



Evaluating a Teacher Training Program for the Integration of Computational Thinking in Primary Education

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ABSTRACT

Computational thinking (CT) is a key competence in the 21st century. Its teaching in Primary Education combines unplugged and plugged-in strategies. The present study evaluates the effect of a training intervention aimed at primary school teachers to develop CT and implement visual block programming (VBP). A quasi-experimental pre-post design was used to assess the effects of the intervention. The final sample consisted of 57 teachers in Spain. The AProPrim scale was used for the measurement, consisting of three dimensions (self-efficacy, relevance and interest), whose structure was confirmed by confirmatory factor analysis. Data analysis was performed with IBM SPSS, applying descriptive statistics, Student's t-tests, Wilcoxon for non-parametric data and Pearson's correlations. The results showed a significant increase in self-efficacy and perceived knowledge and use of VBP, although a decrease in interest was observed. Positive correlations were found between self-efficacy, relevance and use, which were strengthened after the intervention. In addition, the overall assessment of the training was positive, highlighting its applicability and the demand for more sessions. The implications of this study highlight the importance of providing specific teacher training in CT and VBP to improve self-efficacy and the application of these competencies in the classroom, primarily through practical approaches and appropriate resources. It is recommended that training strategies be adjusted according to teacher experience, considering generational differences.

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1. Introduction

Computational thinking (CT) has become a fundamental cross-curricular skill for everyone in the 21st century (Cheng et al., 2023; Sun & Liu, 2024). CT was introduced by Papert (1980) and, years later, Wing (2006) popularised the term and defined it as an essential cognitive skill for problem solving, system design and understanding behaviour through concepts specific to computer science. It is a form of logical, orderly and structured thinking that allows problems to be addressed, modelled and solved efficiently.

In the context of primary education, CT development requires a broad vision that goes beyond simple association with programming. Although programming is a valuable strategy for teaching CT, it should not be viewed as an end but as one of several complementary means to promote computational reasoning. Consequently, CT teaching strategies typically combine both unplugged (non-technological) and plugged (technology-based) activities, each offering specific benefits for learning (Kotsopoulos et al., 2017). For a deeper and more meaningful understanding, numerous authors recommend integrating these activities in an interdisciplinary manner across different subjects in the curriculum (Yadav et al., 2014), so that CT is developed in real-world problems and within the framework of cross-curricular competencies.

Unplugged activities allow computational concepts to be explored through manipulating physical objects: cards, building blocks, coloured beads, puzzles; physical actions such as mime or choreography; and mental representations such as the formulation of instructions (Brackmann et al., 2017). These strategies, which do not rely on technological resources, are accessible and practical, as demonstrated by recent studies (Bakala et al., 2021; Tsortanidou et al., 2023; Zapata-Cáceres et al., 2024). Furthermore, they are proposed as a fundamental preliminary step before immersion in digital environments, facilitating the progressive acquisition of computational concepts (Del Olmo-Muñoz et al., 2020).

In contrast, plugged-in activities require technological devices, such as programming or educational robotics. The latter has established itself as a key tool for the development of CT (Toh et al., 2016), primarily through floor robots designed for the early stages of education (Angeli & Valanides, 2020; Berciano-Alcaraz et al., 2022). Since a robot cannot perform any action independently without a program to control it, programming is an essential component of educational robotics. In primary education, the most widely used programming language is visual block-based programming (VBP) (Basu et al., 2021; Ortuño & Serrano, 2024), as it facilitates understanding fundamental programming concepts without the need for code writing. However, the literature has shown that VBP and robotics are widely used and effective strategies for developing CT (Gamito et al., 2022; Ortuño & Serrano, 2024), it is important not to restrict their approach to these practices, a balanced approach that combines unplugged, plugged and integrated activities in different curricular areas allows for a more cross-curricular, coherent and aligned promotion of CT in line with its broader conception.

Despite the diversity of existing approaches to teaching CT in primary education, their application in the classroom depends largely on the profile of the teaching staff. This is key to the effective integration of CT and emerging technologies in the classroom, as their attitudes, perceptions and levels of competence directly influence the way they incorporate these tools into their teaching practice (Çimşir et al., 2024; Collado-Sánchez et al., 2021; Wijnen et al., 2022). Unlike secondary school teachers, primary school teachers are generalists, meaning they teach most subjects. This characteristic forces them to teach science, technology, or programming, even when they do not feel comfortable or motivated (Wijnen et al., 2024).

Several studies highlight that many primary school teachers distrust science and technology, leading them to avoid or address these subjects superficially. These teachers tend to have low self-efficacy in their ability to teach technological content, a tendency to use traditional methodologies, and little openness to inquiry, experimentation, or active learning. In addition, they tend to limit the time devoted

to these subjects, which significantly restricts the development of scientific and digital skills in students (Nordlöf et al., 2017). The study by Wijnen et al. (2022) reinforces this idea: while some consider that technology does not add value to learning, others recognise its potential but do not feel capable of using it effectively.

In this sense, teacher training becomes a determining factor. Çimşir et al. (2024) highlight that a training intervention focused on interdisciplinary CT skills significantly improved teachers' perception of competence, directly influencing the methodologies and attitudes transmitted to students. Collado-Sánchez et al. (2021) insist on the need to train teachers in CT, programming and robotics skills, pointing out that this training generates positive feedback in the classroom, while conversely constituting a barrier to its integration into educational environments.

To overcome these limitations and in line with the provisions of the LOMLOE (Boletín Oficial del Estado [BOE], 2020), training sessions were implemented, following the conceptual framework of Kallia and Cutts (2022), aimed at primary school teachers. These included specific strategies to promote the development of CT and the implementation of VBP and provide teachers with the tools, knowledge, and confidence to apply them in their classrooms.

This study has two objectives:

- To evaluate the effect of the training intervention with primary school teachers on self-efficacy, relevance, interest, perception of knowledge and use of VBP.
- To assess teachers' level of satisfaction with the intervention and analyse the extent to which it has contributed to their professional development and the integration of the pedagogical approach into their teaching practice.

Derived from the first objective, the following hypotheses are proposed:

H1: It is expected that participants will show significantly higher post-test scores than pre-test scores in self-efficacy, relevance, interest, perceived knowledge, and use of VBP following the training intervention.

H2: It is expected that self-efficacy, perceived relevance, interest, perceived knowledge, and use of VBP will be positively correlated both before and after the intervention.

H3: It is expected that teaching experience will show a negative correlation with self-efficacy, interest, and use of VBP both before and after the intervention.

2. Method

This study follows a quasi-experimental design, as it intervenes in natural contexts where assigning participants randomly is impossible. Specifically, it is a pre-post design, with measurements taken before and after the intervention (Montero & León, 2007). A single-group pre-post-test design was used, meaning that the treatment was applied to a single group of participants, without a control group.

This type of design allows the effects of the intervention to be evaluated by comparing the scores obtained before and after its implementation. However, as there is no random assignment or comparison group, it is important to consider the possible limitations in the causal inference of the results.

2.1. Participants

The sample consisted of 74 primary school teachers, of whom 33.33% were men and 66.67% were women, aged between 25 and 55 ($M = 39.35$; $SD = 7.89$). However, during the study, there was an experimental mortality rate of 29.82%, consisting of 17 lost cases, 11 attributed to errors in identifying participants between the pre-test and post-test and 6 to the absence of a response in at least one of the

two assessment instruments. These limitations prevented the complete comparison of some observations, reducing the final sample size to 57 for statistical analysis.

A non-probability convenience sample was used. In some cases, the educational centres directly requested that the intervention be carried out on their premises. At the same time, on other occasions, the training was offered openly to teachers from different centres who registered voluntarily.

In terms of professional experience, 49.12% ($n = 28$) of teachers had less than 10 years of experience; 31.58% ($n = 18$) had between 10 and 20 years; and 19.30% ($n = 11$) had more than 20 years of professional experience. Although this variable is presented in a categorised form in this section for clarity and ease of reading, it was used as a continuous numerical variable in the statistical analyses to preserve the richness of the original information and explore its relationship with other variables through correlations.

2.2. Procedure

The study was conducted in three phases. In the first phase, a pre-test was administered to assess the participants' initial level of CT and VBP.

The 6-hour training intervention was divided into three sessions in the second phase. Most of these sessions were conducted in person, although a virtual session was included in some cases due to the distance from the institution that requested the training. The methodological approach of the training was theoretical-practical, prioritising experiential learning based on the active exploration of concepts.

In the first session (awareness and conceptualisation), the concept of a CT was introduced through unplugged activities aimed at understanding the basic logic of programming (sequences, loops, and repetitions). These included executing step-by-step instructions based on daily routines, structuring movements in a choreography, and identifying patterns with coloured blocks—techniques intended to promote algorithmic thinking without digital tools.

The second session (application and problem-solving) incorporated floor robots to reinforce CT processes such as decomposition and debugging, focusing on cognitive strategies rather than the robot's technical operation. The third session (integration and digital transfer) focused on transferring this understanding to a digital environment using Scratch, a VBP language suitable for the primary level. During this phase, teachers explored the basic programming concepts within an accessible digital environment suitable for teaching.

Across the three sessions, the expected learning outcomes were the development of conceptual understanding, problem-solving autonomy, and confidence in integrating CT and VBP into classroom practice.

Finally, in the third phase, the post-test was administered to evaluate the impact of the intervention, ensuring voluntary participation and guaranteeing the confidentiality of the data collected.

The intervention was delivered by a teaching team of university professors from the Faculties of Education and Engineering. This interdisciplinary composition aimed to offer a complementary vision that integrated both the pedagogical foundations and the technical aspects of CT.

2.3. Instrument

The AProPrim scale assessed attitudes towards VBP and CT among primary school teachers. This is a five-point Likert scale, with response options ranging from 'Strongly disagree' to 'Strongly agree'. Although this study's main objective is not the instrument's psychometric validation, the previously validated AProPrim scale was used to assess teachers' perceptions of CT. Content validity was established using the Delphi method (González-Cervera et al., 2024).

The scale comprises three dimensions: Self-efficacy (e.g., “I am able to answer questions about programming from primary school pupils on the fundamentals of VBP”), Perceived Relevance (e.g., “I believe that teaching VBP at an early age helps develop a more positive attitude towards technology in the future”), and Interest (e.g., “I am interested in advances in VBP”).

In addition to this main scale, the questionnaire included questions related to socio-demographic data (gender, age, teaching experience, among others). Two additional items were also included: one to assess the perception of the level of knowledge about VBP, using a five-category Likert scale (‘none’, ‘fundamental’, ‘basic’, ‘intermediate’ and ‘advanced’), and another to analyse the frequency of use of VBP in teaching practice, also using a five-point Likert scale (‘never’, ‘rarely’, ‘occasionally’, “frequently” and ‘always’). Four questions were also included to evaluate the training sessions. Two of them asked about the overall evaluation of the training and its usefulness in teaching, with a five-point Likert-type response format, where 1 represents the lowest option and five the highest. The other two questions were qualitative and aimed at identifying the most noteworthy aspects of the training and those that participants would have liked to address during the training.

Subsequently, an Exploratory Factor Analysis (EFA) was performed with an independent sample of 202 teachers. The KMO sample adequacy index was .906, and Bartlett's sphericity test was significant ($p < .001$), which justified factor analysis. The extraction was performed using the Maximum Likelihood method, and an Equamax rotation was used, seeking a balance between factor simplification and variable interpretation (García-Jiménez et al., 2000). Three main factors were extracted, and the items were categorised into Relevance, Self-efficacy, and Interest.

Confirmatory factor analysis (CFA) was conducted with an independent sample of 492 teachers. The initial model, with 15 items, showed a moderate fit ($\chi^2 = 490$, $df = 87$, $p < .001$; CFI = .932; TLI = .919; RMSEA = .097; SRMR = .091). After removing one item for theoretical and empirical reasons, the final model with 14 items and three factors showed significant improvements: $\chi^2/df = 3.75$, CFI = .964, TLI = .955, SRMR = .0748, and RMSEA = .084, indicating an adequate fit of the proposed theoretical model (Cho et al., 2020).

Regarding reliability, the instrument demonstrated high internal consistency, with an overall Cronbach's alpha = .916. By dimension, the values were as follows: Relevance (6 items, $\alpha = .927$), Self-efficacy (5 items, $\alpha = .926$), and Interest (3 items, $\alpha = .831$).

2.4. Data analysis

Data processing was performed using IBM SPSS for Windows version 29.0.2.0. First, a descriptive analysis of the dimensions was carried out, calculating the mean (M) and standard deviation (SD). To analyse the changes between the results obtained in the pre-test and post-test, the Student's t-test for related samples was used when the data met the assumption of normality. The normality of the variables was evaluated using kurtosis and skewness indices, following the criteria of Ferrando and Anguiano-Carrasco (2010), who consider that variables with indices between ± 1 can be treated as normally distributed. When this assumption was not met, non-parametric methods were applied, specifically the Wilcoxon signed-rank test (W), which compares paired samples when the distribution is abnormal. In addition to reporting the statistical significance values (p), effect size measures were calculated to complete the interpretation of the results. Cohen's d coefficient was used for parametric tests, and for non-parametric tests, the effect size r was used, as recommended in comparative studies (Cohen, 1988). The interpretation of both indicators was carried out according to the following reference points: for d , a value of .20 is considered a small effect, .50 a medium effect, and $\geq .80$ a significant effect; for r , values of .10, .30, and .50 are interpreted as small, medium, and large effects, respectively (Cohen, 1988).

Secondly, correlations were calculated between the scale dimensions, the perception of knowledge level, the use of VBP in teaching, and years of professional experience in both the pretest and posttest.

This analysis aimed to explore the relationships among teachers' perceptions of self-efficacy, relevance, interest, and the use of VBP, as previous studies suggest that these constructs are conceptually interrelated and may evolve together after training (Çimşir et al., 2024; Collado-Sánchez et al., 2021).

Correlational analyses were used with Pearson's r coefficient to examine these bivariate relationships, given that the data met the assumptions of normality. The magnitude of the correlations was interpreted according to Cohen's criteria (1988), where values of $r = .10$ are considered small, $r = .30$ moderate, and $r \geq .50$ large. These analyses do not imply cause-and-effect relationships but provide insight into how the studied constructs are related within the intervention context.

For all inferential statistical tests, a significance level of $\alpha = .05$ was set to reduce the risk of type I error and increase the robustness of the results.

Finally, the mean and standard deviation of the participants' assessments of the training received were calculated, as well as their perception of the usefulness of this training for their teaching practice. These calculations provided a descriptive analysis of the participating teachers' perceptions of the quality and applicability of the training intervention. In addition, the participants' most representative and recurring comments about the positive aspects and the opportunities for improvement identified in the training were incorporated into the qualitative analysis.

3. Results

To address objective 1, the results corresponding to the hypotheses derived from it are presented. In particular, to test H1, a comparative analysis was performed between the pre-test and post-test measurements, see Table 1.

Participating teachers showed a significant increase ($t(56) = -3.87, p < .01$) in self-efficacy, with higher scores after the intervention than before, and a high effect size between the two measures ($d = 1.06$).

Regarding the Relevance dimension, no significant differences were found ($t(56) = -0.06, p > .05$), indicating that teachers' perception of the relevance of VBP remained stable throughout the intervention. This stability suggests that participants already recognised the importance of VBP before the training, and their perception did not diminish afterwards. Although the change was not statistically significant, the effect size ($d = .83$) indicates a substantial level of consistency in this perception, which may have practical value in understanding teachers' sustained appreciation of the topic.

In contrast, an adverse effect of the intervention was observed in the Interest dimension, reflected in a decrease in scores after the intervention. This dimension included items related to teachers' willingness to continue training, to learn more about advances in VBP, and to apply it in their practice. This change was statistically significant ($W = -3.10, p < .05$) and showed a medium effect size ($r = .411$). A possible explanation is that, after becoming more aware of the complexity of programming through the training, some teachers perceived VBP as more demanding, temporarily reducing their interest in continuing training in this area.

Participating teachers showed a significant increase ($W = -4.89, p < .01$) in their perception of their level of knowledge about VBP, with higher scores after the intervention than before, and a large effect size ($r = .647$).

On the other hand, there was a significant increase ($W = -3.51, p < .01$) in the use of VBP in teaching practice, with higher scores after the intervention than before, and a large effect size ($r = .465$).

Table 1. Pre-test and Post-test Comparison of Dimensions of the AProPrim Scale

Dimensions	Test	M	SD	Statistical contrast	Effect size
Self-efficacy	Pre-test	2.55	1.19	$t = -3.87^{**}$	$d = 1.062$
	Post-test	3.09	1.04		
Relevance	Pre-test	3.84	0.91	$t = -0.06$	$d = .831$
	Post-test	3.85	0.94		
Interest	Pre-test	3.90	0.86	$W = -3.10^*$	$r = .411$
	Post-test	3.39	1.20		
Perception Level Knowledge	Pre-test	2.32	1.38	$W = -4.89^{**}$	$r = .647$
	Post-test	3.16	1.21		
Utilisation	Pre-test	2.04	1.22	$W = -3.51^{**}$	$r = .465$
	Post-test	2.54	1.42		

Note. $^*p < .05$; $^{**}p < .001$.

To verify H2, correlations were calculated between the scale dimensions, Perceived Level of Knowledge, and Use of VBP in teaching in the pretest and posttest (see Table 2), showing significant correlations between the variables analysed.

The pretest results show that Self-Efficacy towards VBP has positive and significant correlations with Perceived Relevance ($r = .296$, $p = .025$) and Interest ($r = .293$, $p = .027$). In addition, the correlation between perceived relevance and interest is particularly high ($r = .726$, $p < .001$). Likewise, high and significant correlations are found between Self-Efficacy and Perceived Level of Knowledge ($r = .728$, $p < .001$), as well as with the Use of VBP in teaching ($r = .712$, $p < .001$). Similarly, Relevance is positively associated with Perceived Level of Knowledge ($r = .440$, $p < .001$). On the other hand, interest showed no significant correlations between the perceived level of knowledge and the use of VBP in teaching. However, Perceived Level of Knowledge and Use of VBP show a strong correlation ($r = .789$, $p < .001$). It is important to note that these results only describe associations between variables and do not imply causal relationships. The correlations should therefore be interpreted as patterns of co-variation that provide contextual information about how teachers' perceptions are related, rather than as evidence of direct effects. This interpretative caution is consistent with the recommendations of Altman and Krzywinski (2015) and Rohrer (2018), who emphasise that correlations reveal relationships but not causation.

After administering the post-test, the correlations between the variables remained significant in the same cases observed in the pre-test, although with an increase in significance level. However, relevant changes were identified in the correlation between Interest and other variables. In the pretest, interest did not show a significant correlation between perception of knowledge level and use of VBP in teaching. However, in the post-test, both relationships became significant, showing a moderate-high positive correlation between Interest and Perception of Knowledge Level ($r = .634$; $p < .001$) and between Interest and Use of VBP ($r = .549$; $p < .001$).

Table 2. Correlations between variables in the pre-test and post-test

Dimensions	Test	Self- efficacy	Relevance	Interest	Perception Level Knowledge	Utilisation
Self-efficacy	Pre-test					
	Post-test					
Relevance	Pre-test	.296*				
	Post-test	.533**				
Interest	Pre-test	.293*	.726**			
	Post-test	.669**	.761**			
Perception Level Knowledge	Pre-test	.728**	.440**	.784		
	Post-test	.773**	.586**	.634**		
Utilisation	Pre-test	.712**	.336*	.252	.798**	
	Post-test	.739**	.462**	.549**	.848**	

Note. * $p < .05$; ** $p < .001$.

To test H3, correlations between the scale dimensions and years of professional experience were calculated (see Table 3). Pearson's correlation analyses show mostly weak or insignificant associations. In the pretest, a significant negative correlation was identified between professional experience and self-efficacy ($r = -.261$, $p = .05$). However, this relationship did not hold in the posttest, where a change in the pattern of correlations was observed. At this point, significant correlations emerged between years of experience and the dimensions of Interest ($r = -.274$, $p < .05$) and Use of VBP ($r = -.302$, $p < .05$). Despite their statistical significance, these coefficients correspond to low effect sizes and should therefore be interpreted with caution, as they do not allow for the establishment of a solid or conclusive relationship between the variables.

Table 3. Correlations between variables in the pre-test and post-test

Dimensions	Test	Self- efficacy	Relevance	Interest	Perception Level Knowledge	Utilisation
Years of experience	Pre-test	-.261*	.018	-.084	-.182	-.158
	Post-test	-.216	-.168	-.274*	-.217	-.302*

Note. * $p < .05$; ** $p < .001$.

To verify objective 2, the overall assessment of the training intervention on CT development was analysed, suggesting a positive assessment by the participating teachers ($M = 4.12$; $SD = 0.91$). On the other hand, the perception of the usefulness of the training for their teaching practice indicates a favourable evaluation ($M = 3.89$ with $SD = 1.01$).

After the training intervention, the analysis of the perceptions of the participating teachers reflects a positive assessment of it. The aspects most highlighted by the participating teachers were the practical part of the training, using Scratch as a learning tool, and the possibility of learning something new. In addition, the participants highlighted the usefulness and applicability of the content, the quality of the resources offered, the clarity of the explanations, and the incorporation of unplugged activities.

Similarly, the areas for improvement indicated by participants were related to the need for more sessions and the inclusion of more applications for working on VBP. Some participants also wanted more time to participate in the program. The possibility of including examples of success to relate the content to specific situations was also mentioned. There was also a desire for all sessions to be held in person, given that, in some centres, due to distance, one session was held online. It should be noted that several responses indicated that they did not consider it necessary to add anything else to the training, stating that they were satisfied with the training received.

4. Discussion and Conclusions

This study seeks, on the one hand, to evaluate the effect of a training intervention on primary school teachers on the development of CT and VBP, in response to the requirements of the LOMLOE (BOE, 2020) on the promotion of CT in the early stages of education, and, on the other hand, to evaluate satisfaction with the intervention. The first objective has been analysed through three hypotheses, whose results and implications are discussed below.

Regarding H1, the analyses indicate that teachers' self-efficacy towards VBP increased significantly after the intervention. This suggests that the training intervention strengthened primary school teachers' perception of self-efficacy in CT and VBP. The low initial self-efficacy could be due to a lack of programming knowledge, which aligns with the findings of Rich et al. (2020) and Sun and Zhou (2023), who highlight the need to improve teacher training in this area. In contrast, no significant differences between the pretest and post-test measurements were found in the relevance dimension. Scores remained stable throughout the study, indicating that teachers considered CT and VBP important. This is encouraging, as the perception of relevance was not negatively affected after the training. The literature has shown that teachers' subject assessment influences their teaching and students' learning and perception (Ronan et al., 2023). Therefore, these findings reinforce the importance of promoting technical training in CT and VBP for teachers and raising their awareness of its impact on developing students' skills.

The results also show a decrease in interest in VBP, possibly due to the items used to measure it, which included the desire to continue training and interest in advances in VBP. However, perception of knowledge level increased significantly after the intervention, indicating an improvement in understanding of the content and reinforcing the need for training in CT and VBP (Avcı & Deniz, 2022). Likewise, the increase in the use of VBP indicates a positive effect of the intervention, although its application in the classroom remains low. This may be due to low self-efficacy in programming (Liu et al., 2021; Rich et al., 2020).

In summary, given that teachers' attitudes and beliefs about self-efficacy have a significant influence on both their performance in the classroom and students' interest in STEM (Science, Technology, Engineering, and Mathematics) subjects and their future career choices (Demirkol et al., 2022), it is essential to provide teacher training in CT and VBP. By promoting greater confidence and perception of relevance about these competencies, teachers are more likely to incorporate them into their teaching practices, favouring the development of key skills for the 21st century (Cheng et al., 2023; Sun & Liu, 2024) and promoting vocations in STEM disciplines among their students (Jiang et al., 2023). This broadens students' learning and development opportunities, providing them with essential tools to function in an increasingly digitised and technologically advanced environment (Ronan et al., 2023). According to the literature, it is advisable to offer training and capacity building to primary school teachers to meet the requirements of the LOMLOE (BOE, 2020) on the development of CT in the early stages of education. A variety of practices should be included, starting with offline activities that enable the meaningful acquisition of programming concepts and CT skills, and then moving on to educational robotics and visual languages for use in VBP, facilitating the effective integration of the CT (Rodrigues et al., 2024).

Regarding H2, the direction of the correlation between the pretest and post-test is the same. After the training intervention, the correlations in all dimensions strengthened, suggesting a positive impact of the training sessions. Specifically, after the intervention, participating teachers who perceive themselves as more competent in CT and VBP consider these competencies more relevant to their teaching practice. Likewise, the correlation between self-efficacy and interest increased, indicating increased motivation toward teaching these competencies. Similarly, as seen in the results, the training intervention has generated a significant increase in the perception of the level of knowledge and use of VBP in teaching practice. According to Pérez-Garcías et al. (2024), practical experiences, such as this training intervention, favour acquiring knowledge and its application in the classroom. These two variables have been positively related to interest, which does not necessarily imply an increase in interest after the training intervention, but instead suggests that, as understanding and practical experience of VBP and CT have increased, the relationship between these variables has been strengthened, resulting in a significant direct correlation with interest. On the other hand, the increase in the correlation between relevance and use suggests that, after the intervention, teachers who consider CT and VBP to be more relevant are more willing to incorporate these practices into their primary school classrooms. This is consistent with research highlighting the importance of the perception of relevance in adopting new educational methodologies (Sun & Zhou, 2023). However, these results should be interpreted with caution, as correlation analyses describe associations rather than causal relationships. They provide contextual insight into how teachers' perceptions and practices co-evolve within the intervention, without implying direct cause-effect links (Altman & Krzywinski, 2015; Rohrer, 2018).

The results of H3 suggest that the intervention strengthened teachers' perceptions of self-efficacy in CT and VBP. In the pretest, a significant negative correlation was observed between self-efficacy and years of experience, which ceased to be significant in the post-test. However, the direction of the association remained the same. This pattern could indicate a tendency for teachers with more professional experience to perceive more barriers to their competence in implementing VBP. However, given that the correlation coefficient was low (Cohen, 1988), this conclusion should be interpreted cautiously and understood as a preliminary observation rather than a conclusive relationship. This finding would be consistent with previous studies that indicate that self-efficacy in VBP decreases with age, being higher among young teachers (González-Cervera et al., 2026). Initially, teachers' interest in VBP was similar, regardless of their professional experience. However, after the intervention, a low negative correlation emerged, which could suggest a slight disconnect between more experienced teachers and the CT approach. This is consistent with previous studies showing how some teachers with more years of experience perceive less urgency in integrating digital approaches into the classroom (Sun & Zhou, 2023).

Likewise, a negative correlation was identified between years of experience and the use of VBP after the intervention, the highest among those observed, although still within a low range. Although the average use increased overall, this result suggests that more experienced teachers may need additional support to incorporate VBP and CT, which aligns with studies that point to a generational gap in incorporating innovative methodologies and technology (Fagerlund et al., 2022). Previous research has identified that young teachers incorporate new technological tools more easily and express favourable attitudes toward programming (Pérez-Calderón et al., 2021; Sun & Zhou, 2023). Even so, the magnitude of these associations does not allow for firm generalisations, so it is recommended that these findings be interpreted with caution and as lines of exploration for future research. As with the previous hypothesis, these correlations provide descriptive evidence of relationships among variables within the training context, rather than causal effects.

These results have important implications for the design of training strategies aimed at teachers. Depending on their experience, teachers may require different approaches: younger teachers, who are familiar with digital environments, could benefit from short, application-focused training courses, while teachers with more professional experience may need more extensive, progressive, and supportive pro-

grams that reinforce their self-efficacy, spark interest, and explicitly address perceived barriers (Bocconi et al., 2022; Villalustre & Cueli, 2023). Furthermore, regarding the second objective, useful material was designed based on the results. Teachers rated the training intervention positively and highlighted its usefulness, practical approach, and resources. According to Pérez-Garcías et al. (2024), offering active learning opportunities in varied contexts is recommended, allowing for the acquisition of programming content. The qualitative perceptions of the participants will serve to improve future training and better tailor it to the needs of teachers.

This study presents key strengths for teacher training in CT, responding to the requirements set out in the LOMLOE (BOE, 2020). Specific training has been provided to address the lack of knowledge in this area (Avcı & Deniz, 2022; Sun & Zhou, 2023), and the recommendations of Del Olmo-Muñoz et al. (2020) have been followed regarding the use of pre-device activities to improve understanding of computational concepts before working in digital environments. However, the present study has some limitations that should be considered when interpreting the results. First, the absence of a control group and, therefore, random assignment, limits the possibility of establishing direct causal relationships between the intervention and the observed changes. Consequently, it is suggested that future research adopt experimental or quasi-experimental designs with a control group to strengthen internal validity and allow for a more accurate attribution of the observed effects. Secondly, the sample used presents an imbalance in the gender of the participants (38 women and 19 men), which could condition the generalisation of the findings, especially about variables that gender issues could mediate. In addition, there was a loss of participants due to identification errors and non-response in some assessment instruments, which reduced the sample size and, consequently, the statistical power of the analysis. On the other hand, although some statistically significant associations were identified between teaching experience and certain variables on the AProPrim scale, the magnitude of these relationships was low. Therefore, these findings should be interpreted cautiously, as rather than showing conclusive relationships, they could point to emerging trends. In this sense, it is considered relevant to continue exploring how teachers' professional trajectories and individual characteristics affect the incorporation of CT in their educational practice.

In addition, it should be noted that the post-test was administered immediately after the intervention. Therefore, a certain degree of improvement in the evaluated variables was expected at that stage. However, the inclusion of a follow-up or permanence test would allow for a more precise assessment of whether these effects persist over time. As the reviewer rightly pointed out, measuring the impact immediately after the intervention is not equivalent to assessing its stability after a period of implementation; only through longitudinal evaluation can the lasting quality of the learning outcomes be fully understood.

Despite these limitations, the study provides relevant evidence on teacher training in CT and VBP, highlighting the importance of strengthening this knowledge among primary school teachers for its effective integration into educational practice.

In future research, it would be valuable to include follow-up or permanence tests to examine whether the observed improvements are maintained over time, as immediate post-intervention effects may not fully capture the long-term impact of the training.

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