The impact of educational robotics on teachers' computational thinking

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ABSTRACT

This paper studies preservice early years teachers' computational thinking and self-efficacy beliefs as they engaged in an educational robotics learning environment. Computational thinking is perceived as the thought processes involved in formulating problems and their solutions so that the solutions can be represented as algorithms. Computational thinking is considered as a fundamental set of cognitive skills suggested for everyone, not only for computer scientists. The involvement of teachers with the educational robotics activities has helped them to improve their computational thinking skills and their self-efficacy about robotics and coding knowledge.

KEYWORDS

Educational robotics, teachers training, computational thinking, self-efficacy

RÉSUMÉ

Cet article étudie la pensée computationnelle et les croyances d'auto-efficacité chez les étudiants tout au long de leur apprentissage dans un environnement d'apprentissage de la robotique éducative. La pensée computationnelle est perçue comme les processus de pensée impliqués dans la formulation des problèmes et de leurs solutions afin que les solutions puissent être représentées sous forme d'algorithmes. La pensée computationnelle est considérée comme un ensemble fondamental de compétences cognitives suggérées à tous, pas seulement aux informaticiens. La participation des enseignants aux activités de robotique éducative les a aidés à améliorer leurs capacités de raisonnement informatique et leur efficacité personnelle en robotique et en connaissances de codage.

MOTS-CLÉS

Robotique éducative, formation des enseignants, pensée computationnelle, auto-efficacité

THEORETICAL FRAMEWORK

In recent years, educational robotics has been regarded as a powerful learning tool that supports students to develop their knowledge in the disciplines of STEM (Science, Technology, Engineering and Mathematics). At the same time, there is a small number of teachers who have

the necessary skills and experience to design and implement educational robotics activities in the classroom (Bers et al., 2002). Forty students of the Department of Preschool Education at the Faculty of Education of the Aristotle University of Thessaloniki were involved in educational robotics activities from the field of science. The purpose of this paper is to explore the impact of student engagement in educational robotics activities on their computational thinking and their self - efficacy.

The educational robotics learning environment
Learning is a dynamically process based on human's experience from the real world, as well as on social interaction (Vygotsky, 1978). In an educational robotics learning environment, students work collaboratively in a way to understand the problem posed by the teacher and plan, implement and present their own solutions (Carbonaro, Rex & Chambers, 2004). In such a context, the role of the teacher and the role of the student are different than in the traditional behavioral approach.

Carbonaro et al. (2004) consider engagement as an important process for learning. Engagement refers to the quality of a student' s connection or involvement with the endeavor of schooling and hence with the ingredients that compose it, such as people, activities, goals, values, and place (Skinner, Thomas & Furrer, 2009). The active participation of learners in all stages of an educational program for teachers is very important. Bers et al. (2002) indicate the necessity for teachers to be able to understand, evaluate, and integrate developmentally appropriate methods with educational robotics and at the same time state that educational robotics provides a pleasant and playful way for teachers to incorporate academic content through the creation of projects which make sense.

The concept of computational thinking
Computational thinking is a fundamental skill for everyone, not just for computer scientists (Wing, 2006). Wing (2011) defined computational thinking as "*the thought processes involved in formulating problems and their solutions so that the solutions are presented in a form that can be effectively carried out by an information processing agent*". Selby & Woolard (2013) consider computational thinking as a set of cognitive processes, like abstraction, decomposition, generalization, thinking algorithmically and evaluation.

The concept of self-efficacy
The founder of the concept of self-efficacy Albert Bandura (1995) considered that the level of motivation, emotional states and actions of people is based more on what they think themselves than on unbiassed criteria. He expressed the concept of self-efficacy as the perceptions of the individual as to his ability to respond successfully to a given situation. Stohlmann, Moore & Roehrig (2012) consider the effectiveness of teachers as a critical factor for the success of teaching.

METHODOLOGICAL FRAMEWORK

Objectives
This research aims to study the level of engagement of the preservice teachers in an educational robotics context and how their computational thinking and self-efficacy are affected. The research is guided by the following research questions:

(a) RQ1: What is the level of engagement of pre-service teachers in educational robotics activities?

(b) RQ2: Does the engagement of pre-service teachers in the educational robotics activities improve their computational thinking skills? and

(c) RQ3: How does the engagement in robotics activities influence preservice teachers' self-efficacy toward educational robotics?

Procedure and participants

The research was conducted in the setting of a laboratory educational unit titled "Getting Familiar with Educational Robotics", which is part of the course "Interdisciplinary Approaches to ICT and Science in Education" in the Pre-school Education Department of the Pedagogical Faculty of Aristotle University of Thessaloniki. The workshop was joined by 40 undergraduate students of the department (38 female and 2 male). The educational intervention was completed throughout 6 workshops, lasting 90 minutes each. The main goal of the educational intervention was to provide authentic learning activities integrated into problem solving from the real world.

Data collection

For the data collection we used three quantitative research instruments, as they appear in table 1.

TABLE 1
Data collection methods used

Research question	Data collection method	Source
Q1	Engagement versus disaffection with learning: Student report	Skinner, Thomas & Furrer (2009)
Q2	Computational thinking test	Roman-González (2015)
Q3	Self-efficacy for teaching robotics questionnaire	Jaipal-Jamani & Angeli (2016)

Skinner et al. (2009) use two key components to estimate engagement. They consider engagement as a bipolar size (engagement - disaffection), which is determined by two dimensions (behavior - emotion).

- The dimensions included in the student report are:
- The engaged behavior, (5 items).
- The engaged emotion (5 items).
- The disaffected behavior (8 items).
- The disaffected emotion (9 items).

All items in the instrument are expressions by which learners are asked to declare their degree of agreement through a 5-point Likert scale, ranging from "I strongly disagree" to "I totally agree".

The Computational Thinking test (CTt) (Roman-Gonzalez, 2015; Roman-Gonzalez, Perez-Gonzalez, & Jimenez-Fernadez, 2017) was used to evaluate the improvement of the computational thinking skills of learners throughout the learning intervention, which is recommended by its creators as suitable for use as pretest - posttest. CTt is a multiple-choice test with 28 items and 4 answer options for each item, with only one correct. Each item is designed and characterized according to the following five dimensions of the sampling domain. CTt

involves the ability to formulate and solve problems by relying on the fundamental concepts of computing such as basic sequences, loops, iteration, conditionals, functions and variables.

The questionnaire developed by Jaipal-Jamani & Angeli (2016) was used to assess self-efficacy, specifically to investigate the self-efficacy of prospective teachers in educational robotics. The questionnaire consists of two modules:

(a) The "Robotics Self-Efficacy" section, where the students were asked to answer four questions in a scale of 0 to 10. The point "0" corresponded to the answer "no self-confidence", while "10" to the answer "completely confident".

(b) The "Robotics and Coding Knowledge" section, where students were asked to declare their agreement level on three expressions, in a scale of 1 to 5. The point "1" corresponded to the "I strongly disagree" declaration, while "5" to the "I strongly agree" declaration.

RESULTS

The results of descriptive statistics of engagement measurements are shown in Table 2.

TABLE 2
The results of descriptive statistics of the model of the four factors of engagement

	Behavioral engagement	**Emotional engagement**	**Behavioral disaffection**	**Emotional disaffection**
Mean	3.74	4.16	2.38	2.12
SD	.477	.514	.486	.578

We found that the mean values of engagement, behavioral and emotional, are greater than 3 that is the middle of the interval [1,5], while the average dissatisfaction is less than 3. For the calculation of an overall indicator of engagement was considered a variable that calculated from the mean value of behavioral engagement, emotional engagement, reversed behavioral disaffection, and reversed emotional dissafection. This variable receives values in the range from 1 to 5, where 1 corresponds to maximum disaffection and 5 to maximum engagement. From the descriptive statistical analysis of the total engagement marker was found an average Mean = 3.85 and a standard deviation SD = 0.36.

For the measurement of the computational thinking skills, the total score of the participants, a variable in a range of 0 to 28 values, was given to the participant for each correct answer to CTt's questions. The results of the data obtained from the pre-test and post-test of CTt are shown in Table 3 and their distributions are shown in figure 1.
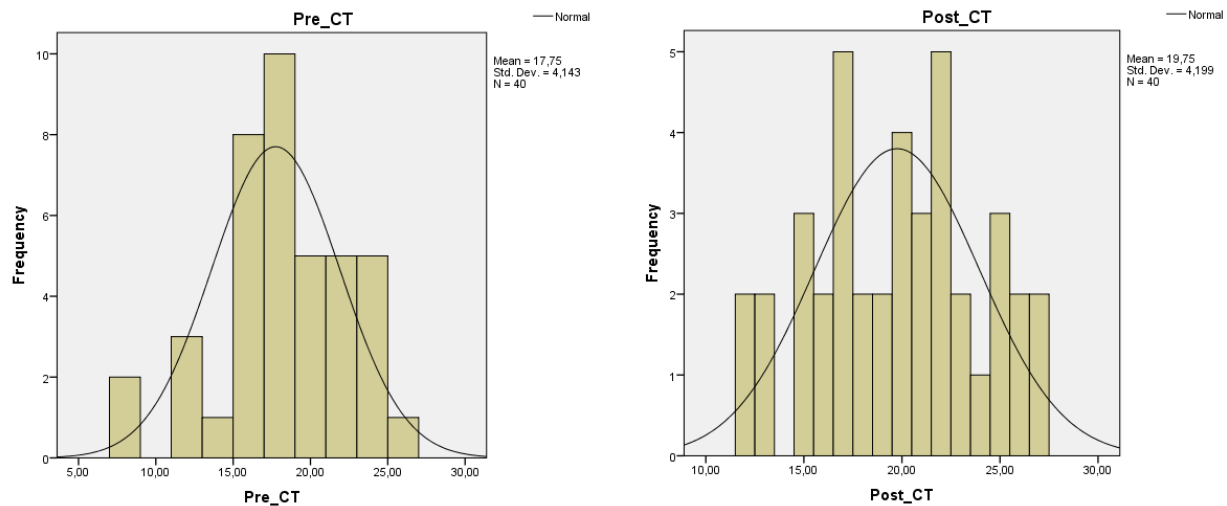
TABLE 3
The CTt results

	CTt pretest	**CTt posttest**
Mean	17.75	19.75
Std. Deviation	4,14	4,19

We conducted a Shapiro -Wilk test to find out if the distribution of the measurements was normal. The results of the test were 25.9% for the pretest and 32.9% for the posttest, so we could conduct a paired samples t-test to find out if there is a statistically significant difference in the measures. The results of the paired samples t-test ($p<0.05$) showed that there is a statistically significant gain between the pretest and the posttest.

FIGURE 1

The CTt results

About the measurements concerning the participants' self-efficacy, Table 4 presents the results for the first set of self-efficacy questionnaire questions.

TABLE 4
The "Robotics self-efficacy" section results

	SE_1		SE_2		SE_3		SE_4	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**	**Post**
Mean	4.92	5.60	5.42	5.72	5.25	5.25	5.25	5.00
SD	1.91	1.87	1.89	1.96	2.32	1.89	2.61	1.94

There was an increase in the mean values of the statements in expressions 1 and 2, in the third statement the mean value was maintained and in the fourth statement the mean value decreased in the posttest compared to the pretest. In each statement, however, differences in the mean values recorded do not lead to the conclusion that they are statistically significant, as shown by the results of the paired samples t-test ($p_1=0.087, p_2=0.375, p_3=1, p_4=0.529 > 0.05$).

Regarding how students are self-defined for the level of robotics and coding knowledge the results are shown in Table 5.

TABLE 5
The "Robotics and coding knowledge" section results

	SE_5		SE_6		SE_7	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Mean	2.32	3.05	2.35	2.90	2.05	2.80
SD	.79	.71	1.05	.81	.81	.93

We observe that all statements made by learners after their participation in educational intervention show an increased mean value. To examine the statistical significance of pretest differentiation through posttest values, we performed paired samples t-test. The results of the paired samples t-test showed a statistically significant increase in the mean values of the participant's statements regarding the knowledge of robotics and programming (*p_1 = 0.000, p_2 = 0.001, p_3 = 0.000 <0.05*).

Then we explored correlations between the variables of engagement, computational thinking and self-efficacy. The results of the tests (Pearson's r indicator) did not show any strong correlation between the variables we examined.

CONCLUSION

The preservice teachers who participated in the educational intervention had the opportunity to engage with intensity in educational robotics activities in terms of behavior and in terms of emotion. The analysis of the data showed that the preservice teachers presented statistically significant improvement in their computational thinking skills. The involvement of students with the educational robotics activities has helped them to improve their performance on the skills examined in CTt. In terms of self-efficacy for the robotics of the participants there was no statistically significant difference in the measurements after the completion of the educational intervention. On the other hand, in the "robotics and coding knowledge" section, the trainees after their participation in educational intervention showed statistically significant improvement. While before the start of the educational intervention they were anxious and believed that educational robotics was difficult as a scientific field, after completing the course they felt more confident about their level of knowledge about robotics and the programming.

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