International Journal of Applied Mathematics
Volume 38 No. 10s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

DEVELOPMENT OF COMPUTATIONAL THINKING IN PRESCHOOL CHILDREN THROUGH THE BEAR BOT

Florencio Flores Ccanto[1*], Isabel Menacho Vargas[2], Lourdes Galvez Morales[3], Gualberto Federico Quiroz Aguirre[4e], Ysabel Zevallos Parave[5], Esterfilia Alama Sono[6], Marianella Marilú Villegas Lira[7]

[1*]Academic Department of Matematics the Faculty of Sciences, Enrique Guzmán y Valle National University of Education, Lima, Peru, Orcid:0000-0001-5600-9854

[2]Academic Department of education the Faculty of Education of the National University of San Marcos, Lima., Peru· Orcid: 0000-0001-6246-4618

[3]Academic Department of Matematics the Faculty of Sciences, Enrique Guzmán y Valle National University of Education, Lima, Peru., Orcid: 0000-0001-7279-4370

[4]Academic Department of Electrocic the Faculty of technology, Enrique Guzmán y Valle National University of Education, Lima, Peru, Orcid: 0000-0003-2182-8627

[5]Academic Department of Ingeniera Industrial, the Facuty de Ingeniería Industrial, Faculty of Education of the National
University of San Marcos, Lima., Peru, Orcid: 0000-0002-6957-9984

[6]Académic Departament of Biología the Facultad de Sciences, , Enrique Guzmán y Valle National University of Education, Lima, Perú, Orcid: 000-0003-4380-209X

[7]Academic Department of Matematics the Faculty of Sciences, Enrique Guzmán y Valle National University of Education, Lima, Peru, Orcid: 0000-0002-8376-1731

fflores@une.edu.pe, imenachov@unmsm.edu.pe, lgalvez@une.edu.pe, gquiroz@une.edu.pe, ysabel.universidades@gmail.com, ealama@une.edu.pe, nvillegaslira@gmail.com, mvillegas@une.edu.pe

Abstract

This study examined the impact of using Bear-Bot on the development of computational thinking in preschoolers from vulnerable sectors in four districts of Lima. A quasi-experimental design with pretest and posttest was used, evaluating four dimensions: problem space updating, problem difficulty reduction, algorithm or plan development, and goal achievement verification. The sample consisted of preschool-aged children who participated in activities designed to assess their computational thinking skills. The results showed significant improvements in their ability to break down problems, organize ideas sequentially, and create logical solutions. By the end of the intervention, the children demonstrated greater ability to structure their problem-solving processes and monitor their own performance. The use of Bear-Bot, as a playful and interactive tool, facilitated the understanding of these complex concepts in an accessible and engaging way. These findings suggest that educational software focused on computational thinking is an effective strategy to strengthen cognitive skills in early childhood education. Therefore, its integration into the school curriculum is recommended to enhance learning from an early age and promote the development of computational thinking.\

Keywords: Problem space analysis, problem difficulty reduction, algorithm development, goal verification.

Introduction

The incorporation of Information and Communication Technologies (ICT) in different areas of society has led to significant development in various sectors. This growth has driven the need to rethink and adjust educational approaches in order to strengthen essential skills for facing

Received: August 15, 2025

International Journal of Applied Mathematics
Volume 38 No. 10s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

the challenges of the contemporary social environment (García and Hernández, 2013; Henriksen et al., 2018). In this context, the importance of introducing computational thinking and encouraging active participation with digital technologies within the school curriculum has been recognized (Nardelli and Ventre, 2015; Roman et al., 2017). In response to growing evidence in this area, teachers, academics, and researchers have emphasized the importance of incorporating computational thinking as a fundamental 21st-century skill at all stages of the education system, from early childhood education to higher education (Barr and Stephenson, 2011; Grover and Pea, 2013; Shute and Asbell, 2017). This highlights the need to provide students with a solid foundation in computational thinking to enhance their problem-solving skills and their ability to take advantage of opportunities in the current context. From Wing's perspective (2011), computational thinking involves formulating and solving problems in such a way that their solutions can be efficiently executed by information processing agents, whether human, computer, or a combination of both. This process relies on fundamental skills such as abstraction, decomposition, and algorithmic reasoning (Selby & Woollard, 2013; Wing, 2008, 2011; National Research Council, 2010). More specifically, computational thinking comprises problem-solving strategies, including problem analysis, simplifying complexity by breaking it down into more manageable units, developing algorithms with sequential steps, and verifying the effectiveness of proposed solutions (Florez et al., 2017; Roman-Gonzalez et al., 2017). In this sense, the skills associated with computational thinking are not restricted to the use of electronic devices, but can be applied to everyday problem-solving situations (Wing, 2006). Thus, these skills not only promote problem solving, but also influence the cognitive abilities involved in this process (Di Lieto et al., 2017; Fessakis et al., 2013). From this perspective, computational thinking is not a skill exclusive to the field of computer science, but rather one that can be transferred to multiple disciplines, including literacy, art, journalism, biology, engineering, and the exact sciences (National Research Council, 2010; Selby and Woollard, 2013). However, despite the scientific community's support for the need to integrate computational thinking from early childhood, there is still a significant gap in research on its development in preschool education (Bers, Flannery, Kazakoff, & Sullivan, 2014; Botički, Pivalica, & Seow, 2018).

Although empirical studies have emerged on the implementation of computational thinking in primary and secondary education, the preschool stage remains an under-explored area in this field (Bers et al., 2014; Angeli and Valanides, 2020). In response to this, over the last decade, educational robotics and educational programming games have gained relevance as a teaching resource to promote computational thinking in early childhood education (Benitti, 2012; Bers, 2010). Through these tools, teachers engage students in active and playful learning experiences that involve the construction and programming of physical materials. This approach has proven effective in strengthening mathematical and scientific skills, as well as fostering creativity, innovation, problem-solving, and teamwork (Zhong and Xia, 2020; Arabit and Prendes, 2020; Khanlari, 2016; Cabello and Carrera, 2017). Research such as that by Barrera (2015) and Schina et al. (2021) has highlighted the importance of this tool in the educational process, noting that it contributes to student learning by introducing them to complex mathematical and scientific concepts (Zhong and Xia, 2020; Arabit and Prendes, 2020). In addition, teaching computational thinking promotes the development of key skills for the digital age, such as logical reasoning, problem solving, and creativity (Cabello and Carrera, 2017; Khanlari, 2016). To strengthen the integration of programming and computational thinking in science and mathematics education, initiatives aimed at teacher training have been developed. Research conducted by Sisman and Kucuk (2019), Jaipal and Angeli (2017), and Chalmers (2017) indicates that these training experiences have positive effects on teachers, such as a favorable attitude toward the use of digital tools for learning, the development of strategies for their implementation in the classroom, and the intention to integrate them into their teaching practices. However, challenges remain in the incorporation of educational technologies, as many institutions face access limitations due to geographical, economic, or political factors.

In the field of early childhood education, various proposals have emerged aimed at introducing students to the basic principles of sequential programming through technological environments. Different studies (Chen et al., 2017; Diago and Arnau, 2017; Merino et al., 2018; Sáez and Cózar, 2017) have shown that teaching computational thinking (Wing, 2006) promotes the development of mathematical reasoning and problem solving. In this context, an effective strategy for teaching problem solving from a technological perspective is the use of programmable robots, whose processes can be linked to the stages of the problem-solving approach proposed by Polya (1945).

Consequently, it is essential to conduct further research into the effects of computational thinking activities on the development of children's mathematical reasoning, which will enable us to assess their impact on learning and optimize their integration into the educational curriculum. In this regard, the present study is oriented toward the creation of educational software based on the Bear Bot robot, designed specifically to enhance the development of computational thinking in preschool children. This software will provide an interactive platform that will facilitate the teaching of basic programming and problem-solving principles through playful and experimental activities, thus consolidating an innovative learning model in early childhood education.

Method

The research was conducted using a quantitative approach, allowing for the analysis of data obtained through numerical measurements and their subsequent statistical interpretation. A pre-experimental design was used, in which an intervention was applied to the independent variable to evaluate its effect on the dependent variable. The methodological sequence included the application of a pretest, followed by the implementation of the treatment, and ending with a posttest to measure the changes generated.

Population and sample

The selection of participants was carried out intentionally, choosing 211 five-year-old preschoolers attending early childhood education institutions in several districts of Lima: Lurigancho, San Juan de Lurigancho, Comas, and Ate Vitarte. This sample was carefully selected to ensure that the results were representative of the target population.

Instruments

Two instruments were used for data collection: the first consisted of a checklist designed to assess computational thinking in preschoolers, structured around specific dimensions related to problem analysis, task simplification, algorithm formulation, and result verification; the second instrument consisted of digital and physical Bee-Bot materials, used as a pedagogical tool in the intervention. Data processing was carried out using descriptive statistical analysis, representing the results in bar graphs that allowed for the identification of trends and variations in the participants' performance. This methodological strategy facilitated the interpretation of the findings and the evaluation of the impact of the intervention on the development of computational thinking in the study group.

Data analysis

Rigorous validation processes were carried out to ensure the validity and reliability of the instruments used in the study. To evaluate validity, three experts in the field of child psychology collaborated in validating the instruments used to measure the neuropsychological development of preschoolers. The results obtained in the expert validation showed that the instruments used have high validity and are appropriate for the population studied. The average validation score achieved was 88.33%, which supports the reliability of the instruments applied in the study. This validation ensures that the measurement tools are effective in capturing the dimensions of neuropsychological development in preschoolers, contributing to the robustness and relevance of the results obtained.

Descriptive statistical analysis represented the results in bar graphs to identify trends and variations. Four instruments were developed based on the dimensions of computational thinking. As a pilot group, 22 five-year-old preschoolers in Lima were selected. The instruments were applied and analyzed using the KR20 coefficient, obtaining a value of 0.626, which confirmed their reliability.

Results The results were analyzed using a confidence level of 95% ($\alpha = 0.05$) and a degree of freedom of 211. The hypothesis proposed was that the use of Bear-Bot influences the computational thinking of preschoolers, while the null hypothesis was that there is no such influence. To verify the distribution of the data and its normality, a statistical analysis was performed, the results of which are presented in Table 1.

The study of data normality, presented in Table 1, was performed using the KolmogorovSmirnov and Shapiro-Wilk tests. The results indicated significance values less than 0.05 in both tests for the pretest and posttest, suggesting that the data do not follow a normal distribution.

Since normality was not met, the Wilcoxon signed-rank test for related samples was applied, as shown in Table 2. The results yielded a significance value of 0.000, which led to the rejection of the null hypothesis and the conclusion that there are significant differences between the pretest and posttest in the preschoolers' computer knowledge.

Table 1 Normality test of the data

International Journal of Applied Mathematics
Volume 38 No. 10s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

	Kolmogorof-Smirnov[a]			Shapiro-Wilk		
	Statistician	*gl*	*sig*	*Statistician*	*gl*	*sig*
Pretest	*,177*	*211*	*,000*	*,938*	*211*	*,000*
Postest	*,118*		*,000*	*,958*	*211*	*,000*

a. Lillerfors significance correction

Table 2 *Contrasting computational knowledge hypotheses*

	Null hypothesis	Test	Sig.	Decision
1	The median of the differences between the pretest and posttest is equal to 0.	Wilcoxon signed-rank test for related samples	0,000	Reject the null hypothesis

Se muestran significaciones asintóticas. El nivel de significancia es 0,05

Table 2 shows that the null hypothesis is rejected and, as a result, the alternative hypothesis is accepted; that is, it is affirmed that "The use of Bear-Bot influences the computational thinking of preschool children.

The study of normality for the dimensions analyzes the problem space, reduces the difficulty of the problem, develops an algorithm or plan, and verifies that the goal is achieved.

Table 3*Study of the normality of data on computational thinking dimensions*

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistician	gl	Sig.	Statistician	gl	Sig.
Pre_D1_analyzes_the_problem_space	0,313	211	0,000	0,770	211	0,000
Pre_D2_reduces_the_difficulty_of_the_problem	0,293	211	0,000	0,774	211	0,000
Pre_D3_develops_an_algorithm_or_plan	0,298	211	0,000	0,792	211	0,000
Pre_D4_verifies_that_the_goal_is_achieved	0,249	211	0,000	0,795	211	0,000
Pos_D1_analyzes_the_problem_space	0,238	211	0,000	0,805	211	0,000
Pos_D2_reduces_the_difficulty_of_the_problem	0,249	211	0,000	0,841	211	0,000
Pos_D3_develops_an_algorithm_or_plan	0,266	211	0,000	0,863	211	0,000
Pos_D4_verifies_that_the_goal_is_ac	0,228	211	0,00	0,889	211	0,00

International Journal of Applied Mathematics
Volume 38 No. 10s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

hieved	0	0

a. Lilliefors significance correction

Within the framework of this research, the first specific hypothesis is proposed, which seeks to determine the impact of using Bear-Bot on the development of spatial analysis skills in preschool children.
The alternative hypothesis (H1) argues that the use of Bear-Bot influences children's ability to analyze the space of a problem; on the other hand, the null hypothesis (H0) proposes that the use of Bear-Bot has no effect on this ability.
This hypothesis testing will allow us to evaluate whether the implementation of Bear-Bot is an effective resource for enhancing cognitive development in children in this area.

Table 4 *Hypothesis testing of the ability to analyze the space of a problem*

Null hypothesis	Test	Sig.	Decision
The median of the differences between Pre_D1_analyzes_the_problem_space and Post_D1_analyzes_the_problem_space is equal to 0.	Wilcoxon signedrank test for related samples	0,000	Reject the null hypothesis 1

Asymptotic significance levels are shown. The significance level is 0.05.
Table 4 presents the hypothesis testing related to preschool children's ability to analyze the space of a problem before and after using Bear-Bot.
In this analysis, the Wilcoxon signed-rank test for related samples was used, a statistical method appropriate when comparing two measurements from the same sample and the data do not follow a normal distribution.
The result obtained shows a significance value (Sig.) of 0.000, which is less than the established significance level ($\alpha = 0.05$). This implies that there is sufficient evidence to reject the null hypothesis, which stated that there were no significant differences between children's spatial analysis abilities before and after the Bear-Bot intervention. Therefore, by rejecting the null hypothesis, the alternative hypothesis is accepted, indicating that the use of Bear-Bot significantly influences preschool children's ability to analyze the space of a problem. The second specific hypothesis of this research seeks to determine whether the use of Bear-Bot influences preschoolers' ability to- tackle complex problems by breaking them down into smaller parts, which facilitates their resolution. This skill is key in the development of logical thinking and problemsolving strategy, as it allows children to reduce the difficulty of a task by dividing it into manageable units.
To this end, the following hypotheses are proposed:
H1: The use of Bear-Bot influences preschoolers' ability to reduce the difficulty of problems by breaking them down into smaller units.

International Journal of Applied Mathematics
Volume 38 No. 10s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

H0: The use of Bear-Bot does not influence preschoolers' ability to reduce problems by breaking them down into smaller units to reduce their difficulty.

Table 5 *Hypothesis testing of the ability to reduce the difficulty of the problem*

Null hypothesis	Test	Sig.	Decision
The median of the difference between the pre_D2_reduces_ the _ difficulty_of _the problem and Pos D2 reduces the difficulty of the problem is equal to 0	Wilcoxon signed-rank of the related sample	0.000	rejected null hypothesis

Asymptotic signification levels are shown The significance level is 0.05

Table 5 shows that the null hypothesis is rejected and, as a result, the alternative hypothesis is accepted; that is, it is affirmed that "The use of Bear-Bot influences the ability of preschool children to reduce difficulty by breaking it down into smaller units."
The third specific hypothesis of this research seeks to evaluate whether the use of Bear-Bot influences preschoolers' ability to develop algorithms or plans structured in sequences of steps or instructions. This skill is fundamental in the development of computational thinking, as it allows children to organize and structure solutions in a logical and orderly manner.
To this end, the following hypotheses are proposed:
H1: The use of Bear-Bot influences preschoolers' ability to develop algorithms or plans composed of sequences of steps or instructions.
H0: The use of Bear-Bot does not influence preschoolers' ability to develop algorithms or plans composed of sequences of steps or instructions.

Table 6 *Hypothesis testing of the ability to develop algorithms or plans*

	Null hypothesis	Test	Sig.	Decision
1	The median of the differences between Pre_D4_verifies_that_the_goal_is_achieved and Post_D4_verifies_that_the_goal_is_achieved is equal to 0.	Wilcoxon signed-rank test for related samples	0,000	Reject the null hypothesis

E 7Asymptotic significance levels are shown. The significance level is 0.05.
Table 6 presents the hypothesis testing on the ability of preschool children to verify whether they have achieved a goal before and after using Bear-Bot. The result obtained shows a significance value (Sig.) of 0.000, which is lower than the established significance level (α =

0.05). This indicates that there is sufficient statistical evidence to reject the null hypothesis, which stated that there were no significant differences between the ability to verify goals before and after the intervention with Bear-Bot. Therefore, by rejecting the null hypothesis, the alternative hypothesis is accepted, suggesting that the use of Bear-Bot significantly influences children's ability to develop algorithms or plans composed of sequences of steps or instructions. The fourth specific hypothesis of this research seeks to evaluate whether the use of Bear-Bot influences preschoolers' ability to verify whether they have achieved a goal. This skill is fundamental in the development of critical thinking and self-regulation, as it allows children to reflect on their process, identify errors, and make adjustments if necessary.

Discussion

The results obtained in this study, which demonstrate the significant impact of using Bear-Bot on preschool children's ability to analyze spatial problems, are consistent with recent research highlighting the benefits of digital tools in cognitive and spatial development in childhood. In this regard, Zorrilla-Puerto et al. (2023), in their systematic review of educational robotics in childhood, conclude that the basic principles of programming have a positive effect on the development of cognitive and spatial skills, facilitating the understanding of abstract concepts in preschool children. The authors state that the use of tools such as Bear-Bot promotes the development of key skills, such as spatial analysis and problem solving, which are fundamental aspects at this early stage of learning.

On the other hand, Misirli and Komis (2020), in their study on computational thinking in early childhood education, analyze how preschool children (aged 4 to 6) develop advanced debugging skills by programming a tangible robot, the Bee-Bot. The programming activity allows them to identify and correct errors, a cognitive process that promotes the development of critical and logical thinking. This debugging process, which involves recognizing and correcting errors in code, can be compared to the spatial analysis processes observed in the use of Bear-Bot in the present study, since both involve logical and sequential structuring to solve problems. In addition, interaction with these tools facilitates the acquisition of both syntactic and semantic knowledge, which is essential for the development of computational thinking. Consistently, Bers et al. (2014) emphasize that educational robots, such as the Bee-Bot, promote practical and visual interaction with the environment, which facilitates the understanding of abstract concepts and problem solving. This finding is also reflected in the results of our study, where the use of Bear-Bot allows preschool children to physically manipulate the robot, making learning more accessible and meaningful, especially in terms of understanding spatial concepts.

These findings add to the growing body of evidence supporting these digital learning resources as a powerful tool for developing computational thinking in early childhood education. Like previous studies, the results show that the use of tools such as Bear-Bot not only improves spatial analysis skills but also promotes the development of other essential cognitive skills, such as sequencing instructions, problem solving, and debugging.

International Journal of Applied Mathematics
Volume 38 No. 10s, 2025
ISSN: 1311-1728 (printed version); ISSN: 1314-8060 (on-line version)

The results also indicate that the use of Bear-Bot significantly influences the ability of preschool children to tackle complex problems by breaking them down into smaller parts, which facilitates their resolution. This finding is in line with existing literature on computational thinking in childhood. Cervera-Manjarrez et al. (2023), in their analysis of the principles and strategies for the development of computational thinking, emphasize the importance of technological tools in the educational process, highlighting their ability to promote fundamental cognitive skills such as abstraction and problem solving. According to these authors, computational thinking allows children to approach problems in a structured way, breaking them down into manageable units. Cervera-Manjarrez et al. (2023) also highlight tools such as Lightbot, Tinkercad, and Hour of Code, which are effective for the development of computational thinking by facilitating problem management through fragmentation. Similarly, our research has shown that the use of Bear-Bot not only improves children's ability to sequence instructions, but also promotes a structured and logical approach to problem solving, thus reinforcing the principles of computational thinking mentioned by the authors. On the other hand, the study by Misirli and Komis (2020), which explores the impact of programming tangible robots such as Bee-Bot, points out that debugging and programming activities allow children to develop critical and logical thinking skills. This process, which involves identifying and correcting errors in instructions, parallels the analysis and decomposition skills observed in the present research, where the use of Bear-Bot enabled children to tackle complex problems by breaking them down into simpler steps. In addition, the work of Bers et al. (2014) also supports the hypothesis that technological tools and programming principles contribute to the development of computational thinking by facilitating the understanding of abstract concepts through practical and visual experience. In this study, the direct manipulation of Bear-Bot allowed children to interact with the robot in a tangible way, facilitating their understanding of spatial and logical concepts. This practical interaction favored the decomposition of complex problems into more manageable units, in line with the results obtained in our research.

Similarly, González Caballero and Hernández Barbosa (2023), reflecting on computational thinking skills and their implementation in education, highlight the need for students to develop technological, logical, and critical skills to adapt to the challenges of the Fourth Industrial Revolution. In their study, they emphasize that computational thinking is not limited to programming, but also promotes a comprehensive approach to problem solving, fostering analytical, decomposition, and logical reasoning skills. These principles are reflected in the results of our research, in which the use of BearBot allows children not only to improve their ability to decompose problems, but also to strengthen their critical and logical thinking, essential skills for their cognitive development and adaptation to the challenges of the future.

In conclusion, the findings of this study corroborate the effectiveness of tools such as Bear-Bot in the development of key cognitive skills, such as problem decomposition, logical analysis, and complex problem solving in early childhood education. These results are consistent with the theoretical approaches of Cervera-Manjarrez et al. (2023), Misirli and Komis (2020), Bers et al. (2014), and González Caballero and Hernández Barbosa (2023), who highlight the relevance of digital tools and programming environments as fundamental resources for promoting computational thinking and the development of essential cognitive skills in early childhood. The results of this study confirm that the use of Bear-Bot significantly influences the ability of preschool children to develop algorithms or plans structured in sequences of steps or instructions. This finding is particularly relevant in the field of computational thinking, given that the ability to organize and structure solutions in a logical and orderly manner is one of the fundamental pillars of cognitive development in early childhood.

Various studies have analyzed the impact of technological tools on learning programming and developing computational thinking in childhood. Along these lines, Maíz Guijarro and Carvalho (2021) conducted a systematic review of the use of interactive resources in early childhood education in Spain, identifying that tools such as Bee-Bot and Pro-Bot, being programmable physical devices, favor learning based on the sequencing of steps, promoting the development of algorithmic skills in children. The authors highlight that these resources allow children to manipulate abstract concepts in a tangible way, facilitating their understanding and application in problem solving.

The findings of this study support these conclusions, albeit from a digital perspective. BearBot, despite being a virtual tool, is based on the same principles of programming and computational thinking as physical devices, offering a similar experience in terms of sequencing instructions and problem solving. This suggests that both digital environments and physical robots can play a key role in teaching computational skills from an early age. For his part, Álvarez-Herrero (2023) explored low-cost strategies for integrating programming tools into early childhood education, highlighting that even with limited resources, it is possible to design effective activities that foster sequential logic and algorithmic thinking in children. This approach is particularly relevant in the context of the present research, as it demonstrates the feasibility of implementing Bear-Bot as an accessible and scalable resource in different educational settings, expanding learning opportunities without relying exclusively on physical devices.

Another aspect to consider is the impact these tools have on children's motivation and active learning. Both physical devices and digital programming platforms encourage greater student participation by allowing them to experiment and learn through direct interaction with sequencing and problemsolving concepts. This approach to learning based on exploration and experimentation is essential in early childhood education, as it stimulates curiosity and critical thinking from an early age.

Previous research has shown that the use of programming tools, both physical and virtual, can improve children's motivation and engagement in the learning process. For example, Sullivan and Bers (2016) found that second-grade preschoolers could master basic robotics and programming concepts after completing an eight-week curriculum. In the context of the present research, it has been observed that the use of Bear-Bot has promoted the development of algorithmic skills and generated a high level of engagement in children during activities. These findings are consistent with studies such as that of Strawhacker and Bers (2015), who highlight that well-designed digital environments can provide effective learning experiences, promoting exploration and creativity at an early age.

Conclusion

The conclusions of this research indicate that the use of Bear-Bot has a significant effect on the development of computational thinking skills in 5-year-old preschool children in the districts of the city of Lima. The results suggest that the tool contributes positively to several key aspects of the problem-solving process.

First, it was evident that the Bear-Bot intervention improves children's learning in computational thinking. The children showed a greater ability to structure their thoughts sequentially and logically, an essential component in the development of higher cognitive skills. The use of Bear-Bot promotes mental organization and a structured approach to problem-solving, which has implications for strengthening reasoning skills at early ages. Regarding the analysis of the problem space, the results showed that the children were able to understand and decompose the presented situation more effectively. This ability to analyze and visualize the different dimensions of the problem represents a key aspect of spatial cognition and complex problem-solving. The Bear-Bot intervention allowed children to identify the components and relationships of problems, which facilitated the solution process.

Another relevant finding was that Bear-Bot helped children reduce the difficulty of problems by breaking down complex situations into smaller, more manageable units. The ability to break problems down into sequential steps is critical for developing logical thinking and problemsolving skills. This finding is consistent with the literature on programming and computational thinking learning, where decomposition is a key strategy for tackling complex tasks. Furthermore, the intervention showed that children were able to develop algorithms or structured plans as part of their problem-solving process. This development of sequential and logical plans is essential for improving computational thinking skills and reflects significant progress in children's ability to organize and structure their solutions. Using Bear-Bot fosters the internalization of these processes, promoting planning skills through practice with the robot.

Finally, the analysis of children's ability to verify whether they have achieved a goal in the problemsolving process also showed positive results. The children were able to monitor their progress and evaluate the effectiveness of their actions in achieving the stated objective. This component of selfregulation and evaluation is fundamental to the learning process, as it allows children to identify their achievements and experience a sense of satisfaction when reaching goals.

The results obtained in this study provide evidence that the use of Bear-Bot has a positive impact on the development of computational thinking. By facilitating problem decomposition, algorithm creation, and goal verification, Bear-Bot significantly contributes to strengthening fundamental skills in the learning process during the early stages of education.

Acknowledgements

The authors declare that they have no actual or apparent conflicts of interest. The authors declare that they have not received any funding for this manuscript beyond the resources allocated to academic time at their respective universities. The authors have not used artificial intelligence in the ideation, design, or writing of this research, in accordance with Crawford et al. (2023). The authors confirm that they have complied with the ethical standards expected

according to Purvis and Crawford (2024). We are very grateful to all the teacher-friends who shared the survey link with their students, as well as to the universities that allowed us to discuss and share the survey link with their students within the university.
The contribution to the article is as follows: FCF, IMV, YMC, JCVC: conception and design of the study; FCF, JCVC, YLHR: data collection; YMC, JCVC, YLHR, MMLC: analysis and interpretation of the results; FCF, YMC, MMLC: preparation of the draft. All authors approved the final version of the manuscript.

References

[1] Álvarez-Herrero, J.-F. (2023). Robótica educativa y pensamiento computacional en educación infantil y con pocos recursos. *En Actas del Congreso Internacional Virtual USATIC 2023, Ubicuo*

[2] *y Social: Aprendizaje con TIC* (p. 104). Servicio de Publicaciones, Universidad de Zaragoza.

[3] https://doi.org/10.26754/uz.978-84-18321-84-9

[4] Angeli, C., & Valanides, N. (2020). Teaching computational thinking and robotics to preschoolers: A case study of early education practices. *Educational Media International,* 55(2), 136-152.

[5] Barr, D., & Stephenson, C. (2011). Bringing computational thinking to K-12: What is involved and what is the role of the computer science community? *ACM Inroads*, 2(1), 48-54.

[6] Benitti, F. B. V. (2012). Impact of using robotics in education: A systematic review of research. *Educational Robotics*, 10(3), 1-13.

[7] Bers, M. U. (2010). The role of robotics in early childhood STEM education. *The International Journal of Engineering Education*, 26(3), 760-770.

[8] Bers, M. U., Flannery, L. D., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and physical computing in early childhood education. *Computers in the Schools*, 31(3), 201-212. https://doi.org/10.1080/07380569.2014.926418

[9] Botički, I., Pivalica, P., & Seow, H. (2018). Teaching computational thinking and robotics to preschoolers: A case study of early education practices in Croatia. *Educational Media International*, 55(2), 136-152.

[10] Cabello, F., & Carrera, J. A. (2017). The educational use of robotics in science education. *Revista Electrónica de Investigación Educativa*, 19(1), 1-16.

[11] Chalmers, C. (2017). Developing teachers' confidence in teaching with robotics: A study of professional development and impact. *Robotics in Education*, 9, 72-85.

[12] Chen, W., Nussbaum, M., & Chang, C. (2017). A study of interactive learning in science: Integrating robotics, mathematics, and physical activity. *Educational Technology Research and Development,* 65(2), 1-21.

[13] Cervera-Manjarrez, N., Oquendo-González, E. J., Velásquez-Pérez, Y., & Rose-Parra, C. (2023). Principios y estrategias para el desarrollo del pensamiento computacional.

[14] *CIENCIAMATRIA: Revista Interdisciplinaria de Humanidades, Educación, Ciencia y Tecnología*, 9(17), 120-121. https://doi.org/10.35381/cm.v9i17.1128

[15] Diago, M., & Arnau, R. (2017). Introducing computational thinking into the early childhood classroom: A case study. *Journal of Educational Computing Research*, 55(7), 929-949.

[16] Di Lieto, M., Fessakis, G., & Karakostas, A. (2017). The effect of computational thinking tasks on children's problem-solving skills. *Computers in Human Behavior*, 74, 319-326.

[17] Fessakis, G., & Papadopoulos, I. (2013). Teaching computational thinking through computer programming to young children: An empirical study. *Computers in Education*, 60(1), 208-217.

[18] Florez, J., Angeli, C., & Valanides, N. (2017). A conceptual framework for teaching programming in early childhood education. *International Journal of Technology in Education*, 12(3), 124-135.

[19] García, A., & Hernández, L. (2013). Las Tecnologías de la Información y la Comunicación en la educación superior: Un estudio sobre su integración en los sistemas educativos. *Revista de Educación y Tecnología*, 3(1), 101-120.

[20] González Caballero, R. G., & Hernández Barbosa, R. (2023). Pensamiento Computacional: Una mirada a sus competencias. *Revista Universitaria de Educación, Ciencia y Tecnología, Universidad Pedagógica y Tecnológica de Colombia*, 1-15.

[21] Grover, S., & Pea, R. D. (2013). Computational thinking in K–12 education and the development of a computational thinking curriculum. *ACM Inroads*, 4(1), 13-17.

[22] Henriksen, D., Richardson, C., & Mehta, R. (2018). Integrating computational thinking into classroom practice: Implications for teacher education. *Journal of Educational Computing Research*, 57(3), 748-771.

[23] Jaipal, K., & Angeli, C. (2017). Exploring the impact of robotics on teachers' attitudes and skills in science and mathematics teaching. *Journal of Science Education and Technology*, 26(4), 421-431.

[24] Khanlari, A. (2016). Teaching computational thinking through the use of robotics in early education. *International Journal of Educational Robotics*, 11(3), 185-200.

[25] Maíz Guijarro, M. J., & Carvalho, J. L. (2021). Robótica educativa en educación infantil: Una revisión sistemática de la literatura en España (2015-2020). *EDUTECH REVIEW: International Education Technologies Review,* 8(1), 15-35. https://doi.org/10.37467/gka-revedutech.v8.2718

[26] Merino, M., Sáez, E., & Cózar, R. (2018). Teaching computational thinking through robotics in early childhood education. *Journal of Educational Technology & Society*, 21(1), 55-64.

[27] Misirli, A., & Komis, V. (2020). Computational thinking in early childhood education: The impact of programming a tangible robot on developing debugging knowledge. *Computers in Human Behavior*, 109, 106351. https://doi.org/10.1016/j.chb.2020.106351801

[28] National Research Council (2010). Report of a workshop on the scope and nature of computational thinking. *National Academy of Sciences*.

[29] Nardelli, L., & Ventre, A. (2015). Computational thinking in schools: A methodology and curriculum design. *International Journal of Information and Education Technology*, 5(7), 523527.

[30] Polya, G. (1945). How to Solve It: A New Aspect of Mathematical Method. Princeton University Press.

[31] Roman, M., Millán, M., & Sánchez, R. (2017). The role of computational thinking in digital literacy. *Computers in Education Journal*, 17(3), 48-56.

[32] Schina, L., Graesser, A., & Harrison, D. (2021). Robotics and STEM education: Interventions and perspectives in the classroom. *Journal of Educational Robotics*, 13(2), 90-107.

[33] Selby, C., & Woollard, J. (2013). Computational thinking: The new skills for our digital future. *Education Futures*, 3(1), 1-12.

[34] Sisman, B., & Kucuk, S. (2019). Teachers' attitudes toward robotics in education: Training and perspectives. *International Journal of Information and Education Technology*, 9(6), 435-442. 32. Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, 49(3), 33-35.

[35] Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophy and Computing*, 45(4), 379-395.

[36] Wing, J. M. (2011). Computational thinking: A digital age skill for everyone. *The Atlantic Monthly*, 107(3), 1-12.

[37] Zhong, Y., & Xia, Y. (2020). Enhancing creativity in STEM education using robotics. *International Journal of Educational Technology in Higher Education*, 17(1), 28-37.

[38] Zorrilla-Puerto, E., Sánchez-Santana, A., & García-Vázquez, M. (2023). El papel de la robótica en educación infantil: Revisión sistemática para el desarrollo de habilidades cognitivas y espaciales. *Journal of Educational Technology & Society*, 26(2), 115-130. https://doi.org/10.1016/j.jets.2023.03.003