Computational Thinking Intervention at the Transition Between Early-Childhood and Primary Education

Intervención de Pensamiento Computacional en la Transición entre Educación Infantil y Primaria

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Abstract- Research has been conducted on computational thinking at different educational levels. However, there is a lack of information regarding the transition from one stage to another, especially from Early Childhood Education to Primary Education. This study was executed during the academic year 2022/2023 in two schools in Gran Canaria: CEIP La Zafra and CPEIPS San Antonio María Claret, with the aim to evaluate the transition of computational thinking between educational stages and to observe its state also comparing a center with experience in its development with another one without experience. The total sample consists of 213 students. For the analysis of results, a Z test has been performed to compare proportions, considering a confidence value of 95%. These comparisons are defined by sex, educational level, and center. The recorded data have shown minimal difference in the transition between stages, but significant differences between groups from different schools.

Keywords: Computational Thinking, Early Childhood Education, Primary Education, LOMLOE, Educational Technology.

Resumen- Se han realizado investigaciones acerca del pensamiento computacional en distintos niveles educativos. Sin embargo, falta información con respecto a la transición de una etapa a otra, especialmente de Educación Infantil a Educación Primaria. Este estudio se ha realizado durante el año académico 2022/2023 en dos escuelas de Gran Canaria: CEIP La Zafray CPEIPS San Antonio María Claret, con el objetivo de evaluar la transición del pensamiento computacional entre etapas educativas y además comparar su estado en un centro con experiencia en su desarrollo frente a otro sin experiencia. La muestra total consta de 213 estudiantes. Para el análisis de los resultados, se ha realizado una prueba Z para comparar proporciones, considerando un valor de confianza del 95%. Estas comparaciones se definen por sexo, nivel y centro educativo. Los datos registrados han mostrado poca diferencia en la transición entre etapas, pero diferencias significativas entre los grupos de diferentes escuelas.

Palabras clave: Pensamiento Computacional, Educación Infantil, Educación Primaria, LOMLOE, Tecnología Educativa.

1. Introduction

There is a common viewpoint at the European framework that the educational system must adapt to the changes and developments of society (Bocconi, 2016). For this reason, the European Commission urges member states to promote digital skills at all educational and training levels, with a particular focus on computational thinking (Conrads et al., 2017). The relevance of this concept is becoming increasingly evident. The European Commission estimates that artificial intelligence and robotics will generate around 60 million jobs within a five-year period. The development of cognitive skills has become fundamental in the education system for the growth of students (Roig and Moreno, 2020), which is why Spain has added computational thinking in all educational stages with the approval of the Organic Law 3/2020, which modifies the Organic Law 2/2006, on Education (LOMLOE).

However, even though several projects have been developed to integrate computational thinking into the curricula of different educational levels, there is no formal definition of the term (Adell et al., 2019). In a recent literature review, Polanco et al. (2021) identified several criteria that have been the focus of research including mental skills, mental process, problem-solving process, thinking skills, and strategies. Considering this definition, the present study evaluates students' computational thinking based on their ability to organize their reasoning (observation, decomposition, and sequencing) and their problem-solving proficiency.

In order to approach the concept and study its state and progression in the classroom, some research has been carried out at different educational levels (Cearreta, 2015; Caballero, & García, 2019; Angeli, & Valanides, 2020; Moore et al., 2020). However, there is barely any information regarding the state of computational thinking in the transition between Early

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Childhood Education and the first cycle of Primary Education (Rich et al., 2018).

For this reason, this proposal is born with the aim of evaluating the transition of computational thinking between both stages, as well as observing their differences and similarities conducting an intervention based on active methodologies.

2. Context & Description

The implementation of LOMLOE has granted great relevance to computational thinking in the Spanish educational framework. However, there is still a lack of clear guidance for its proper implementation in each educational stage (Adell et al., 2019). The shortage of research and concrete evidence makes it difficult to establish learning objectives and appropriate methods for each age, especially in Early Childhood Education and the first cycle of Primary Education (Rich et al., 2018).

Therefore, this proposal is presented to evaluate the state of computational thinking that students have in classrooms. The educational intervention aims to assess computational thinking during the transition from 3rd year of Early Childhood Education to 1st year of Primary Education. In addition, it looks for analyze if there is a significant difference in the state of computational thinking skills depending on whether the concept has been previously worked on. For this reason, it has been decided to analyze the difference in a private center with experience in the development of computational thinking and another public school without previous experience. Considering both objectives, the following research questions have been defined:

RQ1: Are there statistically significant differences in the state of computational thinking between 3rd year of Early Childhood Education and 1st year of Primary Education?

RQ2: Are there statistically significant differences between the context of a center with experience in the development of computational thinking and another one without experience?

A. *Intervention description*

The methodological principles on which the intervention is based are active learning, game-based learning, and collaborative learning. This promotes the development of computational thinking abilities, which engage students in learning by allowing them to enhance their problem-solving and coding skills through the creation of basic algorithms and the interaction with robots. To carry out the intervention, the KUBO educational robot has been selected. This is a screenless technological resource. Two working sessions are proposed, one focused on unplugged computational thinking and another on educational robotics without screens using the KUBO robot.

Session 1 proposes two activities to evaluate the computational thinking skills of the students. The first one is a group activity. It consists of placing a grid on the floor with images of water and land, and some animals in both environments. Students must give the corresponding instructions for the animals to reach their homes. The second activity is similar to the first one, but in pairs. Each pair receives a card with a grid and several land and water animals. They must observe where the animals are, think about where they live, and reproduce on paper the path they must follow to reach their homes.

Due to the knowledge and skills inherent to the educational level, a second session has been designed considering differences between Early Childhood (Session 2A) and Primary Education (Session 2B). Both activities are focused on the development of computational thinking through robotics, while working on content from different areas. In Session 2A, a board is used for students to program the route that each animal must take to reach its food. In the case of Session 2B, addition and subtraction operations are added to problem-solving. Students

must solve the operations and then program the path that each animal must follow to reach its food. In both sessions, students were asked to program the KUBO robot to perform the previously solved routes in groups.

Due to the level corresponding to each stage and the difference in contexts in schools, not all sessions were carried out in all classes. In Early Childhood Education, sessions 1 and 2A were held. In Primary education, sessions 1 and 2B were carried out at CEIP La Zafra, and session 2B was held at CPEIPS San Antonio Maria Claret, since the students at this school are familiar with computational thinking and robots. This implies that for stage comparison, the sessions and results of CEIP La Zafra will be taken into account. However, for the comparison of schools, only the results obtained in session 2B in the courses of 1st grade of Primary Education will be taken into account.

B. *Participants*

In population terms, the students of 3rd year of Early Childhood Education and 1st year of Primary Education from CEIP La Zafra have been considered, as well as the students of 1st year of Primary Education from CPEIPS San Antonio María Claret. The total population consists of 221 individuals and the sample size is 213. This means that, for a 95% confidence level, the sample represents the population with a margin of error of 1.3%, according to the Cochran equation for calculating representative samples with finite population correction (Table 1).

Table 1. *Population and sample information*

Educational Center	Educational Level	Population	Sample
Zafra	*Early Childhood*	42	42
	Primary	50	49
Claret	*Primary*	129	122

On the one hand, a comparison was made between the Early Childhood Education and Primary Education classes at CEIP La Zafra in order to find potential differences in performance across educational levels. On the other hand, to compare centers that have different levels of experience in the development of computational thinking, a sample was taken from 1st-grade groups at two institutions: CEIP La Zafra, which lacks experience in this concept; and CPEIPS San Antonio Maria Claret, which has been involved in the development of computational thinking and educational robotics since 2019.

C. *Ethics statement*

All gathered information was anonymized before data analysis, guaranteeing participants' privacy.

3. RESULTS

A. Instrument and data analysis

To evaluate computational thinking skills, Cearreta's (2015) evaluation design has been taken as the main reference. This evaluation is divided into three areas: computational, motivational, and transversal, which have been adapted to the current study according to its objectives and context. To respond to the computational area, observation techniques and analysis of the tasks completed by students have been chosen. In addition, the evaluation instrument is a checklist (Table 2) that summarizes the concepts of computational thinking and their evaluation criteria. This instrument has allowed the analysis of the reasoning process that students follow to solve the proposed problems. However, it only verifies if the item is fulfilled or not.

Regarding the computational field, data has been collected from the eight items that make up the checklist. Intending to establish a result-based comparison between different target groups, a Z-test for comparing proportions has been conducted using *Jamovi software*, considering a confidence value of 95%. Such comparisons are defined by sex, educational stage, and educational center. Results are presented at Table 3.

Table 2. *Checklist*

	Yes	No
1. Observe the problem before acting.		
2. Break down the problem into simple steps.		
3. Sequence the steps for problem resolution.		
4. Solve the problem.		
5. Identify the relative position of objects in space and interpret movements.		
6. Use the robot appropriately.		
7. Participate in the tangible programming problem-solving.		
8.Program the animal's route.		

Table 3. *Z-test results for comparison based on sex, educational stage, and educational center. Bold values represent significant differences (p<0.05)*

	Male vs. Female		Early Childhood vs. Primary		Zafra vs. Claret	
	z-score	*p-value*	*z-score*	*p-value*	*z-score*	*p-value*
1	-0.0275	0.978	0.584	0.559	-2.33	**0.020**
2	-0.0275	0.978	0.584	0.559	-2.33	**0.020**
3	-0.547	0.584	0.230	0.818	-2.32	**0.020**
4	0.635	0.525	1.20	0.229	1.38	0.167
5	0.0196	0.984	2.53	**0.012**	-2.57	**0.010**
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	1.88	0.060	-0.868	0.385	-2.76	**0.006**

According to the evaluated items, there are no significant differences for any items when comparing between sexes.

In relation to the transition from Early Childhood Education to Primary Education, Table 3 shows that the only item with a significant difference is related to the relative position of objects in space. However, no significant difference is observed in the items related to computational thinking and problem- solving between students in 3rd grade of Early Childhood Education and 1st grade of Primary Education. This fact is repeated in item 8, whose analysis reflects that there is no significant difference between both educational levels when programming the animal's route. In the case of items 6 and 7, statistical testing was not applied because results were the same for all items (100% affirmative responses in all cases).

To compare the state of computational thinking in the public school and the private one, the Z-test was also performed. Table 3 shows that there is a significant difference in items 1, 2, 3, 5, and 8. Although differences are observed in key problem- solving skills, no significant difference between educational centers is evidenced in the fact that they finally solve it (item 4). Items 6 and 7 are also left out of comparison due to above mentioned reasoning.

In relation to the motivational and cross-cutting field, a satisfaction questionnaire has been conducted for students, based on the one designed by Cearreta (2015). The instrument consists of four statements with three possible responses and two open questions to qualitatively measure their opinion on the matter. A Likert scale of three points has been chosen to quantitatively measure the degree of agreement or disagreement of students with the proposed statements: 1 (little) to 3 (much) (Table 4).

Table 4. *Motivational and cross-cutting questionnaire*

Statement	Level	Mean	Standard Deviation
I have liked the activities.	Early Childhood	2,944	0,236
	Primary	2,849	0,432
I found it fun to work with the robot.	Early Childhood	2,944	0,236
	Primary	2,869	0,366
The activities have seemed easy to me.	Early Childhood	2,944	0,236
	Primary	2,738	0,482
I would like to work with the robot in other subjects.	Early Childhood	3,000	0,000
	Primary	2,811	0,480

B. Intervention impact

Regarding computational thinking skills in the transition from Early Childhood to Primary Education, it is observed that the only significant difference lies in the concept of laterality (item 5). This suggests that the understanding of the concept improves as a higher educational level is reached. However, the lack of difference in items 1, 2, 3, and 4 may be because there is still no significant change in the organization of reasoning and problem-solving during the transition year.

As for items 6 and 7, they correspond to educational robotics. For this reason, it can be concluded that regardless of the educational level, students do not present difficulties using and programming the robots proposed for the activities. Additionally, the development of these skills increases their motivation towards problem-solving. Therefore, the use of educational robotics is proposed as a suitable means for carrying out activities that develop computational thinking, and as a link that connects different educational areas.

Comparing the computational thinking abilities of different educational centers, the significant difference in items 1, 2, 3, 5, and 8 reflects that the trajectory of CPEIPS San Antonio María Claret in the development of computational thinking positively influences the results. Therefore, it can be concluded that, as more activities of this methodology are developed, there is an improvement on basic competences of computational thinking. However, to the statistical results, it cannot be affirmed that there is a difference between groups in problem solving (item 4).

Lastly, the results obtained in items 6 and 7 reaffirm the idea of educational robotics as an effective tool to motivate students and work on computational thinking in different areas. This is confirmed by the highly satisfactory results obtained in the satisfaction questionnaire to evaluate the motivational and cross-cutting aspects of computational thinking (Table 4), both quantitatively and qualitatively.

4. Conclusions

Computational thinking has become a vital instrument in relation to the Sustainable Development Goals that the United Nations established in 2015, since it helps to understand topics related to society, economy, science, environment, and other fields. In this line, it is necessary to carry out research in this regard and encourage educational interventions that develop this ability from an early age.

It might be relevant to highlight that the proposal presents an opportunity to other public and private educational centers, as well as other educational levels and subjects. This is due to its transferability, as it is based on its execution in two educational centers of different types and resource availabilities, obtaining adaptation and positive reception results in both cases. On the one hand, the first session is based on unplugged computational thinking, and it only requires a grid on the floor and the contents that the designed activity is based on. On the other hand, in order to carry out the second session, the KUBO robot would be necessary, since in the present intervention it has been used as a means to develop computational thinking in a playful and motivational way. However, the essential part of the activity is to propose a problem or challenge that students observe, decompose, sequence, and solve. In this sense, it could also be extrapolated to any educational context as well as to different areas and educational levels.

For its application, it is recommended that the design of the activities allows for collaborative learning and game-based learning, as these are the principles that promote the development of computational thinking skills. Both foster learning in a more engaging way for students and facilitate their development.

Overall, the quantitative evaluation of the computational field answers the RQ1 posed at the beginning. The results demonstrate that while there is a noticeable improvement in the comprehension of the concept of laterality at higher education levels, no significant alterations are observed in the organization of reasoning and problem-solving during the transition year. However, in response to RQ2, it is observed that the previous approach in computational thinking and robotics is significant in the development of these skills, independently of the educational level, which is in line with what García and Caballero (2019) stated. In addition, the use of educational robotics has proven to be an effective tool to motivate students in computational thinking, as stated by previous research (Cearreta, 2015; Angeli & Valanides, 2020; Moore et al., 2020).

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References

Adell, J., Llopis, M. A., Esteve, F. M., & Valdeolivas, M. G. (2019). The debate on computational thinking in education. RIED. Revista Iberoamericana de Educación a Distancia, 22(1), 171-186. http://dx.doi.org/10.5944/ried.22.1.22303

Angeli, C., & Valanides, N. (2020). Developing young children's computational thinking with educational robotics: An interaction effect between gender and scaffolding strategy. Computers in human behavior, 105. https://doi.org/10.1016/j.chb.2019.03.018

Bocconi, S., Chioccariello, A., Dettori, G., Ferrari, A., Engelhardt, K., Kampylis, P., & Punie, Y. (2016). Developing computational thinking in compulsory education. European Commission, JRC Science for Policy Report.

Caballero González, Y. A., & García Valcárcel, A. (2019). Enhancing computational thinking skills in Early Childhood Education: Learning experience through tangible and graphical interfaces. Revista Latinoamericana de Tecnología Educativa, 18(2), 133-149. http://dx.medra.org/10.17398/1695-288X.18.2.133

Cearreta Urbieta, I. (2015). Scratch as a didactic resource for the development of Computational Thinking of Secondary and High School students in the subject of Computer Science and as a transversal resource in other subjects. [Master's thesis, International University of La Rioja].

Conrads, J., Rasmussen, M., Winters, N., Geniets, A., & Langer, L. (2017). Digital education policies in Europe and Beyond: Key design principles for more effective policies. European Commission, JRC Science for Policy Report.

Moore, T.J., Brophy, S.P., Tank, K.M., Lopez, R.D., Johnston, A.C., Hynes, M.M., & Gajdzik, E. (2020). Multiple representations in computational thinking tasks: A clinical study of second-grade students. Journal of Science Education and Technology, 29(1), 19-34. https://doi.org/10.1007/s10956-020-09812-0

Polanco Padrón, N., Ferrer Planchart, S., & Fernández Reina, M. (2021). Approximation to a definition of computational thinking. RIED. Revista Iberoamericana de Educación a Distancia, 24(1), 55-76. http://dx.doi.org/10.5944/ried.24.1.27419

Rich, P. J., Browning, S. F., Perkins, M., Shoop, T., Yoshikawa, E., & Belikov, O. M. (2019). Coding in K - 8: International Trends in Teaching Elementary/Primary Computing. TechTrends, 63, 311-329. https://doi.org/10.1007/s11528-018-0295-4

Roig-Vila, R., & Moreno-Isac, V. (2019). Computational thinking in education: bibliometric and thematic analysis. RED. Revista de Educación a Distancia, 20(63). http://dx.doi.org/10.6018/red.402621