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Exploring Pre-Service Teachers' Perceptions of the Educational Value and Benefits of Computational Thinking and Programming

Vanessa Izquierdo-Álvarez and Ana María Pinto-Llorente *

Research GRoup in InterAction and eLearning (GRIAL), Research Institute for Educational Sciences (IUCE), University of Salamanca, 37008 Salamanca, Spain; vizquierdo@usal.es

* Correspondence: ampintoll@usal.es

Abstract: Computational Thinking (CT) and programming encompass a range of skills that are essential in everyday life and play a crucial role in addressing social and environmental challenges. They facilitate the analysis and understanding of global issues, the evaluation of viable solutions, and the formulation of strategic decisions that contribute to Education for Sustainable Development and the achievement of the Sustainable Development Goals. The primary objective of this study was to examine pre-service teachers' perceptions of these areas. A quantitative study was conducted with 134 university students from the Faculty of Education and Tourism at the University of Salamanca. The findings indicate that CT and programming significantly contribute to enhancing digital competence, fostering essential skills for the effective use of technological tools, developing problem-solving strategies, and increasing self-confidence in identifying and refining solutions to complex problems. Regarding gender differences, significant differences were observed, with women scoring higher on average in various aspects. These included the ability to actively seek, compare, and select digital information from diverse sources and contexts, assess the potential risks associated with digital tools—such as security and identity concerns—and demonstrate confidence in accessing the necessary resources and training to integrate CT and programming into education.

Keywords: computational thinking; programming; algorithmic thinking; pre-service teachers; teacher training; higher education; digital competence; STEM; education for sustainable development; quality education

Academic Editor: Giulio Mario Cappelletti

Received: 17 December 2024
Revised: 21 February 2025
Accepted: 24 February 2025
Published: 3 March 2025

Citation: Izquierdo-Álvarez, V.; Pinto-Llorente, A.M. Exploring Pre-Service Teachers' Perceptions of the Educational Value and Benefits of Computational Thinking and Programming. *Sustainability* **2025**, *17*, 2164. https://doi.org/10.3390/su17052164

1. Introduction

Education is a fundamental tool for promoting sustainable development worldwide. More specifically, Education for Sustainable Development (ESD) equips learners with the knowledge, skills, attitudes, and values necessary to shape a sustainable future in which they can thrive economically, socially, and environmentally. ESD seeks to reduce inequalities and foster inclusiveness, quality, and equity in education. According to UNESCO [1], education plays a crucial role in achieving the Sustainable Development Goals (SDGs).

In this way, the SDGs contribute to global well-being by fostering more efficient education systems that transform teaching and learning environments. In this context, digital technologies can play a key role in advancing education for sustainability and enhancing learners' literacy.

According to the Royal Spanish Academy, literacy in today's society can be understood as 'to alphabetization' or as 'teaching someone to read and write'. It is a concept that has evolved and has been redefined over time, adapting to the historical context [2].

Traditionally, literacy has been associated with the ability to encode and decode written texts on paper. However, technological advances have transformed traditional reading and writing practises, making literacy a broader concept that extends beyond the development of reading, writing, and arithmetic skills.

Culture has become more complex, not only in the different codes and languages of representation but also in how information is accessed. As Bers [3] states, literacy involves the capacity to use a system of symbols and several tools to communicate, to express thoughts, etc., through a product that can be shared and understood by others. A definition that encompasses not only traditional literacy but also coding literacy, or 'code literacy', as some authors have called it [4].

The concept of literacy has, thus, expanded, giving rise to the 'code literacy' movement, which emerged over a decade ago in the United States. This movement advocates the notion that literacy today encompasses coding, a critical skill for navigating and thriving in the digital world. A new literacy that favours new ways of thinking, communicating, etc., to ensure citizens' participation. An early literacy that allows students to learn the principles of coding, integrating it into their natural language [3].

According to Balanskat and Engelhardt [5], ensuring that citizens acquire strong digital skills is a key factor in achieving a successful digital transformation, which also requires the development of CT skills such as problem solving and logical reasoning. Education plays a crucial role in equipping students with these skills, enabling them not only to use but also to create digital technologies, thereby allowing them to thrive in contemporary society.

Other scholars, such as Merle Huerta [6], also emphasise this perspective, highlighting that coding represents a new form of literacy and serves as a powerful tool for promoting educational equity, fostering inclusion, enhancing neuroplasticity, and strengthening STEM skills.

1.1. CT in Education

CT is a term that has been used since the 1950s to describe structured or algorithmic thinking [7]. In 1980, Seymour Papert [8] at MIT further developed the concept of procedural thinking. Today, these terms have regained prominence as they are considered crucial for addressing the challenges of this century [9]. CT refers to a set of skills that are essential for everyday life and are not exclusive to Computing but can be applied across multiple disciplines [10]. It is a fundamental competence that needs to be developed from the earliest stages of education [11–13], as it is crucial for living and managing in the contemporary society [14].

According to Wing [14], CT encompasses a fundamental approach to problem solving that extends beyond the field of computer science, offering valuable skills that individuals from various fields can benefit from learning and applying. It is a logical approach to solving problems, creating systems, and understanding human behaviour by applying key principles of computer science. She [15] later added that it involves developing problem-solving strategies and structuring solutions in a way that enables efficient execution by an information processing system.

CT is a complex concept linked to abstract thinking, mathematical and pragmatic knowledge [16,17], logical and critical thinking [18], and creative thinking [19]. Since Papert [8] first introduced this term, there has been a growing consensus that learning CT fosters the development of social skills, teamwork abilities, and even time management skills [20].

The scientific literature identifies different CT skills such as abstraction, which involves focusing on what is important and disregarding unnecessary details [11,15,21]; problem decomposition, highlighting as one of the most relevant CT skills, as it entails breaking down a problem into its components [11,14,21]. This approach helps to better understand the problem and assess each component in isolation [22]; algorithmic thinking, which involves finding a solution to a problem through a series of steps [11,15,21]; task automation [10,14,15]; debugging, which allows for the correction of errors in the problem-solving process [21]; and generalisation, which involves identifying patterns that can be used to solve similar problems [17,21]. In this regard, Repenning et al. [23] identify three stages: problem formulation (abstraction), solution (automation), and execution and evaluation (analysis). These processes encompass a range of cognitive skills, such as decomposition of problems into smaller subproblems, organising and analysing information, representing abstractly, formulating and evaluating different solutions, and identifying the final solution [24]. These competences associated with CT are essential in advancing sustainable development and achieving the SDGs, addressing global challenges such as climate change, poverty, and inequality, while developing solutions that are both sustainable and equitable across different contexts [25]. Universities play a crucial role in sustainability, acting as fundamental agents of change [26] with the capacity to disseminate knowledge, drive innovation, and achieve social transformation through education [27,28].

In summary, CT is a process in which the application of fundamental computing concepts can help individuals solve everyday problems [13]. It involves skills that are applicable across disciplines, including computing, STEM, humanities, and social sciences [29]. CT plays a crucial role in addressing social, and environmental challenges as a tool to analyse and understand immediate and global issues in social, economic, scientific and environmental contexts, evaluate potential solutions, and make strategic decisions that contribute to developing the SDGs. As stated by Ramírez-Montoya et al. [25], linking sustainable development with CT enhances problem-solving abilities by incorporating key concepts of programming. Integrating CT into educational context can significantly improve students' capacity to address challenges related to sustainable development. By cultivating CT skills, educators can provide learners with the necessary tools to engage with issues that are linked to SDGs such as quality education (SDG 4) or gender equality (SDG 5).

1.2. Integration of CT into Curriculum

As previously discussed, countries integrate CT skills into their compulsory curricula for multiple reasons, reflecting the growing recognition of CT as an essential competency in the 21st century education landscape. One of the primary motivations is to enhance students' problem-solving abilities, enabling them to approach complex challenges systematically and develop efficient and sustainable solutions. CT also helps foster creativity by encouraging innovative thinking and the exploration of multiple approaches to problem solving. Additionally, it strengthens communication and collaboration skills, as many CT-related activities, such as coding and algorithmic design, require teamwork and effective articulation of ideas.

Beyond these cognitive and social benefits, the integration of CT into curricula plays a crucial role in promoting programming and coding literacy, equipping students with fundamental skills for an increasingly technology-driven world. Additionally, it helps develop logical thinking, critical thinking, and analytical reasoning as it encourages students to apply structured reasoning to derive solutions. Moreover, it contributes to the development of digital literacy and numeracy skills, preparing students to engage effectively with digital tools and quantitative information in various contexts.

These predominant rationales highlight the recognition of CT integration as a foundational element of general education, aligning with broader educational goals that are aimed at preparing students for both academic success and future employment opportunities. By integrating CT into curricula, the objective is not only to support learners' cognitive and professional development but also to contribute to the formation of a workforce that must be technologically proficient and capable of driving innovation in an increasingly digital and interconnected sustainable global economy.

There is currently a consensus in various countries to integrate CT into the curriculum [29], as it is a skill that helps individuals navigate today's digital society and offers numerous benefits. In this regard, many European countries have already taken steps to incorporate CT into the teaching–learning process [22], a trend that is also observed globally [13,30].

Authors such as Bocconi et al. [30] highlight the benefits of CT in reducing social gaps and supporting the education system as a means of social mobility. Some countries are integrating CT into their curricula, with some offering it as a compulsory subject and others as an optional one [29]. Sometimes CT is integrated into the curriculum as a specific subject, such as Computing or Information and Communication Technologies (ICT) [30–32]. Another way to integrate CT is through STEM subjects such as Mathematics or Biology [33,34]. In this sense, some authors point out how CT is integrated into different subjects in a way that promotes the development of skills and competences associated with CT such as self-efficacy, motivation, communication, social interaction, or algorithmic thinking.

However, it is not only essential to train students in CT through one or more subjects in the curriculum but also to provide adequate training for teachers. In this regard, teachers and future educators are key actors in the integration of CT into the education system [10,35]. Hamed et al. [36] emphasises the importance of including CT training in initial teacher education so that future teachers are prepared to meet the current demands of the digital landscape and contribute to ESD. Several studies in the scientific literature examine the perceptions and knowledge of both pre-service and in-service teachers regarding CT [37,38]. Research suggests that teachers acknowledge the necessity of developing CT skills as a prerequisite for effectively applying them in the classroom. In this sense, the present study aims to assess how teachers in their first year of training perceive CT and programming and its integration into the educational environment.

2. Literature Review

The recent research on CT across different educational stages has developed a broad body of research focusing on areas such as Coding [39,40], Mathematics [41,42], Linguistics [39,43], Science [44,45], CT [16,17,39,46], Critical Thinking [16,17], Autonomous Learning [46,47], Creative Thinking [17,46–48], and Collaborative Learning [46,47,49].

Some studies highlight the importance of introducing children to CT from early childhood education [11,12,50], with positive effects observed when programmable robots are used [51,52]. For instance, the study by García-Valcárcel and Caballero-González [53], conducted with students aged between 3 and 6 years, demonstrated that the implementation of robotics activities significantly enhanced students' CT skills.

Other experiences in primary education, such as the study developed by Álvarez [54], suggest the benefits of using Scratch to promote CT dimensions and competences.

Another challenge concerns students' perceptions of mathematical tasks [55], particularly in relation to problem solving. This issue is further compounded by documented gender gaps in the scientific literature [55,56]. Additionally, international surveys indicate that boys tend to outperform girls in mathematics [57], highlighting an urgent issue that must be addressed to achieve educational equity [58].

An important challenge, however, is ensuring that teachers themselves are confident and adequately equipped to teach CT to their students [59]. The study by Barkela et al. [59] revealed that pre-service teachers often experience high levels of anxiety towards CT and have low expectations of success, which may hinder effective CT learning.

On the other hand, Çimsir et al. [60] developed a training programme for pre-service primary education teachers to acquire CT skills. The results showed that these teachers experienced positive effects on their CT skills, with qualitative findings highlighting their positive perceptions of the training and the development of CT competences. Similarly, Hamed et al. [36] conducted a study with pre-service teachers and found that the participants demonstrated above-average CT competences. These authors emphasised the importance of prior knowledge and experience in CT as a factor in developing strong CT skills among pre-service teachers.

Finally, some authors stress the importance of further research on this topic due to the growing need to train students in the use and integration of CT into the teaching–learning process [9]. Training in CT primarily contributes to the development of critical thinking skills and digital competence. In this regard, previous research suggests that training pre-service teachers in CT broadens their understanding of how to integrate it into the classroom practice. It is noted that pre-service teachers who lack CT training tend to have a superficial understanding of the concept and its application [9]. Furthermore, earlier studies indicate that there is a limited amount of research on CT with pre-service teachers [61,62].

3. Materials and Methods

3.1. Objective and Research Questions

The aim of the study was to assess the perceptions of teachers in their first year of training regarding CT and programming, as well as their integration into the educational environment.

The study addressed the following research questions:

RQ1. What competencies do pre-service teachers believe are fostered by the integration of CT into the teaching–learning process?

RQ2. What objectives are achieved by integrating CT and programming into the teaching–learning process?

RQ3. What are the attitudes of pre-service teachers towards the implementation of CT and programming in the classroom?

RQ4. What are the benefits of integrating CT and programming into the teaching–learning process?

RQ5. Are there significant gender differences in the perception of CT and programming?

3.2. Method

The research was carried out using a quantitative approach [63]. Based on this approach, the research objectives, and the design, a non-probability sampling method was chosen, specifically convenience or availability sampling. This type of sampling is used in situations where it is not feasible to use a probability sample, but the intention is still to obtain a representative sample of the target population under study.

3.3. Participants

The population consisted of 167 students from the Faculty of Education and Tourism at the University of Salamanca. These students were enrolled in the Bachelor's Degree in Primary Education, the Bachelor's Degree in Early Childhood Education, or the Double Bachelor's Degree in Primary Education and Early Childhood Education. All students were in the first year of their academic training, ensuring a similar level of academic preparation. The selection of this cohort at such an early stage guarantees a homogeneous exposure to pedagogical concepts related to CT. This control over the sample allows for a deeper understanding of their baseline knowledge, perceptions, and potential gaps in their preparation. The sample consisted of 134 participants: 54 were studying for a Bachelor's Degree in Early Childhood Education (40.3%), 59 for a Bachelor's Degree in Primary Education (44%), and 21 for a Double Bachelor's Degree in Primary Education and Early Childhood Education (15.7%). In terms of gender, the sample consisted of 36 males (26.9%) and 98 females (73.1%). The mean age of the sample was 19.19 years, with a standard deviation of 1.803 (Figure 1).

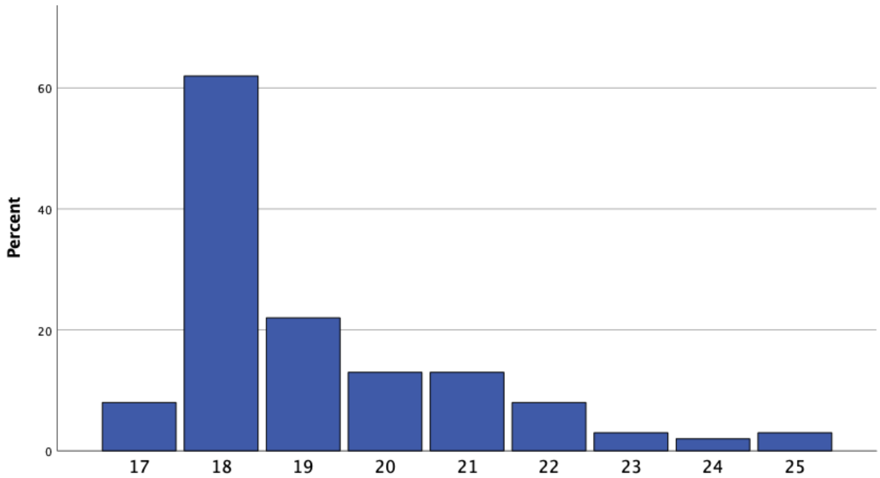

Figure 1. Distribution of the variable age.

3.4. Instrument

The instrument used for data collection was a questionnaire adapted from the research conducted by Peracaula-Bosch et al. [64] and Powers et al. [65]. The questionnaire was developed using Google Forms and distributed online to the students. The questionnaire consisted of four sections: socio-demographic data, competences that pre-service teachers consider to be promoted by the integration of CT into the teaching–learning process, objectives that are achieved by the integration of CT and programming into the teaching–learning process, attitudes of pre-service teachers towards the implementation of CT and programming in the teaching–learning process, and, finally, benefits of integrating CT and programming into the teaching–learning process.

The first section collects the socio-demographic data: age, gender (male, female, other), and degree in which the participants are enrolled (Bachelor's Degree in Primary Education, Bachelor's Degree in Early Childhood Education, Double Bachelor's Degree in Primary Education and Early Childhood Education). The following sections deal with five dimensions: Competences related to children's education, competences related to CT, objectives of integrating CT and programming into the teaching–learning process, pre-service teachers' attitudes towards CT and programming, and benefits of integrating CT and programming into the teaching–learning process. A total of 54 items (Table 1), categorised on a Likert scale from 1 to 4 points, were used for this purpose.

Table 1. Questionnaire items.

Dimension	Item	Text
Competences which are related to children's education	CE01	To coordinate and work with others as part of a team.
	CE02	To communicate efficiently, both verbally and in writing, with others while completing a task.
	CE03	To break down a complex task into smaller, manageable steps and determine the most efficient sequence.
	CE04	To be autonomous in addressing and completing the assigned tasks.
	CE05	To choose and use digital devices and applications effectively for task completion.
	CE06	To actively seek, compare, and select digital information, considering diverse sources and contexts.
	CE07	To consider rules or conditions that make it easier or more efficient to solve a task.
	CE08	To be able to identify methods to know whether you are approaching the solution while in the process of solving a task.
	CE09	To evaluate the potential risks of using digital tools, considering factors like security and identity.
	CE10	To explore creative solutions to problems and recognize that there are multiple solutions.
Competences which are related to CT	CCT01	To coordinate and work with others as part of a team.
	CCT02	To communicate efficiently, both verbally and in writing, with others while completing a task.
	CCT03	To break down a complex task into smaller, manageable steps and determine the most efficient sequence.
	CCT04	To be autonomous in addressing and completing the assigned tasks.
	CCT05	To choose and use digital devices and applications effectively for task completion.
	CCT06	To actively seek, compare, and select digital information, considering diverse sources and contexts.
	CCT07	To consider rules or conditions that make it easier or more efficient to solve a task.
	CCT08	To be able to identify methods to know whether you are approaching the solution while in the process of solving a task.
	CCT09	To evaluate the potential risks of using digital tools, considering factors like security and identity.
	CCT10	To explore creative solutions to problems and recognize that there are multiple solutions.

Table 1. *Cont.*

Dimension	Item	Text
Objectives of integrating CT and programming into the teaching–learning process	O01	To inspire students to pursue careers in science-related fields in the future.
	O02	To encourage students to engage in science and technology-related activities.
	O03	To acquire curricular knowledge and skills from science and mathematics.
	O04	To acquire curricular knowledge and skills in languages, humanities, and social sciences.
	O05	To acquire knowledge and skills in coding and educational robotics.
	O06	To acquire curricular knowledge and skills in any subject.
	O07	To improve digital competence.
	O08	To develop problem-solving strategies and enhance self-confidence when tackling complex projects with multiple potential solutions.
	O09	To acquire transversal skills (communication, critical thinking, etc.)
	O10	To provide an environment where students can engage in practical tasks, explore through play, and conduct experiments.
	O11	To acquire transversal skills (initiative or autonomy).
Attitudes towards CT and programming	A01	I need to motivate students to build confidence and develop strategies for finding and refining solutions to complex problems.
	A02	I think that programming and CT content is essential in compulsory education.
	A03	I have a personal interest in the integration of programming and CT content into compulsory education.
	A04	I am confident in my access to the necessary resources and training regarding programming and CT content in education.
	A05	I feel prepared to integrate programming and CT content into the educational process.
	A06	I will voluntarily take courses in CT and programming if I were given the opportunity.
	A07	I can guide students in CT and programming practices.
	A08	I can design effective learning experiences that promote CT and programming learning.
	A09	I must encourage a positive attitude toward coding and its integration into the classroom is essential.
	A10	I have the required skills to effectively learn and use coding tools.

Table 1. *Cont.*

Dimension	Item	Text
Attitudes towards CT and programming	A11	I lack confidence in my ability to grasp computing concepts (e.g., decomposition, abstraction, etc.).
	A12	I know how to teach computing principles (e.g., algorithms, decomposition, abstraction) in the classroom.
	A13	I can understand computing principles (e.g., algorithms, decomposition, abstraction) to solve problems.
Benefits of integrating CT and programming into the teaching–learning process	B01	Knowledge of CT and programming will allow students to get better jobs.
	B02	CT provides students with a better basis for acting and participating in a democratic society.
	B03	It is important to teach CT from the earliest stages of education.
	B04	Fostering CT is equally important as skills in reading, writing, and mathematics.
	B05	CT can be introduced in the teaching–learning process by encouraging students to engage in problem-solving tasks.
	B06	CT and programming can be integrated into the teaching–learning process without the need for computers.
	B07	CT provides learners with the necessary skills to solve problems efficiently.
	B08	Teachers are a key element in facilitating the teaching of CT and programming.
	B09	CT enables us to grasp both the benefits and challenges of digital technologies in our daily lives and society.
	B10	CT allowed learners to develop essential abilities for effectively using tech tools.

3.5. Data Collection and Analyses

Data were collected at the end of the first semester via a Google form hosted on the Digital Learning Ecosystem of the ICT in Education course. The test remained accessible for three weeks, a timeframe that was considered sufficient for participants to complete it. Once the fieldwork was completed, a coding register was developed to organise the collected data in an ad hoc file. After constructing the data matrix, the data were entered, cleaned, and analysed.

Regarding the analyses, a descriptive analysis of the items of the scales was carried out, and then it was used to test hypothesis tests for two groups of data to test the differences in the results according to the gender of the students. A normality test of the population sample was carried out using the Kolmogorov–Smirnov normality test. This test was chosen because the sample was larger than 30 individuals. The use of this test allowed us to decide whether to use parametric or non-parametric tests to perform statistical hypothesis testing. These analyses were performed using a critical value of <0.05.

Nonparametric tests are more robust than parametric tests and can be applied in a wider range of situations. While parametric tests have greater statistical power, their accuracy depends on the normality of the data distribution. In this study, after assessing the normality of the sample, the results of the Kolmogorov–Smirnov test indicated that the data did not follow a normal distribution [66,67]. The calculated asymptotic significance value was lower than the confidence level set for the analyses, and this led to the use of non-parametric tests such as the Mann–Whitney U test. The IBM SPSS Statistics 28.0 software was used for data analysis, starting with an alpha level of 5%.

4. Results

Once the data had been collected, the descriptive analysis of the items of the scales was carried out (Figures 2–6). These analyses refer to the dimensions: Competences which are related to children's education (McDonald Omega 0.791), Competences which are related to CT (McDonald Omega 0.687), Objectives of working with CT and programming (McDonald Omega 0.730), Attitudes towards CT and programming (McDonald Omega 0.865), and Benefits of integrating CT and programming into the teaching–learning process (McDonald Omega 0.783).

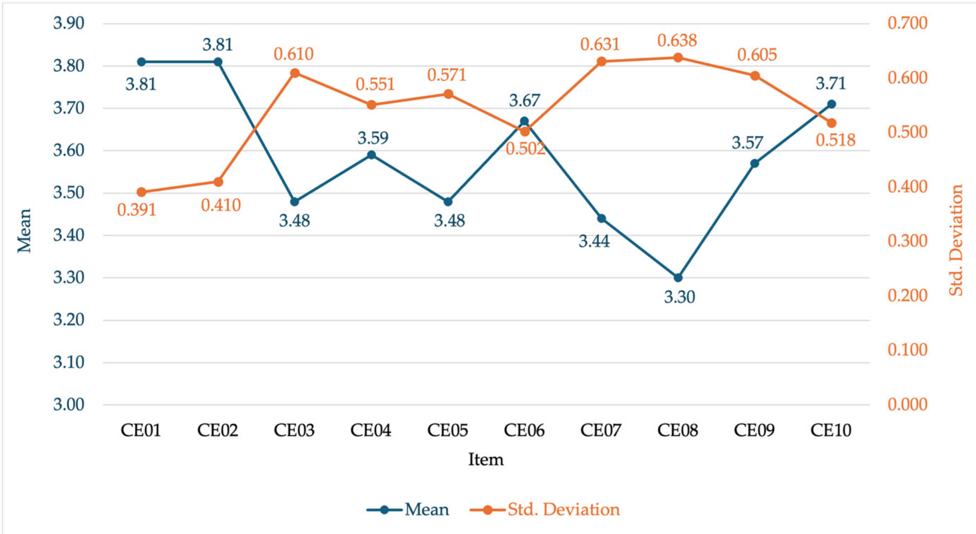

Figure 2. Descriptive statistics of the Dimension Competences which are related to children's education.

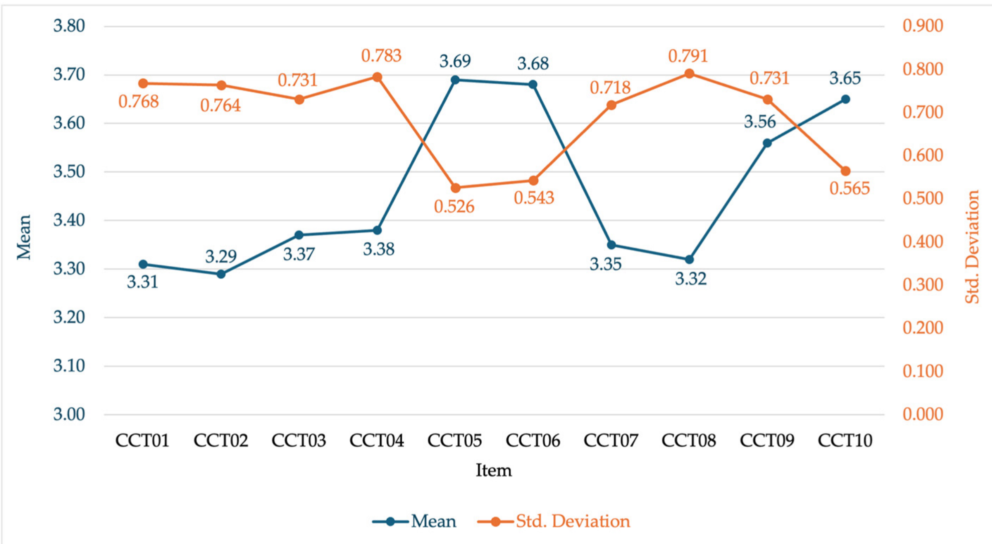

Figure 3. Descriptive statistics of the Dimension *Competences which are related to CT*.

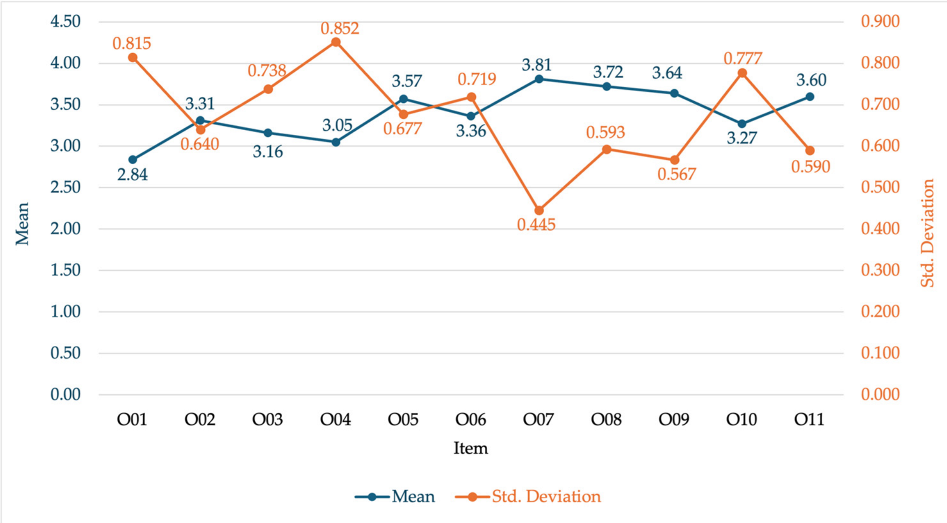

Figure 4. Descriptive statistics of the Dimension Objectives of integrating CT and programming into the teaching–learning process.

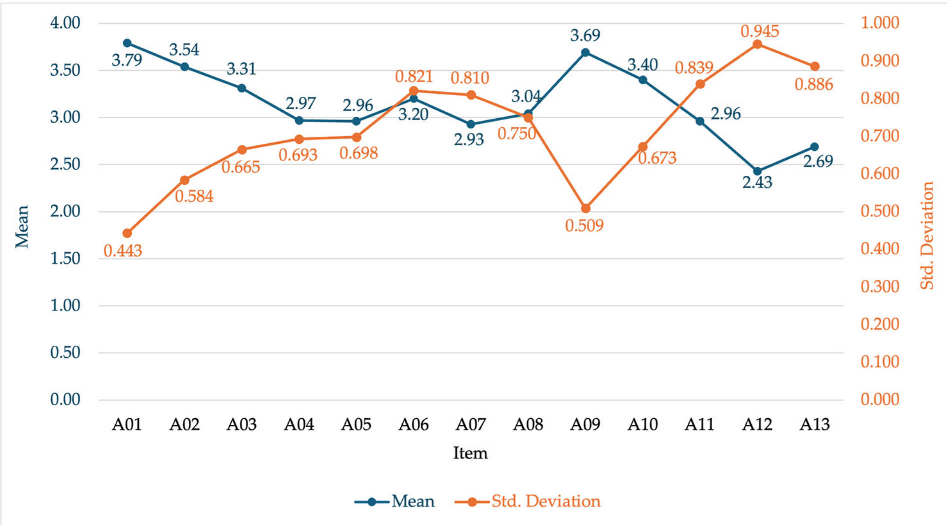

Figure 5. Descriptive statistics of the Dimension *Attitudes towards CT and programming*.

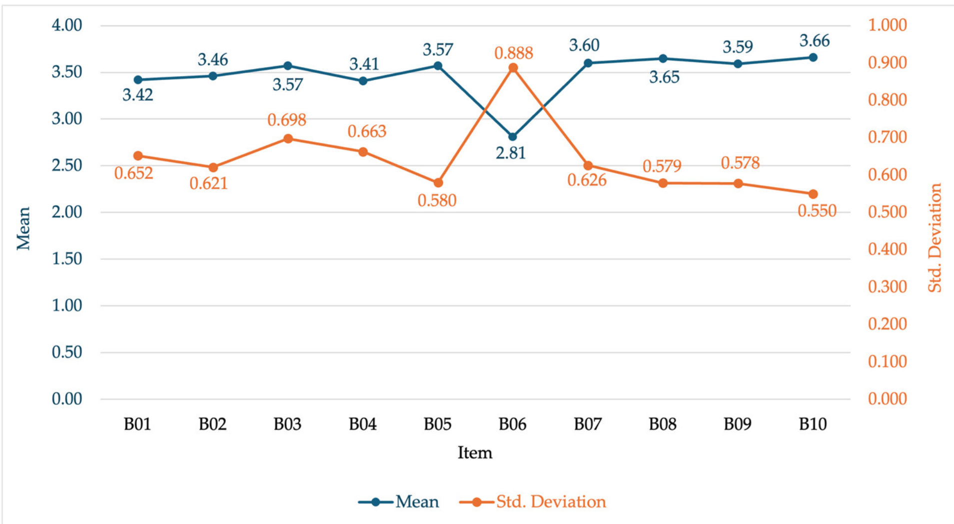

Figure 6. Descriptive statistics of the Dimension *Benefits of integrating CT and programming into the teaching–learning process*.

The results according to the research questions are presented below.

4.1. RQ1. What Competencies Do Pre-Service Teachers Believe Are Fostered by the Integration of CT into the Teaching–Learning Process?

According to the dimension of competences which are related to children's education, the results show that all the items have values above 3. Therefore, the pre-service teachers perceive these competences as quite important or very important for their students' education. Both items E01, *to coordinate and work with others as part of a team*, and E02, *to communicate efficiently, both verbally and in writing, with others while completing a task*, stand out with mean values of 3.81.

Regarding the dimension related to competences that the pre-service teachers consider to be related to CT, again most of the items obtain scores above 3, so they consider the indicated competences to be quite related or very related to CT. The highest scores were obtained in items CST05, ability *to select and use effective digital tools and apps for completing a task*, and CST06, *ability to actively seek, compare, and choose digital information, taking into account diverse sources and contexts*, with mean scores of 3.69 and 3.68, respectively.

4.2. RQ2. What Objectives Are Achieved by Integrating CT and Programming into the Teaching–Learning Process?

The results obtained in the dimension related to the objectives of integrating CT and programming into the teaching–learning process show that the mean scores of most of the items are placed at values higher than 3. This indicates that the pre-service teachers agree or strongly agree with the objectives indicated in the items. There is only one item of this dimension that reaches a lower value, specifically item O01 with a mean score of 2.84. That means that pre-service teachers have little agreement that one of the aims of CT and programming is to inspire students to pursue careers in science-related fields in the future. On the contrary, the items with the highest scores are item O07, to improve digital competence, and item O08, to develop problem-solving strategies and enhance self-confidence when tackling complex projects with multiple potential solutions. These items obtain averages of 3.81 and 3.72, respectively.

4.3. RQ3. What Are the Attitudes of Pre-Service Teachers Towards the Implementation of CT and Programming in the Classroom?

The results of the dimension of pre-service teachers' attitudes towards CT show differences in the means of its items. On the one hand, the items A01, A02, A03, A06, A08, A09 and A10 have a mean higher than 3. In particular, the items A01, I need to motivate students to build confidence and develop strategies for finding and refining solutions to complex problems; and A09, I must encourage a positive attitude toward coding and its integration into the classroom is essential, stand out as they obtain means of 3.79 and 3.69, respectively.

On the other hand, the items A04, A05, A07, A11, A12, and A13 receive scores between 2 and 3. The items A12 and A13 stand out as having the lowest scores with a mean of 2.43 and 2.69, respectively. These items refer to the pre-service teachers' knowledge of teaching computing principles such as decomposition, etc., in the classroom, and being able to grasp fundamental computing concepts such as algorithms, etc., to tackle problems effectively. This illustrates the pre-service teachers' perception of their knowledge about teaching and understanding some concepts related to CT.

4.4. RQ4. What Are the Benefits of Integrating CT and Programming into the Teaching–Learning Process?

Regarding the last dimension, which refers to the benefits of integrating CT and programming into the teaching–learning process, the items again obtain scores above 3. There is only one exception, item B06, which refers to the fact that CT and programming can be integrated in the teaching–learning process without the need for computers whose mean was 2.81. On the other hand, the items with the highest scores are B08 and B10, with 3.65 and 3.66, respectively. Item B08 indicates that teachers are a key element in facilitating the teaching of CT and programming, and item B10 emphasises how CT allowed learners to develop essential abilities for effectively using tech tools.

4.5. RQ5. Are There Significant Gender Differences in the Perception of CT and Programming?

In terms of gender differences (Figures 7 and 8, Table 2), significant differences were found in eight items corresponding to the dimensions: competences related to children's education (CE), competences related to CT (CCT), and pre-service teachers' attitudes towards CT and programming (A). In all cases, women scored higher on average than men. These items refer to break down a complex task into smaller, manageable steps and determine the most efficient sequence (CE03), to be autonomous in addressing and completing the assigned tasks (CE04), to choose and use digital devices and applications effectively for task completion (CE05), to actively seek, compare, and select digital information, considering diverse sources and contexts (CE06), to evaluate the potential risks of using digital tools, considering factors like security and identity (CE09), to actively seek, compare, and select digital information, considering diverse sources and contexts (CCT06), to evaluate the potential risks of using digital tools, considering factors like security and identity (CCT09), and to be confident in my access to the necessary resources and training regarding programming and CT content in education (A04). Low intensity is observed for most of the factors, with medium intensity for items CE09 and CCT06.

Although a clear trend is evident, the observed differences are not substantial, highlighting the necessity of examining the social and contextual factors that may be contributing to these disparities.

Regarding item CE03, the differences may be attributed to the possibility that women are more accustomed to organising tasks systematically due to social roles that have traditionally assigned them responsibilities in planning and management across various contexts. Consequently, this tendency may extend to the academic environment and their future professional engagement in integrating CT into the teaching–learning process.

Concerning item CE04, a higher score on this item may suggest that women perceive themselves to be more confident in working independently, possibly as a result of greater exposure to environments that foster autonomy in their education or socialisation.

With regard to item CE05, women may be more familiar with the use of digital tools in academic contexts, which may contribute to a greater sense of competence in this regard.

The differences in items CE06 and CCT06 may be attributed to the possibility that women have a greater tendency to be more meticulous and critical when searching for, evaluating, or selecting digital information, and that they do so with greater attention to detail.

The results obtained in items CE09 and CCT09 may be attributed to the possibility that women are more sensitised to the risks associated with the use of digital tools, possibly due to a heightened awareness of online dangers or socialisation that emphasises caution.

Finally, the differences observed in item A04 may reflect that women place a higher value on the importance of resources and training related to CT and programming. This could stem from a heightened awareness of the barriers they encounter in traditionally male-dominated fields, such as technology, motivating them to actively seek out training and development opportunities.

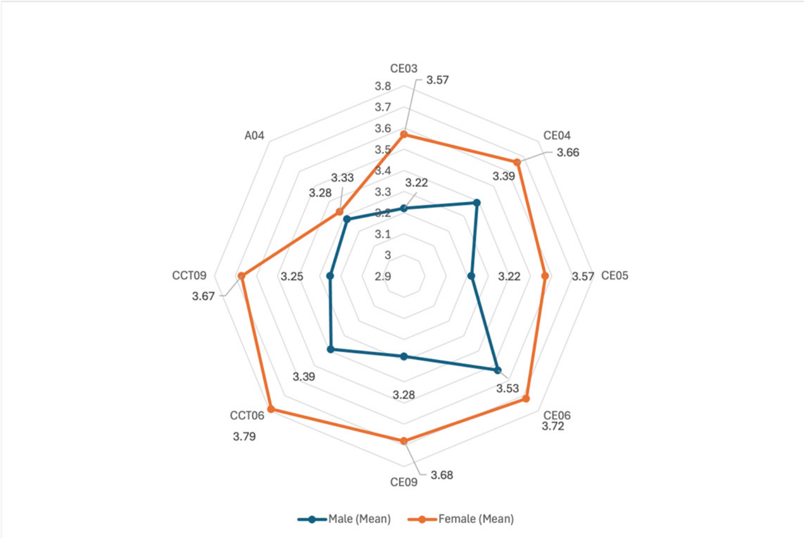

Figure 7. Mean scores of items by gender.

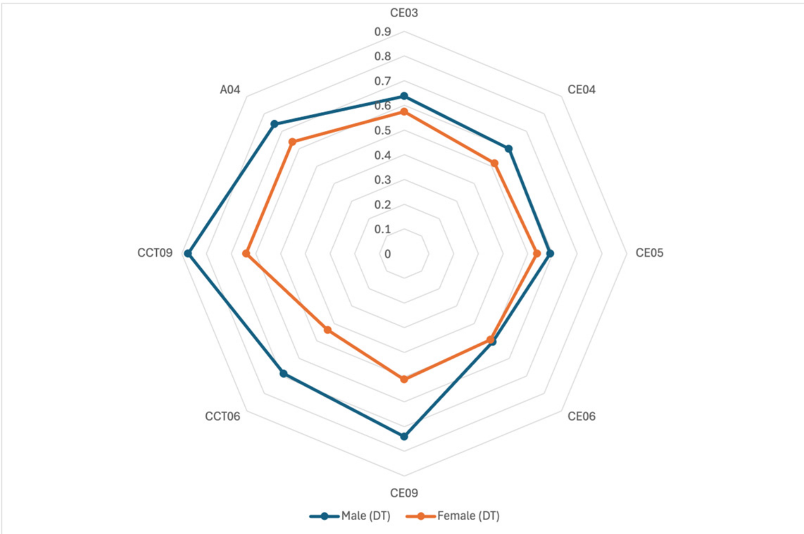

Figure 8. Standard deviation of items by gender.

Table 2. Items with significant differences based on gender. Mann–Whitney *U* Test.

	Gender	W	p	R_{bp}
CE03	Male	1244	0.003	−0.255 **
	Female			
CE04	Male	1331	0.010	−0.221 *
	Female			
CE05	Male	1224	0.002	−0.272 **
	Female			

Table 2. *Cont.*

	Gender	W	p	R_{bp}
CE06	Male	1398	0.023	−0.174 *
	Female			
CE09	Male	1219	0.001	−0.298 **
	Female			
CCT06	Male	1211	0.001	−0.325 **
	Female			
CCT09	Male	1254	0.002	−0.258 **
	Female			
A04	Male	1359	0.024	−0.197 *
	Female			

* $p < 0.05$ ** $p < 0.01$.

5. Discussion

Regarding the results in the dimension of the competences related to children's education, it is noteworthy that most pre-service teachers emphasised the importance of these competencies as essential and necessary for educating 21st century learners. They believed that the teaching–learning process in the classroom prepares children to explore creative solutions to problems and recognise that there are multiple solutions; to actively seek, compare, and choose digital information, taking into account diverse sources and contexts; to be autonomous in addressing and completing the as-signed tasks; or to break down a complex task into smaller, manageable steps and determine the most efficient sequence. Pre-service teachers also highlighted that classroom activities foster greater coordination with others and teamwork, as well as effective communication with their classmates when completing tasks. Both skills are essential for functioning in a global society where interpersonal relationships are crucial.

Regarding the research question on the competences that the participants associate with CT, the results were similar to those previously reported. Participants indicated that all the competences presented in this dimension are either quite important or very important. Particularly noteworthy are the competences related to critical thinking, such as the ability to choose and use digital devices and applications effectively for task completion, and the analytical ability to actively seek, compare, and select digital information, considering diverse sources and contexts. These results align with those from the research conducted by Hamed et al. [36], which demonstrates a growing recognition of the value and importance of integrating ICT into education. In this regard, Peracaula-Bosch and González-Martínez [68] highlight that training pre-service teachers in CT creates the opportunity to develop a didactic discourse on CT, facilitating its integration into the classroom. In this training, it is essential to provide concrete examples of best practises that demonstrate effective instructional strategies to integrate CT into the teaching–learning process. These practises must provide guidelines for educators, enabling them to integrate CT seamlessly into the curricula through well-structured activities and pedagogical approaches. By analysing successful implementations or practises, educators can better understand how to foster problem solving and to teach computing principles in diverse learning environments and with heterogeneous groups of students. Moreover, the analysis of best practises could highlight how the principles of CT and programming can be applied across disciplines, reinforcing its relevance beyond computer science and promoting interdisciplinary connections. On the other hand, it is essential to develop hands-on workshops that integrate both unplugged and plugged activities as a key component of teacher training programmes. These workshops provide valuable practical training opportunities, enabling educators to engage directly with CT and programming in an interactive and experiential manner. By incorporating both unplugged activities, which do not require technology, and plugged activities, which utilise digital tools, these workshops ensure that educators are well prepared to teach CT and programming in a variety of settings, regardless of the available resources.

Tools such as Scratch and various educational robots are central to the plugged activities. They enable educators to explore the fundamental principles of programming and problem-solving in an intuitive and accessible way, allowing them to develop and demonstrate the application of CT concepts in a practical context. By directly interacting with these tools, teachers can gain a deeper understanding of how to facilitate CT learning in their classrooms, offering students opportunities to engage in exploration, creation, and problem solving. Integrating these technologies into teacher training is crucial for preparing educators to design and implement CT-based activities that can be adapted to a wide range of educational contexts and student needs. Ragonis et al. [29] concur, emphasising that CT skills can be applied across all disciplines. They suggest that teachers at all educational levels should receive training through mandatory courses and that professional development should be actively promoted. Moreover, these workshops foster a collaborative environment in which educators can share strategies and discuss approaches for integrating CT and programming across various disciplines. This collaborative approach not only reinforces the interdisciplinary nature of CT but also enhances its relevance within the contemporary educational landscape.

Incorporating CT principles and programming as fundamental components of teacher education curricula is essential for preparing educators to meet the evolving demands of contemporary education. As digital competence becomes increasingly integral to teaching and learning across disciplines, it is imperative that future educators acquire not only technical skills but also a pedagogical understanding of how to integrate CT effectively into their teaching practice. Embedding CT and programming in teacher training programmes ensures that pre-service teachers develop the skills and confidence necessary to design and implement engaging, developmentally appropriate learning experiences for their students. Cabrera et al. [37] agree that teacher training equips educators to integrate CT into the classroom, enhances their understanding of CT, and supports the development of pedagogical content that incorporates CT.

Furthermore, integrating CT into teacher education fosters interdisciplinary teaching approaches, enabling educators to connect CT with various subject areas, thereby enriching students' learning experiences. Given that CT skills are now considered fundamental competences alongside literacy and numeracy, it is crucial that teacher education institutions equip future teachers with the knowledge and strategies required to integrate CT meaningfully within their curricula. In doing so, teacher training programmes can cultivate a new generation of educators who are well-prepared to harness the potential of CT and programming in diverse educational contexts.

Beyond their role in fostering problem-solving skills and digital literacy, CT and programming also serve as powerful tools for promoting educational equity and inclusion [6]. Equipping educators with CT skills enables them to design teaching strategies that bridge the digital divide and ensure that all students, regardless of their socioeconomic background, have access to high-quality learning opportunities, thereby reducing inequalities in technological literacy from an early age. By integrating CT and programming training into teacher education, future educators can be better prepared to create inclusive learning environments that accommodate diverse learners, including those with special educational needs [6].

Thus, the integration of CT and programming into teacher training is not only an essential step towards modernising education but also a crucial strategy for advancing social inclusion. By equipping teachers with the competences to integrate CT within their practice, educational institutions contribute to a more equitable and accessible learning landscape, ensuring that all students, regardless of background or ability, can engage meaningfully with computational concepts and develop essential 21st century skills.

In this context, An and Shin [69] emphasise the importance of promoting digital literacy and CT from an early age to achieve ESD. Additionally, Guss et al. [70] highlight that coding is a key component in fostering inclusive and sustainable education. These findings align with those of Peracaula-Bosch et al. [64], whose research reveals that pre-service teachers hold positive expectations of CT, though there is a need for continued efforts to deepen their understanding of its implications. They also support the conclusions of An and Shin [69], who argue that the development of CT skills has a positive impact on teachers, ensuring their ability to support sustainable development from the earliest stages of education. Regarding the second research question, which explores to the objectives achieved through the integration of CT and programming into the teaching–learning process, the pre-service teachers show good ratings, particularly in areas related to improving digital competence, acquiring problem-solving strategies and developing self-confidence when tackling complex projects with multiple potential solutions. These findings are aligned with those reported by Albayrak and Yilmaz [71], who conducted a course using educational technology to teach CT and found positive results in the development of problem-solving skills, collaboration, and algorithmic thinking among pre-service teachers. On the other hand, the results also reveal that pre-service teachers do not believe the integration of CT and programming into the teaching–learning process will inspire students to pursue careers in science-related fields in the future. These results, however, contrast with those of other studies that emphasise the strong connection between STEM education and CT and programming, as STEM aims to help learners become problem solvers, a skill developed through CT [72,73]. In this regard, Díaz-Lauzurica and Moreno-Salinas [74] note that teaching of CT and programming also seeks to motivate students to acquire essential life skills such as problem solving, collaboration or critical thinking, aligning with the goal of achieving inclusive and quality education.

Regarding the third research question, which focuses on the attitudes of pre-service teachers towards CT and programming, the results show that they hold positive views on the need to encourage students to develop confidence and strategies for solving and optimising solutions to complex problems, promoting a positive attitude toward programming, and integrating it into the teaching–learning process, among other factors. However, the results also reveal that pre-service teachers face difficulties in understanding and teaching computing principles. This highlights the need for training pre-service teachers in CT and programming. In this regard, the findings align with those of Hamed et al. [36], who emphasise the importance of incorporating CT and programming into pre-service teacher training programmes to prepare educators for the demands of the digital age. The study by Voon et al. [75] also suggests that a practical module on CT for offline activities, especially for those not yet computer literate, can be an effective way to prepare pre-service teachers for working with CT and programming. Additionally, research by Yuan et al. [76] highlights the importance of developing talents such as CT, programming and digital literacy as part of the strategy to achieve sustainable development.

Respecting the fourth research question, which examines the benefits of integrating CT and programming into the teaching–learning process, the pre-service teachers gave high ratings to the different items in this dimension. They emphasised how CT and programming provide students with valuable skills in using digital devices and solving problems efficiently, and how teachers play a crucial role in facilitating the teaching of CT and programming. In this context, Hsu et al. [77] highlight that learners must develop CT as a key competence to be digitally competent in a society where computing is omnipresent. In addition, research by Molina-Ayuso et al. [78] suggests that to achieve sustainable education, teachers must adopt innovative pedagogies such as CT and programming to develop essential 21st century skills in students.

Finally, the results of the fifth and last research question related to significant gender differences in the perception of CT and programming, show that women tend to value certain aspects more highly. These include the ability to actively seek, compare, and choose digital information, taking into account diverse sources and contexts, as well as evaluating the potential risks of using digital tools, considering factors like security and identity. Additionally, women rated their access to resources and training on CT and programming in education more positively. These findings contrast with those commonly reported in the scientific literature, where men are typically more proactive toward innovation [79–81]. However, other studies, such as that by Raman et al. [82], also report higher scores for women. Moreover, large-scale assessments such as TIMSS 2019 have reported gender equity in mathematics achievement, suggesting a trend toward balance [55]. Similarly, international data from PISA indicate that the gender gap has either persisted or narrowed [83].

6. Conclusions

In this research, we explore the perceptions of Primary and Early Childhood pre-service teachers regarding CT and programming, as well as their integration into the educational environment. The main findings indicate that teachers have positive perceptions of CT across all examined dimensions. They are positive about the competences, objectives, and benefits promoted by the integration of CT into the teaching–learning process, as well as their attitudes towards CT and programming. Significant gender differences were observed in certain items, particularly those related to online security and identity on the web. In all cases, women scored higher on average than men.

In general, the research warns about the importance of training future teachers in CT, enabling them to integrate it into the teaching–learning process and apply it effectively in the classroom with their students. In this regard, CT and programming have become essential skills for thriving with guarantees in a global society. They are key to ensuring sustainable development, reducing inequalities, promoting inclusion, and quality and equity in education. Therefore, training future teachers in these areas is a priority. This is the only way to engage and involve educators in this critical subject, preparing children and young people from an early age to face the challenges of today's society.

This study presents a few limitations. On the one hand, the research design, as the sample belongs to a single university and all the participants are studying in the same year of study, which makes it difficult to generalise the results. On the other hand, the research was evaluative in nature, so there was little control of the variables to achieve statistical inference. The study examined gender differences, highlighting the aspects in which they were significant. However, it has limitations in identifying their underlying causes. Finally, it would be desirable to use a mixed methods research design to gain a deeper insight into the perceptions of pre-service teachers through interviews or focus groups. These limitations open the possibility of further research, focusing on extending the study to a wider range of universities and to different demographic groups, or conducting mixed methods studies that combine the benefits of quantitative and qualitative methods. Critical pathways are also opened for understanding the underlying causes of the gender gap and its evolution over time. Gaining insight into these phenomena will support the development of more effective educational policies and well-designed curricula, ultimately empowering students for the future.

Author Contributions: Conceptualisation, V.I.-Á. and A.M.P.-LL.; Data curation, V.I.-Á. and A.M.P.-LL.; Formal analysis, V.I.-Á. and A.M.P.-LL.; Investigation, V.I.-Á. and A.M.P.-LL.; Methodology, V.I.-Á. and A.M.P.-LL.; Resources, V.I.-Á. and A.M.P.-LL.; Supervision, V.I.-Á. and A.M.P.-LL.; Validation, V.I.-Á. and A.M.P.-LL.; Visualisation, V.I.-Á. and A.M.P.-LL.; Writing—original draft, V.I.-Á. and A.M.P.-LL.; Writing—review and editing, V.I.-Á. and A.M.P.-LL. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Institutional Review Board (or Ethics Committee) of the University of Salamanca (protocol code 1204 and 2 July 2024).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

Acknowledgments: This research was undertaken with the support of the Project Evaluación de la percepción de los maestros de Educación Infantil y Educación Primaria en pre-servicio sobre Pensamiento Computacional (Reference PIC-2022-17).

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

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