

## **Pre-service and in-service teachers' interest, knowledge, and self-confidence in using educational robotics in learning activities**

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### **Abstract**

This paper presents a study that aims to analyze the interest, knowledge, problem-solving skills, and self-confidence of the pre-service and in-service teachers in using educational robotics for teaching purposes, in particular, to teach programming and computational thinking in primary and secondary education. In the Portuguese context, it is mandatory to attend a masters in teaching in order to become a teacher in primary and secondary education. Computational Thinking, programming, and robotics have been integrated into the schools' curriculum in many countries. Accordingly, it is essential to analyze the teachers' preparation to teach these thematic trends. A descriptive and exploratory quantitative approach was implemented with 49 participants. The results pointed out a positive level of interest, educational robotics knowledge, problem-solving, self-confidence of both pre-service and in-service teachers. It was possible to identify significant correlations in all dimensions, in particular, between "Self-confidence" and "Educational Robotics Knowledge", and "Problem-solving" and "Interest". Therefore, it is necessary to promote these dimensions, in an integrated way, in the pre-service and in-service training programs through learning activities with robotics.

### **Keywords**

Computational thinking. Didactics of informatics. Educational robotics. Pre-service teacher education. Programming.

### **Interesse, conhecimento e autoconfiança de futuros professores e professores em serviço no uso de robótica educacional em atividades de aprendizagem**

### **Resumo**

Este artigo reporta os resultados de um estudo que procurou analisar os níveis de interesse, conhecimento, resolução de problemas e autoconfiança dos professores em formação inicial e professores em exercício na utilização de robótica educativa para ensinar programação e pensamento computacional no Ensino Fundamental e Médio. Em Portugal, para ser professor da Educação Básica, é necessário um mestrado em Ensino. As temáticas ligadas ao Pensamento Computacional, à programação e à robótica vêm sendo integradas nos currículos escolares em vários países. Assim, é importante analisar a preparação dos professores para ensinar essas temáticas. A investigação assumiu uma abordagem quantitativa de caráter descritivo e exploratório e envolveu 49 participantes, professores em formação inicial e professores em serviço. Os resultados evidenciaram níveis positivos de interesse, conhecimento, resolução de problemas e autoconfiança em ambos os grupos. Foi possível

identificar correlações estatisticamente significativas entre todas as dimensões, em particular entre as dimensões “autoconfiança” e “conhecimento” e entre as dimensões “resolução de problemas” e “interesse”. Assim, é necessário promover estas dimensões de forma integrada na formação inicial e contínua de professores através de programa de formação em robótica educativa.

**Palavras-chave**

Didática da informática. Formação inicial de professores. Pensamento computacional. Programação. Robótica educativa.

**Interés, conocimiento y autoconfianza de los docentes en formación inicial y docentes em servicio en el uso de la robótica educativa en las actividades de aprendizaje**

**Resumen**

Este artículo informa sobre los resultados de un estudio en el cual se procuró analizar los niveles de interés, conocimiento, resolución de problemas y autoeficacia de los docentes en la formación inicial y los docentes en la práctica, en el uso de la robótica para enseñar programación y pensamiento computacional en la educación básica y secundaria. En Portugal, para ser profesor, es necesario cursar un master en Enseñanza. Los temas relacionados con el pensamiento computacional, la programación y la robótica se han integrado en los planes de estudio escolares en varios países. Por lo tanto, es importante analizar la preparación de los profesores para enseñar estos temas. La investigación adoptó un enfoque cuantitativo de naturaleza descriptiva y exploratoria con 49 participantes, docentes en formación inicial y docentes en servicio. Los resultados mostraron niveles positivos de interés, conocimiento, resolución de problemas y autoeficacia en ambos los grupos. Fue posible identificar correlaciones estadísticamente significativas entre todas las dimensiones, en particular entre las dimensiones “autoeficacia” y “conocimiento” y entre las dimensiones “resolución de problemas” e “interés”. Por lo tanto, es necesario promover estas dimensiones de manera integrada en la formación inicial continua del profesorado a través de un programa educativo de formación en robótica.

**Palabras clave**

Pensamiento computacional. Didáctica de la informática. Robótica educativa. Formación docente previa al servicio. Programación.

## 1 Introduction

This paper presents a study developed with pre-service and in-service informatics teachers who are or were attending the master in teaching informatics at the University of Lisbon.

In the portuguese context, it is mandatory to attend a master in teaching in order to become a teacher in primary and secondary education. These pre-service teacher training programs are organized in several dimensions, such as specific didactics, general education, scientific area (e.g., mathematics, informatics, sciences, among others), and professional practice initiation. For example, during this program, pre-service informatics teachers learn about education, research methods, curriculum and assessment, and didactics of informatics and start the initiation of teaching with real classes of students.

The master in teaching informatics program aims to prepare pre-service teachers with didactical and pedagogical repertoires to teach several informatics subjects that are part of the national curriculum (such as computational thinking and programming, databases, computer networks, hardware, computers architecture, digital systems, and information and communication technologies).

Computational Thinking (CT) has been pointed out as a thematic trend in education, and as an essential skill that all 21st-century citizens should hold (PIECADE *et al.*, 2019). The development of students' CT skills promotes the improvement of other competencies such as problem-solving, algorithmic thinking, collaboration, and critical thinking. Accordingly, computational thinking and programming have been integrated in the primary and secondary schools' curriculum in many countries around the world (BELL; TYMANN; YEHUDAI, 2018; HUBWIESER; ARMONI; GIANNAKOS, 2015; SÁEZ-LÓPEZ; ROMÁN-GONZÁLEZ; VÁSQUEZ-CANO, 2016). Portuguese curriculum integrates a subject in the computer science area, in each grade between the 5<sup>th</sup> and 9<sup>th</sup> grades, taught by an informatics teacher. The curricular guidelines refer that all students need to learn about CT and programming concepts, design algorithms, programming with blocks applications, programming robots, and other tangible objects, and use digital technologies to create new knowledge (DGE - Minister of Education, 2017).

Educational Robotics has been referred to in many studies as a didactical approach to teach basic programming concepts and computational thinking, even in early education (BERS *et al.*, 2014; CHALMERS, 2018). Programming robotics and block-based programming apps saves the students from the difficulties of traditionally complex text-based languages (FRANKLIN *et al.*, 2017).

According to the primary and secondary school curricular guidelines, in one of the informatics didactics courses of the master program, pre-service teachers are involved in

learning activities to develop knowledge about programming educational robotics and their use in classroom activities with real classes of students.

This research aimed to analyze the interest, knowledge, problem-solving skills, and self-confidence of the pre-service and in-service teachers in using educational robotics for teaching purposes, in particular, to teach programming and computational thinking in primary and secondary education.

The following research questions were assumed:

- Q1. Which levels of interest, knowledge, and self-confidence of the pre-service and in-service teachers does educational robotics use in learning activities?
- Q2. What is the level of problem-solving skills of both groups?
- Q3. Is there a significant correlation between the interest, knowledge, problem-solving, and self-confidence dimensions?
- Q4. How is the impact of gender and age in the levels of interest, problem-solving, knowledge, and self-confidence?
- Q.5 What is the difference among the levels of interest, problem-solving, knowledge, and self-confidence presented by pre-service and in-service teachers?

## **2 Pre-service informatics teachers education**

Bologna process -intergovernmental cooperation of 48 European countries in the field of higher education- has changed the initial teacher education frameworks in Portugal. The regulatory Law no. 74/2006 makes a master degree in teaching mandatory in order to be a teacher in preschool, primary, and secondary education. Besides, law number 43/2007 defined the guidelines and the framework for the initial teacher education courses and created master degrees in education in many subject areas (mathematics, languages, sciences and biology, arts, geography, primary education, informatics, and others). The candidates for new initial teaching education courses need to have a bachelor degree in one subject area in order to attend a master in teaching. It is also mandatory for the candidates to have strong scientific knowledge -in general, 120

ECTS (European Credit Transfer System)- of training in a corresponding area (Ministerial Order No.1189/2010).

The initial teacher education framework defines each training component, as well as their minimum percentage from the total. Accordingly, Universities should create the curricular structures of each master's course through flexible management of 120 ECTS. In the next table, we present the curricular structure of the master degree in Teaching Informatics, created by the University of Lisbon.

**Table 1** – Master in Teaching Informatics framework.

Training components	Minimum percentage	ECTS	
		Compulsory*	Elective**
<b>General Education</b>	20 %	18	6
<b>Specific Didactics - Informatics</b>	25 %	30	
<b>Professional Practice Initiation</b>	40 %	48	
<b>Scientific Teaching Area - Informatics</b>	15 %	0	18

\*Curricular Units defined in the course curriculum. | \*\*Curricular Units that can be chosen by the students.

**Source:** Own elaboration (2020).

The study plan has a set of compulsory curricular units and four elective curricular units in the components of General Education (GE) and the Scientific Teaching Area (ST).

In the General Education component, pre-service teachers can choose curricular units such as Education and Media, Education for Citizenship, Initiation to Educational Research, among others. In the Scientific Teaching Area, they can choose curricular units of the Informatics field such as Mobile Computing, Software Design, Knowledge Management, Object Programming, Hypermedia Systems, Computer Networks, Cybersecurity, Multimedia, Web Applications, Internet of Things. These optional curricular units in the field of Informatics aim to provide future teachers with opportunities to complement and update their basic training, according to their needs, reinforcing their knowledge in the field of Informatics.

In the five curricular units of Specific Didactics, we try to work with the future teachers in pedagogical, curricular, and didactic matters of the teaching of Informatics. These curricular units cover a diversity of areas and themes of computer science education, such as teaching hardware, programming languages, databases, robotics, information and communications technology, computational thinking, or the internet of things.

Finally, in the Introduction to Professional Practice, future teachers are involved in activities of induction to teaching practice in a real classroom context. In each of these curricular units, especially from the second semester of the first year onwards, future teachers begin to develop and apply activities for students in primary and secondary schools, supervised by a University professor and a schoolteacher. At the end of the master degree, students are qualified to be a full computer science teacher in primary and secondary education.

### **3 Literature review**

#### **3.1 Teachers self-efficacy**

The concept of self-efficacy appears widely described and studied in Bandura's social cognitive theory and was presented by the author in 1977 as the idea of “self-directed mastery”, the ability of people to self-orient and actively direct their behavior towards mastery and excellence in personal performance. Self-efficacy is linked to the personal belief in relation to personal skills, or otherwise, the judgment of own ability to put in place the set of actions required to achieve a specific objective, in this way “[...] how people behave can often be better predicted by the beliefs they hold about their capabilities than by what they are actually capable of accomplishing” (BANDURA, 1997, p. 21). Self-efficacy appears as a belief, oriented in the future, about the skills that an individual expects to show in the resolution of a certain situation (TSCHANNEN-MORAN; WOOLFOLK HOY; HOY, 1998).

It is a motivational construct based on self-perceived competence that goes far beyond the current level of performance (TSCHANNEN-MORAN; WOOLFOLK HOY, 2007).

Self-efficacy beliefs are functionally associated with real human behaviors (BANDURA, 1997). They present themselves as a powerful predictor of human behavior, providing more reliable information than that provided by the people's knowledge or skills. According to the author, self-efficacy appears as the psychological construct that most directly and faithfully relates to the individual's behavior.



People with a high sense of effectiveness tend to view difficult tasks as challenging and promoting higher levels of mastery, rather than perceiving them as threatening or intimidating, with high levels of interest, involvement, and investment in such activities.

Tschannen-moran, Woolfolk Hoy e Hoy (1998) advocate that the effectiveness of teachers is associated with the ability to successfully design and carry out the teaching tasks required in a given educational context. Schwarzer e Schmitz (2004) state that a teacher with a high sense of self-efficacy presents himself as a proactive teacher, who believes in the existence of the necessary external and internal resources, who takes responsibility for his own professional growth, who focuses on the search for solutions to problems, regardless of the causes that originate them, who choose their paths of action and that creates meaning and sense for their lives by setting ambitious personal goals. More recent research shows that contextual factors such as teaching resources, support from colleagues, and mediated experiences influence pre-service teachers' self-efficacy and beliefs (TSCHANNEN-MORAN; HOY 2007).

Some studies developed around the concept, and within the scope of Social cognitive theory, have shown that the level of teacher self-efficacy appears strongly correlated with the willingness to adopt new practices and methodologies in the classroom (KAGIMA; HAUSAFUS, 2000; SMYLIE, 1998).

The teachers' self-efficacy and confidence were referred in many studies as important factors to promote the use of digital technologies in education (FONSECA, 2019; PEDRO; PIEDADE, 2013; PIEDADE; PEDRO, 2014) and, in particular the use of educational robotics (JAIPAL-JAMENI; ANGELI, 2017; LEONARD *et al.*, 2018; GÜNBATAR, 2019). Jaipal-Jamani and Angeli (2017) and Leonard *et al.* (2018) reported the positive effects of robotics on pre-service teachers' self-efficacy, science learning, and computational thinking knowledge. Thus, the initial teacher training programs are the right place to develop the future teacher self-efficacy (CARDOSO, 2016; FONSECA, 2019).

### **3.2 Systematic literature review on educational robotics**

Computational thinking and programming has been introduced in the curriculum in many school systems around the world. In the last decade, many international

institutions defined curricular guidelines and frameworks to support that integration in the classroom activities. These documents organize a set of standards and competencies that students should develop in school. As an example, the curricular guidelines developed by the *International Society for Technology in Education* (ISTE), the *Computer Science Teachers Association* (CSTA), and the *Computing at School* (CAS). Inspired by some of these frameworks, many countries designed and actualized their curriculum for primary and secondary education.

However, teaching and learning programming is a complex process that involves a set of difficult concepts to understand, in particular for newcomers. Programming is a subject area which traditionally involves concepts related to computational, algorithmic, and logical thinking, identifying problems, design and coding solutions, understanding the syntax, semantics and complexity of languages, and mastering a set of programming paradigms (PIEIDADE; DOROTEA; SAMPAIO; PEDRO, 2019).

In the last years, a set of block-based programming apps has emerged to promote the programming learning by the school students, and to support the development of computational thinking skills. These visual programming apps are great support for introducing programming and saves students from the difficulties of traditionally text-based languages (FRANKLIN *et al.*, 2017; WILSON; MOFFAT, 2010). Using these applications, students can learn and practice the main concepts of programming, such as instructions, containers (variables, constants and lists), conditional statements, loops, logical operators, and input/output data (PIEIDADE; DOROTEA; SAMPAIO; PEDRO, 2019).

Another characteristic of these block-based programming is the possibility of programming many tangible objects like robotics, drones, and mobile phones. The use educational robotics, as a pedagogical strategy, has been referred in many studies as a powerful approach to teach and learn to program, to develop CT skill, to develop 21st-century skills (CHALMERS, 2018; JUŠKEVIČIENĖ; DAGIENĖ, 2018).

To identify relevant studies about using educational robotics to teach programming and computational thinking, a systematic literature review was done by searching in the three relevant databases related to computer science and education (ACM Digital Library, SCOPUS, Web of Science). This search was done between January and February 2020 and had as restrictions: (i) studies written in English; (ii)



published between 2010 and 2020; (iii) papers published in indexed journals; and (iv) each paper must present abstract and full text. The terms used for searching were “Computational Thinking AND Robotics” or “Computational Thinking AND Robots” or “Computational Thinking AND Educational Robotics”, and 117 papers were obtained. In the second phase were selected papers which contained the following: (i) use of educational robotics as a pedagogical tool; (ii) participants belonging pre-school to K-12 education; (iii) presenting empirical results. After this phase, the total of paper was reduced to 25. In the third phase were selected papers published in Q1 and Q2 (SJR index) journals in the field of computer science, technology, and education. The total of the papers was reduced to 16 (Appendix C).

The results showed that eight studies were developed with elementary school students, three with middle school students, one with preschool students, and four with pre-service teachers. The majority of the studies assumed a quantitative research design (14) and only two a mixed-method design.

Educational Robotics was referred to in many of the studies as an efficient didactical approach or tool to teach basic programming concepts and computational thinking skills (BERLAND; WILENSKY, 2015; GARCIA-PENALVO; MENDES, 2018; LEONARD *et al.*, 2016, 2018; WITHERSPOON *et al.*, 2017; TRAN, 2019), to develop creativity and problem-solving skills (NOH; LEE, 2020), and to improve students’ learning performances (HSIAO, 2019), even in childhood education (BERS *et al.*, 2014; CHALMERS, 2018).

Berland and Wilensky (2015) developed a study with 78 eighth-grade students of two different schools in Chicago aimed to analyze the impact of 2-week educational robotics, both physical and virtual robotics, in the teaching of complex systems and computational thinking. The findings reported an improvement in the students’ outcomes but with different perspectives. The students that use the physical robotics were more likely to analyze the problems from a bottom-up perspective, and the students that use de virtual robotics were more likely to use a top-down perspective. The same impact of using virtual robotics was reported by Witherspoon *et al.* (2017) in two studies developed with 123 fifth-grade students and 441 of sixth, seventh, and eighth grades. Organized with a quasi-experimental design with pre and post-test pointed out a small improvement, yet significative, in the mean scores comparing pre and post-test in both studies.

Another relevant aspect discussed in the literature is the contribution of the educational robotics activities to promote the development of 21st-century skills as problem-solving and creativity. Noah and Lee (2020) noticed an exciting results about the of 11-weeks educational activities with 155 Korean elementary school students. The results showed that programming using robotics improved significantly students computational thinking and creativity skills and that creativity was improved more in the girls.

To analyze the effect of age and gender in the development of computational thinking skills through educational robotics activities, Atmazidou and Demetriadis (2016) assessed the skills ok two groups of students with different ages (89 age 15 and 75 age 18). The results suggested that students reach the same level of CT Skills independent of their age or gender. However, the girls need more training time to reach the same skill level compared to the boys. In the opposite Taylor and Baek (2019) reported no significant difference between gender in the robotics performance.

Ludi and Reichlmayr (2011) reported the importance of the use of robotics to improve the interest and confidence of visual impairments students in computing activities. The physical characteristic of the robotics could potentialize the learning outcomes of students with some special needs.

Finally, three of the selected papers reported the results of studies developed in pre-service teacher education connected with experiences to prepare futures teachers to teach with robotics. Jaipal-Jamani and Angeli (2017) analyzed the positive effects of robotics on pre-service teachers' self-efficacy, science learning, and computational thinking, three crucial aspects that is important contemplate in future teachers preparation courses. The same importance was reported by Leonard *et al.* (2018). Comparing in-service and pre-service teachers' computational thinking skills, Günbatar (2019) found significant differences in the skill levels. The in-service teacher revealed high scores in each CT dimensions when comparing with pre-service teachers.

This literature review aimed to discuss the importance of educational robotics as a strategy to teach programming and to promote the students' computational thinking skills as well as the importance of the development of pre-service teachers' skills in these aspects.

## 4 Method

According to the research questions defined, a quantitative approach design (CREWELL, 2014), with a descriptive, exploratory, and correlational nature, was organized and implemented to collect data from participants. Furthermore, the recommendations of the ethical commission of the Institute of Educations of the University of Lisbon and the ethical guidelines of AERA and BERA for the educational research were respected. The participants were informed about the goals of the study, anonymity, and confidentiality of the data collection and analysis (TUCKMAN, 2012).

### 4.1 Participants

This study involved 49 participants, students, and former students of the Master in Teaching Informatics. The participants were organized in 3 groups: (1) all the students of 1st year of the master course (31%); (ii) all the students of the 2nd year of the master course (24%); and (iii) all the former students who attended the master course in the last two editions (45%). The group of participants is gender-equitable with 25 female and 24 male, and are between 22 and 56 years old. All the participants are or were enrolled in the Master in Teaching Informatics mandatory to become an informatics teacher in Portuguese primary and secondary education.

### 4.2 Instruments and data collection procedures

The data collection process was developed according to a quantitative technique using a self-report scale organized in an online questionnaire to collect data from participants. The self-report scale developed by Jaipal-Jamani & Angeli (2017) was adapted (with de authors' agreement) to measure the interest, self-confidence, and knowledge in use educational robotics to teach CT and programming. The final version of the scale are organized in 33 items and four dimensions: (i) interest; (ii) problem-solving; (iii) Educational Robotics Knowledge; and (iv) Self-confidence. The final version of the scale is available in the appendix A, with all dimensions and items.

The analysis of the scale's metric quality was done according to the reliability, sensitivity, and factor analysis criteria. A high level of internal consistency was found

(FIELD, 2009) with Cronbach  $\alpha$  reliability coefficient of .95 (n=49), and all the 33 items have a good level of sensitivity with values between -3 and 3 of Skewness and -7 and 7 of Kurtosis (MAROCO, 2018). The analysis of the factorial structure of the 33 items was made through an exploratory factor analysis based on the maximum likelihood extraction method. Kaiser Meyer Olkin measure of sample adequacy has a good level (.79). The result of Bartlett's test of sphericity was significant ( $\chi^2=1366.47$  df=528,  $p<0.00$ ), and the four factors explained 65.84% of the variance of the scale.

The online questionnaire was sent by email to all participants with all relevant information about the study, and the data collection occurred between January and February of 2020. After that, the data was exported to SPSS Statistics v.26 used to the statistical data analysis, report in the next topic.

## 5 Results

To analyze the levels of interest, problem-solving, educational robotics knowledge, and self-confidence presented by the participants (Q1 and Q2), a matrix of descriptive scores of each item was constructed (Appendix B). The mean scores observed in each dimension are organized in Table 2. Participants have high scores in the four dimensions; however, the 'Interest' and 'Problem Solving' dimensions presented higher scores comparing with the others (M=4.38, SD=.51; M=4.19, SD=.54 respectively) and the 'Educational Robotic Knowledge' the lowest score (M=3.54, SD=.76). According to the Likert-type scale (between 1 and 5), scores between 1 and 2.4 are weak, between 2.5 and 3.4 are moderate, and between 3.5 and 5 are high. In fact, all items of the 'Interest' dimension have scores between 4 and 5 points, and in 'Educational Robotics Knowledge,' all items have scores between 3 and 4 points.

**Table 2** – Mean and Standard-Deviation of each dimension (n=49)

Dimensions	Mean	SD
Interest	4.38	.51
Problem Solving	4.19	.54
Educational Robotics Knowledge	3.54	.76
Self-confidence	3.80	.75

Source: Own elaboration (2020).

The analysis of the statistical significance of the correlation between the dimensions (Q3) was made through the non-parametric Spearman's Correlation test, used to analyze ordinal variables, and representing in the following table.

**Table 3** – Spearman's Correlation Coefficient between the scale's dimensions (n=26)

	Interest	Problem-solving	Educational robotics knowledge
Problem-solving	.71**		
Educational Robotics knowledge	.45**	.28	
Self-confidence	.61**	.44**	.76**

\*\* Significant  $p < .001$ .

Source: Own elaboration (2020).

The analysis of the Spearman's correlation coefficient revealed a statistically significant correlation between the dimensions ( $.44 < \rho < .76$ ,  $p < .001$ ). The high level of correlations was found between 'Self-confidence and 'Educational Robotics Knowledge ( $\rho = .76$ ,  $p < .001$ ) and between 'Problem-solving' and 'Interest' ( $r = .71$ ,  $p < .001$ ). A non-significant correlation was reported between 'Educational Robotics Knowledge' and 'Problem-solving' dimensions. According to that results, a linear regression model was applied between the dimension with the highest correlation coefficient.

The linear regression of 'Educational Robotics Knowledge' score as the predictor of 'Self-confidence' score reports that the participants 'Educational Robotics Knowledge' can explain 74 % of the variance in 'Problem Solving' score and the regression model predicts a significantly high problem-solving level ( $F(1,47) = 132.43$ ,  $p < .001$ ;  $r^2 = .74$ ). Results report that each 1 point increase in 'Educational Robotics Knowledge' score also increases 'Self-confidence' score by .88 ( $b_1 = .88$ ,  $t = 11.51$ ,  $p < .001$ ).

The linear regression of 'Interest' score as the predictor of 'Problem-solving' score suggests that the participants' 'Interest' can explain 55 % of the variance in 'Problem-solving' score and the regression model predicts a significantly high self-confidence level ( $F(1,47) = 57.21$ ,  $p < .001$ ;  $r^2 = .55$ ). Results show that each 1 point increase in the 'Interest' score also increases 'Problem-solving' score by .67 ( $b_1 = .67$ ,  $t = 3.72$ ,  $p < .001$ ).

To analyze the gender and age impact (Q4) in the levels of interest, problem-solving, educational robotics knowledge, and Self-confident, a comparative analysis of mean was made using an *independent-sample t-test* for gender and *One-way ANOVA*

*test* for age. Although the differences between scores of all dimensions (Appendix C) according to gender and age variables, the results of both tests reported that these differences did not have statistical significance.

The last research question (Q5) aimed to analyze the differences between the participants' levels in each dimensions scores according to the groups organized with students of first and second years (pre-service teachers) and former students (in-service teachers) of the master in teaching informatics program. Notwithstanding the differences between scores of all dimensions (in particular for self-confidence dimension) (Appendix C), the results of the *One-way ANOVA test* show that these differences did not have statistical significance.

## 6 Discussion and conclusions

Returning to the paper's objective, which was to analyze comparatively the levels of interest, educational robotics knowledge, problem-solving skills, and self-confidence of the pre-service and in-service teachers to use robotics for teaching purposes, positive levels were found in each dimension for both groups.

The results of self-report scale analysis revealed high levels of interest and self-confidence in using educational robotic as well as high levels of knowledge about robotics and problem-solving skills. The importance of the interest, knowledge, and self-efficacy or self-confidence was highlighted in many studies as relevant factors to promote de use of educational robotics with real classes of students (GÜNBAR, 2019; JAIPAL-JAMENI; ANGELI, 2017; LEONARD *et al.*, 2018). Only the teachers with strong interest and self-confidence will able to use robotics to teach programming and computational thinking in their school classes.

No significant difference in the level between pre-service and in-service teachers was founded in this study. In the opposite, Günbar (2019) reported high levels of educational robotics skills of in-service teachers when compared with pre-service teachers.

It was possible to identify significant correlations in all dimensions, in particular, between "Self-confidence" and "Educational Robotics Knowledge", and "Problem-solving" and "Interest". Accordingly, it is necessary to promote these dimensions, in an integrated



way, in the pre-service and in-service training programs through learning activities with robotics. The training programs should provide the pedagogical context to involve teachers (pre and in-service) in learning activities to promote their knowledge about robotics and their confidence to use this tool for teaching purposes. Teachers should be challenged with collaborative problem-solving learning activities in order to develop or improve their skills. This study proved that educational robotics knowledge has a significant impact on teachers' self-confidence; the more knowledge teachers have more confidence they are to use robotics to teach programming and computational thinking. When teachers are involved in the planning, designing, and implementing of learning activities with robotics and thinking about the solutions, they rethink all the possible pedagogic approaches that they learned in theory and transfers the knowledge they learned to new situations and problems.

Finally, the results revealed no significant differences between gender and age of the participants. This is an essential result because different authors signalize gender as a distinctive factor, and the educational robotics activities could help to close the gap between girls and boys skills (ATMAZIDOU; DEMETRIADIS, 2016; NOAH; LEE, 2020).

Additionally, the systematic literature review allowed to identify relevant studies that highlighted the educational robotics as a strong path to promote students' knowledge and skills and the importance of preparation of the pre and in-service to their use in classroom activities.

This research has some methodological limitations. First, the small size of the sample does not permit the results' generalization, and second, the self-report scale does not allow to analyze the effective use of this tool, but rather how interest and confidence teachers have in using it. Although the limitations, a set of relevant results are systematized about pre-service and in-service teachers' levels of interest and self-confidence to use robotics for educational purposes that need be taken in to account in the teacher training programs. Future studies should explore the real classroom teachers' practices with robotics and the impact on the students' achievements on robotics, programming, and computational thinking.

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**Appendix A – List of selected papers for Literature review**

Authors	Title	Participants	Methods	Journal	SJR
LUDI, Stephanie; REICHLMAYR, Tom. (2011)	The Use of Robotics to Promote Computing to Pre-College Students with Visual Impairments	Elementary	Mixed-Method	ACM Transactions on Computing Education	Q1
WITHERSPOON, Eben B.; HIGASHI, Ross M.; SCHUNN, Christian D.; BAEHR, Emily C.; SHOOP, Robin. (2017)	Developing Computational Thinking through a Virtual Robotics Programming Curriculum	Elementary	Quantitative	ACM Transactions on Computing Education	Q1
BERS, Marina Umaschi; FLANNERY, Louise; KAZAKOFF, Elizabeth R.; SULLIVAN, Amanda. (2014)	Computational thinking and tinkering: Exploration of an early childhood robotics curriculum	Pre-school	Quantitative	Computers & Education	Q1
JOSE GARCIA-PENALVO, Francisco; JOSE MENDES, Antonio. (2018)	Exploring the computational thinking effects in pre-university education	Middle School	Quantitative	Computers in Human Behavior	Q1
TAYLOR, Kellie; BAEK, Youngkyun. (2019)	Grouping matters in computational robotic activities	Elementary	Quantitative	Computers in Human Behavior	Q1
GUNBATAR, Mustafa Serkan. (2019)	Computational thinking within the context of professional life: Change in CT skill from the viewpoint of teachers	Pre-service Teachers	Quantitative	Education and Information Technologies	Q2
NOH, Jiyae; LEE, Jeongmin. (2020)	Effects of robotics programming on the computational thinking and creativity of elementary school students	Elementary	Quantitative	Educational Technology Research and Development	Q1



HSIAO, Hsien-Sheng; LIN, Yi-Wei; LIN, Kuen-Yi; LIN, Chien-Yu; CHEN, JHENG-HAN; CHEN, Jyun-Chen. (2019)	Using robot-based practices to develop an activity that incorporated the 6E model to improve elementary school students' learning performances	Elementary	Quantitative	Interactive Learning Environments	Q1
CHALMERS, Christina. (2018)	Robotics and computational thinking in primary school	In-service teachers	Mixed-Method	International Journal of Child-Computer Interaction	Q2
YUNE, Tran. (2019)	Computational Thinking Equity in Elementary Classrooms: What Third-Grade Students Know and Can Do	Elementary	Quantitative	Journal of Educational Computing Research	Q1
ATMATZIDOU, Soumela; DEMETRIADIS, Stavros; NIKA, Panagiota. (2018)	How Does the Degree of Guidance Support Students' Metacognitive and Problem-Solving Skills in Educational Robotics?	Elementary	Quantitative	Journal of Science Education And Technology	Q1
BERLAND, Matthew; WILENSKY, Uri. (2015)	Comparing Virtual and Physical Robotics Environments for Supporting Complex Systems and Computational Thinking	Middle School	Quantitative	Journal of Science Education and Technology	Q1
JAIPAL-JAMANI, Kamini; ANGELI, Charoula. (2017)	Effect of Robotics on Elementary Preservice Teachers' Self-Efficacy, Science Learning, and Computational Thinking	Pre-service Teachers	Quantitative	Journal of Science Education and Technology	Q1
LEONARD, Jacqueline; BUSS, Alan; GAMBOA, Ruben; MITCHELL, Monica; FASHOLA, Olatokunbo S.; HUBERT, Tarcia; ALMUGHYIRAH, Sultan. (2016)	Using Robotics and Game Design to Enhance Children's Self-Efficacy, STEM Attitudes, and Computational Thinking Skills	Elementary	Quantitative	Journal of Science Education and Technology	Q1
LEONARD, Jacqueline; MITCHELL, Monica; BARNES-JOHNSON, Joy; UNERTL, Adrienne; OUTKA-HILL, Jill; ROBINSON, Roland; HESTER-CROFF, Carla. (2018)	Preparing Teachers to Engage Rural Students in Computational Thinking Through Robotics, Game Design, and Culturally Responsive Teaching	Pre-service teachers	Quantitative	Journal of Teacher Education	Q1



ATMATZIDOU, Soumela; DEMETRIADIS, Stavros. (2016)	Advancing students' computational thinking skills through educational robotics: A study on age and gender relevant differences	Middle School	Quantitative	Robotics and Autonomous Systems	Q1
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**Appendix B – Robotics Interest Questionnaire (adapted from Jaipal-Jamani; Angeli, 2017)**

Items	Mean (n=49)	Sd	Skewness	Kurtosis
<b>Interest</b>				
I1. I like learning about new technologies like robotics	4.55	.58	-.88	-1.18
I2. I like using scientific methods to solve problems	4.32	.77	-.93	.29
I3. I like using mathematical formulas and calculations to solve problems.	3.97	.95	-.42	-.91
I4. I think careers in science, technology, engineering or math are interesting	4.53	.65	-1.55	3.38
I5. I would like to learn more about careers that involve science, technology engineering, and mathematics.	4.31	.80	-1.12	1.14
I6. I find it interesting to learn about robots or robotics technology	4.61	.53	-.90	-.32
I7. I would like to use robotics to learn mathematics or science	4.22	.74	-.39	-1.07
I8. I would use robotics in my classroom teaching	4.47	.74	-1.02	-.38
<b>Total Score:</b>	<b>4.38</b>	<b>.51</b>	<b>-.85</b>	<b>1.24</b>
<b>Problem-solving</b>				
P1. I use a step-by-step process to solve problems	4.33	.67	-.93	1.33
P2. I make a plan before I start to solve a problem	4.08	.81	-.64	.05
P3. I try new methods to solve a problem when one does not work	4.27	.70	-.80	.95
P4. I carefully analyze a problem before I begin to develop a solution	4.02	.85	-.88	.58
P5. In order to solve a complex problem, I break it down into smaller steps	4.21	.82	-.89	.38
P6. I like listening to others when trying to decide how to approach a task or problem	4.39	.61	-.43	-.62
P7. I like being part of a team that is trying to solve a problem	4.47	.68	-1.34	2.27
P8. When working in teams, I ask my teammates for help when I run into a problem or do not understand something	4.39	.64	-.56	-.58
P9. I am confident that I could learn how to make a robot do something that I had not done before today	3.98	.92	-.62	-.34
P10. I believe that I could work with a robot in a science investigation	4.00	.91	-.69	-.21
P11. I believe that I could fix a software problem if I needed to do so	3.82	.99	-.68	.12
P12. I like to work with others to complete Projects	4.38	.64	-.56	-.58
<b>Total Score:</b>	<b>4.19</b>	<b>.54</b>	<b>-1.40</b>	<b>3.05</b>
<b>Educational robotics knowledge</b>				
K1. I have sufficient knowledge about robotics for use in teaching and learning activities	3.53	.96	-.39	-.84
K2. I have sufficient knowledge of coding as it applies to robotics	3.59	.89	-.57	-.43

<b>K3.</b> I have sufficient knowledge of the engineering and design process as it applies to robotics	3.22	.98	.07	-.59
<b>K4.</b> I have sufficient knowledge to select the most appropriate robot to teaching and learning according to students ages	3.49	.92	-.48	-.77
<b>K5.</b> I have sufficient knowledge to analyze the pedagogical potentialities of different type of robots	3.63	.91	-.59	-.41
<b>K6.</b> I have sufficient knowledge about block-based programming apps that can be used to teach programming concepts	3.82	.81	-.64	.31
<b>Total Score:</b>	<b>3.54</b>	<b>.76</b>	<b>-.59</b>	<b>-.16</b>
<b>Self-confidence</b>				
<b>S1.</b> I feel confident that I have the necessary skills to use robotics for classroom instruction	3.71	.84	-.94	.36
<b>S2.</b> I feel confident that I can engage my students to participate in robotics-based projects	3.82	.86	-.66	.10
<b>S3.</b> I feel confident that I can help students when they have difficulties with robotics	3.80	.93	-.69	-.22
<b>S4.</b> I feel confident that I can plan and design learning scenarios with robotics	3.92	.89	-.77	.19
<b>S5.</b> I feel confident about teaching computer science with different type of robotics	3.49	.94	-.21	-.83
<b>S6.</b> I feel confident that I can assess students' outcomes in robotics learning activities	3.51	.98	-.51	-.32
<b>S7.</b> I feel confident that robotics is a good strategy to teach computer science concepts	4.36	.60	-.96	3.12
<b>Total Score:</b>	<b>3.80</b>	<b>.75</b>	<b>-.64</b>	<b>-.20</b>

### Appendix C – Mean scores

#### Mean Scores by Gender

Gender	Interest		Problem-Solving		Educational Knowledge		Self-confidence	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<b>Male (n=24)</b>	4.37	.44	4.21	.41	3.53	.14	3.83	.75
<b>Female (n=25)</b>	4.38	.58	4.17	.65	3.56	.79	3.77	.75

#### Mean Scores by Age

Age	Interest		Problem-Solving		Educational Knowledge		Self-confidence	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<b>21 to 30 (n=2)</b>	4.69	.88	4.58	.41	3.75	.35	4.00	.00
<b>31 to 40 (n=20)</b>	4.38	.44	4.22	.43	3.65	.70	3.73	.70
<b>41 to 50 (n=21)</b>	4.43	.55	4.25	.55	3.62	.76	4.01	.68
<b>51 to 60 (n=6)</b>	4.04	.58	3.8	.79	2.86	.85	3.26	1.00

#### Mean Scores by pre and in-service teachers

Course	Interest		Problem-Solving		Educational Knowledge		Self-confidence	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Computer Science Teacher	4.32	.48	4.12	.54	3.32	.80	3.56	.78

who attended the Master Course in Teaching Informatics ins last two editions (n=22)								
Student of 1st year of the Master Course in Teaching Informatics (2019/2020) (n=15)	4.46	.43	4.30	.41	3.74	.60	4.12	.51
Student of 2nd year of the Master Course in Teaching Informatics (2019/2020) (n=12)	4.36	.67	4.18	.70	3.72	.80	3.85	.83

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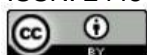
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