared during the first session of the Programming and robotics course for teachers. In addition, a message was posted on the forum for students who could not attend this first session, allowing all those enrolled in the subject the possibility to participate.

Table 1. Distribution of the sample by school level and subject area.

	Kindergarten (3–5 years)	Basic school (6–12 years)	High school (13–18 years)	University and others (+18)	Total
General	35	59	2	5	101
Steam	0	14	18	10	42
No steam	3	37	6	6	52
Total	38	110	26	21	195

Table 2. Questionnaire items and corresponding dimension (objective).

N°	Descripción del ítem	Dimensión
1	Indicate the (main) educational stage at which you teach.	VI
2	Indicate to which area the main subject you teach belongs (if you work in several areas, mark "general").	
3	I am familiar with educational programming tools (Scratch, code.org …)	
4	I use educational programming tools (Scratch, App Inventor …)	
5	I am familiar with educational robotics tools (Beebot, LEGO …)	
6	I use educational robotics tools (Beebot, LEGO …)	
7	I consider programming to be (level of difficulty)	OBJETIVE 1
8	I think I will be able to learn to program	
9	I am good at making sequences of steps for everyday actions (ability)	
10	I consider myself to be a person who uses logic well	
11	I am good at applying solutions from one problem to another similar problem.	
12	I am good at automating tasks	
13	I am able to break down complex tasks into small independent tasks.	
14	I am able to understand and create simple instructions such as: as long as I press the "right arrow" key, the character moves to the right.	
15	I consider robotics to be …. (Level of difficulty)	OBJETIVE 2
16	I believe that I will be able to understand how to create a robot.	
17	The use of technological devices	
18	I understand how technological devices work	
19	I am able to identify what can go wrong with a device (e.g. a sensor).	
20	When something technological breaks at home, I am able to fix it.	
21	I understand what hardware is and can clearly differentiate it from software.	
22	I am able to understand and create simple instructions such as the following: if a light sensor detects low light, an LED has to be switched on.	
23	I believe that I will be able to use programming easily in my educational stage.	OBJETIVE 3
24	I think I will be able to use robotics easily in my educational stage.	
25	I think I will be able to use programming to teach content in my subject area.	
26	I believe that I will be able to use robotics to teach content in my subject area	
27	I think I will be able to use programming in my classes if I have a step-by-step guide on how to do it.	
28	I think I will be able to use programming in my classes even if I have to make small decisions about bugs in the programming and their results.	
29	I think I will be able to use robotics in my classes if I have a step-by-step guide on how to do it.	
30	I think I will be able to use robotics in my classes even if I have to make small decisions about bugs in the creation of robots and their results.	

At the beginning of the questionnaire, there is an explanation of the purpose of the study, and it is indicated that participation is voluntary. Therefore, respondents give their consent to treat their data anonymously.

Data analysis

Before analysing the results, the alpha Cronbach was obtained to learn about the instrument's accuracy in the sample, obtaining a high result of (0.937), indicating that the instrument successfully evaluates teachers' perception about the difficulties and use of programming and robotics in the classroom.

Once it has been confirmed that the questionnaire is adequate, the results are analysed. Since they are dependent variables with 10 scale points and the amount of subjects of the sample, tests for quantitative data are used.

Firstly, the ANOVA test is used to determine if there are significant differences between the groups, with a reliability level of 95%. Secondly, Descriptive statistics have been used to gain a better understanding of how different groups behave, using the average score.

Results

The results are set out below according to which objective they respond to.

Perception of difficulties in learning programming

Table 3 shows that there are no significant differences in perceived ability to learn and understand simple instructions (items 8 and 14). Similarly, there are no differences in the perceived ease of performing sequences, using analogies, automating tasks, and decomposing problems (items 9, 11–13), with total mean scores between 7 and 8.

There are significant differences in the knowledge and use of educational programming tools, the perceived difficulty of programming and the use of logic. Table 4 shows the averages for each group, where a moderate increase can be seen as the educational stages in which they work to progress, except that high school teachers (stage 3) consider programming to be easier than university and other teachers (stage 4).

Table 5 shows that there are no significant differences according to the teachers' area of knowledge in the perceived ease of using analogies, automating, and decomposing tasks (items 11–13). Neither there are differences in the understanding of simple instructions (item 14).

Table 6 shows the averages of the groups in the different areas to check where the differences between groups are found, obtaining similar results between teachers of lower stages who teach almost all subjects (general) and teachers of non-STEM areas; on the other hand, teachers of STEAM areas show higher results both in knowledge and use of the tools, and in perceived ease of programming and its learning, as well as obtaining higher results in the ease of creating sequences and using logic.

Perception of difficulties in learning robotics

Table 7 shows that there are no significant differences for any of the items on robotics in the different educational stages in which the teachers teach. In this case, we see how they have low knowledge of tools (item 5), so their use is even lower (item 6), and they also have a general perception that robotics is quite difficult (item 15). They also have relatively low scores in identifying faults and fixing electronic devices (items 19–20). In the remaining items, they all show a remarkable understanding of electronic devices (items 16–18, 21) and of the instructions given to the robots (item 22).

Table 8 shows that there are no significant differences in the ability to understand the basic parts of a robot (item 21) and to understand simple instructions (item 22).

Table 9 shows in more detail the average scores of each group according to the area of knowledge.

Higher average scores were found for STEAM teachers compared to other teachers: in knowledge and use of educational robots (items 5–6), in perceived ease and ability to learn (items 15–16), and in ease to understand electronic devices in depth (items 17–20), which requires more knowledge than for basic understanding (items 21–22), which showed no significant differences between the groups.

Table 3. *p*-value of ANOVA (Sig.) average scores (X) of items on learning programming by educational stage.

Item	Description	X	Sig.
3	Knowledge of educational programming tools	2.78	.016
4	Use of educational programming tools	2.00	.005
7	Perceived difficulty in learning programming	4.45	.011
8	Perception of programming learning ability	8.22	.209
9	Ease of making sequences	7.35	.232
10	Ease of using logic	7.70	.023
11	Ease of using analogies	7.68	.085
12	Ease of automating tasks	7.73	.928
13	Ease of breaking down tasks or problems	7.38	.532
14	Understanding simple programming instructions	8.48	.916

Table 4. Average scores on programming learning items (with significant differences) by stage.

Item	Kindergarten	Basic school	High school	University & others
3	2.24	2.57	3.62	3.86
4	1.37	1.85	2.81	2.95
7	4.16	4.25	5.69	4.48
10	7.32	7.58	8.15	8.43

Perception of the possibilities for introducing programming and robotics in the classroom

Table 10 shows that there are no significant differences in terms of the possibility of introducing programming and robotics in the classroom according to the educational stage at which the teachers teach any of the items.

Table 11 shows that there are significant differences in all items according to the area of knowledge to which the teachers belong.

Table 12 shows the average scores of each group with respect to the area, showing that in general, STEAM teachers believe that they have more possibilities to apply these resources than the rest of the teachers.

Some interesting results can be observed when comparing the groups of generalist teachers (kindergarten and basic school levels) and teachers of non-STEM areas (higher stages):

- Generalist teachers believe that they can use programming and especially robotics at their stage more than teachers of non-STEM areas.
- Generalist teachers are more willing to apply these resources both with and without guidelines in their classes.

Discussion and conclusion

Teachers at all educational stages consider themselves to have a high capacity to learn programming and can understand simple instructions. They also have a good perception of their basic programming skills (sequencing, using analogies, automating, and decomposing tasks). On the other hand, as the educational stage increases, teachers know and use more programming tools, and consider that they make better use of logic.

In the case of the perceived difficulty of programming, this trend is also seen in the early stages, in line with the results of Çoban et al. (2020), except that high school teachers consider programming to be easier than teachers at higher stages. This analysis allows for the reflection that, if teachers at any stage are able to understand simple instructions, it could improve their perception of educational programming after training, according to Álvarez (2019), as their perception of learning ability is also similar across all stages.

Table 5. *p*-value of ANOVA (Sig.) average scores (X) of items on learning programming by area of knowledge.

Item	Description	Sig.
3	Knowledge of educational programming tools	.001
4	Use of educational programming tools	.000
7	Perceived difficulty in learning programming	.000
8	Perception of programming learning ability	.000
9	Ease of making sequences	.024
10	Ease of using logic	.044
11	Ease of using analogies	.057
12	Ease of automating tasks	.100
13	Ease of breaking down tasks or problems	.062
14	Understanding simple programming instructions	.419

Table 6. Average scores by area on programming learning items with significant differences.

Ítem	General	STEAM Area	No STEAM Area
3	2.5	3.98	2.38
4	1.65	3.45	1.5
7	4.11	5.67	4.13
8	7.98	9.24	7.87
9	7.07	8.1	7.31
10	7.55	8.25	7.54

Table 7. *p*-value ANOVA and mean scores of robotics learning items by educational stage.

Item	Description	X	Sig.
5	Knowledge of educational robotics tools	3.17	.081
6	Use of educational robotics tools	2.15	.386
15	Perceived difficulty in learning robotics	4.94	.076
16	Perception of robotic learning ability	7.65	.649
17	Ease of use of electronic devices	8.03	.145
18	Ease of understanding how electronic devices work	7.19	.205
19	Ease of identifying faults in electronic devices	5.27	.368
20	Ease of fixing broken electronic devices	5.44	.276
21	Ability to differentiate hardware-software	8.29	.433
22	Understanding simple instructions for robots	7.32	.613

Table 8. *p*-value of the ANOVA of items on robotics learning by subject area.

Item	Description	Sig.
5	Knowledge of educational robotics tools	.024
6	Use of educational robotics tools	.014
15	Perceived difficulty in learning robotics	.000
16	Perception of robotic learning ability	.005
17	Ease of use of electronic devices	.005
18	Ease of understanding how electronic devices work	.005
19	Ease of identifying faults in electronic devices	.033
20	Ease of fixing broken electronic devices	.030
21	Ability to differentiate hardware-software	.597
22	Understanding simple instructions for robots	.992

Table 9. Average scores by area on robotics learning items with significant differences.

Item	General	STEAM Area	No STEAM Area
5	3.36	3.74	2.37
6	2.11	2.93	1.62
15	4.73	6.19	4.35
16	7.52	8.43	7.27
17	7.78	8.64	8.02
18	6.93	7.95	7.08
19	5.06	6.07	5.02
20	5.06	6.29	5.50

Teachers in STEAM areas know and use more educational programming tools than the rest, and they also consider that programming is easier and that they have a greater capacity to learn. Therefore, one reason why they may consider the latter may be due to their greater knowledge and use of these tools, even though they are just as capable of understanding simple instructions as teachers in other subject areas. They also consider themselves more capable of creating sequences and using logic, something basic in programming. With these results, it could be intuited that, if teachers in other areas (generalist and non-STEM) had the opportunity to learn more about educational

Table 10. *p*-value ANOVA of items on the possibilities of using programming and robotics according to educational stage and average scores of the total sample.

Item	Description	X	Sig.
23	Use of programming in education	6.97	.474
24	Use of robotics in education	7.07	.233
25	Use of programming in knowledge area	6.94	.687
26	Use of robotics in knowledge area	7.01	.438
27	Use of programming with guidelines	7.79	.627
28	Use of robotics with guidelines	7.85	.567
29	Use of programming without guidelines	7.25	.078
30	Use of robotics without guidelines	7.12	.587

Table 11. *p*-value of the ANOVA of items on the possibilities of using programming and robotics according to knowledge area.

Item	Description	Sig.
23	Use of programming in education	.002
24	Use of robotics in education	.016
25	Use of programming in knowledge area	.000
26	Use of robotics in knowledge area	.001
27	Use of programming with guidelines	.006
28	Use of robotics with guidelines	.012
29	Use of programming without guidelines	.000
30	Use of robotics without guidelines	.001

Table 12. Average scores by areas on items of possibilities of introducing these resources in the classroom with significant differences.

Item	General	STEAM Area	No STEAM Area
23	6.78	7.98	6.54
24	7.05	7.81	6.50
25	6.90	8.07	6.10
26	7.05	7.95	6.17
27	7.83	8.50	7.15
28	8.04	8.29	7.13
29	7.13	8.31	6.56
30	7.13	8.00	6.38

programming tools, their perception of this resource could improve, as they consider themselves equally capable of applying the necessary thinking to programming as teachers in STEAM areas.

In the case of the perceived difficulty of educational robotics, teachers at all stages hardly know about or use educational robot resources. In general, they consider robotics to be somewhat less difficult to learn than programming. Regardless of the stage, they have a fairly high basic knowledge of electronic devices, differentiate the parts of a robot and understand its operation, contrary to the findings of Çoban et al. However, in general, at any stage they see themselves less able to identify faults and fix them. The latter perception could be improved by receiving a full course on educational robotics, according to Mallik et al. (2018), as a brief introduction to this resource has led them to have a fairly high perception of their basic knowledge, so further deepening could improve their perception of gaining a greater knowledge of robotics.

STEAM teachers know and use educational robotics more than other teachers, so they feel that robotics is easier and that they are better able to learn it, and they feel more able to understand in depth how robotics works. This may be mainly due to two reasons: on the one hand, they have more knowledge about disciplines related to robotics (mathematics, physics, etc.) and, on the other hand, the greater contact with educational robotics resources makes them see these tools as easier and more capable of learning. But, if we look at the basic questions about the basic understanding of the parts of a robot and how to give it instructions, it makes us reflect those teachers of other areas could improve their perception if they had more contact with these tools.

Teachers at all educational stages think that they could introduce programming and robotics in their respective subject areas, although they qualify that they could implement it better with a guideline than without such guidelines, according to Chevalier et al. (2016), Quevedo et al. (2020), and Uğur-Erdoğmuş (2020).

Regarding the inclusion of programming and robotics in the classroom according to the teachers' area of knowledge, there is a greater acceptance of STEAM teachers than other teachers, according to the results of Zha et al. (2020), as they have more training in related areas. Increasing the training of other teachers in these resources could improve their motivation (Aksu & Durak, 2019), as well as their interest and self-efficacy towards the use of robotics (Mallik et al., 2018) and STEAM projects (Chalmers, 2017; Smyrnova-Trybulska et al., 2017).

Of the teachers who do not belong to STEAM areas, it stands out that teachers at lower levels (kindergarten and basic school) consider that they can introduce these resources more than teachers at higher levels (high school and university and others), believing that they can apply them better in their areas. This may be due to the fact that generalist teachers tend to teach natural science and mathematics subjects at their respective stages. In addition, generalist teachers are more daring than non-STEM teachers to introduce these resources. One possible reason for this is that their training is more general (teacher training), as opposed to teachers at higher levels who study for a specialised degree in their area. In addition, generalist teachers are equally able to introduce these resources both with and without application guidelines, while both STEAM and non-STEM teachers at higher levels are more able to introduce these resources with guidelines than without them. Overall, this indicates that teachers need to address how to introduce these resources into the classroom in trainings, in line with research by Kucuk and Sisman (2018) and Tang et al. (2020), in addition to learning about programming and robotics, something that is not always achieved (Guven & Cakir, 2020; Jaipal-Jamani & Angeli, 2017).

These results allow us to conclude that the initial perception of teachers towards programming and robotics as educational tools is similar in all educational stages, while, if we differentiate by areas, teachers of STEAM areas have better perceptions of these resources and their application in the classroom than the rest of the teachers.

The main limitation of the study is the unequal number of participants in each group, with more than double the number of primary school teachers, in the case of the stage, and generalist teachers, in the case of the area. As a prospective, the aim is to qualitatively investigate the opinions of the teachers, and to find out the effect that training on these resources may have on their perception of their educational usefulness.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability

Figshare: https://doi.org/10.6084/m9.figshare.16733692.v1

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