# EDUCATIONAL APPLICATION FOR THE DEVELOPMENT OF COMPUTATIONAL THINKING SKILLS IN STUDENTS WITH SPECIAL NEEDS

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## Abstract

This study describes the experience of using an educational application to develop computational thinking (CT) skills in post-primary school students, made up of students with special needs. We designed a case study that included 50 post-primary students. The students were randomly assigned to the experimental (EG) or control group (CG). The students in the EG used the educational application, while the students in the CG used traditional lectures. The case study consisted of six sessions in which students of both groups worked on key elements of CT, such as Algorithmic Thinking, Decomposition, Patterns Generalization, Abstraction, and Representation. Following Cohen's *d* guidelines, the effect of the educational application on students' performance was found to be high ($d$ = 0.96) in favour of students in the EG. Similarly, the results of the motivation survey showed significant differences in favour of the students in the EG. Similarly, the effect of the educational application on students' motivation was found to be very high ($d$ = 1.43). We can conclude that using digital educational applications is more effective in developing computational thinking skills than traditional lectures. These applications allow active learning methods to be implemented, which motivates the students and turns in better academic performance.

Keywords: Computational Thinking; Educational Application; Motivation; Special Needs Education.

## 1 INTRODUCTION

Some studies suggest the advantages of using technology in the classroom since it is attractive to students because it allows a better disposition for learning. Technology use is multiplying and leads to the conclusion that not all digital resources have these advantages. The use of an educational application or digital resources must be analysed with great care since it is essential first to know the application's structure and the possibilities it offers for fulfilling the objectives.

The term computational thinking was spread in the educational field by Professor Jeannette Wing [1]; computational thinking poses the recognition of problems and practical solutions in such a way that machines or people can solve them and is made up of five components according to Csizmadia et al. [2]: Algorithmic Thinking, Decomposition, Pattern Generalization, Abstraction and Representation, and Evaluation. For the development of each of its components and, therefore, of Computational Thinking, the following techniques must be applied: Reflection, Coding, Design, Analysis, and Application. The educational application to be used in the classroom must allow the application of each of the techniques that focus on the stimulation of its components.

Post-primary is a model adopted by the Ministry of National Education of Colombia to guarantee the access and permanence of extra-age students in the educational system of the rural zones. In this sense, extra-age refers to students with ages above the expected average age to attend a given grade who have dropped out of formal education environments. These students complete the 6th, 7th, and 8th grades, in a single calendar year. Students in post-primary have been described as students with low academic performance, demotivation towards learning, and resistance to traditional education. Therefore, different studies suggest that the educational process in these types of educational situations be oriented through active learning methodologies that motivate the students to acquire the knowledge and skills that the educational system requires from them. Additionally, these rural populations tend to have special educational needs due to cultural customs of endogamic reproduction; in these classrooms, different types of conditions coexist; unlike those mentioned, one of the predominant ones is attention deficit hyperactivity disorder (ADHD).



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## 1.1 How is computational thinking assessed?

Regarding the evaluation of Computational Thinking, there is no specific definition, technique, or methodology because it is a new term for which there still needs to be a consensus. However, there are some proposals for measuring its development in students, and some studies have been based on its evaluation from computer programming, limiting the vision of Computational Thinking that what it seeks is to take this mental process to other areas, even non-digital ones. It is essential to take into account that when evaluating Computational Thinking, it is investigated by skills and not by concepts, which is why for this research, the tests known as Bebras tests were used previously for the same objective in the United Kingdom in annual contests and created by the University of Oxford, these same tests have been used in other studies such as Lockwood [3], Lockwood and Mooney [4] and Lee et al. [5].

## 1.2 How is motivation assessed?

For the independent variable "Motivation," the four aspects proposed by Keller [6], Attention, Relevance, Satisfaction, and Trust, were evaluated:

- Attention: surprise or uncertainty that arouses interest. Stimulates curiosity to ask difficult questions or problems to solve.
- Relevance: the importance that the student attributes to the contents concerning their interests.
- Satisfaction: the student's feeling and perceiving the activity as something beneficial.
- Confidence: the estimate of the probability of success in meeting the evaluation criteria.

The instrument used to compare the levels of "Motivation" achieved with the educational software, and the traditional rural post-primary methodology was a Likert scale survey with three options: I liked it, I don't care, I didn't like it.

## 1.3 Purpose of the study

This study describes the experience of using an educational application to develop CT skills in post-primary school students and using pre-test and post-test to identify the development of computational thinking skills through an educational application. The chosen application must meet some conditions to promote these skills and the teaching methodologies used by the teacher.

The pre-test developed activities in both groups to assess students' initial state of computational thinking skills. Subsequently, the educational application was implemented in EG and with CG were traditional lectures. The Experimental Group explored an educational application and teacher orientation based on Bruner's Theory of Discovery Learning [7]. The Control Group carried out the activities with the help of traditional lectures and instructions from the teacher. Exercises to demonstrate the development of Computational Thinking skills were included and the motivation.

# 2 RELATED STUDIES

Different proposals and results are presented that Computational support Thinking as a process that allows addressing a complex problem, understanding it, and developing the most appropriate solutions. These initiatives have focused on developing specific capacities that coincide with the positive influence of digital tools in the learning process. It also shows that the use of technological resources has a positive effect on students' perceptions of the teaching and learning processes.

The study by García & Caballero [8], through a quasi-experimental research methodology using an experimental and control group, verified the effect of developing computational thinking skills through robotics activities. Thus, it concludes that students who use robotics programs establish the dimensions of computational competence more quickly than those who do not use them.

In another investigation [9] with a similar methodology, in which an experiment was implemented between an experimental group with robotics activities and a control group through projects. It was shown that computational thinking skills contribute significantly to problem-solving and that robotics activities can be recommended for students to improve their STEM skills compared to project development.

The work of Arastoopour Irgens et al. [10], carried out with high school students from the area of natural sciences, used pre-test and post-test, in addition to assessments incorporated throughout the unit, participating in the development of guides with computational models. It was demonstrated by the methodology used, advances, and achievements of the participants in computational learning, changing their way of thinking to solve questions.

The study The Effect of Using STEAM Approach on Developing Computational Thinking Skills [11], made up of an experimental and control group, confirms that the development of computational thinking activities in the STEAM areas significantly increases computational thinking skills, precisely algorithmic thinking, and abstraction, concluding that it is an effective teaching method.

# 3 METHODS

This study describes the experience of using an educational application to develop CT skills in post-primary school students. We designed a case study that included 50 post-primary students. The students were randomly assigned to the experimental (EG) or control group (CG). The students in the EG used the educational application, while the students in the CG traditional lectures. The case study consisted of six sessions. In the first session, the students of both groups took a pre-test to identify their previous knowledge. In sessions second to fifth, the students were involved in an educational intervention. Each session lasted two hours and included simulated experiments in the proposed educational application for the EG and traditional lectures for the CG. In each session, the students worked on critical elements of CT, such as Algorithmic Thinking, Decomposition, Patterns Generalisation, Abstraction, and Representation. Finally, in the sixth session, the students took a post-test to identify the learning acquired by the students. Additionally, the students completed a motivation survey to determine the degree of motivation of the students toward the activities.

The study comprised 50 students from third to eighth, aged between 9 and 14 years with an average age of 10.8 years, from a rural and official educational institution during the 2022 school year. The students were notified of the study's intention, and their responsible adults' informed consent was recorded in writing. Both groups with the same number of students (EG 25 students representing 50%) and (CG 25 students with the exact representation of 50%); therefore, a balance was observed in terms of the number of participants.

In the research design, two types of variables were defined, "Dependent Variables": Algorithmic Thinking, Decomposition, Pattern Generalisation, Abstraction and Representation, which are directly related to the object of the study on Computational Thinking and, therefore, each of the skills that integrate it and "Independent Variable" for the Motivation.

The Pre-test evaluated the dependent variables, and the Post-test the two types of variables. The Motivation variable was only implemented in the final evaluation once the proposed activities had been applied.

# 4 RESULTS

The results of the pre-test indicate a similar academic level in each group. However, the results in the EG were higher. Following Cohen's *d* guidelines, the effect of the educational application on students' performance was high ($d$ = 0.96) in favour of students in the EG. Similarly, the results of the motivation survey showed significant differences in favour of the students in the EG. The effect of the educational application on students' motivation was found to be very high ($d$ = 1.43), according to Cohen's guidelines.

## 4.1 Computational thinking skills

### *4.1.1 Algorithmic Thinking*

In the pre-test, of the 25 students in each group, nine students from the experimental group answered the test correctly, and ten from the control group. For the post-test, in the EG, all the students managed to solve the test correctly, and in the CG, this number increased to 13 students, as can be seen in figure 1, where it is mentioned with the Experimental Group as Ge and the Control Group as Gc.

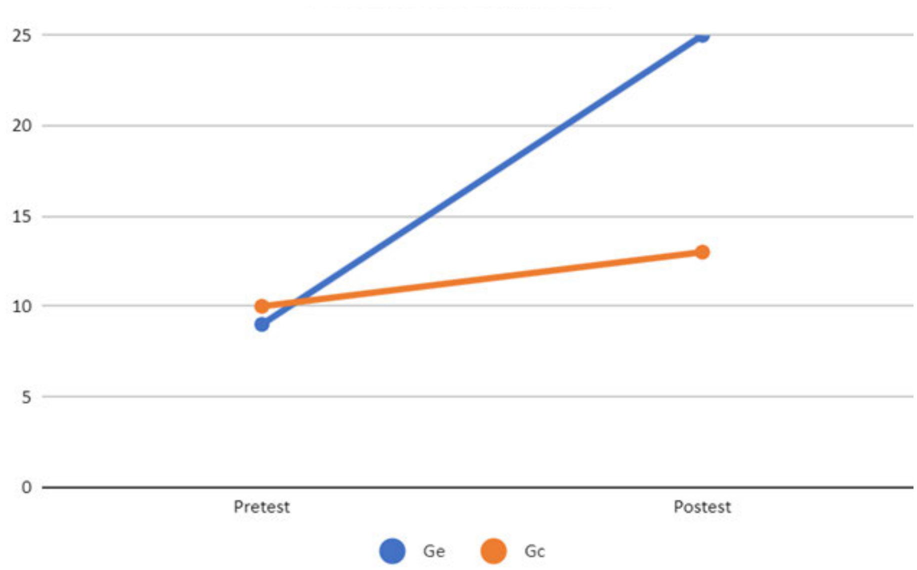


*Figure 1. Algorithmic Thinking*

### *4.1.2 Decomposition*

According to Figure 2, for this ability, in pre-test 3 and 4, students managed to solve the test correctly for the EG and CG, respectively; in the end, it was found that the number of students who could pass the test in the EG was ten and in CG 5.

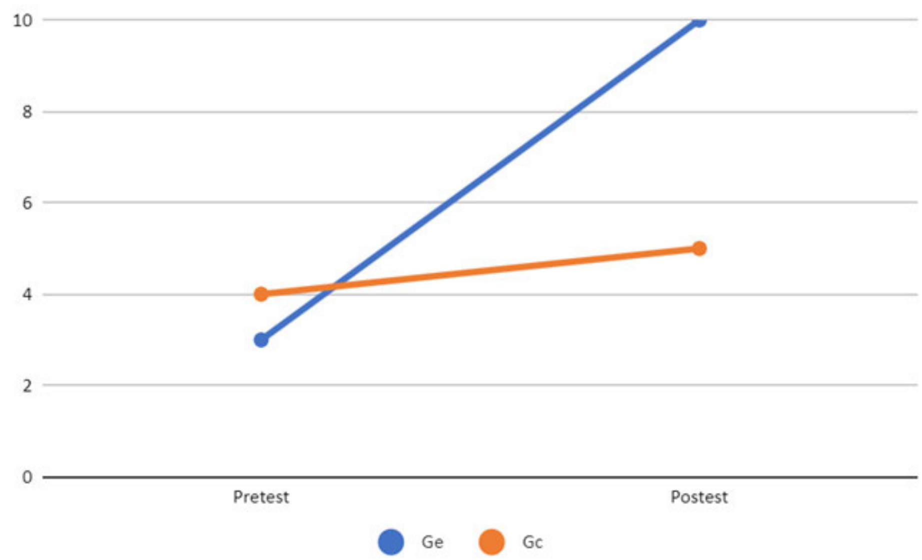


*Figure 2. Decomposition*

### *4.1.3 Generalisation*

As seen in Figure 3, this ability presented similar results in both groups in the pre-test and the post-test, being the least developed ability according to the results.

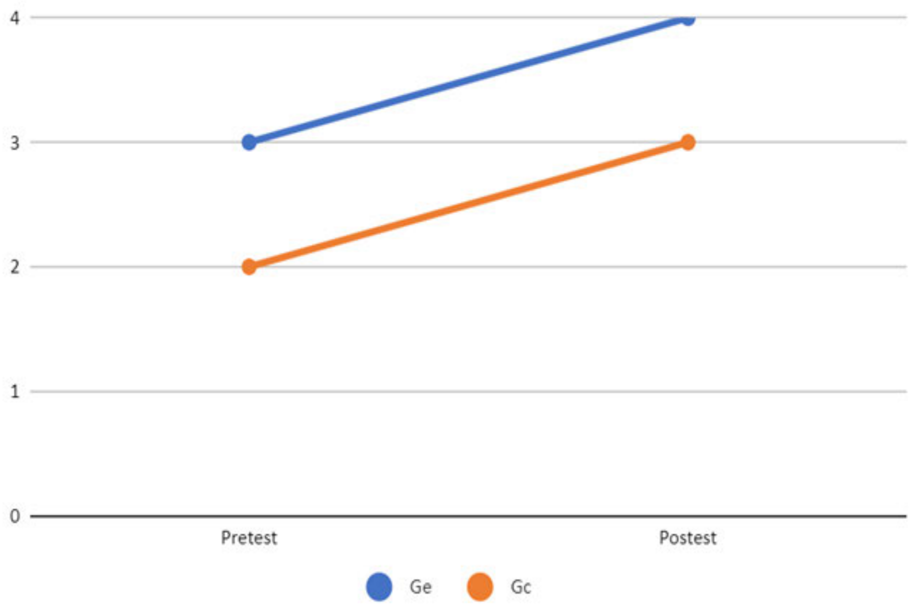


*Figure 3. Generalisation*

### *4.1.4 Abstraction*

In Figure 4, we can see that four students in each of the groups correctly solved the test in the pre-test; for the final evaluation, this number increased to 12 in the EG and 5 in the CG.

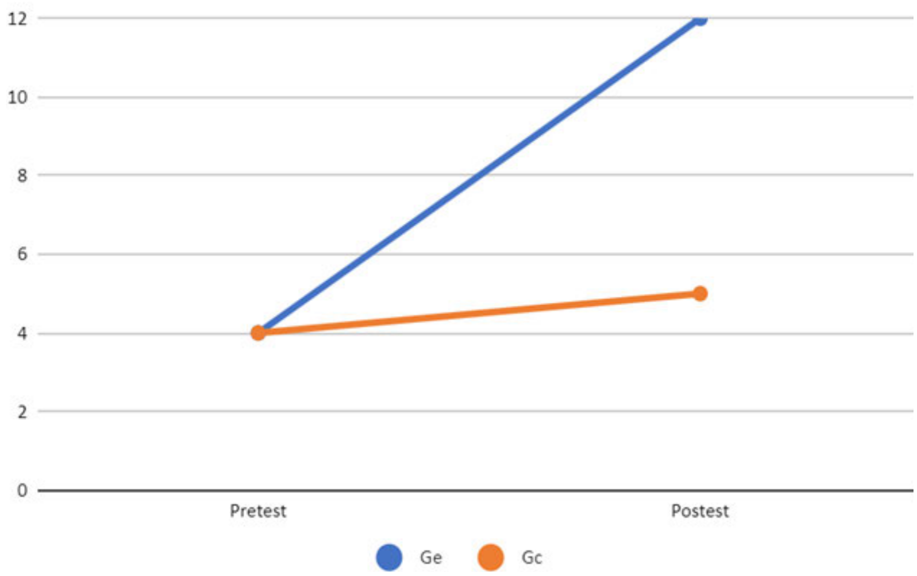


*Figure 4. Abstraction*

### *4.1.5 Evaluation*

In the pre-test, a similar starting point is evident in both groups, with seven students answering correctly in the EG and 6 in the CG, and for the post-test, this number increased to 16 and 8, respectively, as can be seen in Figure 5.

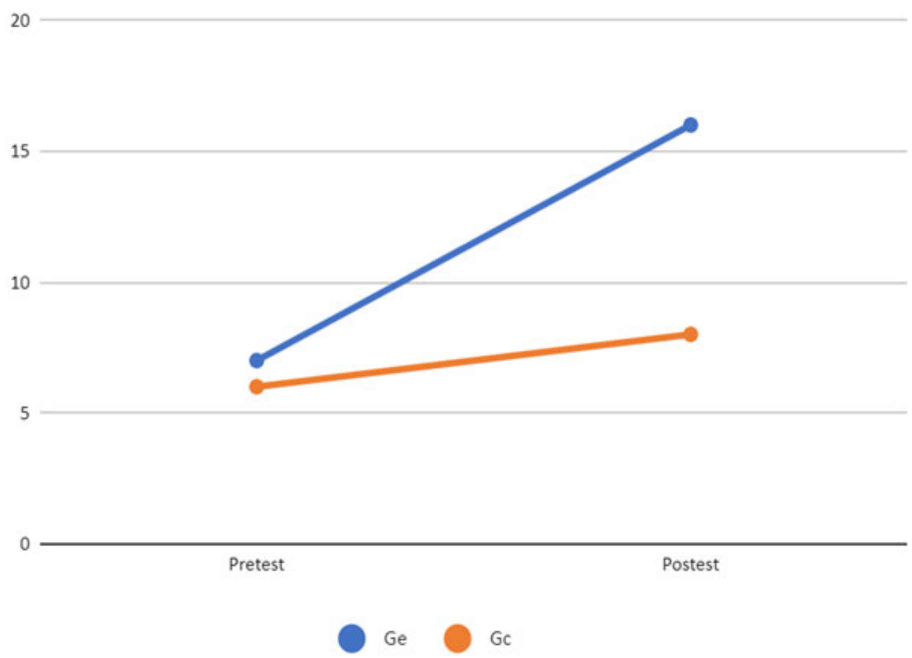


*Figure 5. Evaluation*

### 4.2 Results of the Motivation survey

Regarding the Motivation variable, at the end of the experiment, the survey was applied, finding favourable results with the EG, which show significant differences concerning the CG, with the "Satisfaction" aspect being the one with the most considerable distance between the averages of both groups, as shown. Can be seen in Figure 6.

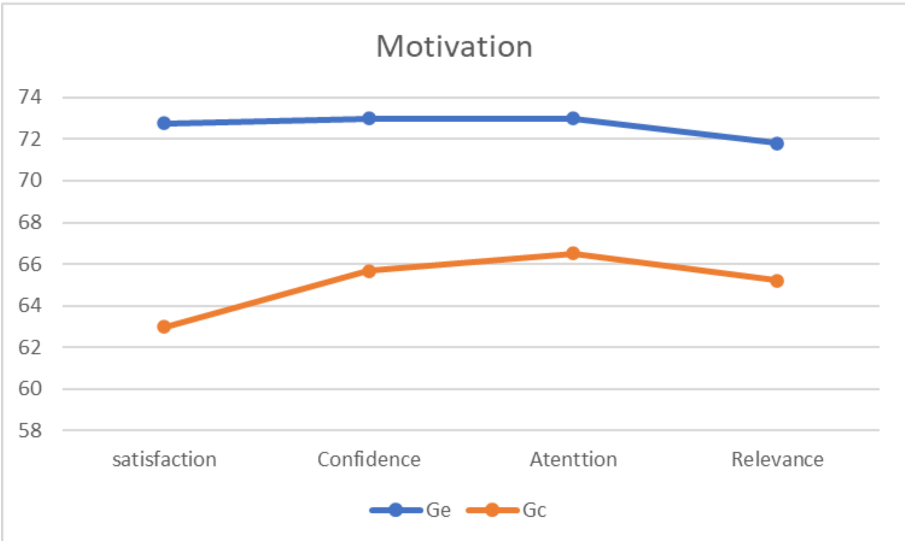


*Figure 6. Motivation*

## 5 DISCUSSION

The research showed that the use of an educational application that complies with some techniques could help develop computational thinking skills and increase motivation in students. The methodology used with the experimental and control groups allowed for diagnosing the initial state of the students regarding computational thinking skills through the application of Bebras tests with some adaptations. The pre-test evidenced the computational thinking skills addressed in the research, abstraction, decomposition, generalization, algorithmic thinking, and evaluation, finding that both groups had a similar performance.

According to the results, the development of computational thinking skills was favoured in the Experimental Group over the Control Group, with the implementation of the didactic sequence accompanied by an educational application. The traditional post-primary methodology approached by the Control Group did not prove to be an adequate strategy for the development of computational thinking skills. The results of this investigation indicate that the proposed objective was met. The activities designed open the possibilities for the development of computational thinking skills in students and motivated them for their learning. The chosen educational software facilitated the interaction between the students and each of the skills addressed, complying with the techniques that indicate that not all digital educational resources promote the development of computational thinking.

Based on the results, using digital educational applications is more effective in developing computational thinking skills than traditional lectures. These applications allow active learning methods to be implemented, which motivates the students and turns in better academic performance.

## REFERENCES

[1] Togyer J, Wing JM. Research Notebook: Computational Thinking-What and Why?

[2] Csizmadia A, Curzon P, Humphreys S, Ng T, Selby C, Woollard J. Mark Dorling Digital Schoolhouse London Project [Internet] 2015. Available from: http://www.digitalschoolhouse.org.ukhttp://www.teachinglondoncomputing.orghttp://www.digitalschoolhouse.org.ukhttp://www.computingatschool.org.ukhttp://www.southampton.ac.uk/education/about/staffhttp://www.southampton.ac.uk/education/about/staff

[3] Computer Science To Go (CS2Go): Developing a course to introduce and teach Computer Science and Computational Thinking to secondary school students. 2019.

[4] Piotrkowicz A, Dent-Spargo R, Dennerlein S, Koren I, Antoniou P, Bailey P, et al. Developing a Computational Thinking Test using Bebras problems [Internet] 2018. Available from: http://ceur-ws.org

[5] Lee, G., Lin, Y. T., & Lin, J., editor. Assessment of Computational Thinking Skill among High School and Vocational School Students in Taiwan. Association for the Advancement of Computing in Education; 2014.

[6] Keller JM. Motivational Design for Learning and Performance.

[7] Bruner J. Biografía y Teoría del Aprendizaje por Descubrimiento. https://www. lifeder. com/jerome-bruner.; 1960.

[8] García V, Muñoz R, & Caballero G. Robotics to develop computational thinking in early Childhood Education. Vol. 27. Comunicar. Media Education Research Journal; 2019.

[9] Karaahmetoğlu K, Korkmaz Ö. The effect of project-based Arduino educational robot applications on students' computational thinking skills and their perception of basic stem skill levels. Participatory Educational Research. 2019;6(2):1–14.

[10] Arastoopour Irgens G, Dabholkar S, Bain C, Woods P, Hall K, Swanson H, et al. Modelling and Measuring High School Students' Computational Thinking Practices in Science. J Sci Educ Technol. 2020 Feb 1;29(1):137–61.

[11] Bedar RAH, Al-Shboul M. The effect of using STEAM approach on developing computational thinking skills among high school students in Jordan. International Journal of Interactive Mobile Technologies. 2020;14(14):80–94.