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Assessment of a professional development program on computational thinking for disciplinary teachers

Alejandro Espinal

Electronic Engineer. PhD Student in Education. Visiting Scholar in the Computer & Information Technology Department at Purdue University. With experience in Computer Science Education. Digital Skills Leader at ICT Ministry of Colombia.

Alejandra J. Magana (W.C. Furnas Professor in Enterprise Excellence)

Alejandra J. Magana is the W.C. Furnas Professor in Enterprise Excellence in Computer and Information Technology with a courtesy appointment in Engineering Education. She holds a B.E. in Information Systems and an M.S. in Technology, both from Tec de Monterrey; and an M.S. in Educational Technology and a Ph.D. in Engineering Education, both from Purdue University. Her research program investigates how model-based cognition in Science, Technology, Engineering, and Mathematics (STEM) can be better supported by means of expert tools and disciplinary practices such as data science computation, modeling, and simulation. In 2015 Dr. Magana received the National Science Foundation's Faculty Early Career Development (CAREER) Award to investigate modeling and simulation practices in undergraduate engineering education. In 2016 she was conferred the status of Purdue Faculty Scholar for being on an accelerated path toward academic distinction.

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Abstract

This work in progress paper analyzes disciplinary teachers' self-efficacy beliefs in Computational Thinking (CT) during a professional development program on (CT). The increasing number of professional development programs to promote the integration of CT into the curricula brings the challenge of understanding how to effectively assess them. The research team designed, implemented, and assessed a 20-hour professional development program to incorporate computational practices into disciplinary learning environments at the K-12 level in Colombia. In total, 101 in-service teachers from Colombian public middle and high schools participated in this program. We used the learning progression use-modify-create as the pedagogical framework to scaffold participants' learning process. The participating teachers completed a pretest and a post-test regarding their experience in the program, their self-efficacy beliefs in CT, and their understanding of CT concepts. As a final project of the program, the participating teachers presented a lesson plan to integrate computational thinking skills into their disciplinary courses. This lesson plan was assessed using a rubric including criteria such as the context, the learning outcomes, the assessment strategy, the pedagogical strategies, and the alignment among these components.

Keywords: Computational Thinking, K-12, Professional Development, Teachers.

Introduction

Computational Thinking (CT) involves a set of concepts and practices for problem-solving that can be automated with a computing device and can be transferred and applied across subjects (Barr & Stephenson, 2011). CT may be defined as a set of practices, concepts, and methods from computer science that support problem-solving and representation of complex phenomena across disciplinary areas (Wing, 2011). These practices can support student learning within disciplinary learning environments, while the disciplines provide a meaningful context to develop computational thinking skills (Weintrop et al., 2016). The relevance of CT is growing due to the increasingly common use of computational technology (Iversen et al., 2018). Therefore, introducing CT into the K-12 curricula is gaining traction in several countries (Angeli, 2020) (e.g., Australia, Israel, New Zealand, United Kingdom, and the United States). These governments are updating their computing curricula to help all students learn concepts and skills from computer science (Mouza et al., 2017). In Colombia, for example, the national government started to prepare K-12 teachers from public schools to integrate computational thinking concepts and skills using the micro:bit device. This represents an advance in the integration of CT into existing curricula, but it is also necessary to increase professional programs to other disciplinary teachers and other computational thinking practices (Lee et al., 2011). According to Webb (Webb et al., 2017), the lack of professional development programs was defined as a major challenge in different countries by the International Federation of Information Processing (IFIP). They discussed that: (a) Existing teachers who have taught a different curriculum may not have sufficient technical knowledge and skills, (b) The teachers' pedagogical content knowledge (PCK) (Shulman, 1986) has not been developed about the new curriculum content, and (c) few new Computer Science graduates are coming into teaching. Moreover, since these programs are only starting to emerge, identifying effective approaches and instruments for assessing them is an essential endeavor at this point (Boulden et al., 2021; Haseski, 2019).

Teacher self-efficacy beliefs may affect their motivation and their abilities to actually implement the teaching activities. Self-efficacy beliefs are people's thoughts or ideas about their abilities to perform the tasks necessary to achieve the desired outcome (Hutchison , 2006). Several investigations relate self-efficacy beliefs to academic achievement (Bryne, 1996; Valentine, DuBois, & Cooper, 2004). Thus, assessing teacher self-efficacy beliefs and knowledge is an important step for professional development programs (Zhang et al., 2019). Teacher beliefs are also an essential first step toward technology acceptance and integration (Dusick, 1998; Ertmer, 2005).

The research team designed and implemented an online professional development program for K-12 disciplinary teachers to integrate computational thinking practices into their courses. This study explores the teachers' self-efficacy beliefs in CT in the professional development program for K-12 disciplinary teachers in Colombia. The guiding research question is: RQ1- what is the change in the teachers' self-efficacy beliefs in CT of the professional development program?

Pedagogical Framework

The “Use-Modify-Create” (UMC) progression has been suggested to support student learning of complex concepts in computational thinking. Students start by first "Using" a given artifact, before "Modifying" an existing one, and then eventually "Creating" new ones The UMC progression has been widely used to facilitate student engagement in CT (Martin et al., 2020). Existing research has explored the UMC progression in different contexts. We argue that this progression may also be useful in professional development programs to support the learning process of disciplinary teachers on computational thinking concepts and skills. UMC may be particularly helpful when the teachers are novices in computational thinking, to develop the knowledge to design learning environments for integrating CT.

The Learning Experience

The online learning experience was designed as a 20-hour virtual workshop for in-service disciplinary teachers in Antioquia, Colombia. The learning goals for this program are: (1) Recognize the importance of integrating computation in different areas, (2) Explain how the CT can be integrated into different areas, and (3) Design a learning environment where CT is integrated within a disciplinary context. We introduced a set of lesson plans of Physics, Natural Science, and Social Sciences for the participating teachers to explore. The lesson plans contained a set of activities using the UMC progression to support student learning. For example, the Physics lesson plan had the structure presented is Table I. The teachers start by exploring sample lesson plans, and explain them to each other (i.e., use). They should then introduce a change into the lesson plan to extend it or adapt it to a specific context (i.e., modify). Then, as the final project of the program, the participating teachers submitted a new lesson plan to integrate computational thinking skills into their disciplinary courses.

Table I. Lesson Plan - Physics

Activity	**Using Netlogo to simulate the Conservation of mechanical energy during free fall**
Learning goals	Describe the effects that distance, velocity, and acceleration can have on an object in a free fall.
	How to use a computational model to learn about the free fall of an object.
	How to build a computational model of the free fall of an object using a block-based programming language.
UMC Progression	Use: Exploring the Model in Netlogo
	Modify: Changes in mechanical energy of the ball.
	Create: Constructing the model using blocks.

Methods

The participants for this study include 101 in-service teachers from Colombian public middle and high schools participated in this program. The governors’ office supported this program by inviting the teachers to participate. These participants were divided into three groups: two groups in 2020 (one for elementary school teachers and one for secondary school teachers), and another one in 2021. Table II displays the distribution of teaching levels and disciplines for the participants along with other demographic information.

Table II. Participants teaching levels and disciplines

Discipline	Gender		Level		Area	
	Male	Female	E	S	Rural	Urban
Technology	2	5	1	6	0	7
Natural Sciences	2	0	0	2	0	2
Social Sciences	1	2	1	2	0	2
Math	1	2	0	3	0	3
All the areas	4	7	7	4	10	2

**E: Elementary – S: Secondary*

The participants answered items such as: *I can define "Computational Thinking";* I can describe the computational thinking practices and skills; and, I know different ways to assess Computational Thinking skills. For example, figure 1 shows answers to the question: I can define "Computational Thinking". In the Pretest, most teachers (67.74%) respond Neutral and Agree. While in Posttest all responses (100%) are concentrated in Agree and Strongly Agree.

Results and discussion

This work in progress paper describes the changes on participants' self-beliefs after participating in the professional development program. The assessment at this level was intended to provide helpful information for workshop designers and administrators to improve future implementations of the professional development program. Figure 1 shows the distribution of participants' responses to the question: *I can define "Computational Thinking".* In the pretest, the majority of teachers (68%) selected *Neutral* and *Agree*. While in the posttest all the participants' responses (100%) are located between *Agree* and *Strongly Agree*.

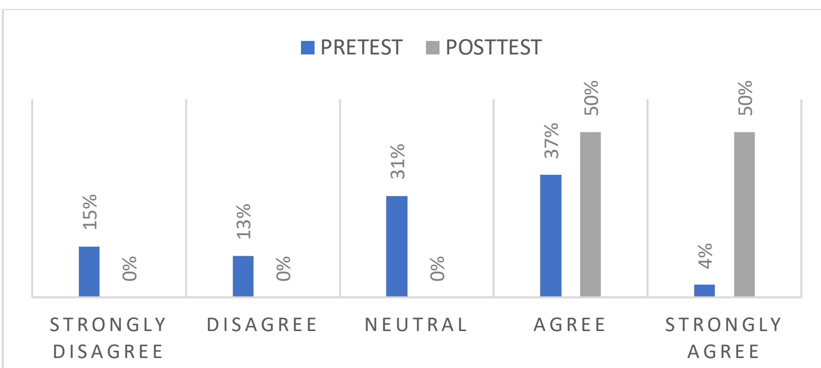

Figure 1 - I can define CT.

Figure 2 present the participants' responses to the question: I can describe the computational thinking practices and skills. We identified an increase in the responses Agree (25%) and Strongly Agree (29%) on the posttest, compared to the pretest results.

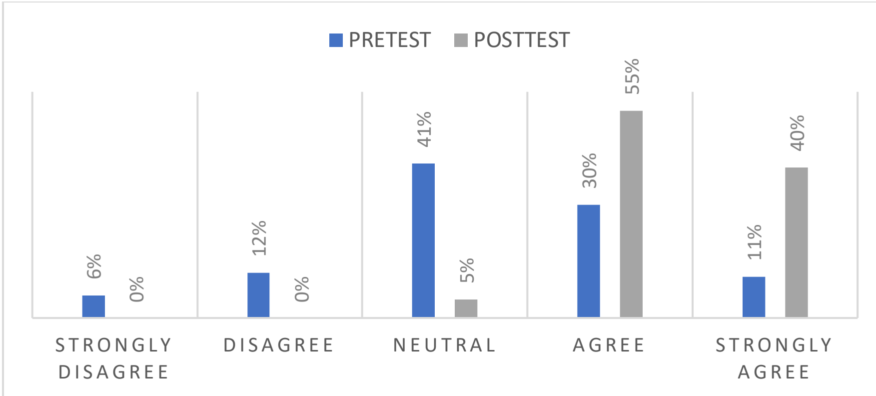

Figure 2 - CT practices and Skills

Figure 3 shows the participants' responses to the statement: I know different ways to assess Computational Thinking skills. The responses in the pretest that focused on Strongly Disagree or Disagree comprise 23% of the participants, while no responses in the posttest fell under these categories. Conversely, the option Strongly Agree changed from 8% in the pretest to 40% in the posttest.

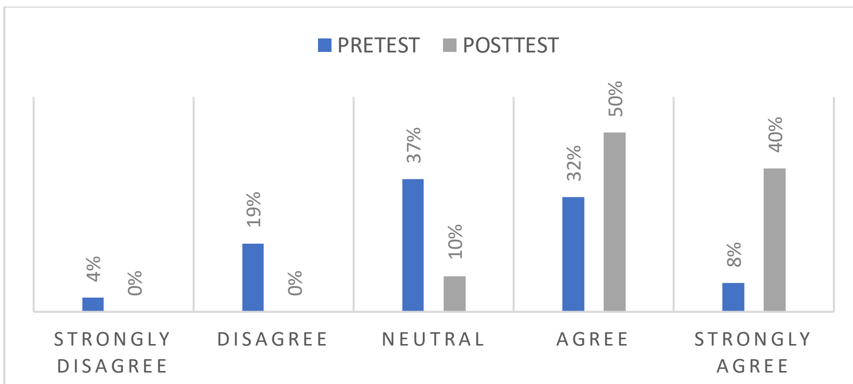

Figure 3 - Assess CT learnings

In the following questions, we ask the teachers to rate the statements based on how much they agree with using some practices as pedagogical approach to teach computational thinking. The first question asked about the use of Unplugged learning activities. While we identify that, in the pretest, 27% did not know the unplugged learning activities, this percent was reduced to 7% in the posttest (see Figure 4). Also, most participants' responses (80%) in the posttest fell under Agree and Strongly Agree.

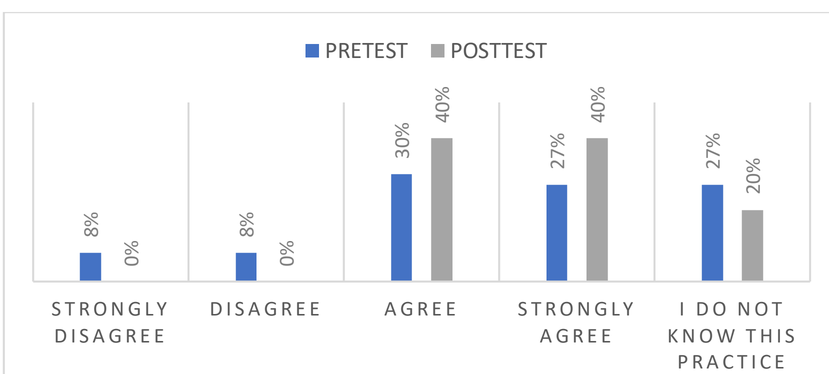

Figure 4 - Unplugged Activities

In a similar question but related to the teaching progression Use-Modify-Create, the participating teachers increased their responses to Agree (12.36%) and Strongly Agree (10.55%) from pretest to posttest. Also, the percentage of teachers who did not know this practice was reduced by 6.29%.

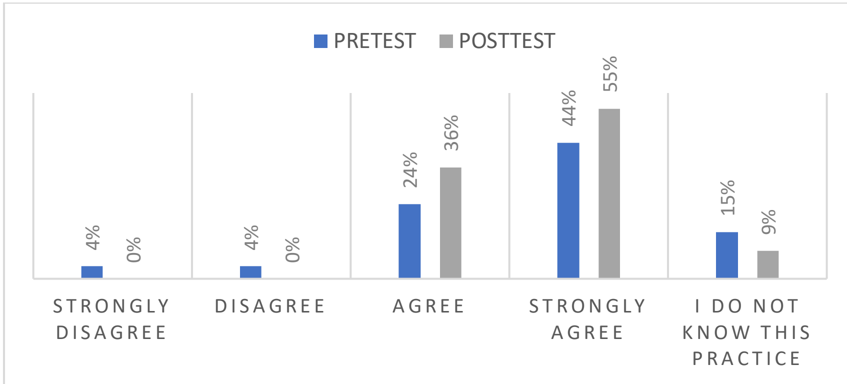

Figure 5 - Use-Modify-Create Progression

Conclusion and next steps

This working progress paper investigated teachers' self-efficacy beliefs in CT of a professional development program in CT. Exploring self-efficacy beliefs is valuable because the literature suggests that students' self-beliefs are related to academic achievement and cognitive engagement (Magana, 2016). The results indicate that more teachers can define what is CT, describe CT practices and skills, and assess CT earnings. Also, the results show that more teachers knew about pedagogical approaches to teach computational thinking (i.e., Use-Modify-Create, Unplugged activities), although some teachers still were unfamiliar with these practices. To increase the integration of these practices into the classroom, it is necessary to highlight the importance of using these pedagogical techniques to facilitate the learning process in CT and show other strategies that can contribute in this way.

The main limitation of this work in progress paper is that we only focused on participants' self-efficacy beliefs in CT. As a next step, Kirkpatrick's Training Evaluation Model will analyze the other facts in the program (i.e., teachers' learning, support, use of knowledge and skills, and Research Outcomes). This model is an approach to measuring a training program's impact (Kirkpatrick,1998).

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