WIP: Professional Learning in Computational Thinking for Early Childhood Teachers in Latin America

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Abstract*— This research to practice work in progress paper explores changes in teachers' knowledge of integrating computational thinking (CT) into early childhood education in a professional learning (PL) initiative. The main goal of the program is to prepare teachers to develop CT practices into early childhood learning environments by fostering several key components: recognizing the significance of CT development from early childhood, applying pedagogical practices (i.e. unplugged activities, Use-Modify-Create), identifying socially constructed roles and stereotypes surrounding toys, implications of screen and device usage in learning, and developing skills to design CT learning activities tailored for their own classroom settings. To achieve our goals, the research team designed, implemented, and evaluated an online 30-hour PL program with educators from Latin American countries. Approximately 80 teachers completed the online PL program. The participating teachers engaged with the PL program weekly by providing written journal reflections. In the final week, they were asked to design a lesson based on what they learned and implement it into their classroom. Teachers completed a pre- and post-survey surrounding their self-efficacy and technological, pedagogical, and content knowledge (TPACK) in CT. Data sources include pre- and post-surveys, teacher journal reflections, and lesson plans developed by teachers. In this paper, we analyzed their journal reflections to qualitatively develop an understanding of how teachers progressed in the PL. The lesson plans will be analyzed to identify: (1) the learning goals for the students, (2) which activities teachers preferred to implement, and (3) how they assessed student learning in CT in their classroom. Preliminary findings demonstrate the types of CT activities they implemented in their classrooms. Teachers also created lessons that met their students' needs which further provides examples of how CT is integrated within the existing curriculum surrounding student interest and culture. Many PL programs often teach about CT concepts, but do not offer a chance to implement a lesson plan and reflect on their experience. This process helps teachers develop self-efficacy for teaching CT in an elementary classroom and teachers reported that they would continue to integrate CT within their future instruction. Also, this program contributes to the reduction of the gender gap in CT, promoting equitable practices in early childhood education.

Keywords – Computer Science, Computational Thinking, Professional Development

I. INTRODUCTION

Computational thinking is an essential cognitive skill focused on problem-solving, representing complex phenomena, and computationally expressing ideas [1]. It involves practices like abstraction, decomposition, algorithm design, automation, and debugging from computer science [2]. Integrating computational thinking into education has become a priority in many countries, from early education to secondary school in the global north, and is emerging as a priority in some Latin American countries [3, 4].

Learning computational thinking has been suggested to be as important as learning mathematics or literacy [5, 6]. However, integrating this approach into the school curricula remains a challenge, especially in elementary contexts [7].

In the context of early childhood education, computational thinking emphasizes the development of skills such as algorithm design, problem decomposition, and understanding fundamental concepts like the design process, control structures, and hardware and software [8]. Programming has emerged as a pivotal tool for developing these skills, employing activities that involve sequences of instructions for educational robots like BeeBot or Roversa, along with online platforms like Code Studio by Code.org.

Integrating CT into early childhood education faces several challenges, including inconsistent approaches to what to teach. Zeng et al. [9] proposed a curriculum framework for CT in early childhood education, emphasizing concepts, practices, and perspectives. Despite this progress, key questions remain about the relationship between children's developmental process and their acquisition of CT skills, requiring further exploration. Research on the stages children go through when learning to code is limited [10], highlighting the need to understand how children develop these skills in increasingly sophisticated ways. Additionally, addressing teacher training and professional learning is essential, as few pre-service programs include CT for early childhood, and in-service programs often lack opportunities for implementation and reflection [11]. Rigorous evaluation of professional development programs is critical to ensure their effectiveness and impact on pedagogical practice [12].

In 2023 and 2024, our research team designed and implemented a professional learning (PL) program in Computational Thinking for early childhood teachers in several Latin American countries, including Colombia, Costa Rica, Peru, Ecuador, and Uruguay. This work-in-progress paper explores early childhood teachers' reflections after implementing sample learning activities as part of the program assignments, and the opportunities they identify for integrating these practices into their classrooms. The guiding research question is: *RQ1 - What are the perceptions and challenges of* *early childhood teachers in Latin America regarding the integration of computational thinking into their teaching practices?*

II. Pedagogical Framework

To integrate computational thinking into classroom activities, it is crucial to incorporate pedagogical practices that help manage students' cognitive load. Unplugged activities are proposed to develop student understanding and skills in computational thinking without the need for computers [13,14]. These hands-on activities facilitate better comprehension of key concepts and processes by regulating cognitive load and reducing distractions from technological devices. Furthermore, unplugged activities have proven effective at all ages, as they regulate cognitive load and minimize the distracting effect of screens [14,15]. They offer an efficient way to introduce computer science concepts without requiring extensive time and resources.

To reduce cognitive loads, the Use-Modify-Create (UMC) approach has been suggested to support student learning [16]. Students first use and explore an example; then modify or extend it, and finally create their solution. The UMC progression promotes engagement in computational thinking [16] and can be used in professional development programs for early childhood educators to first use and modify learning activities before creating their own.

III. Conceptual Framework

Guskey's evaluation framework [17] provides a structured approach for measuring the impact of training initiatives. This model consists of five levels for assessing the program's effectiveness: (1) Reaction: This initial level gauges participants' immediate feedback and satisfaction with the workshop, as well as their overall attitudes toward the learning experience. (2) Learning: This level focuses on identifying what participants have learned from the PL program. (3) Support: This level assesses participants' perceptions of the support provided in the training program, including the accessibility of resources and their transferability to their context or institution. (4) Use of Knowledge and Skills: This level, typically assessed annually starting a year after the workshop, evaluates the extent to which participants apply their learning in their practices within their context or institution. (5) Research Outcomes: Also evaluated annually starting a year after the workshop, this level examines the broader impact of the training, such as increased collaborations or improved student performance [17]. In this work-in-progress paper, we will focus on participants' reactions and learning, to gain insights into the opportunities, perceptions, and challenges related to the learning experience.

IV. The learning experience

The online learning experience was designed as a 30-hour workshop for in-service early childhood teachers. The learning goals for this program include: (1) Recognizing the importance of the development of computational thinking from early childhood, (2) Applying relevant pedagogical practices, such as unplugged strategies and the use-modify-create progression, for the development of computational thinking in early childhood. (3) Identifying socially generated roles and stereotypes around early childhood toys, (4) Identifying the advantages and disadvantages of the use of screens in early childhood, and (4) Designing activities for teaching/learning computational thinking in early childhood.

The program was divided into six units. The first unit focused on understanding Computational Thinking and the different skills associated with it. The second unit specifically addressed computational thinking in early childhood and the main skills for these educational levels (e.g. Algorithmic Thinking, Debug). The third unit consisted of recognizing the characteristics of unplugged activities and how these can support student learning. The fourth unit presented the pedagogical progression Use-Modify-Create as a practice to reduce cognitive load in students. The third unit consisted of recognizing the characteristics of unplugged activities and how these can support student learning. The fifth unit addressed the value and challenges of using educational robotics for early childhood, starting from an explanation of what a robot is and what it can be used for in the classroom, to the discussion of different options of educational robots and activities to integrate them into the classroom. The last unit is a cross-cutting module that addresses factors influencing the gender gap in computational thinking and practices to reduce this gap. During each unit, the participating teachers generated reflections on the topics covered in a journal that presented questions about the experience of implementing sample learning activities in their classrooms. Then, as the final project of the program, the participating teachers submitted a new lesson plan to integrate computational thinking skills into their early childhood courses.

IV. Methods

The program was supported by an international organization aimed at providing equitable CS education experiences to all [18], which invited teachers from early childhood to participate in Colombia and Latin America.

In total, 193 participants started the course from different cities in various Latin American countries (e.g., Colombia, Costa Rica, Perú, Argentina, México, and Ecuador). We found that 96 percent of the teachers participating in the program were women. At the end of the program, 80 teachers met the certification criteria by submitting the reflection journal and the design of the learning environment.

Throughout the program, teachers responded to reflection journals with questions associated with the units they were developing. These questions aimed to prompt teachers to reflect on their understanding, experiences, and application of the content covered in each unit. The qualitative analysis of the reflection journals involved reviewing each response and organizing them into a matrix. This process allowed for the emergence of categories, which facilitated the analysis of the content. The categories were then used to identify common themes and insights regarding the teachers' experiences and understanding of the course material.

At the end of the PL, teachers developed a learning environment that includes components such as contextual characteristics, participant details, learning objectives, evaluation methods, and instructional strategies.

V. RESULTS

The results describe the participants' reflections on the topics covered in the professional learning program. Throughout the program, 80 teachers completed a reflection journal, and we qualitatively analyzed their responses. The questions and respective answers are presented along with qualitative categories that summarize these experiences.

In the first unit, which addressed the general aspects of computational thinking, most teachers associated computational thinking with problem-solving (88%), followed by logic (26%), and algorithms (8%). The total percentages exceed 100% because a response could fall into multiple categories. Regarding what they did not understand about computational thinking in the first unit, teachers mentioned that they were unclear about how to integrate these concepts with early childhood students (52%). Other teachers also focused on inclusive activities (16%), how to assess CT skills in students (16%), and others (16%).

TABLE I. ANSWERS QUESTION 1

What is Computational Thinking?		
Questions	Categories	Quotes
What do you understand by computational thinking?	Problem-solving (88%)	“The ability to analyze and solve problems, it is independent of technology and is linked to mental and cognitive tools”
	Logic (26%)	“It is an ability to develop activities that involve logical thinking”
	Algorithms (8%)	“It is the ability to pose and solve problems following an orderly and organized series of steps”
What don't you understand about computational thinking?	Early childhood teaching (52%)	"I am still not clear how to work CT with early childhood”
	Inclusive education 16%)	“I would like to understand about inclusive practices of the CT component in the curriculum, from early childhood”
	Assessment (16%)	“I don't understand what the assessment should be like”

In the second unit, which focuses on developing computational thinking (CT) in early childhood, teachers provided examples of situations where Algorithmic Thinking occurs. The participants' responses primarily centered around three themes: descriptions of daily routines (40%), instructions for recipes (25%), and choreographies (10%), with a variety of other examples (15%). Additionally, we asked them how they would introduce computational thinking concepts without using screens. Most responses emphasized the use of Unplugged activities (70%), followed by Physical computing (30%).

TABLE II. ANSWERS QUESTION 2

How to develop computational thinking in early childhood?		
Questions	Categories	Quotes
Provide an example of a situation where Algorithmic Thinking occurs.	Daily routines descriptions (40%)	“One of the activities where algorithms can be used are the daily activities of children such as: tying their shoelaces, brushing their teeth, the route they take back home, etc”
	Recipes instructions (25%)	“An example could be the preparation of a juice. First you must choose the fruit, peel it, cut it, add it to the blender, add water, press the button to start the blender, strain the juice, add sugar, stir, add ice, and serve to taste”
	Choreographies (10%)	“When children must prepare a musical choreography by themselves, they begin to order and organize steps that go according to the musical rhythm chosen by them”
How to approach computational thinking ideas if there are no basic resources like a screen?	Unplugged activities (70%)	“Through disconnected programming activities: mazes, sequences and patterns, displacement games and spatial location”
	Physical computing (30%)	“In computational thinking there are tangible tools, you can use the strategy of the robot with the same body so that another child is the one who indicates the movement patterns and then use a real robot like the beebot”

Regarding reflections associated with the Use-Modify-Create strategy in computational thinking, most teachers either did not respond or indicated that they were unsure how to apply it (95%). A few others (5%) mentioned activities involving geometric figures, such as providing the students with geometric shapes and asking them to create a form given by the teacher. Then, ask them to create a figure of their choice using geometric shapes. We also asked teachers about their use of Educational Robotics at the initial levels. We found that most responses (90%) focused on the category of 'Sequence of movements,' indicating how they would utilize educational robots in their learning environments. The remaining responses (10%) centered around understanding the concept of a robot, starting from its basic principles.

When asked about the main limitations of using educational robots in their learning environment, teachers' responses were distributed into three categories: economic resources (90%), classroom management (6%), and training (4%).

TABLE III. ANSWERS QUESTION 4

Educational Robotics for initial levels		
Questions	Categories	Quotes
How would you use educational robots in your learning environment?	Sequence of movements (90%)	“Propose students simulate being robots and follow instructions, then implement robots for students to program”
	What is a robot? (10%)	“Generating expectation, curiosity, leading students to pose hypotheses or answers about what a robot is and what it could do, generating questions and answers”
What do you think could be the main limitation to using educational robots in your learning environment?	Economic resources (90%)	“The main limitation is the cost of purchasing and/or making them, considering that the ideal would be to have a necessary quantity for the students, which increases costs significantly”
	Classroom management (6%)	“The main limitation to using educational robots would be the lack of classroom management, leading students to lose concentration and fail to follow instructions.”
	Training (4%)	“Lack of knowledge on the part of teachers and institutions about robotics, which generates training needs.”

We also analyzed teachers' responses regarding whether they noticed any differences in how boys and girls engaged in CT activities. Many teachers mentioned that they did not notice any difference (95%).

IV. DISCUSSION

Our findings indicate that teachers linked computational thinking with problem-solving, logic, and algorithms. This observation is consistent with several studies emphasizing the significance of logical thinking in computational tasks [19]. Designing algorithms requires rigorous logical thinking, abstraction skills, and a deep understanding of core concepts [20]. Moreover, Genesereth and colleagues [21] underscored the essential nature of logical thinking for computational thinking, as it provides the framework for reasoning about program and algorithm correctness.

However, the main aspects of computational thinking that teachers find challenging to understand are how to work with it in early childhood (52%), how to implement inclusive practices (16%), and how to conduct appropriate assessments (16%). Yadav et al. [22] propose that the development of these skills "should start in the early stages" through play and simple problems. Therefore, the assignment of designing lesson plans is an essential activity in the development of teacher training programs. Regarding inclusion, Gonzalez et al. [23] emphasize the need for teaching to be "accessible to all" by adapting activities and materials, highlighting the importance of recognizing the context in which the activities will take place.

According to teachers' reflections on how algorithmic thinking is understood, most teachers exemplify it using examples from daily routines. Bers [9] suggests that "children's daily routines, such as tying their shoes or the route back home" are ideal activities for practicing simple algorithms. Bers et al. [24] describe a successful intervention where "4-6-year-old children were able to create and follow basic algorithms" through games and storytelling.

The alternative strategies mentioned by teachers for developing computational thinking without the use of screens are "unplugged" activities and physical computing. Barragán et al. [25] propose using these activities to develop computational skills without screens. Berciano-Alcaraz et al. [26] suggests the "body-as-robot strategy," where a child guides movements before using a real robot. These hands-on and kinesthetic approaches allow for the exploration of key concepts in an accessible and inclusive manner, as discussed for effective teaching of computational thinking.

The main limitation mentioned by teachers for using educational robots is the economic cost. Bers [9] points out that the cost of purchasing or creating them, especially in the necessary quantities for students, significantly increases expenses. Another factor mentioned by Leidó et al. [27] is the challenge of "classroom management and maintaining concentration" when working with these novel resources. The high cost of educational robots and the challenges of classroom management pose significant barriers to implementation, highlighting the need to reinforce actions to make computer science education training courses and resources more accessible and affordable.

V. CONCLUSION AND NEXT STEPS

This WIP presented PL teachers' reflections on computational thinking for early childhood education. A limitation at this stage is that only reflections were evaluated. However, for future work, we will analyze the levels of Guskey's evaluation framework: (2) Learning, with pre and post-test and analysis of lesson plans designed for teachers, (3) Organizational Support, with a semi-structured interview with teachers about support and support in the school, (4) Use of Knowledge and Skills, with classroom observations. This analysis will provide a better understanding of the impact of teacher training in computational thinking beyond initial perceptions. These additional steps will provide valuable information to refine training programs and ensure successful integration from an early age.

IV. ACKNOWLEDGEMENTS

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V. REFERENCES

[1] M. Román-Gonzalez, J. C. Pérez-González, and C. Jiménez-Fernández, "Test de Pensamiento Computacional: diseño y psicometría general," in *III Congreso Internacional sobre Aprendizaje, Innovación y Competitividad (CINAIC 2015)*, Oct. 2015, pp. 1-6, DOI: 10.13140/RG.2.1.3056.5521

[2] V. Barr and C. Stephenson, "Bringing computational thinking to K-12: What is Involved and What is the Role of the Computer Science Education Community?" ACM Inroads, vol. 2, no. 1, pp. 48-54, 2011, DOI: 10.1145/1929887.1929905

[3] Ministry of Education of Chile, "What is the Digital Languages Plan?", Website, https://sitios.mineduc.cl/lenguajesdigitales/que-es-el-plan.html, Accessed: May 10, 2024.

[4] Plan Ceibal, "Pensamiento Computacional," Website, https://pensamientocomputacional.ceibal.edu.uy/, Accessed: May 10, 2024.

[5] S. Grover and R. Pea, "Computational thinking in K–12: A review of the state of the field," Educational Researcher, vol. 42, no. 1, pp. 38-43, 2013, DOI: 10.3102/0013189X12463051

[6] J. F. Sanford and J. T. Naidu, "Computational thinking concepts for grade school," Contemporary Issues in Education Research (CIER), vol. 9, no. 1, pp. 23-32, 2016, DOI: 10.19030/cier.v9i1.9547

[7] F. Heintz et al., "Introducing programming and digital competence in Swedish K-9 education," in Informatics in Schools: Focus on Learning Programming: 10th International Conference on Informatics in Schools: Situation, Evolution, and Perspectives, ISSEP 2017, Helsinki, Finland, November 13-15, 2017, Proceedings 10, pp. 117-128, Springer International Publishing, 2017, DOI: 10.1007/978-3-319-71483-7_10

[8] M. U. Bers, "Coding as a playground: Programming and computational thinking in the early childhood classroom," Routledge, 2017, URL: https://www.routledge.com/Coding-as-a-Playground-Programming-and-Computational-Thinking-in-the-Early-Childhood-Classroom/Bers/p/book/9780367900502

[9] Y. Zeng, W. Yang, and A. Bautista, "Computational thinking in early childhood education: Reviewing the literature and redeveloping the three-dimensional framework," Educational Research Review, vol. 39, pp. 100520, 2023, DOI: 10.1016/j.edurev.2023.100520

[10] M. U. Bers, C. González-González, and M. B. Armas–Torres, "Coding as a playground: Promoting positive learning experiences in childhood classrooms," Computers & Education, vol. 138, pp. 130-145, 2019, DOI: https://doi.org/10.1016/j.compedu.2019.04.013

[11] A. Espinal, C. Vieira, and A. J. Magana, "Professional Development in Computational Thinking: A Systematic Literature Review," *ACM Trans. Comput. Educ.*, vol. 24, no. 2, pp. 1-24, 2024, DOI: https://doi.org/10.1145/3648477

[12] L. Darling-Hammond and N. Richardson, "Research review/teacher learning: What matters," Educational leadership, vol. 66, no. 5, pp. 46-53, 2009, URL: https://ascd.org/el/articles/teacher-learning-what-matters

[13] G. Aranda and J. P. Ferguson, "Unplugged Programming: The future of teaching computational thinking?," Pedagogika, vol. 68, no. 3, 2018, DOI: 10.14712/23362189.2018.859

[14] D. A. Bell, Fundamentals of electronic devices and circuits, Oxford University Press, Inc., 2009, DOI: https://dl.acm.org/doi/10.5555/1538607

[15] E. N. Caeli and A. Yadav, "Unplugged approaches to computational thinking: A historical perspective," TechTrends, vol. 64, no. 1, pp. 29-36, 2020, DOI: 10.1007/s11528-019-00410-5

[16] F. Martin, I. Lee, N. Lytle, S. Sentance, Extending and Evaluating the Use-Modify-Create Progression for Engaging Youth in Computational Thinking, SIGCSE '20: Proceedings of the 51st ACM Technical Symposium on Computer Science Education Pages 807–808, 2020, DOI: https://doi.org/10.1145/3328778.3366971

[17] T. R. Guskey, "Professional development and teacher change," Teachers and teaching: theory and practice, vol. 8, no. 3-4, pp. 381-391, 2002, DOI: 10.1080/135406002100000512

[18] A. Espinal, C. Vieira, J. Chiu, E. Bredder, and P. Harris, "Hacia una educación equitativa en ciencias de la computación," *Revista EIA*, vol. 21, no. 42, pp. 4210-pp, 2024, DOI: https://doi.org/10.24050/reia.v21i42.1734

[19] J. M. Wing, "Computational Thinking" en Communications of the ACM, Vol. 49, No. 3, pp. 33-35, Marzo 2006, DOI: https://doi.org/10.1145/1118178.111821

[20] T. H. Cormen, et al., "Introduction to Algorithms", 3ra ed. Cambridge, MA: MIT Press, 2009, URL: https://mitpress.mit.edu/9780262533058/introduction-to-algorithms/

[21] M. R. Genesereth and N. J. Nilsson, Logical Foundations of Artificial Intelligence, Morgan Kaufmann, 2012, DOI: https://doi.org/10.1016/C2009-0-27551-9

[22] S. Yadav, C. Mayfield, N. Zhou, S. Hambrusch y J.T. Korb, "Computational Thinking in Elementary and Secondary Teacher Education", ACM Transactions on Computing Education, vol. 17, no. 1, art. 5, 2016, DOI: https://doi.org/10.1145/2576872

[23] [1] C. S. González González, "Estrategias para la enseñanza del pensamiento computacional y uso efectivo de tecnologías en educación infantil: una propuesta inclusiva," *RiiTE Revista Interuniversitaria de Investigación en Tecnología Educativa*, no. 7, 2019. [Online]. Available: https://doi.org/10.6018/riite.405171

[24] M. Umaschi Bers, "Coding and Computational Thinking in Early Childhood: The Impact of ScratchJr in Europe," *EJSTEME*, vol. 3, no. 3, Article No: 08, Sep. 2018. [Online]. Available: https://doi.org/10.20897/ejsteme/3868

[25] E. A. Barragán Perea, "Pensamiento computacional y programación en la formación de estudiantes desde edades tempranas," Jul. 31, 2023. [Online]. Available: https://doi.org/10.15517/revedu.v47i2.53645

[26] A. Berciano-Alcaraz, M. Salgado-Somoza, and C. Jiménez-Gestal, "Computer Literacy in Early Childhood Education: Difficulties and Benefits in a 3-year-old Classroom," *Universidad del País Vasco, Universidad de Santiago de Compostela, Universidad de La Rioja, Spain*. DOI: https://doi.org/10.15359/ree.26-2.15

[27] I. M. L. Souza, W. L. Andrade and L. M. R. Sampaio, "Educational Robotics Applied to Computational Thinking Development: A Systematic Mapping Study," *2021 IEEE Frontiers in Education Conference (FIE)*, Lincoln, NE, USA, 2021, pp. 1-8, DOI: https://10.1109/FIE49875.2021.9637185