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Author for correspondence:
Rita Neves Rodrigues
ritanevesrodrigues@hotmail.com
Polytechnic University of Coimbra, Coimbra, Portugal; University of Trás-os-Montes and Alto Douro, Vila Real, Portugal; Research Centre on Didactics and Technology in the Education of Trainers (CIDTFF), University of Aveiro, Aveiro, Portugal

From Potential to Practice: Training as a Promoter of Self-Efficacy in Computational Thinking for Pre-service Primary School Teachers

Rita Neves Rodrigues, Cecília Costa, Maryam Abbasi, Sónia Brito-Costa, Fernando Martins

Abstract

Background/purpose. Computational Thinking is a fundamental problem-solving skill. As its importance has been recognized by the scientific community, it has been incorporated into the curricula of several countries to foster its development from the earliest years of schooling. Therefore, it is essential to design training programs that equip teachers to integrate this skill into their practice. Since self-efficacy influences learning, these programs should include strategies to enhance participants' perception of self-efficacy.

Thus, the aim of this study is to evaluate pre-service primary school teachers' perceptions of self-efficacy in Computational Thinking within the context of a training program implementation.

Materials/methods. A mixed-methods approach was followed to analyze the impact of the training program, implemented over nine months, on the perception of self-efficacy in Computational Thinking among 38 pre-service primary school teachers enrolled at a higher education institution in mainland Portugal. Quantitative data were collected using the Computational Thinking Self-Efficacy Scale at Pre- and Post-Intervention phases. Qualitative data were gathered throughout the intervention, including task resolutions, lesson plans, critical reflections, photography, videos, and transcriptions of audio records.

Results. The results revealed statistically significant differences in all four analyzed dimensions of self-efficacy (Abstraction, Reasoning, Decomposition, and Generalization) between the Pre-Intervention and Post-Intervention phases.

Conclusion. This study presents an approach that improves pre-service primary school teachers' self-efficacy in Computational Thinking through the implementation of a training program within Initial Teacher Training.

1. Introduction

In the current context marked by digital and technological transformation, Computational Thinking stands out as an essential skill for facing the challenges of the 21st century (Rao & Bhagat, 2024). This concept integrates processes such as abstraction, decomposition, pattern recognition, algorithm development and debugging, which, when developed simultaneously, improve the resolution of complex problems (Dong et al., 2024; Espinal et al., 2024). Recent research on Computational Thinking has demonstrated that this skill is not only crucial for students and professionals in computer science and programming but also fundamental for individuals across various fields (Li et al., 2024). The scientific community has recognized Computational Thinking as essential, leading to its integration into school curricula worldwide. This aims to foster its development from early schooling (Nordby et al., 2022; Pewkam & Chamrat, 2022; Rodrigues et al., 2024). Despite the integration of Computational Thinking into educational curricula, systematic reviews continue to highlight the persistent gap in specific training for teachers and pre-service teachers in this area (Haşlaman et al., 2024; Tariq et al., 2025). In this sense, it is necessary to create training programs that enable teachers and pre-service teachers to integrate the development of Computational Thinking into their teaching practices. While research linking self-efficacy to Computational Thinking remains limited, existing studies suggest that an individual's self-efficacy levels significantly influence their learning outcomes in training programs (Guo et al., 2024; Şen, 2023). Therefore, when developing training programs for teachers, it is essential to consider strategies that promote an increase in the participants' perception of self-efficacy, creating conditions for teachers to feel more prepared and motivated to integrate Computational Thinking into their practices.

In this sense, a training program was designed and implemented to enhance pre-service primary school teachers' didactic knowledge. This program aims to enable them to proficiently select, adapt, and implement tasks that integrate Computational Thinking dimensions into their practices while simultaneously fostering mathematical learning. Despite the increasing recognition of the importance of self-efficacy and Computational Thinking in teacher education, empirical studies examining pre-service teachers’ perceptions of self-efficacy in Computational Thinking remain limited (Polat et al., 2025). Considering this, it is important to analyze the influence of the implemented program on the pre-service primary school teachers' perception of self-efficacy in Computational Thinking, thus addressing a gap identified in existing literature. The Computational Thinking Self-efficacy Scale (Rodrigues, Costa, Abbasi, et al., 2025) was used to evaluate pre-service primary school teachers’ perceptions across the four dimensions of self-efficacy in Computational Thinking within the context of a training program. Aligned with this perspective, this study aims to answer the following research question: Are there statistically significant differences in pre-service primary school teachers’ perceptions of self-efficacy in Computational Thinking between the Pre- and Post-Intervention phases?

The main contribution of this study is the presentation of an approach to enhance pre-service primary school teachers' perceptions of self-efficacy in Computational Thinking, within the context of implementing a training program integrated into Initial Teacher Training.

2. Theoretical Background

Bandura (1986) defines self-efficacy as an individual's belief in their ability to accomplish something, stating that it is as important as the skills required to achieve a certain goal. In this sense, self-efficacy does not refer to technical skills, but rather to an individual's confidence in their own abilities to face challenges and achieve success (Avcı & Deniz, 2022). Several studies have shown that high levels of self-efficacy are linked to increased motivation, persistence, and determination in pursuing ambitious goals, as individuals believe in their ability to achieve them (Guo et al., 2024;

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Macann & Hartnett, 2025; E. Polat et al., 2025; Şen, 2023; Tankiz & Atman Uslu, 2023). In the context of Initial Teacher Training, Polat (2022) states that pre-service teachers must develop professional skills and feel prepared to teach during their initial training in order to achieve high levels of self-efficacy to become effective teachers. It is therefore essential to analyze how to promote an increase in pre-service teachers' perception of self-efficacy.

A meta-analysis by Täschner et al. (2025) identified four primary sources for developing pre-service teachers' self-efficacy, based on the studies analyzed by the authors. The first and most impactful source is mastery experiences, which involve direct teaching practices, such as internships, teaching mini-lessons to peers, and micro-teaching sessions, allowing trainee teachers to gain confidence from real-world experience. The second source, vicarious experiences, involves learning through observation, where pre-service teachers watch recorded teaching models or observe colleagues and experienced educators. This approach allows them to learn effective teaching practices without direct experience. The third source is social persuasion, which consists of obtaining feedback through collaboration and discussion with colleagues or teachers. Finally, physiological reactions encompass the emotional and physical states of pre-service teachers, which can be regulated through practices such as yoga, meditation, or other mindfulness exercises. In addition to the four topics mentioned by Täschner et al. (2025), other authors (e.g. Butler & Leahy, 2021; Dong et al., 2024; Freitas et al., 2025; Mason & Rich, 2019; Rodrigues et al., 2024; Silva et al., 2024; Tankiz & Atman Uslu, 2022) discuss aspects that can significantly contribute to the development of pre-service teachers' perception of self-efficacy. Mason and Rich (2019) suggest that the most effective training programs should be extended and continuous, integrating both practical and reflective components. This approach enables pre-service teachers to acquire practical experience while simultaneously promoting a deeper and more enduring understanding of their competencies, thereby enhancing their confidence. Beyond practical tasks, training programs must incorporate lesson planning activities to ensure a more comprehensive and confident preparation for pre-service teachers (Freitas et al., 2025; Tankiz & Atman Uslu, 2023). Engaging in lesson planning, receiving feedback, and reflecting on their own teaching will strengthen the training process, helping pre-service teachers feel more prepared for classroom practice and boosting their self-efficacy (Dong et al., 2024). Training programs should therefore integrate theoretical, practical and reflective components, monitoring both the skills acquired and the attitudes of pre-service teachers throughout their training (Butler & Leahy, 2021; Rodrigues et al., 2024; Silva et al., 2024). Therefore, incorporating diverse data collection instruments is essential to thoroughly assess the impact of the training program on pre-service teachers. In the context of Initial Teacher Training, Dong et al. (2024) highlight that self-efficacy plays a crucial role in teachers' willingness to adopt new methodologies and approaches, such as Computational Thinking, which has recently been incorporated into curricula in various countries.

Computational Thinking is recognized as a fundamental skill in problem-solving, encompassing multiple dimensions (Espinal et al., 2024). In Portugal, Computational Thinking is acknowledged as a key competency in the Mathematics curricula from Basic to Secondary Education, incorporating dimensions aligned with specialized literature (Dong et al., 2024; Grover & Pea, 2013; Voon et al., 2022). According to the Ministry of Education (Portugal) (2021), Computational Thinking is a competency that encompasses five core dimensions—abstraction, decomposition, pattern recognition, algorithm design, and debugging—which are to be developed in students to equip them with effective problem-solving strategies. As such, teachers are expected to be prepared to incorporate Computational Thinking into their classroom practices. In this context, the development of self-efficacy in Computational Thinking becomes an important component of Initial Teacher Training, as it influences the confidence and ability of pre-service teachers to implement Computational Thinking effectively into their practices (Polat, 2022). Given its relevance, it is essential

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to identify appropriate instruments to assess pre-service teachers' self-efficacy in Computational Thinking.

Kukul and Karatas (2019) suggest that self-efficacy in Computational Thinking can be assessed through four dimensions: Abstraction, Reasoning, Decomposition, and Generalization. Consistent with definitions in specialized literature, the authors highlight algorithmic thinking and evaluation as integral dimensions of Computational Thinking. However, in their developed scale, these aspects were consolidated into a single factor corresponding to the Reasoning dimension. Drawing from literature review and statistical analysis, the authors structured the scale into four primary dimensions — Abstraction, Reasoning, Decomposition, and Generalization — which are presented next. The Abstraction dimension is a fundamental process in Computational Thinking, as it allows individuals to reduce the information presented and focus only on the essential details to solve a problem (Martínez et al., 2022). This dimension involves identifying and extracting the most relevant information, filtering out secondary elements and organizing data efficiently to structure a solution (Dong et al., 2024). Consequently, this dimension is recognized when pre-service teachers can identify and prioritize essential elements to effectively solve a task. In line with Kukul and Karatas (2019), the Reasoning dimension involves the ability to analyze and solve logical problems, as well as structuring a resolution plan (algorithmic thinking), refining it, and systematically testing strategies (Evaluation) (Román-González et al., 2017). Evaluation or debugging is a crucial component of this process, enabling individuals to assess whether the chosen solution aligns with the intended objective. This step is essential for determining whether the applied strategy is effective or requires adjustment. The development of the Reasoning dimension becomes evident when pre-service teachers, faced with complex tasks, can formulate a resolution plan, critically reflect on it, and refine it until they reach a final solution (Li et al., 2024). The Decomposition dimension is characterized by the individual's ability to break down a complex problem into smaller, simpler problems and recognize how these are interconnected in order to reach the final solution (Voon et al., 2022). Therefore, in this context, the Decomposition dimension is demonstrated when pre-service teachers systematically break down a given task into smaller components and solve them sequentially until they achieve the intended objective (Haşlaman et al., 2024). The Generalization dimension is the ability to recognize patterns in solved problems that can be applied to new problems (Hsu & Tsai, 2024). The development of Generalization is recognized when pre-service teachers identify effective solutions from previous experiences or observations and successfully apply them to new problem-solving tasks (Shute et al., 2017; Yun & Crippen, 2024).

3. Material and Methods

3.1. Study Design

This study employed a mixed-methods design (Cohen et al., 2018), integrating both quantitative and qualitative approaches to evaluate pre-service primary school teachers' perceptions of self-efficacy in Computational Thinking. Combining quantitative analysis with qualitative analysis through the use of mixed methods provides a richer, more in-depth understanding of the quantitative results (Cohen et al., 2018; Creswell & Creswell, 2017). The quantitative analysis focused on changes in perception across four key dimensions, Abstraction, Reasoning, Decomposition, and Generalization, by using pre- and post-intervention comparisons. The qualitative analysis contextualizes and explains the changes in pre-service primary school teachers' perceptions of self-efficacy in Computational Thinking that were found in the quantitative analyses. This approach enabled a more holistic evaluation of the impact of the intervention, integrating the analysis of the two types of data for a more comprehensive understanding.

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3.2. Participants

This study was conducted with data sample of 38 pre-service primary school teachers, aged 20 to 54 years (M = 23.55, SD = 6.79), enrolled at a higher education institution in mainland Portugal during the 2023/2024 academic year.

Regarding gender, 37 participants identified themselves as female and 1 as male. Half of the participants (n = 19) were enrolled in the master's program in "Preschool Education and Primary School Teaching". Of the remaining participants, 12 were enrolled in the master's program in "Primary School Teaching and 2nd Grade School Teaching in Mathematics and Experimental Sciences", while the other 7 were enrolled in the master's program in "Primary School Teaching and 2nd Grade School Teaching in Portuguese and History and Geography of Portugal". During these master's programs, pre-service primary school teachers undertake a year-long internship in a primary school, collaborating in groups of two or three. Thus, throughout the training, participants maintained their pre-established internship groups, enabling them to develop proposals tailored to the specific needs and contexts of their internship settings.

The selection process of these participants followed a non-probabilistic convenience sampling method. The inclusion criteria were: all pre-service primary school teachers who voluntarily agreed to participate and who were enrolled in the Master's programs in "Preschool Education and Primary School Teaching," "Primary School Teaching and 2nd Grade School Teaching in Mathematics and Experimental Sciences," and "Primary School Teaching and 2nd Grade School Teaching in Portuguese and History and Geography of Portugal" at the institution where the study was conducted. The exclusion criteria included all individuals who did not agree to participate, were absent from key practical sessions, or failed to complete the required tasks (e.g., lesson planning, task resolution).

3.3. Ethical Statement

This study was conducted in full compliance with ethical standards as outlined in the Declaration of Helsinki, with a clear emphasis on safeguarding participants' dignity, rights, and well-being. Ethical approval was granted by the Ethics Committee of the Polytechnic University of Coimbra (reference 101_CEIPC/2022, approved on 24 June 2022), confirming that all procedures aligned with institutional and international guidelines. Prior to participation, individuals were fully informed about the study's aims, the voluntary nature of their involvement, and their right to withdraw at any stage without penalty. Written informed consent was obtained accordingly.

3.4. Instruments

The study employed the Portuguese version of the *Computational Thinking Self-Efficacy Scale* (Kukul & Karatas, 2019), as adapted and validated by Rodrigues, Costa, Abbasi, et al. (2025). The scale comprises 18 items grouped into four factors: Abstraction (DAbstr), Reasoning (DRacc), Decomposition (DDecomp), and Generalization (DGener). Each item is rated on a five-point Likert scale (1 = "Completely Disagree", 2 = "Disagree", 3 = "Neutral", 4 = "Agree", and 5 = "Agree Fully"). The original (English) version of the Computational Thinking Self-Efficacy Scale (Kukul & Karatas, 2019) is presented in Table 1.

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Table 1. Computational Thinking Self-Efficacy Scale (Kukul & Karatas, 2019).

DAbstr	2. I evaluate the steps necessary for solving the problem from different perspectives.
	5. I analyze the data I collect to solve the problem.
	10. I comment on the data I use to solve the problem.
	15. I organize the data I collect in a way that is more understandable for solving the problem.
	18. I develop different solutions for solving a problem
DRacc	1. I recognize repetitive structures in data or images.
	7. I sort data according to their types (text, number, sequence, etc.).
	9. I have decided whether the data to be used to solve the problem is sufficient.
	13. I find the fastest solution that works correctly among different process steps.
	16. I decide whether the problem solution I choose is appropriate for the purpose.
DDecomp	3. I carry out more than one task at the same time to solve a problem.
	8. I understand whether the problem consists of sub-problems.
	12. If the problem has sub-problems, I manage the solution processes of these sub problems.
	17. If the problem has sub-problems, I break it down into smaller sub-problems.
DGener	4. I distinguish whether a problem I encounter is similar to problems I have encountered before.
	6. I relate problems to real life.
	11. I make connections between the problems I encounter and the problems I have encountered before.
	14. I understand how a problem I encounter differs from problems I have encountered before.

3.5. Intervention Program

The training program was implemented throughout the 2023/2024 academic year, in the Mathematics and Didactics of Mathematics curricular units of the master's degree program in "Primary School Teaching and 2nd Grade School Teaching in Mathematics and Experimental Sciences / Portuguese and History and Geography of Portugal" and in the master's degree in "Preschool Education and Primary School Teaching". Additionally, the program was integrated with the Educational Practice curricular unit, which oversees the curricular internships of pre-service primary school teachers. The intervention was organized into six stages distributed over two academic semesters: Stages 1, 2, and 3 were conducted in the first semester, while Stages 4, 5, and 6 took place in the second semester (see Figure 1).

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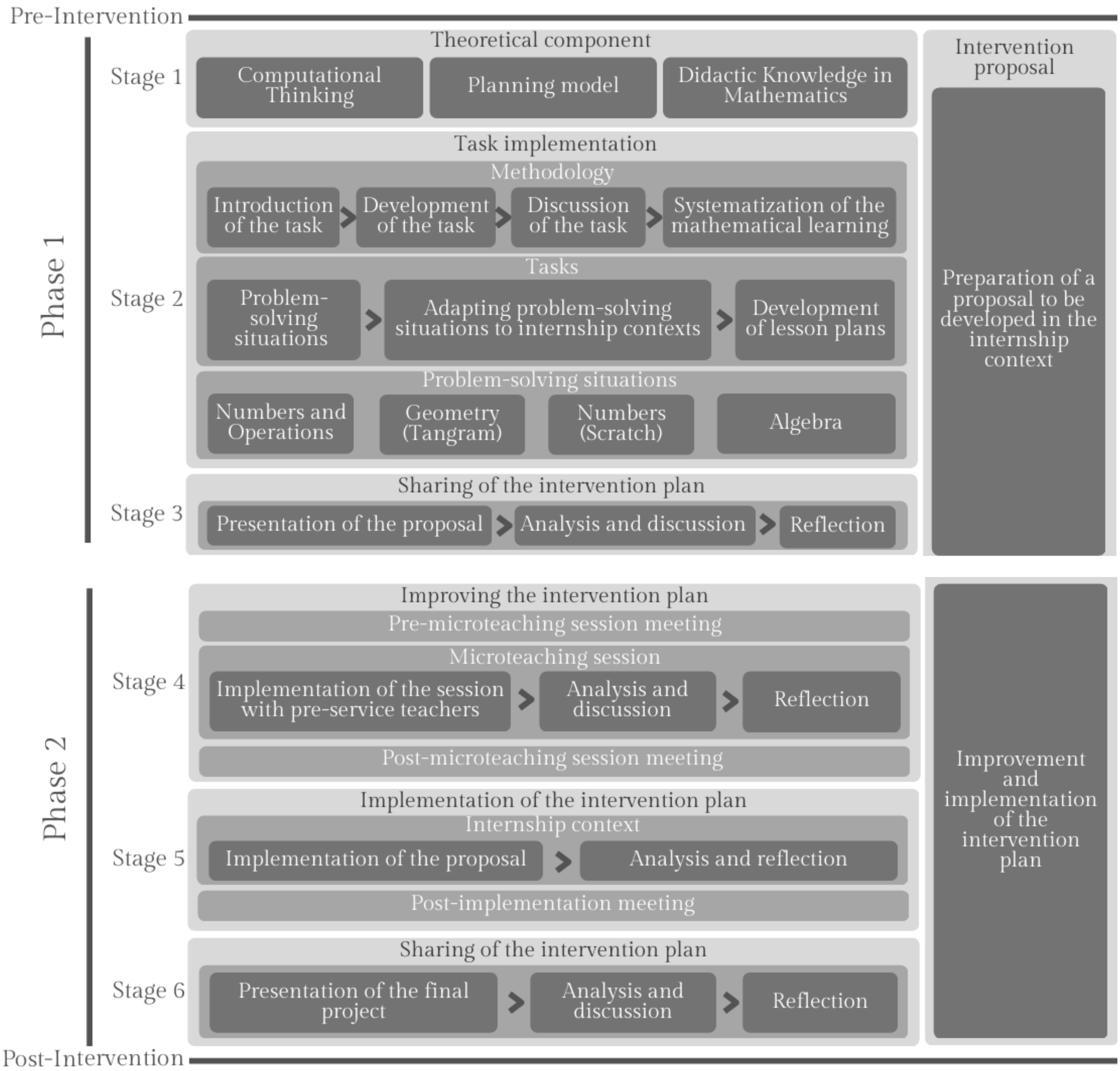

Figure 1. General Structure of the Intervention Plan.

The primary objective of the intervention was to enhance the didactic knowledge of pre-service primary school teachers. This enhancement enabled them to proficiently select, adapt, and implement tasks that integrate Computational Thinking dimensions into their teaching while concurrently promoting the learning of mathematical content. The following two subsections provide a brief overview of each phase of the program. A detailed description of the training program can be found in Rodrigues, Costa, Brito-Costa, et al. (2025).

3.5.1. Phase 1 (First Semester)

Phase 1 ran from September 28, 2023, to January 6, 2024, and consisted of three stages, spread over 13 sessions of two hours each. The focus was on deepening the theoretical knowledge that underpins the training program and enhancing the didactic knowledge of mathematics of pre-service primary school teachers.

Stage 1: The aim was to provide pre-service primary school teachers with theoretical knowledge about Computational Thinking, situating it within the Portuguese curriculum, and introducing the planning model to be used throughout the school year, following the Exploratory Teaching Practices

Model. (Canavarro et al., 2012). The first session involved solving a problem focused on the dimensions of Computational Thinking. In the following sessions, participants developed a lesson plan, exploring resources, learning objectives, and assessment strategies. The process concluded with a discussion on the knowledge required for teaching mathematics, following the model proposed by Ponte (2012).

Stage 2: Over eight sessions, pre-service primary school teachers explored four problem situations, each containing ten tasks divided into two parts. The first part aimed to develop the dimensions of Computational Thinking, while the second focused on drafting a plan to promote Didactic Knowledge in Mathematics. The tasks were completed in groups, followed by a collective discussion on the solutions to encourage reflection on teaching and learning practices.

Stage 3: This stage involved designing and sharing an intervention plan to be implemented during the placements. Each pre-service primary school teacher presented their proposal, discussed their choices with colleagues, and received feedback from both the researcher and peers to refine the plan before implementation.

3.5.2. Phase 2 (Second Semester)

Phase 2, which ran from February 15 to May 23, 2024, consisted of three stages, spread over 13 two-hour sessions. The primary objective was the practical implementation of the intervention plan developed in Phase 1, with a focus on reflection and refinement of the proposals.

Stage 4: This stage involved micro-teaching sessions, where pre-service primary school teachers implemented parts of their intervention plan in preparation for their internship contexts, working with colleagues in the Didactics of Mathematics curricular unit. Before each session, the researcher met with the groups to prepare the tasks and clarify any doubts. During the micro-teaching sessions, pre-service primary school teachers assumed the role of primary school teachers, while their colleagues played the role of students. After each session, a discussion was held to analyze the strengths and areas for improvement, leading to suggestions for refining the proposals.

Stage 5: Pre-service primary school teachers implemented the improved intervention plan in their internship contexts. Following the implementation, they met with the researcher to reflect on their experience and discuss how Computational Thinking and mathematical knowledge developed through their proposed activities.

Stage 6: Phase 2 concluded with a sharing and discussion session on the intervention. Over two sessions, pre-service primary school teachers presented the results of their interventions and reflected on the implementation of Exploratory Teaching Practices, emphasizing the impact of these practices on the development of Computational Thinking and students' mathematical learning. Additionally, each pre-service primary school teacher wrote an individual critical reflection on their experiences throughout the school year.

The tasks mentioned in stages 1 and 2 of Phase 1, as well as those implemented in the Pre- and Post-Intervention phases, were designed to assess pre-service primary school teachers' knowledge of the dimensions of Computational Thinking and their Didactic Knowledge in Mathematics, drawing on the framework proposed by Ponte (2012). This set of tasks, developed by the research group to align with those implemented during the training program, was divided into two parts. The first part began with a problematic situation, followed by six tasks focusing on the dimensions of Computational Thinking and Didactic Knowledge in Mathematics (Ponte, 2012). For example, Task 1 required participants to solve the problematic situation sequentially, employing appropriate mathematical language and providing detailed justifications for their reasoning at each stage. In Task 2, which targeted the Abstraction dimension, pre-service primary school teachers were asked to identify all elements of the problem situation deemed fundamental to solving Task 1. The second

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part comprised four tasks that culminated in the creation of a lesson plan based on the problematic situation introduced in the first part. These tasks directly related to the dimensions of Knowledge of Students and Learning, Knowledge of the Curriculum, and Knowledge of Teaching Practice (Ponte, 2012). For example, in Task 2 of this part, pre-service primary school teachers were asked to specify the learning objectives related to the mathematical knowledge and skills to be acquired, thereby guiding the development of the lesson plan's components.

3.6. Data Collection

Quantitative data were collected using the scale at the Pre- and Post-Intervention phases. The two applications of the scale were done individually and online, via a link that gave access to the scale available on Google Forms.

Qualitative data was collected throughout the intervention program. This included pre- and post-intervention task resolutions, previously described in the "Intervention Program" section, as well as documents produced by pre-service primary school teachers during the intervention, such as the task resolutions, detailed lesson plans and critical reflections. Photographic, video and audio records were also collected and transcribed for subsequent analysis.

3.7. Data Analysis

3.7.1. Analysis of Quantitative Data

The reliability of the Computational Thinking Self-Efficacy Scale was analyzed using Cronbach's alpha coefficient. The internal consistency of the dimensions was classified according to the following criteria: very good ($\alpha \geq 0.9$), good ($0.8 \leq \alpha < 0.9$), reasonable ($0.7 \leq \alpha < 0.8$), weak ($0.6 \leq \alpha < 0.7$), and unacceptable ($\alpha < 0.6$) (Pallant, 2020; Pestana & Gageiro, 2014).

To characterize the participants' perceptions during the Pre-Intervention and Post-Intervention phases, descriptive statistics were employed, specifically relative and absolute frequency tables. The means (M) and standard deviations (SD) were calculated to describe the participants' perceptions. The positive or negative trend was established by classifying levels 1 and 2 as negative, levels 4 and 5 as positive, and level 3 as neutral.

To determine whether pre-service primary school teachers' self-efficacy in Computational Thinking showed statistically significant differences between the Pre- and Post-Intervention phases, a paired-samples Student's t-test was conducted. The normality assumption was verified using the Kolmogorov-Smirnov test (Field, 2018; Marôco, 2021). When the data did not follow a normal distribution, the Central Limit Theorem was invoked, indicating that for sufficiently large samples ($n \geq 30$), the sampling distribution of the mean approximates normality, thereby justifying the use of the t-test (Marôco, 2021; Pestana & Gageiro, 2014). The effect size was calculated using Cohen's d and classified as small ($d \leq 0.2$), medium ($0.2 < d \leq 0.5$), large ($0.5 < d \leq 0.8$), and very large ($d > 0.8$) (Marôco, 2021; Pallant, 2020).

All statistical analyses were conducted at a 5% significance level ($p < 0.05$) using the IBM Statistical Package for the Social Sciences (SPSS, version 28).

3.7.2. Qualitative Data Analysis

During stages 1 and 2 of Phase 1, various data types were collected, including group dialogues, task resolutions, collaborative projects, and critical reflections from pre-service primary school teachers. Using this data, Multimodal Narratives (MN) of the sessions were constructed, totaling eleven MN, which chronologically document each session implemented. The MN were built according to the protocol of Lopes et al. (2018), to report the events of each session in a detailed, self-contained and multimodal way. Each MN included the most important moments of the intervention sessions, as well as the dialogues between the groups, providing a comprehensive view of the dynamics and interactions during the learning process. Once the MN had been constructed, they were validated by independent researchers, who ensured that they strictly followed the protocol established for their structure. The validation process involved comparing the multimodal elements collected (dialogues, images, and videos) and assessing the accuracy, reliability, and readability of the MN. The qualitative data was analyzed using an exploratory content analysis approach, which was applied to both the MN and the other documents produced by the participants during the intervention phases. Content analysis enabled the identification of evidence of the participants' difficulties and/or progress throughout the intervention.

The following section presents the findings, starting with reliability measures for the self-efficacy scale.

4. Results

In both the Pre- and Post-Intervention phases, Cronbach's alpha coefficients were calculated to assess the reliability and internal consistency of both the entire scale and each dimension. As shown in Table 2, the total scale (DTotal) had a Cronbach's alpha of $\alpha = 0.923$ before the intervention and $\alpha = 0.927$ afterward, indicating consistent reliability across both time points. Cronbach's alpha coefficients by dimension, the following values were obtained: Abstraction (DAbstr) $\alpha = 0.779$ vs $\alpha = 0.810$; Reasoning (DRacc) $\alpha = 0.765$ vs $\alpha = 0.724$; Decomposition (DDecomp) $\alpha = 0.711$ vs $\alpha = 0.754$; Generalization (DGener) $\alpha = 0.703$ vs $\alpha = 0.794$) (Table 2).

Table 2. Cronbach's Alpha Coefficients in Pre-Intervention and Post-Intervention.

Factors	Items	Cronbach's Alpha (*α*)	
		Pre-Intervention	Post-Intervention
Abstraction (DAbstr)	2,5,10,15,18	0.779	0.810
Reasoning (DRacc)	1,7,9,13,16	0.765	0.724
Decomposition (DDecomp)	3,8,12,17	0.711	0.754
Generalization (DGener)	4,6,11,14	0.703	0.794
Total Scale (DTotal)	1 to 18	0.923	0.927

To better visualize the changes in the Cronbach's alpha coefficients presented in Table 2, a radar chart was created (Figure 2). This chart provides a graphical representation of the reliability measures for each dimension before and after the intervention.

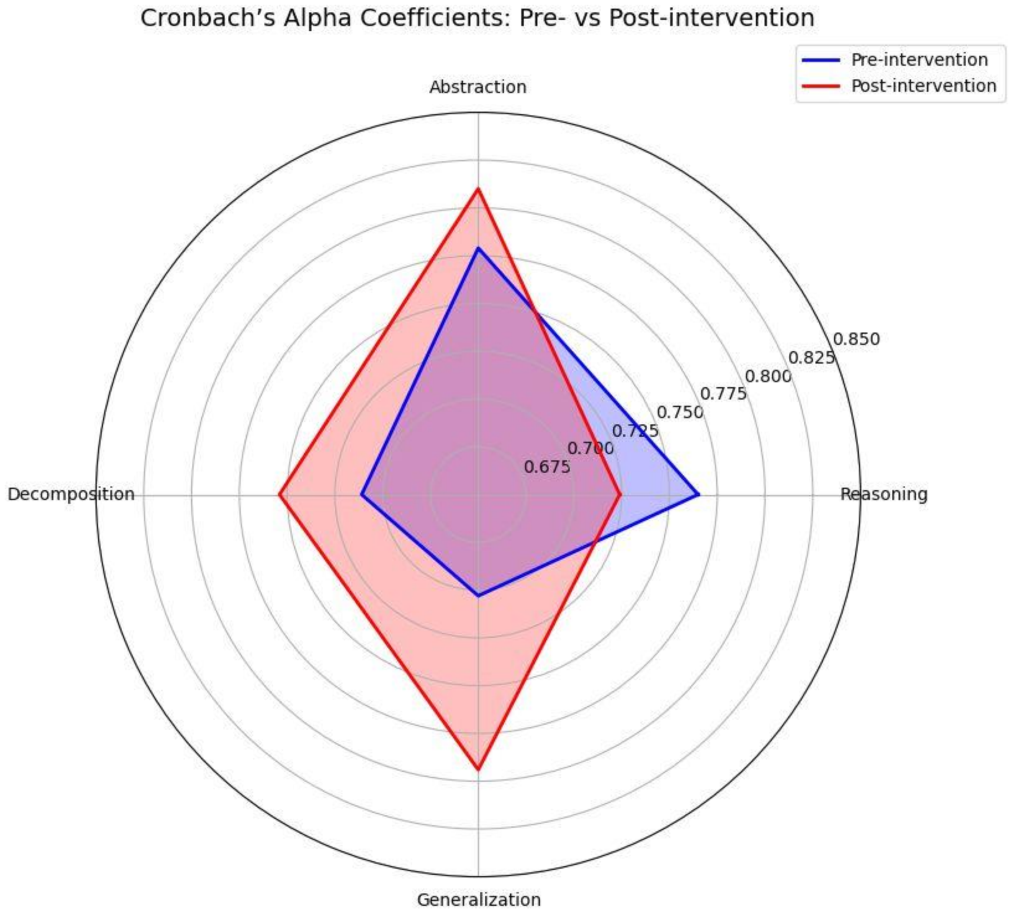

Figure 2. Radar Chart Illustrating Cronbach's Alpha Coefficients for Each Dimension, Pre- and Post-Intervention.

In the next four subsections, the results are organized as follows: first, we present descriptive statistics, including absolute and relative frequency tables for each dimension (DAbstr, DRacc, DDecomp, and DGener). We then discuss the means and standard deviations, along with the paired-samples Student's t-test results and corresponding Cohen's d values, which reveal both the statistical significance and effect size between the two applications of the scale. For each dimension, evidence based on qualitative data analysis is presented to complement the quantitative analysis. These qualitative analysis help explain the progression of the participants throughout the intervention and contextualize the quantitative findings, enabling a more in-depth analysis of pre-service primary school teachers' perceptions regarding the assessed dimensions.

4.1. Abstraction

The results of the distribution of relative and absolute frequencies for the Abstraction dimension (Table 3) show a change in the participants' perceptions from the first to the second application of the scale. In the Pre-Intervention, 10.5% of the answers were negative and 20.0% neutral. In the Post-Intervention, there were no negative responses and only 5.8% of the responses were neutral. This indicates a substantial increase in positive responses, rising from 69.5% Pre-Intervention to 94.3% Post-Intervention (see Table 3). All items showed an increase in positive perception responses, with a particularly notable improvement in participants' perception of their ability to describe the data needed to solve a problem(item Q10) that saw an increase from 57.9% in the Pre-Intervention phase to 92.1% in the Post-Intervention phase, suggesting a significant development in their awareness and articulation of key information in problem-solving contexts. The results presented suggest that the intervention implemented led to an improvement in the pre-service primary school teachers' perception of the Abstraction dimension of the Computational Thinking self-efficacy scale.

Table 3. Distribution of Relative (%) and Absolute Frequencies of DAbstr.

Item	Pre-Intervention (%(n))					Post-Intervention (%(n))				
	Negative		Neutral	Positive		Negative		Neutral	Positive	
	1	2	3	4	5	1	2	3	4	5
Q2	0.0(0)	2.6(1)	23.7(9)	65.8(25)	7.9(3)	0.0(0)	0.0(0)	2.6(1)	50.0(19)	47.4(18)
Q5	0.0(0)	7.9(3)	5.3(2)	57.9(22)	28.9(11)	0.0(0)	0.0(0)	0.0(0)	44.7(17)	55.3(21)
Q10	0.0(0)	10.5(4)	31.6(12)	44.7(17)	13.2(5)	0.0(0)	0.0(0)	7.9(3)	52.6(20)	39.5(15)
Q15	0.0(0)	5.3(2)	2.6(1)	68.4(26)	23.7(9)	0.0(0)	0.0(0)	2.6(1)	50.0(19)	47.4(18)
Q18	0.0(0)	26.3(10)	36.8(14)	31.6(12)	5.3(2)	0.0(0)	0.0(0)	15.8(6)	57.9(22)	26.3(10)
M (%)	0.0%	10.5%	20.0%	53.7%	15.8%	0.0%	0.0%	5.8%	51.1%	43.2%

Table 4 presents the distribution of relative and absolute frequencies, highlighting a significant shift in participants' perceptions after the intervention. The mean score increased from 18.74 (SD = 2.81) in the Pre-Intervention to 21.87 (SD = 2.17) in the Post-Intervention, indicating an overall improvement in responses. The observed difference was statistically significant ($t = -5.928$, $p = 0.001$), confirming the effectiveness of the intervention. Cohen's d was 0.962, indicating a very large effect size, which reinforces the substantial impact of the intervention on participants' perceptions. These results suggest that the training program positively influenced pre-service primary school teachers' perceptions of the Abstraction dimension, leading to a meaningful improvement. This means that, regarding the Abstraction dimension, pre-service primary school teachers demonstrated an overall improvement in their ability to perceive how they analyze and organize relevant data to consider different perspectives for solving problems and develop multiple solution proposals.

Table 4. Descriptive Statistics and Comparison Between the Two Applications of the Scale – DAbstr (Pre-Intervention and Post-Intervention).

		M	*SD*	*t*	*p*	*d*	Effect size
DAbstr	Pre-Intervention	18.74	2.81	-5.928	0.001	0.962	Very large
	Post-Intervention	21.87	2.17				

During Phase 1 of the training program, while solving problem situations, pre-service primary school teachers were asked to identify the essential information needed to solve the presented tasks.

Through qualitative analysis, evidence of the development of the Abstraction dimension of self-efficacy in Computational Thinking was identified, which helps explain the improvements found in the quantitative analysis of this dimension. Figure 3 presents an excerpt from one group's worksheet, illustrating their ability to extract and describe the key information from the problem statement to arrive at a solution.

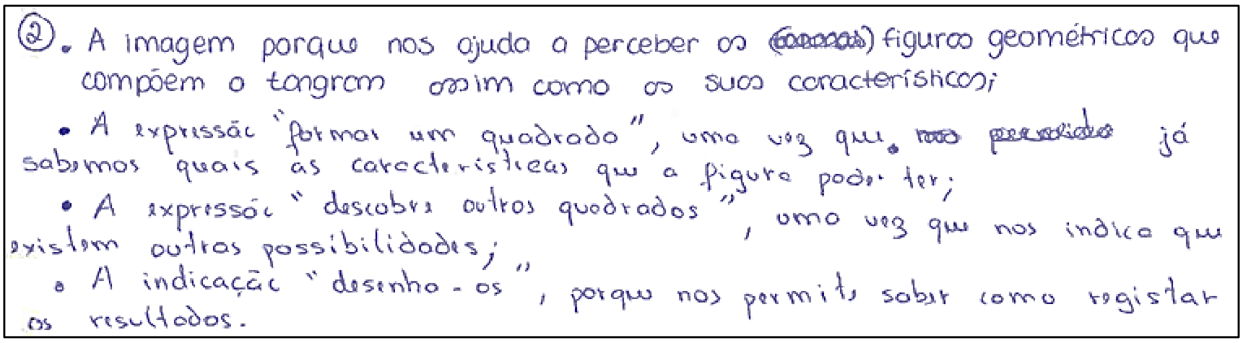
② • A imagem porque nos ajuda a perceber as figuras geométricas que compõem o tangram assim como as suas características;
• A expressão "formar um quadrado", uma vez que, já sabemos quais as características que a figura pode ter;
• A expressão "descobre outros quadrados", uma vez que nos indica que existem outras possibilidades;
• A indicação "desenha-os", porque nos permite saber como registar os resultados.

Figure 3. Excerpt from the Exploration Sheet of One of the Groups of Pre-Service Primary School Teachers. (Translation: The image helps us understand the geometric shapes that make up the tangram, along with their characteristics. The phrase "form a square" is important because we already know the characteristics that the shape must have. The phrase "discover other squares" indicates that there are multiple possibilities. The instruction "draw them" guides us on how to document the results.)

Still in Phase 1, after addressing the problem situations, the pre-service primary school teachers were asked to develop a hypothetical plan for their internship contexts. In each session, the planning proposals were discussed with the whole class. Initially, the pre-service primary school teachers didn't seem to be able to select the essential objective of each task and ended up writing various objectives they found in the curriculum in their planning proposals. In her critical reflection, one of the pre-service primary school teachers highlights the development of Abstraction throughout the training process, as shown in the excerpt below.

> *"...I used to set several learning objectives without realizing that in practice it would be completely impossible to develop them all. Later, I learned to focus on fewer objectives and focus on identifying the potential of a single task and how I could mobilize knowledge through it..."*

In Phase 2 of the training program, another pre-service primary school teacher mentions in her critical reflection that she ended up reformulating the plan she had drawn up for her internship context several times. The pre-service primary school teacher highlights the development of the Abstraction dimension throughout the training, mentioning that she focused on recognizing the essential characteristics of the internship class, including the students' interests, values, and reactions, in order to create a proposal that was truly adapted to her context. The excerpt from the critical reflection is presented below.

> *"Since the beginning of the semester, there have been many changes to the lesson plan for the final project. Together with my colleagues, I felt that what we had proposed didn't suit our internship class, so after better understanding their interests, their values and essentially their reactions, we adapted the proposal."*

4.2. Reasoning

Table 5 presents the distribution of relative and absolute frequencies for the five items constituting the Reasoning dimension. The data analysis indicates a substantial improvement in pre-service primary school teachers' self-efficacy in Computational Thinking following the intervention. Post-Intervention, negative responses (levels 1 and 2) were completely absent, and neutral responses (level 3) dropped dramatically from 26.3% Pre-Intervention to only 3.7% (see Table 5). Moreover, positive responses (levels 4 and 5) increased significantly across all items, with a particular improvement in pre-service primary school teachers perceived ability to assess the adequacy of the solutions they choose in relation to the problem's objective (item Q16). This aspect showed an increase in positive responses from 47.3% in the Pre-Intervention phase to 94.8% in the Post-Intervention phase, indicating a strengthened capacity for critical evaluation in problem-solving.

Table 5. Distribution of Relative (%) and Absolute Frequencies of DRacc.

Item	Pre-Intervention (%(*n*))					Post-Intervention (%(*n*))				
	Negative		Neutral	Positive		Negative		Neutral	Positive	
	1	2	3	4	5	1	2	3	4	5
Q1	0.0(0)	0.0(0)	5.3(2)	71.1(27)	23.7(9)	0.0(0)	0.0(0)	0.0(0)	50.0(19)	50.0(19)
Q7	0.0(0)	7.9(3)	18.4(7)	60.5(23)	13.2(5)	0.0(0)	0.0(0)	5.3(2)	65.8(25)	28.9(11)
Q9	0.0(0)	5.3(2)	28.9(11)	47.4(18)	18.4(7)	0.0(0)	0.0(0)	0.0(0)	57.9(22)	42.1(16)
Q13	0.0(0)	15.8(6)	36.8(14)	44.7(17)	2.6(1)	0.0(0)	0.0(0)	7.9(3)	71.1(27)	21.1(8)
Q16	0.0(0)	10.5(4)	42.1(16)	36.8(14)	10.5(4)	0.0(0)	0.0(0)	5.3(2)	47.4(18)	47.4(18)
M (%)	0.0%	7.9%	26.3%	52.1%	13.7%	0.0%	0.0%	3.7%	58.4%	37.9%

Table 6 presents the descriptive statistics and a comparison of Pre- and Post-Intervention results for the Reasoning dimension (DRacc). The mean score increased from 18.58 (SD = 2.70) before the intervention to 21.71 (SD = 1.84) afterward, indicating a notable improvement. The difference is statistically significant (t = -7.671, p = 0.001), with a very large effect size (d = 1.244). These findings suggest that the intervention had a substantial impact on enhancing the self-efficacy of pre-service primary school teachers regarding the Reasoning dimension of Computational Thinking. This means that pre-service primary school teachers demonstrated an increased perception of their ability to recognize patterns in data, classify them by type, assess the adequacy and sufficiency of data, and select the most efficient and appropriate solutions to achieve specific goals.

Table 6. Descriptive Statistics and Comparison Between the Two Applications of the Scale – DRacc (Pre-Intervention and Post-Intervention).

		M	*SD*	*t*	*p*	*d*	Effect size
DRacc	Pre-Intervention	18.58	2.70	-7.671	0.001	1.244	Very large
	Post-Intervention	21.71	1.84				

Qualitative analysis revealed evidence of the development of the Reasoning dimension, supporting the improvements identified in the quantitative findings for this dimension. In Phase 1 of the training program, Stage 2 began with pre-service primary school teachers engaging in problem-solving tasks designed to develop Computational Thinking dimensions. Beyond solving the tasks, they were required to articulate the reasoning behind their solutions. The following dialogue illustrates the development of the Reasoning dimension, as a pre-service primary school teacher explains to the researcher how her group approached the problem, emphasizing their critical evaluation of the solutions they formulated.

> *Pre-service* primary school *teacher E: So, to solve this question, we looked at the divisors of 140 and then, given the divisors, we checked how many rows there could be and how many chairs each row would have. [...] We found that if we had a row of 140 chairs, the people standing to one side probably wouldn't be able to hear or see. So, by excluding parts and following this reasoning, we decided that the only*

possibilities would be to have five rows with 28 chairs, [...] seven rows with 20 chairs, twenty rows with seven chairs and 14 rows with ten chairs.

This excerpt illustrates a process of analysis and decision-making based on the adequacy of the solution to the context of the situation, an essential aspect of Reasoning. The pre-service primary school teachers not only identified mathematically valid solutions but also applied an evaluation criterion to select those that best suited the spatial requirements. In this way, Reasoning manifests itself in the ability to formulate, test, and refine strategies until reaching the best solution to the problem.

In Phase 2 of the training program, during the micro-teaching sessions, pre-service primary school teachers had the opportunity to implement their proposals with their peers acting as primary school students. At the end of each session, a discussion was held to analyze both the strengths and areas for improvement in the proposal, with pre-service primary school teachers receiving feedback from their colleagues and the researcher. This process contributed to the development of the Reasoning dimension. It required pre-service primary school teachers to structure a revised plan based on critical evaluation and feedback. This revision ultimately refined the final solution for their internship intervention. One pre-service primary school teacher highlights the significance of this stage in her critical reflection at the end of the training program, as shown in the excerpt below.

"I think that implementing the educational practice in the classroom, before implementing it in the internship context, was very beneficial. This experimentation allowed me to assess the feasibility of the educational practice, identify its weaknesses and anticipate what difficulties the students might experience, leaving me better prepared to deal with them."

The excerpt shows that the pre-service primary school teacher has developed the ability to identify and improve the less positive points of her proposal, to find the solution that best fits the intended objective.

4.3. Decomposition

The distribution of the relative and absolute frequencies of the items in the Decomposition dimension, shown in Table 7, indicates a positive evolution in the participants' perceptions after the intervention. Negative responses decreased from 10.5% Pre-Intervention to 1.3% Post-Intervention. Neutral perception responses also decreased, from 36.2% to 7.2% after the intervention. Regarding positive perception responses, there was an increase from 53.3% to 91.5% after the intervention (see Table 7). An especially significant increase in positive perception responses was recorded for the ability to break down complex problems into simpler sub-problems (Item Q17). Positive responses for this aspect increased from 29% in the Pre-Intervention phase to 89.5% in the Post-Intervention phase, suggesting a development in participants' perception of their Decomposition skills.

Table 7. Distribution of Relative (%) and Absolute Frequencies of DDecomp.

Item	Pre-Intervention (%(*n*))					Post-Intervention (%(*n*))				
	Negative		Neutral	Positive		Negative		Neutral	Positive	
	1	2	3	4	5	1	2	3	4	5
Q3	0.0(0)	18.4(7)	36.8(14)	36.8(14)	7.9(3)	0.0(0)	5.3(2)	15.8(6)	50.0(19)	28.9(11)
Q8	0.0(0)	5.3(2)	34.2(13)	50.0(19)	10.5(4)	0.0(0)	0.0(0)	0.0(0)	47.4(18)	52.6(20)
Q12	0.0(0)	5.3(2)	15.8(6)	65.8(25)	13.2(5)	0.0(0)	0.0(0)	2.6(1)	47.4(18)	50.0(19)
Q17	0.0(0)	13.2(5)	57.9(22)	23.7(9)	5.3(2)	0.0(0)	0.0(0)	10.5(4)	57.9(22)	31.6(12)

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M (%)	0.0%	10.5%	36.2%	44.1%	9.2%	0.0%	1.3%	7.2%	50.7%	40.8%

Analysis of the data shown in Table 8 reveals a significant evolution in the participants' perceptions of the Decomposition dimension after the intervention. The mean score increased from 14.08 Pre-Intervention to 17.24 Post-Intervention, reflecting a clear improvement in responses. The difference observed between the means was statistically significant, as can be seen from the value of Student t-test of -8.269 and p-value of 0.001, which suggests that the change was not random, but a result of the intervention implemented. Cohen's d value of 1.341 indicates that the effect size was very large. The results presented here, as well as the increase in the distribution of positive perception responses presented above, reinforce the effectiveness of the intervention implemented. These results show that the intervention had a positive and relevant impact, bringing about a significant change in the participants' perception of the dimension analyzed. For the Decomposition dimension, this means that the perception of pre-service primary school teachers showed an improvement in their perception of their ability to identify the structure of a problem, recognize sub-problems, organize the processes for solving them, and, when necessary, break them down into even simpler components to facilitate resolution.

Table 8. Descriptive Statistics and Comparison Between the Two Applications of the Scale – DDecomp (Pre-Intervention and Post-Intervention).

		M	*SD*	*t*	*p*	*d*	**Effect size**
DDecomp	Pre-Intervention	14.08	2.22	-8.269	0.001	1.341	Very large
	Post-Intervention	17.24	1.91				

The qualitative analysis of pre-service primary school teachers' verbal explanations and interactions reveals evidence supporting the development of the Decomposition dimension. While solving the problem situations, the pre-service primary school teachers were asked to subdivide and list small steps that they had to solve to reach the final solution for each situation. The following dialogue illustrates the development of the Decomposition dimension, as a pre-service primary school teacher explains to the researcher how her group systematically approached the problem, with each stage contributing to the construction of the final solution.

> *Pre-service* primary school *teacher N: So, we did it in stages. First, the analysis of the statement, then removing the fundamental elements from the statement, then exploring the Tangram pieces by trial and error.*
>
> *Researcher: Okay.*
>
> *Pre-service* primary school *teacher N: Identify the number of pieces that make up the requested figure, which is the square. Diagram each set obtained, recognizing the pattern. Analyze the results obtained and then reflect on what was schematized to see if it corresponded to the request or not and correct something.*

This process of breaking down a larger problem into smaller parts reinforces the importance of Decomposition when tackling complex tasks, allowing pre-service primary school teachers to develop more effective and organized strategies. In Phase 2 of the training, while preparing their intervention proposal for the internship context, pre-service primary school teachers demonstrated their development of the Decomposition dimension by breaking down tasks into smaller, interconnected steps. In this process, the pre-service primary school teachers had to anticipate the students' possible difficulties, formulate guiding questions, and adapt their strategies accordingly.

Below is an excerpt from a pre-service primary school teacher's critical reflection, demonstrating how she structured the assigned task by breaking it down into smaller steps, ultimately leading to the development of the final lesson plan.

> *"I think that during the implementation in the internship context I was able to identify the students' difficulties and ask guiding questions to clarify them. Experimenting the implementation in the class helped me a lot to understand what kind of questions I would have to ask depending on the difficulties the students had. When planning, I had already anticipated the students' possible difficulties and prepared guiding questions in this regard."*

4.4. Generalization

Table 9 illustrates a positive shift in perceptions within the Generalization dimension, with an increase in positive responses and a decline in both negative and neutral responses, consistent with trends observed in other dimensions. In the post-intervention phase, there were no more negative perception responses, while neutral responses dropped to 2.6%, compared to 4.6% negative and 15.1% neutral responses recorded in the Pre-Intervention phase (see Table 9). All the items saw an increase in positive perception responses. This suggests an improvement in pre-service primary school teachers' perception of their ability to relate new problems to previously solved ones, for example, by recognizing whether they are similar (item Q4) or different (item Q14) from problems encountered earlier. This was especially evident in item Q14 that exhibited a substantial rise in positive responses, increasing from 65.8% in the Pre-Intervention phase to 100% in the Post-Intervention phase.

Table 9. Distribution of Relative (%) and Absolute Frequencies of DGener.

Item	Pre-Intervention (%(*n*))					Post-Intervention (%(*n*))				
	Negative		Neutral	Positive		Negative		Neutral	Positive	
	1	2	3	4	5	1	2	3	4	5
Q4	0.0(0)	5.3(2)	7.9(3)	52.6(20)	34.2(13)	0.0(0)	0.0(0)	0.0(0)	44.7(17)	55.3(21)
Q6	0.0(0)	2.6(1)	18.4(7)	65.8(25)	13.2(5)	0.0(0)	0.0(0)	7.9(3)	44.7(17)	47.4(18)
Q11	0.0(0)	2.6(1)	7.9(3)	73.7(28)	15.8(6)	0.0(0)	0.0(0)	2.6(1)	47.4(18)	50.0(19)
Q14	0.0(0)	7.9(3)	26.3(10)	55.3(21)	10.5(4)	0.0(0)	0.0(0)	0.0(0)	63.2(24)	36.8(14)
M (%)	0.0%	4.6%	15.1%	61.8%	18.4%	0.0%	0.0%	2.6%	50.0%	47.4%

Table 10 highlights the impact of the intervention on participants' perceptions of the Generalization dimension, demonstrating a measurable improvement. The mean score increased from 15.76 Pre-Intervention to 17.79 Post-Intervention, reflecting a positive shift in participants' self-efficacy. The values of t = -5.498 and p = 0.001 indicate that the differences observed were statistically significant and with a very large effect size, as shown by the d value = 0.892. These findings suggest that, in the Generalization dimension, pre-service primary school teachers improved their perception of their ability to relate current problems to both real-life contexts and previously encountered situations, through the identification of similarities and differences and the establishment of meaningful connections.

Table 10. Descriptive Statistics and Comparison Between the Two Applications of the Scale – DGener (Pre-Intervention and Post-Intervention).

	M	*SD*	*t*	*p*	*d*	Effect size

DGener	Pre-Intervention	15.76	2.03	-5.498	0.001	0.892	Very large
	Post-Intervention	17.79	1.71				

Based on the qualitative analysis, evidence is presented to support the identified changes in the Generalization dimension. While solving the problem situations in Phase 1, the pre-service primary school teachers were asked to explore different strategies and identify common elements between them. This process led them to reflect and recognize effective steps in solving the situations that could be applied to new solutions, thus developing the Generalization dimension. Figure 4 shows a record made by a group of pre-service primary school teachers, in which they identified and recorded effective steps in the resolution they made and then applied them to the other resolutions of the situation.

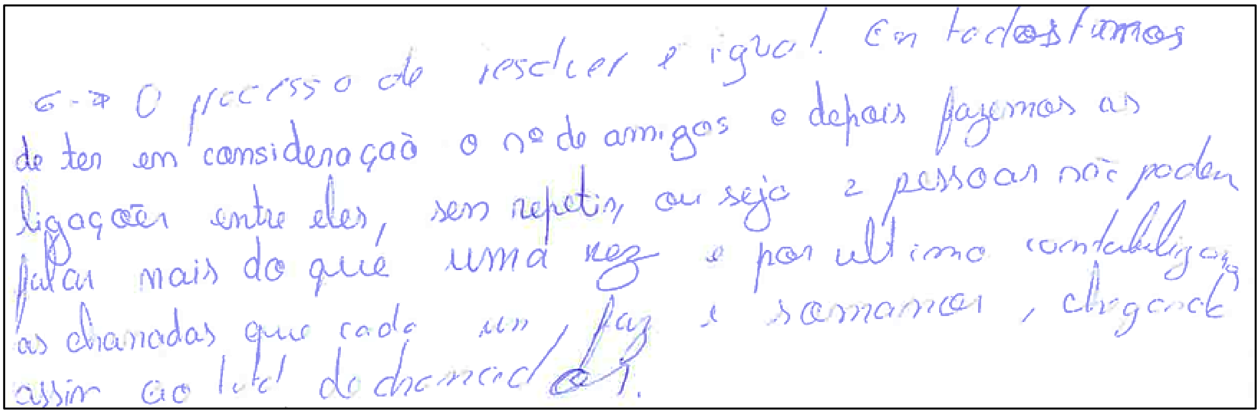
6-> O processo de resolver é igual. Em todos temos
de ter em consideração o nº de amigos e depois fazemos as
ligações entre eles, sem repetir, ou seja 2 pessoas não podem
falar mais do que uma vez e por último contabilizamos
as chamadas que cada um faz e somamos, chegando
assim ao total de chamadas.

Figure 4. Excerpt from the Exploration Sheet of One of the Groups of Pre-Service Primary School Teachers. (Translation: The process of solving is the same. In every case, we must consider the number of friends, then establish the connections between them without repetition—meaning that two people cannot talk more than once. Finally, we count the calls each person makes and sum them up to reach the total number of calls.)

The micro-teaching sessions implemented in Phase 2 of the training program allowed pre-service primary school teachers to observe the implementation of various teaching strategies and resources suitable for primary school students. By analyzing these sessions and incorporating feedback from colleagues and the researcher, pre-service primary school teachers identified effective teaching strategies and adapted them to their internship contexts. In the critical reflection excerpt below, the pre-service primary school teacher demonstrates the development of the Generalization dimension as she recognizes the effectiveness of a resource in exploring and systematizing mathematical content, which led her to integrate it into her teaching practice.

> *"By observing my colleagues' different implementation preparations, I was able to see various resources that can be used both to develop a topic and to systematize it, such as HypatiaMat. Several groups used this platform, which gave me a practical insight into its importance. Although my group didn't use this platform in the intended implementation, we began to use it more frequently during the internship. In this way, I was able to see the importance of using this resource with the students, since they became more autonomous and were able to deepen and systematize various mathematical contents in a playful and interesting way."*

5. Discussion

The following discussion will explore how these substantial improvements in self-efficacy relate to the key characteristics of the training program, drawing on insights from the specialist literature.

To contextualize the discussion of the results, it is useful to briefly recall the overall structure of the training program, whose design may help explain the improvements observed in pre-service primary school teachers' self-efficacy. The training program was implemented over a school year, integrating theoretical, practical, and reflective components, in line with recommendations from studies in the field (Butler & Leahy, 2021; Mason & Rich, 2019; Rodrigues et al., 2024). Phase 1 of the study was divided into three stages, starting with Stage 1, which focused on equipping pre-service primary school teachers with the theoretical knowledge needed for the topics covered during the school year. Stage 2 aimed to provide pre-service primary school teachers with hands-on experience in implementing tasks designed for primary education, allowing them to adapt and plan a hypothetical application tailored to their internship context. In stage 3, the pre-service primary school teachers shared with the rest of their colleagues and the researcher an intervention proposal for their internship, which had been prepared throughout Stage 1 under the guidance of the researcher.

The significant improvement observed in the Abstraction dimension can be attributed to the nature of the tasks designed, which explicitly required pre-service primary school teachers to identify essential information for solving problem situations, an approach aligned with the theoretical definition of Abstraction as highlighted by Martínez et al. (2022). Furthermore, the Abstraction appeared to strengthen from Phase 1 to Phase 2, particularly through the lesson planning activities. In this stage, pre-service primary school teachers refined their intervention proposals by focusing more selectively on key elements, demonstrating the capacity to prioritize core information and structure solutions effectively. This suggests that engaging in lesson planning, reflection, and feedback may help pre-service primary school teachers focus on the essential aspects to be improved in their intervention proposals, thereby enhancing their Abstraction skills, as mentioned by Dong et al. (2024). The development of the Reasoning dimension is evident in Phase 1, as the pre-service primary school teachers were encouraged to explain and justify their choices to both the researcher and their colleagues. This reflective process occurred during problem-solving activities and lesson planning, enabling them to critically assess and refine their decisions, aligning with Li et al. (2024). The improvements observed in the Decomposition dimension can be explained by the characteristics of the tasks and the Exploratory Teaching Practices adopted during the intervention, which required pre-service primary school teachers to break down tasks into smaller steps and articulate their step-by-step solutions during discussions. This approach is consistent with what Voon et al. (2022) highlight as essential for fostering Decomposition skills. Finally, the changes observed in the Generalization dimension can be explained from the way pre-service primary school teachers were encouraged to recognize patterns across different problem-solving approaches. This process enabled them to identify the most effective steps and systematically apply them to other solutions, as highlighted by Hsu and Tsai (2024).

It is also important to highlight that Stage 2 of the training program, where problem situations were implemented with pre-service primary school teachers, aligns with the recommendations of Täschner et al. (2025). These authors mention that pre-service teachers' self-efficacy, in general, can be enhanced through experiences involving the observation of best practices. Furthermore, the discussion of problem situations, the development of planning proposals, and Stage 3 of this phase are linked to another key factor in increasing self-efficacy—social persuasion—as collaboration and feedback from both the researcher and Initial Teacher Training colleagues played a crucial role in this process.

In Phase 2 of the training program, during Stage 4, each group conducted micro-teaching sessions, implementing a portion of their intervention plan with their colleagues acting as primary school students. Stage 5 involved the implementation of the refined intervention plan in their actual internship contexts, followed by Stage 6, where they shared the results of their implementation with the rest of their colleagues. Regarding the Abstraction dimension in Phase 2, the continued improvement is linked to the reflective lesson planning process begun in Phase 1. Pre-service primary school teachers revisited and adapted their initial plans to better fit the specific characteristics of their teaching contexts. This ongoing reflection allowed them to refine their intervention proposals, ensuring relevance and effectiveness. As previously noted, this process helps pre-service primary school teachers enhance their ability to focus on essential elements, thereby further developing their Abstraction skills, as defined by Martínez et al. (2022) and Dong et al. (2024). The process of developing the intervention plan may explain the improvement observed in the Reasoning dimension, as pre-service primary school teachers not only structured the plan but also systematically refined it, tested strategies, and iterated their approach until reaching a final proposal. This iterative approach reflects core aspects of Reasoning dimension, particularly the ability to evaluate the adequacy of a solution and make adjustments as needed, which is in line with what is mentioned by Román-González et al. (2017). The enhancement in the Decomposition dimension can be understood considering the process of developing the implementation plans. This required that pre-service primary school teachers break down the overall activity into smaller, manageable parts and solve each part until achieving the overall objective. This approach reflects the characteristics of Decomposition skills as outlined by Haşlaman et al. (2024). The micro-teaching sessions and the final sharing of the implementation, where the pre-service primary school teachers had the opportunity to observe different implementations with different resources and strategies, helps to understand the improvement in the Generalization dimension. In line with Yun and Crippen (2024), Generalization dimension develops when pre-service primary school teachers can identify effective solutions and successfully apply them to new tasks, which was evident in this phase of the program.

Finally, it should be noted that the micro-teaching sessions implemented in Phase 2 of the program are impactful experiences that helped pre-service primary school teachers to gain confidence, as mentioned by Täschner et al. (2025). Throughout the program, pre-service primary school teachers engaged in multiple opportunities to learn through observation, collaborate with peers, receive feedback, and reflect on their practices, all of which contributed to strengthening their self-efficacy (Dong et al., 2024; Täschner et al., 2025).

Although the results of this study provide relevant contributions to the field of research, some aspects stand out that could be improved in future studies. Exploring the long-term impact of this type of training on primary school teachers' professional practice would be particularly relevant. Longitudinal studies could examine whether the skills developed during initial training are sustained in professional teaching practice. Extending the duration of the training program could also provide deeper insights into the evolution of pre-service primary school teachers' self-efficacy.

The sample composition, predominantly female participants from a Portuguese higher education institution, reflects the typical demographics of Initial Teacher Training courses in the country. To enhance the generalizability of the findings, it is recommended that this training program be adapted and replicated in different contexts, including other higher education institutions and in-service teacher training programs. This would help assess its effectiveness among teachers with varying backgrounds and across different educational levels.

6. Conclusion

This study analyzed the perceptions of pre-service primary school teachers regarding their self-efficacy following the implementation of a training program designed to enhance their didactic knowledge. Thus, we aimed to answer the research question: Are there statistically significant differences in pre-service primary school teachers' perceptions of self-efficacy in Computational Thinking between the Pre- and Post-Intervention phases?

Based on the research question and the results obtained, it can be concluded that the implemented training program had a positive and significant impact on pre-service primary school teachers' perceptions of self-efficacy in Computational Thinking. This study showed an improvement in pre-service primary school teachers' perceptions of self-efficacy, resulting from participation in a training program combining theoretical, practical, and reflective components. This structure contributed to increased confidence, competence, and ultimately enhanced self-efficacy in Computational Thinking. The improvement in the Reasoning dimension was driven by the implementation of complex tasks throughout the study, which required pre-service primary school teachers to structure intervention plans, reflect on them, and share their insights. The Abstraction dimension improved due to the need to identify and focus on essential task elements throughout the program, enhancing pre-service primary school teachers' ability to adapt tasks to real educational contexts. The Decomposition dimension showed progress as tasks were progressively structured, requiring pre-service primary school teachers to break down problems into smaller, more manageable parts, facilitating their resolution. Meanwhile, the improvement in the Generalization dimension can be attributed to both the nature of the tasks implemented and the structured opportunities for sharing and discussion. These collaborative moments allowed pre-service primary school teachers to identify effective strategies and apply them across different contexts. In addition, the training program provided pre-service primary school teachers with opportunities to observe classroom practices, conduct micro-teaching sessions, and participate in discussions that fostered peer collaboration and constructive feedback. These aspects also played a crucial role in enhancing pre-service primary school teachers' self-efficacy.

Thus, this study demonstrates an approach to enhancing pre-service primary school teachers' perceptions of self-efficacy in Computational Thinking, through the implementation of a training program within Initial Teacher Training. Grounded in both theory and practice, this approach reinforces the importance of integrating Computational Thinking into teacher training, equipping future educators with the confidence and competence to apply this skill in their professional contexts.

7. Implications and Suggestions

The results of this study have important implications for Initial Teacher Training for primary education, highlighting how the development of self-efficacy in Computational Thinking can be promoted through structured programs that integrate theoretical, practical, and reflective components. Given the significant importance of self-efficacy in the professional development of pre-service primary school teachers, it is recommended that programs with the characteristics of the one implemented in this study continue to be developed and applied. Thus, research on promoting self-efficacy among pre-service primary school teachers will be continued and contribute to a more robust understanding of effective training strategies in Computational Thinking.

Declarations

Author Contributions. RNR, CC, MA, SB-C & FM: resources, visualization, writing – review & editing; RNR: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, software, validation, writing – original draft; CC: conceptualization, data curation, supervision, validation; MA: writing – review & editing original draft; SB-C: conceptualization, formal analysis, funding acquisition, methodology, software, supervision, writing – original draft; FM: conceptualization, data curation, formal analysis, funding acquisition, methodology, project administration, software, supervision, validation. All authors have read and approved the final version of the article.

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About the Contributor(s)

Rita Neves Rodrigues, is a PhD student in Science and Technology Education Research of the University of Trás-os-Montes and Alto Douro, Portugal and an invited lecturer at the Polytechnic University of Coimbra. PhD Research Fellow at the Foundation for Science and Technology, researcher at the research Centre on Didactics and Technology in the Education of Trainers at the University of Aveiro. Research interests include Mathematical Education, focusing on developing the didactic knowledge of pre-service teachers so that they can integrate the dimensions of Computational Thinking into their practices, simultaneously promoting learning of mathematical knowledge.
Email: ritanevesrodrigues@hotmail.com
ORCID: https://orcid.org/0000-0001-8072-8453

Cecília Costa, is an Associate Professor at the School of Science and Technology of the University of Trás-os-Montes e Alto Douro, Portugal. With a PhD in Mathematics and Habilitation in Didactics of Science and Technology, she is the director of the doctoral course in Science and Technology Didactics, and she teaches Didactics of Mathematics in several teacher training courses and a researcher at the research Centre on Didactics and Technology in the Education of Trainers at the University of Aveiro (UIDB/00194/2020). Her main research areas are Sciences and Technological Education (STEM) Research, in particular: teaching practices and teacher mediation of student learning, teacher education and professional development, artefacts as epistemic tools to enhance STEM learning, and Instrumental Orchestration.
Email: mcosta@utad.pt
ORCID: https://orcid.org/0000-0002-9962-562X

Maryam Abbasi, is a researcher specializing in Artificial Intelligence (AI) and Machine Learning, with a strong academic background that includes a PhD in Informatics Engineering, a Master's degree, and a Bachelor's degree in Computer Science. She is affiliated with the Institute of Applied Research (i2A) at the Polytechnic Institute of Coimbra (IPC), the Centre for Natural Resources, Environment and Society (CERNAS), and the Laboratory of Artificial Neural Networks (LARN) at the Center for Informatics and Systems of the University of Coimbra (CISUC). Her research focuses on advanced data science and pattern recognition techniques in AI and machine learning to address complex biological problems. She develops innovative algorithms that leverage these methods to model challenges and provide meaningful insights. Her interdisciplinary expertise bridges computational modeling and practical applications, contributing to advancements in both AI methodologies and their implementation in diverse domains.
Email: maryam.abbasi@ipc.pt
ORCID: https://orcid.org/0000-0002-9011-0734

Sónia Brito Costa, is a lecturer and researcher at the Polytechnic University of Coimbra. She holds a Bachelor's, Master's, PhD, and Post-Doctorate in Psychology. She is also certified in Cognitive Behavioral Psychotherapy (APTC), Legal Medicine and Forensic Sciences, Health Ethics, Gender Equality, and Human Trafficking Prevention and Victim Support. Recognized as a Specialist in Clinical and Health Psychology and an Advanced Specialist in Justice Psychology by the Portuguese Psychologists' Order, she is additionally a certified trainer (CNQF). She also coordinates the Coimbra Branch of the Centre for Research and Innovation in Education (INED). She has authored over 80 publications and contributed extensively to international conferences. She acts as Expert Evaluator at the European Commission, and she is also reviewer and editor in various editorial boards, dedicated to advancing research in psychology.
Email: sonya.b.costa@gmail.com
ORCID: https://orcid.org/0000-0002-7074-887X

Fernando Martins, is a Full Professor at the Polytechnic University of Coimbra - Coimbra Education School, Portugal. With Aggregate Degree in Child Studies and a PhD in Mathematics, he teaches Mathematics and Didactics of Mathematics subjects in Basic Education degrees and Master's in Training for Educators and Teachers. Researcher at the inED - Centre for Research and Innovation in Education (UIDB/05198/2020, and DOI identifier https://doi.org/10.54499/UIDB/05198/2020), Instituto de Telecomunicações (UIDB/50008/2020, and DOI identifier https://doi.org/10.54499/UIDB/50008/2020) and Research Group in Training, Education, and Intervention. Research interests include mathematical knowledge for teaching, mathematical methods applied to sports sciences problems and engineering, social network analysis, elementary mathematics, computational thinking, educational robotics, and STEAM education.
Email: fmlmartins@esec.pt
ORCID: https://orcid.org/0000-0002-1812-2300