Data and Metadata. 2025; 4:837
doi: 10.56294/dm2025837

ORIGINAL

Computational Thinking: Empowering Elementary School Teachers to Transform the Classroom

Pensamiento Computacional: Empoderando a Maestros de Primaria para Transformar el Aula

Armando Sofonías Muñoz del Castillo[1], Gladys Patricia Torres Murillo[1], Juan Carlos Salazar Losada[1], Deixy Ximena Ramos Rivadeneira[2], Javier Alejandro Jiménez Toledo[2]

[1]Universidad de Santander. Colombia.
[2]Universidad CESMAG. Colombia.

Cite as: Muñoz del Castillo AS, Torres Murillo GP, Salazar Losada JC, Ramos Rivadeneira DX, Jiménez Toledo JA. Computational Thinking: Empowering Elementary School Teachers to Transform the Classroom. Data and Metadata. 2025; 4:837. https://doi.org/10.56294/dm2025837

Submitted: 24-02-2025 **Revised:** 11-05-2025 **Accepted:** 28-05-2025 **Published:** 29-05-2025

Editor: Dr. Adrián Alejandro Vitón Castillo

Corresponding Author: Deixy Ximena Ramos Rivadeneira

ABSTRACT

The effectiveness of a curricular proposal designed to develop Computational Thinking competencies in primary school teachers in Colombia was evaluated. The main objective was to determine whether the educational intervention was able to improve the level of competence of teachers. A quasi-experimental design was used with a group of 99 teachers in training and in practice, through a series of reflective workshops based on the curricular proposal, their learning process was intervened. A pretest and a posttest were applied to evaluate the level of competence. The results showed a significant increase in the level of competence. Substantial improvements were observed in the understanding of fundamental concepts and in the ability to solve problems using computational tools. It is important to recognize some limitations. The quasi-experimental design and the sample size could limit the generalizability of the findings. In addition, the duration of the intervention might not be sufficient to evaluate the long-term impact. Future studies with more robust designs and large samples are recommended to corroborate these results and explore the impact. Furthermore, it is suggested that quantitative analyses be complemented with qualitative studies to gain a deeper understanding of teachers' learning processes. Despite these limitations, the results support the effectiveness of the curricular proposal in developing CT skills in primary school teachers and suggest the need to implement similar programs in other educational contexts.

Keywords: Digital Skills; Primary Teacher Education; Educational Strategies; Primary Education; Computational Thinking.

RESUMEN

Se evaluó la eficacia de una propuesta curricular diseñada para desarrollar competencias en Pensamiento Computacional en maestros de educación básica primaria en Colombia. El objetivo principal fue determinar si la intervención educativa lograba mejorar el nivel de competencia los docentes. Se empleó un diseño cuasiexperimental con un grupo de 99 maestros en formación y en ejercicio, a través de una serie de talleres reflexivos basados en la propuesta curricular, se intervino en su proceso de aprendizaje. Se aplicó un pretest y un postest para evaluar el nivel de competencia. Los resultados mostraron un aumento significativo en el nivel de competencia. Se observaron mejoras sustanciales en la comprensión de conceptos fundamentales y en la capacidad para resolver problemas utilizando herramientas computacionales. Es importante reconocer algunas limitaciones. El diseño cuasiexperimental y el tamaño de la muestra podrían limitar la generalizabilidad de los hallazgos. Además, la duración de la intervención podría no ser suficiente para evaluar el impacto a largo plazo. Se recomiendan futuros estudios con diseños más robustos y muestras grandes para corroborar estos resultados y explorar el impacto. Asimismo, se sugiere complementar los análisis cuantitativos con estudios cualitativos para comprender en profundidad los procesos de aprendizaje de los maestros. A pesar de estas limitaciones, los resultados, respaldan la efectividad de la propuesta curricular en el desarrollo de competencias en PC en maestros de básica primaria y sugieren la necesidad de implementar programas similares en otros contextos educativos.

Palabras clave: Competencia Digital; Formación de Docentes de Primaria; Estrategias Educativas; Enseñanza Primaria; Pensamiento Computacional.

INTRODUCTION

The term Computational Thinking (CT) was first introduced in 2006 by Janeth Wing, referring to the set of mental skills that, based on critical thinking and the fundamental processes of computing, allow problems to be solved and whose solution can be implemented in a computer system. Critical thinking, defined as the mental capacity to analyze a situation with autonomy and objectivity, is considered a fundamental support for understanding the problem to be solved, according to Rodríguez[1]. Likewise, Pršala[2] suggests that by involving structured problem-solving skills and systematic analysis, CP complements critical thinking, thus reinforcing the competencies needed in the modern educational landscape.

About the fundamental processes of computing, at least the following should be considered: abstraction, which, for a study, is a process by which the understanding of a situation is simplified by concentrating on the fundamental characteristics, managing the complexity of a problem; decomposition, which in terms of Pinzón et al.[3], is oriented towards analyzing a problem from its components to its totality, facilitating its solution. Pattern recognition, as stated by a study, aims to identify the structural relationships that objects or processes retain while they are compared to each other, and, finally, algorithms, which researchers such as Pinedo et al.[4], state are a finite set of instructions that are performed in a particular order to solve a problem, which can be translated as the step-by-step of a sequence.

PC has gained momentum in the last decade, becoming a necessary skill to face and understand today's world and, therefore, should be developed by any person. This is reinforced by Zetra et al.[5], who state that developing PC skills among primary school teachers is crucial to preparing students for the demands of the 21st century and insist on including this topic in the curriculum. In turn, Molina et al.[6] establish PC as one of the universally applicable skills for students.

Consequently, education is a favorable environment for the development of CP. Thus, it has gained ground in education systems, consolidating itself in recent years as a new competence to be introduced in the curricula of the most advanced countries, which have adopted different measures, approaches, visions, and paces for its implementation. In some countries, it has been introduced as part of digital technologies, while in others, it has been introduced as a transversal competence.[7] Such is the case of the initiative proposed by the European Commission, 'Digital Education Action Plan 2021-2027', in which the priority is to improve digital skills and competencies through computer education, where the PC is an essential component. The study outlines what happened in 22 EU and eight non-EU Member States, analyses significant progress related to integrating PC skills in compulsory education in Europe between 2016 and 2021, and includes recommendations as set out Bocconi et al.[8].

In 2014, England introduced computer science into the curriculum, considering programming as a component close to the PC. In the United States, they have incorporated the development of this type of thinking from kindergarten to K12. In Australia, the aim is for students to be more producers than consumers of technology, for which PC training is fundamental.[9]

PC interests the academic community in Latin America, and its integration into primary and secondary education is evident through concrete strategies. However, it has not yet been consolidated as a formal part of the curriculum.[10] An example is the work carried out in Argentina by the Sadosky Foundation with the Programa—Ar initiative, which was introduced at the school level.[11] With the Ceibal plan, Uruguay was one of the first countries to start working with CP, linking educational institutions at primary and secondary levels(CP - Ceibal - CP). In Brazil, CP is included in the basis of the standard national curriculum linked to Mathematics.

In the Colombian case, experiences have also been developed, among which we can mention those proposed by the Ministry of National Education MEN in support of the Ministry of Digital Technologies MINTIC, which makes a serious call for the inclusion of CP in the curricula in the national territory. This proposal is to incorporate the PC in students who are finishing primary school (grade 5) or starting high school (grade 6), aged between 10 and 12 years old. The methodology is based on a virtual environment on the Moodle platform and, with the advice of a teacher trained for this course, carrying out blended learning (face-to-face and online) with the students. Another noteworthy experience led by the Ministry of ICTs is the ICT Mission, which aims to train 100 000 programmers. It aims to train students from public and private schools free of charge from ninth to eleventh grade, and it has been underway since 2020.

In the same vein, the MinTIC has been offering training in programming through short courses aimed at people over 15 years of age with a bachelor's degree and availability of at least 30 hours per week. Finally, the program Programming for Children is worth mentioning, which calls for applications supported by the Ministry of National Education and the British Council MinTIC(12). On the other hand, from the Research Ecosystem of the Virtual Education Centre of the University of Santander in Colombia CVUDES, and through the research groups Fénix UDES and Grávate, the PC project is being developed in the training of primary school teachers, whose purpose is to build PC competences in teachers through the construction and validation of a curricular proposal. This project is being developed in phases, the first of which has been completed, resulting in the formulation of a curriculum proposal that involves identification, description, justification, problem node, global competence, competence elements, knowledge, performance criteria, didactic strategies, evaluation strategies, resources, time and bibliography.(13)

In the second phase, the validation process was carried out with the cooperation of MTDAE students who, through their research projects, designed and implemented didactic strategies for the different competencies established in the curricular proposal, but not before applying the diagnostic test and, at the end of the intervention, the final test. The results were consolidated and statistically processed, answering the question: What level of PC competencies is achieved in primary school teachers by applying the pedagogical proposal under validation? Confirming the hypothesis derived from the same. This article describes the results obtained in this second phase. Once the proposal has been validated, it is necessary to insist on and extend its application not only with primary school teachers but also with teachers at other levels and even motivate them to share this knowledge with their students, a process that is planned to continue in the third phase of this project.

METHOD

The project was developed under a quantitative approach, with a descriptive scope and a pre-experimental design, with a single group and the application of pretest and posttest tests that allowed us to test the hypothesis aimed at giving validity to the curricular proposal (independent variable) to raise the level of PC competence (dependent variable) in primary school teachers. It is aimed at teachers in training or in practice who work at the basic primary level of the Colombian education system, which allowed us to take as a population sample a group of 99 teachers belonging to this level who work in different regions of the country and who were linked to the research through the participation in degree projects carried out by students of the Master's Degree in Digital Technologies Applied to Education -MTDAE, offered by the University of Santander from its Virtual Education Centre, CVUDES. This population sample was selected for convenience.

The process was developed in three steps: diagnosis, implementation, and evaluation. In the diagnosis, the pretest Muñoz et al.(14) was applied to know some characteristics of the population and the initial state of the level of PC competence. In the implementation, eight reflective workshops were carried out. It should be noted that a reflective seminar is considered a collaborative workspace in which educational resources are analyzed and knowledge and experiences are exchanged around a central theme based on a methodological route that allows conclusions to be reached reflectively.(15) Thus, studies by Harjanto cited in Yucheng(16) showed that the workshops significantly improved teachers' understanding of CP principles, indicating a positive impact on instructional practices, a situation also mentioned by Zetra et al.(5), which together emphasize the importance of CP training for teachers that subsequently facilitates transfer to students.

The workshops developed corresponded to an improved version of those produced in the first phase of the macro project(17) and addressed issues related to the different CP competencies contemplated in the curricular proposal. The following figure shows the organization of the workshops hosted on the macro project's website, whose URL is https://site-rle5f.powerappsportals.com/Material/Talleres/.(18)

These workshops were attended by 31 teachers studying the MTDAE and developing their degree projects. These teachers subsequently designed didactic strategies by adapting, incorporating, and executing these workshops with groups of primary school teachers participating in the development of each degree project, who comprise the sample of this research. As part of the evaluation, the post-test,(19) was applied to determine the PC level achieved after the different didactic strategies were developed. Once the data from both the pretest and the posttest were collected and statistical techniques of descriptive and inferential data analysis were applied, the effect and validity of the curricular proposal were determined, leading to the acceptance of the alternative hypothesis that corresponds to the difference between the pretest mean. The posttest means it is less than 0, i.e., there is a significant positive effect of the didactic strategies on the level of PC competence in primary school teachers, which is symbolized as U1- U2< 0.

Figure 1. Screenshot: reflective workshops PC

The pretest consists of 45 items, divided into nine sections, the first and second of which are composed of 15 questions aimed at collecting information on some general characteristics of the population. The remaining seven sections focus on determining the level of PC competence. In turn, the post-test has 33 questions, organized into eight sections, the first of them with three questions that allow establishing articulation with the pre-test; the remaining seven sections contain 30 questions distributed in the same way as the pre-test, also to determine the level of PC competence.

The instruments in question were previously subjected to internal reliability and structure tests. To determine the internal reliability, 31 primary school teachers answered the tests. Subsequently, the Richardson k 20 test was applied to the results obtained, obtaining a coefficient of 0,64 for the pretest and 0,89 for the posttest. On the other hand, to ascertain the structure's reliability, validation was requested from two experts in the field, who gave a favorable opinion. On the other hand, it is important to highlight that the project was submitted to the consideration of the Ethics Committee of the University of Santander, who gave their approval, arguing that it is within the established norms and that the basic principles of ethics in research were taken into account, such as non-maleficence, autonomy, justice, the law of confidentiality of data or habeas data and respect for the author's rights.

RESULTS

The results presented here correspond to a process of descriptive and inferential analysis. The descriptive analysis compares the results obtained in the pre-test with those obtained in the post-test, and the hypothesis is tested in the post-test.

Comparison of pre-and post-test results by dimensions

The teachers' initial PC competence levels were determined through items 15 to 45 of the pretest and the final level through items 4 to 33 of the posttest. Their comparison is presented below. The aim was to identify the concept of CP initially, with item 15 of the pretest and item 4 of the posttest.

The pre-test showed 47 correct answers, equivalent to 47,5 %, while the post-test showed 86,9 % with 86 correct answers. In other words, the population sample achieved an increase in assertiveness of 42 % in terms of the concept of PC as a result of the application of the intervention proposal, leading them to understand the concept.

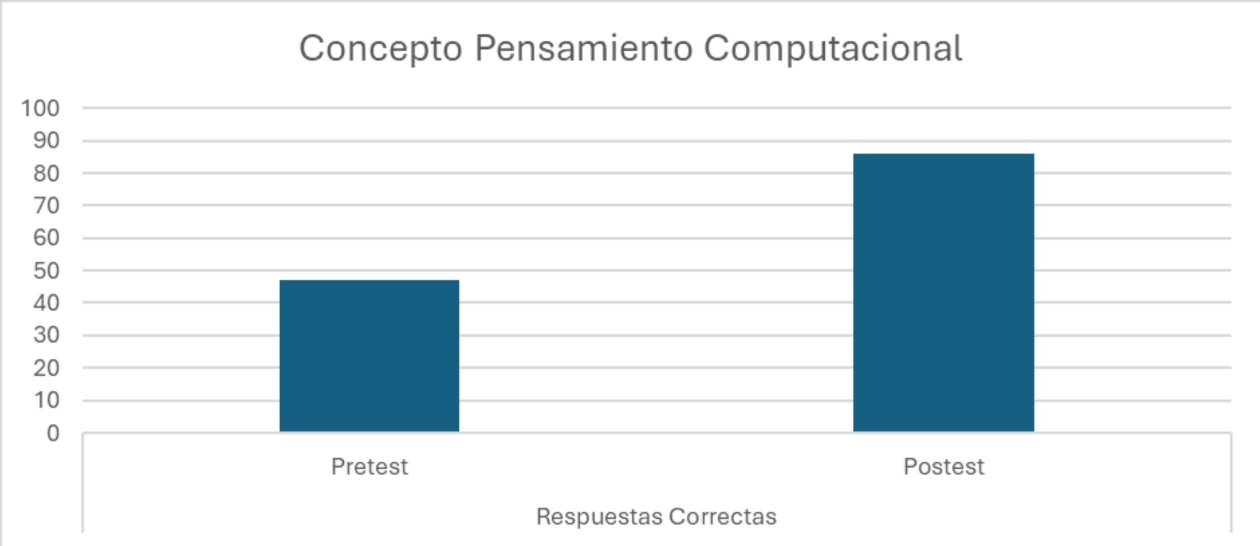

Figure 2. PC concept

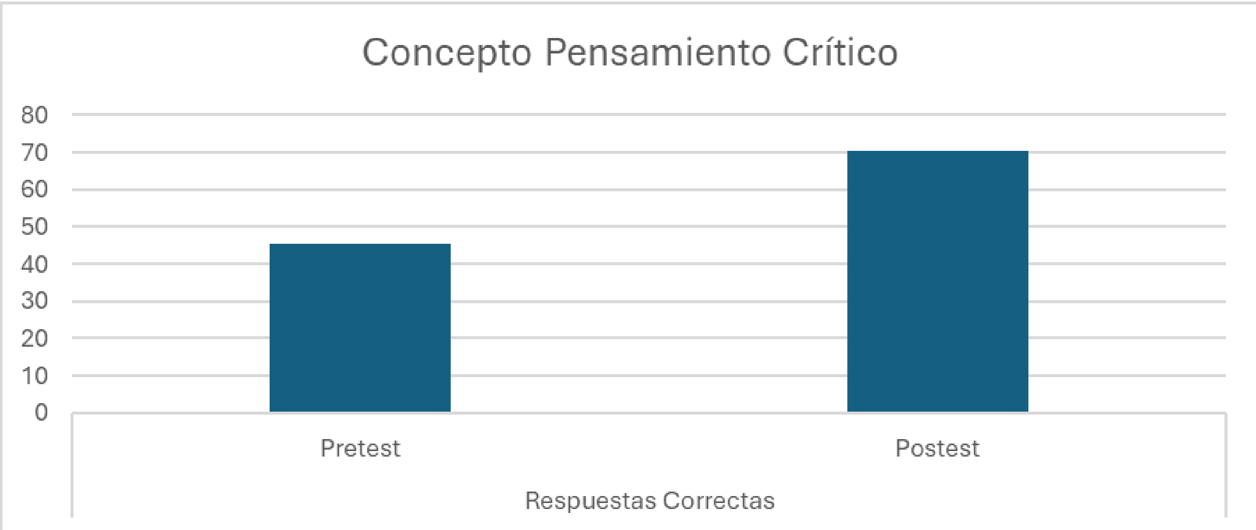

Figure 3. Concept of Critical Thinking

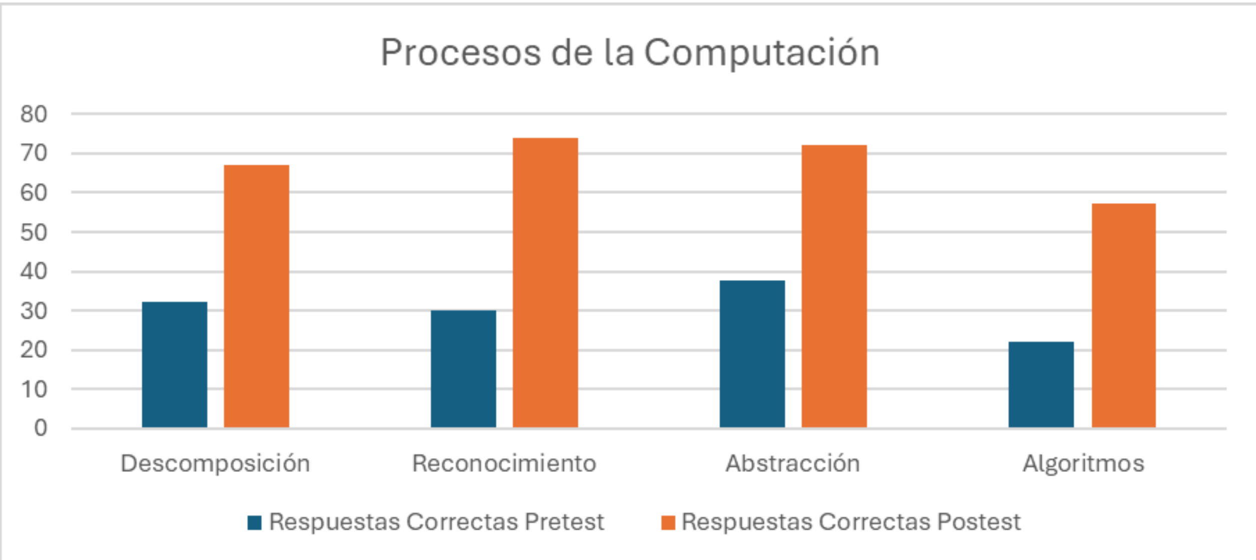

Figure 4. Computing Processes

https://doi.org/10.56294/dm2025837

Critical Thinking is an ally for developing PC skills and competencies, as established by a study, which is addressed in items 21, 22, 23, and 24 of the pretest and with items 9, 10, 11, and 12 of the posttest, in the initial test, an assertiveness of 46,0 % is achieved, represented in 46 correct answers. The posttest achieved 71,2 % with 71 correct answers. That is to say, a difference of 25,2 % is evident. Similarly, about the results obtained in the Computer processes, which are dealt with in items 17, 37, 38, 39, 40, 18, 29, 30, 31, 32, 19, 25, 26, 27, 28, 20, 33, 34, 35 and 36 of the pretest and with items 5, 25, 26, 27, 28, 7, 17, 38, 39, 40, 18, 29, 30, 31, 32, 19, 25, 26, 27, 28, 7, 17, 39, 40, 35 and 36 of the pretest and with items 5, 25, 26, 27, 28, 7, 17, 18, 19, 20, 6, 13, 14, 15, 16, 8, 21, 22, 23 and 24 of the post-test, the aim was to determine the level of competence related to computer processes or components of the PC, such as decomposition, pattern recognition, abstraction and algorithms.

In the dimension of decomposition, the pre-test yielded a figure of 32,5 %, equivalent to 32 correct answers, which, compared with the post-test, increased by 35 % to 67,7 %. As for pattern recognition, the initial figures are 30,3 % and the final ones 74,7 %, which suggests a percentage increase of 44 %. These are highly positive figures due to their importance in terms of getting the target population to appropriate these concepts and key dimensions in order to get their students to solve problems by thinking computationally.

As for the abstraction dimension, the figures fluctuate between 38,2 % and 72,9 %, indicating a post-test assertiveness of 34 %, also achieving an increase. Finally, about the algorithms component, the figures reached 57,8 % in the post-test, while in the pre-test, it was 22,2 %, with an increase of 35 %. In light of the final results, these figures allow us to infer that the dimensions with the best score are pattern recognition with an improvement of 42 %, decomposition with 35 %, and abstraction with the exact figures. In comparison, the lowest figure is obtained for algorithms with 34 %.

Finally, we have the results obtained for problem-solving, which include items 41, 42, 43, 44, and 45 of the pretest and items 29, 30, 31, 32, and 33 of the posttest, which sought to determine the ability to solve problems by applying PC. In the pretest, 39,4 % assertiveness was observed, while in the posttest, 60,4 % was achieved, which is equivalent to a percentage increase of 21 %, as shown in the following figure.

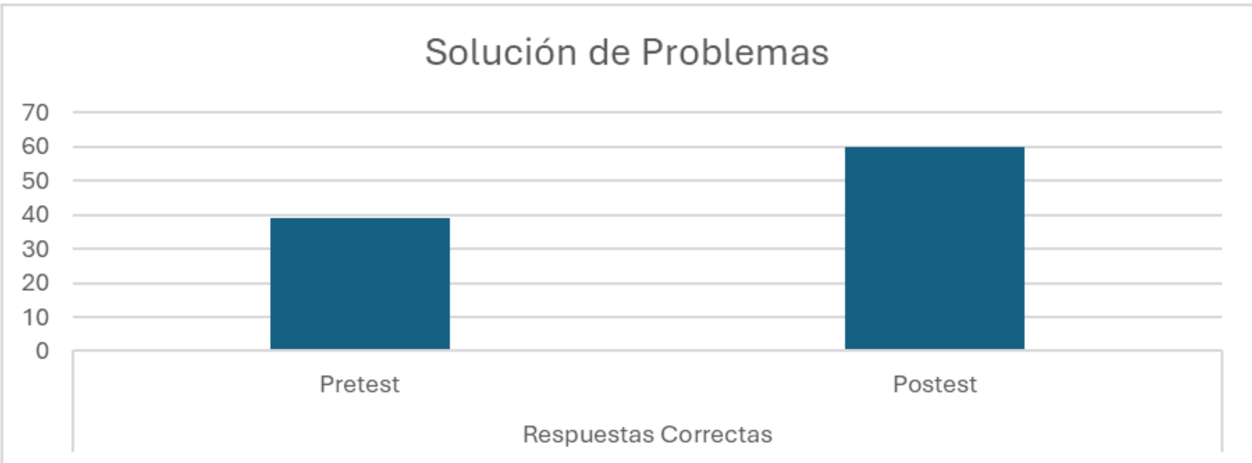

Figure 5. Problem Solving

Similarly, in this quantitative analysis, it is pertinent to point out that the 99 respondents' lowest figures correspond to two teachers who only reached 4 % assertiveness in the pre-test and 7 % in the post-test. It should also be noted that one participant initially reached 4 % but ended up with 27 %, which is a highly favorable result. However, another participant remained at 16 % in the pre-test and with the exact figures in the post-test without achieving any variation.

Hypothesis testing

To test the hypothesis, initially, the Shapiro-Wilk test was applied, showing that the pretest data have a normal distribution, but not the posttest data; however, using the d'Agostino-Pearson graph symmetry analysis test, a normal distribution was obtained for the two sets of data. Subsequently, the z-test for differences in means of large and related samples was applied, formulating the hypotheses to be tested as follows:

Under the null hypothesis, the difference between the pretest mean (U1) and the posttest mean (U2) is equal to or greater than 0; that is, teaching strategies do not positively affect the level of PC competence in primary school teachers, which is symbolized as: U1 - U2 >= 0.

The alternate hypothesis: that the difference between the pretest mean and the posttest means is less than 0, teaching strategies significantly positively affect the PC competence level of primary school teachers, which is symbolized as U1- U2< 0. Next, the value of the z-function was calculated, as shown in table 1.

https://doi.org/10.56294/dm2025837

Table 1. Hypothesis testing

z-test for related two-sample large sample means	Pretest	Postest
Mean	10,909091	21,202020
Variance (known)	16,654900	24,040400
Observations	99	99
Hypothetical difference of means	0	
z	-16,054044	
P(Z<=z) one-tailed	0	
Critical value of z (one-tailed)	1,644854	
Critical value of z (two-tailed)	0	
Critical value of z (two-tailed)	1,959964	

Finally, the critical value of z for one tail is compared, revealing that z is lower than the critical value. This means that z is in the non-acceptance zone, and therefore, the null hypothesis is rejected, and the alternative hypothesis is accepted. Thus, the didactic strategies applied have a positive influence on the level of PC competences in primary school teachers in Colombia.

DISCUSSION

Including CP at all educational levels requires implementing programs and workshops that teach fundamental concepts to students of all ages. In line with this conceptualization, the research shows that the proposed intervention has impacted the understanding of CP, evidenced by a 42 % increase in the accuracy of the answers, which went from 47,5 % in the pretest to 86,9 % in the posttest. Therefore, the effectiveness of the intervention in improving the understanding and application of the fundamental concepts of CP and the relationship between the concept and the perspective (knowing and knowing how to be) is highlighted, highlighting how these dimensions foster the ability to make informed decisions and manage knowledge effectively. These results confirm that the intervention has successfully strengthened the conceptualization of CP and its practical application and is in line with the above,[2] he states that CP is crucial for addressing problems and developing critical thinking skills, which are fundamental in today's educational context.

Therefore, implementing strategies based on reflective workshops has proven to be effective in improving the competence level of primary basic education teachers, evidenced by a remarkable increase in the post-test scores compared to the pretest. This finding is consistent with the proposal of Ríos[20], who suggests that a specific methodological approach, which integrates a creative dimension, can foster the development of critical, computational, and innovative thinking. Rodríguez[1] argues that critical thinking, defined as the mental ability to autonomously and objectively analyze a situation, is a key resource for understanding the problem to be solved. On the other hand, Sarmiento[21] states that a well-structured methodology can enhance the skills of students and teachers by stimulating curiosity in the generation of new knowledge.

However, the research by Muñoz et al.[17] underlines that a solid methodology can improve skills and competencies in CP. Also, this approach has had a positive impact on strengthening critical thinking and enhancing their ability to solve problems logically and creatively. Consequently, the significant improvement in the accuracy of the students' answers, from 46 % to 71,2 % between the pre-test and post-test, suggests that the focus on Critical Thinking has been practical in developing CP skills.[22,23,24] For this reason, the Computer Processes assessment also shows progress in key competencies such as decomposition, pattern recognition, abstraction, and algorithms, confirming that the applied methodology has reinforced critical thinking and strengthened essential PC competencies.[25,26,27]

These results suggest that the applied methodology has comprehensively strengthened the understanding and application of CP. In the words of a study CP is essential for problem-solving and fostering skills in digital environments. This perspective aligns with the research findings, highlighting significant advances in key areas such as decomposition, pattern recognition, abstraction, and algorithms, underlining their role in developing skills to address challenges and promote innovation. In line with the above, it revealed that the intervention increased skills in each of the PC dimensions assessed; the most significant strength was observed in pattern recognition, followed by decomposition and abstraction in the words of a study the target population through abstraction simplified the understanding of a situation by focusing on its essential characteristics and managing the complexity of the problem. Pinzón et al.[3] explain that decomposition involves analyzing a problem by breaking it down into smaller components to facilitate its resolution.

While algorithms showed more modest progress in the words of Pinedo et al.[4], describe these as a set of finite

https://doi.org/10.56294/dm2025837

and ordered instructions to solve a problem, representing the step-by-step. Consequently, according to a study, the PC is crucial for solving problems and enhancing creativity in digital environments.[28,29,30] This perspective aligns with the research findings, which show progress in fundamental aspects such as decomposition, pattern recognition, abstraction, and algorithms, highlighting their importance in developing skills to face challenges and foster innovation.[31,32]

It is relevant to connect Halmos cited in Cabra et al.[22] assertion about the importance of problem-solving in learning with the current findings, considering it as an essential component in learning, which underlines the need for practical approaches to improving this skill. The research results reflect variability in participants' progress in terms of problem-solving; some strengthened problem-solving competence, while others had minimal or no change. This variability confirms the importance of addressing problem-solving as a critical area in education. It suggests that, despite the gains made with the intervention, additional strategies should be developed to support students with limited progress.[33,34]

In summary, this study's findings are not only in line with previous research on PCs and educational curricula but also provide additional evidence on the effectiveness of the didactic strategies implemented to develop these competencies among primary school teachers in Colombia. The results show that relevant generalizations that impact the Colombian educational context can be drawn. The didactic strategies employed in this study suggest their applicability in different educational contexts within the Colombian system, especially in the continuous training of PC teachers in the digital era.

CONCLUSIONS

The importance of integrating these competencies from the initial training of primary school teachers is highlighted, which not only improves their professional skills but also prepares students to face contemporary technological challenges. Furthermore, the findings underline the need for future research that delves into the implementation of specific strategies to strengthen PCs at different stages and educational contexts, as well as the impact of these strategies on other competencies related to digital technologies in education. Additionally, this study provides a solid framework for understanding how didactic strategy can positively influence CP development in primary school teachers, highlighting the importance of curricular validity and the rigorous use of quantitative methods in evaluating similar educational interventions. These results support a study idea about the importance of active and practical learning in acquiring deep and applicable knowledge.

It should be noted that the intervention applied has proven to be effective in improving CP competencies among primary school teachers. Consequently, the results have shown an increase in the accuracy of responses, especially in areas such as pattern recognition, decomposition, and abstraction. Therefore, this development suggests that the didactic strategies implemented have significantly strengthened the understanding and application of the fundamental concepts of CP. Furthermore, the research reinforces the importance of CP not only for problem-solving. Thus, the findings underline that improvement in key competencies such as decomposition and pattern recognition contributes significantly to developing critical and creative skills in the educational context.

This is in line with a study perspective, which highlights the essential role of CP in promoting innovation. However, despite significant advances in the understanding of CP, variability in the improvement of problem-solving competence was observed among participants. This, therefore, indicates the need to implement additional strategies to support those students who show limited progress in this area. Consequently, the variability in results underlines the importance of developing specific approaches that effectively address problem-solving challenges within the educational context using different learning strategies

BIBLIOGRAPHIC REFERENCES

1. Rodríguez AG. Enseñanza de la programación a través de Scratch para el desarrollo del PC en educación básica secundaria. Rev Acad Virtualidad. 2022;15(1):161-82.

2. Pršala J. El efecto de las actividades de programación basadas en bloques en las habilidades de PC de los maestros de primaria en formación. Rev Sociol Pedag Psicol. 2024. doi:10.33902/jpsp.202426267.

3. Pinzón L, Paredes J. Desarrollo de habilidades de PC por medio de actividades conectadas y desconectadas en estudiantes de grados sexto y séptimo. Universidad Pedagógica Nacional; 2022. http://repository.pedagogica.edu.co/bitstream/handle/20.500.12209/17730/Pensamiento%20computacional.pdf?sequence=1

4. Pinedo A, Ramírez J. Análisis de algoritmos de predicción y optimización para la mejora de la cadena de suministro del efectivo. 2022. https://tesis.pucp.edu.pe/repositorio/handle/20.500.12404/22537

5. Zetra Hainul Putra, Neni Hermita, Jesi Alexander Alim, Muhammad Fendrik, Riyan Hidayat, Zaldi Harfal,

et al. Development of mathematics learning based on computational thinking for primary school teachers. Transformasi. 2023;19(2). doi:10.20414/transformasi.v19i2.8430.

6. Álvaro MA, Natividad AP, Rafael BL, Manuel TR. Introduction to Computational Thinking with Scratch for Teacher Training for Spanish Primary School Teachers in Mathematics. Educ Sci. 2022;12(12):899. doi:10.3390/educsci12120899.

7. Bilbao J, Bravo E, García O, Rebollar C, Varela C. Computational Thinking as a New Cross-Curricular 17 Competence. INTED2021 Proceedings. 2021:3748-54.

8. Bocconi S, Chioccariello A, Kampylis P, Dagienė V, Wastiau P, Engelhardt K, et al. Reviewing Computational Thinking in Compulsory Education. Luxembourg: Publications Office of the European Union; 2022. ISBN 978-92-76-47208-7. doi:10.2760/126955.

9. Motoa S. PC. Rev Educ Pensam. 2019;26. http://educacionypensamiento.colegiohispano.edu.co/index.php/revistaeyp/oai

10. Quiroz-Vallejo DA, Carmona-Mesa JA, Castrillón-Yepes A, Villa-Ochoa JA. Integración del PC en la educación primaria y secundaria en Latinoamérica: una revisión sistemática de literatura. Rev Educ Distancia. 2021;21(68). doi:10.6018/red.485321.

11. Fundación Sadosky. Propuesta curricular para la inclusión de las Ciencias de la Computación en la educación obligatoria de la Argentina. Fundación Sadosky; 2024. https://curriculum.program.ar/

12. Ministerio de Educación Nacional. Base Nacional Común Curricular: Educação é a Base. Brasil; 2022. http://basenacionalcomum.mec.gov.br/images BNCC_EI_EF_110518_versaofinal_site.pdf

13. Muñoz A, Torres P, Salazar J. Talleres reflexivos para el desarrollo del PC en la formación de maestros de básica Primaria en Colombia. In: Romero J, et al., editors. Escenarios educativos investigadores: hacia una educación sostenible. Madrid: Editorial DYKINSON, S.L.; 2021. p. 556-66.

14. Muñoz A, Torres P, Salazar J. PC en la formación inicial de maestros de básica primaria en la escuela Normal Superior de Pasto. In: Jiménez J, et al., editors. PC en la formación de docentes de básica primaria en Colombia. Editorial Universidad CESMAG; 2021.

15. Tobón S. Formación integral y competencias. Pensamiento complejo, currículo, didáctica y evaluación. 4th ed. Bogotá: ECOE; 2013.

16. Kang Y. Enhancing Computational and Data Science Thinking Skills for K-12 Education. Lect Notes Educ Psychol Public Media. 2024. doi:10.54254/2753-7048/43/20240609.

17. Muñoz A, Torres P, Salazar J. Pretest docentes básica primaria [Formulario]. PC en la formación de docentes de básica primaria. 2021. https://site-rle5f.powerappsportals.com/Documentos/Instrumentos/

18. Muñoz A, Torres P, Salazar J. Postest docentes básica primaria [Archivos pdf]. PC en la formación de docentes de básica primaria. 2021. https://site-rle5f.powerappsportals.com/Material/Talleres/

19. Muñoz A, Torres P, Salazar J. Postest docentes básica primaria [Formulario]. PC en la formación de docentes de básica primaria. 2021. https://site-rle5f.powerappsportals.com/Documentos/Instrumentos/

20. Ríos J. Enseñanza de los algoritmos de programación en estudiantes iniciales de Ingeniería a través de la Dimensión Creativa. Universidad Santo Tomás; 2019.

21. Sarmiento M. Propuesta metodológica para el desarrollo de competencias vinculadas con el PC. Tecné Episteme Didaxis TED. 2022;(52):153-74. doi:10.17227/ted.num52-12796.

22. Cabra Páez ML, Ramírez Gamboa SA. Desarrollo del PC y las competencias matemáticas en análisis y solución de problemas: una experiencia de aprendizaje con Scratch en la plataforma Moodle. Rev Educ. 2022;46(1):180-97. https://www.redalyc.org/journal/440/44068165016/html/

23. Wing J. Computational Thinking: What and why? Thelink - The Magazine of the Carnegie Mellon University School of Computer Science. 2010;(March 2006):1-6. http://www.cs.cmu.edu/link/research-notebook-computational-thinking-what-and-why

24. Ortega Rosero EM, Chitán JL, Mora Ortega YD, Pianda L. Explorando las bases del PC en la educación básica primaria: Una revisión de literatura.

25. PC: Reflexiones sobre la Formación Inicial Docente en Brasil. In: PC en Iberoamérica. Academia Mexicana de Computación (AmexComp); 2023.

26. Piaget J. Cognitive development in children: Piaget, development and learning. J Res Sci Teach. 1964;2:176-86.

27. Giraldo L. Competencias mínimas en PC que debe tener un estudiante aspirante a la media técnica para mejorar su desempeño en la media técnica de las instituciones educativas de la Alianza Futuro Digital Medellín. Universidad EAFIT; 2014. https://repository.eafit.edu.co/bitstream/handle/10784/4488/LeidyYoana_GiraldoGomez_2014.pdf?sequence=2&isAllowed=y

28. Guerrero-Ortega LR, Rodríguez-Hernández AA, Forero FA. Aprendizaje significativo en ciencias naturales mediante el uso de la aplicación móvil Amazonía biodiversa: una experiencia educativa en el departamento del Putumayo. Rev Interam Investig Educ Pedagogía RIIEP. 2024;17(1):325-46.

29. Castro Velasco L, Ceballos Coral MG, Guerrero Rosero J, Sánchez EA, Silva Fuquén N. PC en la educación colombiana.

30. Code.org. 2019. http://www.code.org/

31. Code.org. Computational Thinking. Learn today, build a brighter tomorrow. 2023. https://code.org/curriculum/course3/1/Teacher

32. Fundación Sadosky. 2013. http://www.fundacionsadosky.org.ar/programas/programar/

33. Bastidas Castro D, Chagüezá OA, Imbago LP, Imbago LJ. Estrategias para el desarrollo del PC en Colombia: Revisión sistemática de la literatura.

34. Álvarez FO. Instrumentos para la evaluación del PC: una revisión de la literatura.

FINANCING
None.

CONFLICT OF INTEREST
None.

AUTHORSHIP CONTRIBUTION
Conceptualization: Armando Sofonías Muñoz del Castillo, Gladys Patricia Torres Murillo, Juan Carlos Salazar Losada, Deixy Ximena Ramos Rivadeneira, Javier Alejandro Jiménez Toledo.

Data curation: Armando Sofonías Muñoz del Castillo, Gladys Patricia Torres Murillo, Juan Carlos Salazar Losada, Deixy Ximena Ramos Rivadeneira, Javier Alejandro Jiménez Toledo.

Formal analysis: Armando Sofonías Muñoz del Castillo, Gladys Patricia Torres Murillo, Juan Carlos Salazar Losada, Deixy Ximena Ramos Rivadeneira, Javier Alejandro Jiménez Toledo.

Drafting - original draft: Armando Sofonías Muñoz del Castillo, Gladys Patricia Torres Murillo, Juan Carlos Salazar Losada, Deixy Ximena Ramos Rivadeneira, Javier Alejandro Jiménez Toledo.

Writing - proofreading and editing: Armando Sofonías Muñoz del Castillo, Gladys Patricia Torres Murillo, Juan Carlos Salazar Losada, Deixy Ximena Ramos Rivadeneira, Javier Alejandro Jiménez Toledo.