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Integrating Computational Thinking Into Mathematics Class: Curriculum Opportunities and the Use of the Bee-Bot

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Abstract: The incorporation of Computer Science teaching in educational systems has increased in recent years. Given international interest, Chile has promoted projects to promote the development of students' digital skills. Focusing on this new educational context, this research reports the results regarding the identification of computational concepts and practices that can be articulated with the contents and skills of the curriculum. of Chilean mathematics. for first grade of primary school based on the use of the Bee-Bot robot. For this, the study followed a qualitative approach, developing a case study of the Chilean study program with the content analysis technique and using, as analysis categories, computational concepts and practices from the field of educational computing. In total, 30 learning objectives of the study program were analyzed. The results indicate that, although there is little articulation between computational concepts and first grade content proposed in the curriculum, there is greater articulation between computational practices and mathematical skills suggested in the Chilean curriculum. It is concluded that Computational Thinking can be developed from the earliest school levels using the Bee-Bot robot (or similar), and this is demonstrated by the structure of the Chilean primary mathematics curricular program.

Keywords: *Bee-bot, computational thinking, mathematical thinking, primary education.*

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Introduction

The exponential development of technology that has been observed in recent decades has prompted countries to transform their public policies in various fields. In education, the so-called digital literacy emerges as a new priority, understood as the skills that every citizen must develop to be considered literate in the 21st century (Vázquez Uscanga et al., 2019). In this line, one of the initiatives that have gained the most strength on an international level is the integration of Computational Thinking (CT) in the school curriculum (Caballero-Gonzalez & Muñoz-Repiso, 2019; Forsström & Kaufmann, 2018). Wing (2006) who defined CT as a fundamental skill for everyone, not only for computer scientists, proposed to consider this concept as a fundamental skill for children and young people, that is, in addition to reading, writing, and arithmetic, he also suggested to insert CT among the set of skills to be developed in school. Since then, the argument for developing CT from the first grades of schooling has gained strength, showing that the new generations not only need to be trained to use technology but also to participate actively in its creation (Hitschfeld et al., 2015).

The review of the literature allows us to recognize that there is no consensus on how to implement and develop CT in schools (Sánchez, 2019). Countries such as England, Finland, and Japan are pioneers in introducing CT as a subject, while other countries introduce its development within the framework of an existing subject in the curriculum (Barker & Ansorge, 2007). From this paradigm, considering the historical relationship between mathematical and computational thinking (Barker & Ansorge, 2007; Papert, 1980), an alternative to integrate CT in schools is its development within the subject of mathematics. At the same time, it is observed that one of the strategies used to develop CT in the first years of schooling (Grover & Pea, 2013; Jara & Hepp, 2016) has been through programming and Educational Robotics (ER)

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(García-Peñalvo & Mendes, 2018; Llorens Largo et al., 2017). However, the question arises about CT's role as a teaching and learning tool in the mathematics class with this type of initiative. What to teach? How are mathematical and computational concepts and skills related? The answer to this question is the challenge that teachers often face alone and, sometimes, the lack of information about it leads to the abandonment of these innovative teaching practices and the disuse of technological resources acquired in schools. In this regard, (Mondada et al., 2017) state that teachers will use these resources in the classroom to the extent that clear guidance is given on the possibilities of use.

In the case of Chile, the development of the CT has been implemented through teaching practices where it acts as a support for the implementation of the current curriculum. In particular, within the framework of the National Plan for Digital Languages, a pilot plan was promoted and allowed to deliver Bee-Bot robots to various schools in five regions of the country (Vázquez Uscanga et al., 2019) and, regarding these guidelines, the development of research on the use of this robot in the mathematics class in the Chilean school context is observed, mainly in the field of teacher training (Ferrada et al., 2021; Seckel, Breda et al., 2021; Seckel, Vásquez et al., 2022). Despite the latter, there are still no clear guidelines on the role of this resource in the development of the CT by integrating it into the mathematics class. For this reason, the objective of this study is to identify the computational concepts and practices that can be articulated with the contents and skills of the Chilean mathematics curriculum for the first year of primary school based on the use of the Bee-Bot robot. Although there is a history of how to approach the teaching of mathematics with this type of resources, the studies do not clearly explain the relationship of said teaching with the computational concepts and practices that are worked on in parallel (Ferrada et al., 2021; Sáez-López, 2017). In this way, the relevance of this study lies in the delivery of guidelines that allow for clearing up doubts about the CT's role when integrating it into the mathematics class. Consequently, we believe that these results will become a support for teachers who assume the challenge of developing these innovation processes in their mathematics teaching practices, particularly for teachers from the Chilean context. However, the method with which the curriculum is analyzed will serve as an example to develop the same study, taking the curriculum of other countries as a reference.

To achieve the purpose stated above, it is necessary to take into account that the curricular program that is the object of study is organized into learning objectives (LO) related to: a) knowledge, configured in contents present in the thematic axes of numbers and operations, patterns and algebra, geometry, measurement, data and probability; b) skills, abilities to perform tasks and solve problems with precision and adaptability (problem solving, modeling, representing, arguing and communicating) and; c) attitudes, learned dispositions to respond (favorably or unfavorably) to objects, ideas or people. Furthermore, it is important to consider that one of the guidelines proposed by the Ministry of Education, Chile (MINEDUC, 2012) to implement the curricular program is the incorporation of Information and Communications Technologies (ICT) in the mathematics classroom. These guidelines do not observe the use of ICT to promote the development of CT through programming, however, this aspect is considered in the National Plan for Digital Languages (MINEDUC, 2018), which introduced, among other elements, the use of the Bee-Bot educational Robot in the Primary Education stage. In particular, the proposed progression for the development of Thinking and Computational Programming in the ages of 0 to 6 years is initial robotics based on block programming.

Literature Review

Computational Thinking

Papert defending learning through the construction of knowledge using the student's prior knowledge and a Logo and Super Logo programming language (Papert, 1985), was the first to highlight the importance of learning to program at an early age. However, only in the current century, this concept had an impact at the school curriculum level (Bordignon & Iglesias, 2020), where an increase in the development of research in this line is observed, especially in the European continent (Dong et al., 2023). It was in 2006 when the CT concept emerged and the importance of its development at the school level was highlighted. At that time (Wing, 2006) stated that CT is "the solution of problems, the design of systems, and the understanding of human behavior, making use of the fundamental concepts of computing" (Wing, 2006, p.33). Later, this same author affirmed that "if we wanted to ensure a common and solid basis of understanding and applying computational thinking for all, then this learning should best be done in the early years of childhood" (Wing, 2008, p. 3720). Likewise, the introduction of computational thinking from an early age has been justified by stating that this type of thinking develops progressively (Guirado Maeso, 2022).

Barr et al., (2011) mention that CT combines unique thinking skills that, when used together, provide the basis for a new and powerful way of solving problems in complex contexts. Zapata-Ros (2019), coinciding with the approach proposed by Wing (2006), points out that CT constitutes a skill related to a specific way of thinking about the organization of problem-solving. Likewise, we highlight the definition of CT proposed by Valverde Berrocoso et al. (2015), who indicate that it "is not synonymous with the ability to program a computer, since it requires thinking at various levels of abstraction and is independent of devices" (Valverde Berrocoso et al., 2015, p. 04). The search for a definition of CT reveals that it is a polysemic concept that, as a whole (the various definitions), sheds light on some characteristics of the activities that can be addressed in the teaching and learning processes. X. Tang et al. (2020) set out to characterize in greater detail what is understood by CT, and in their work, they highlight the approach of various authors regarding the definition of CT (see Figure 1).

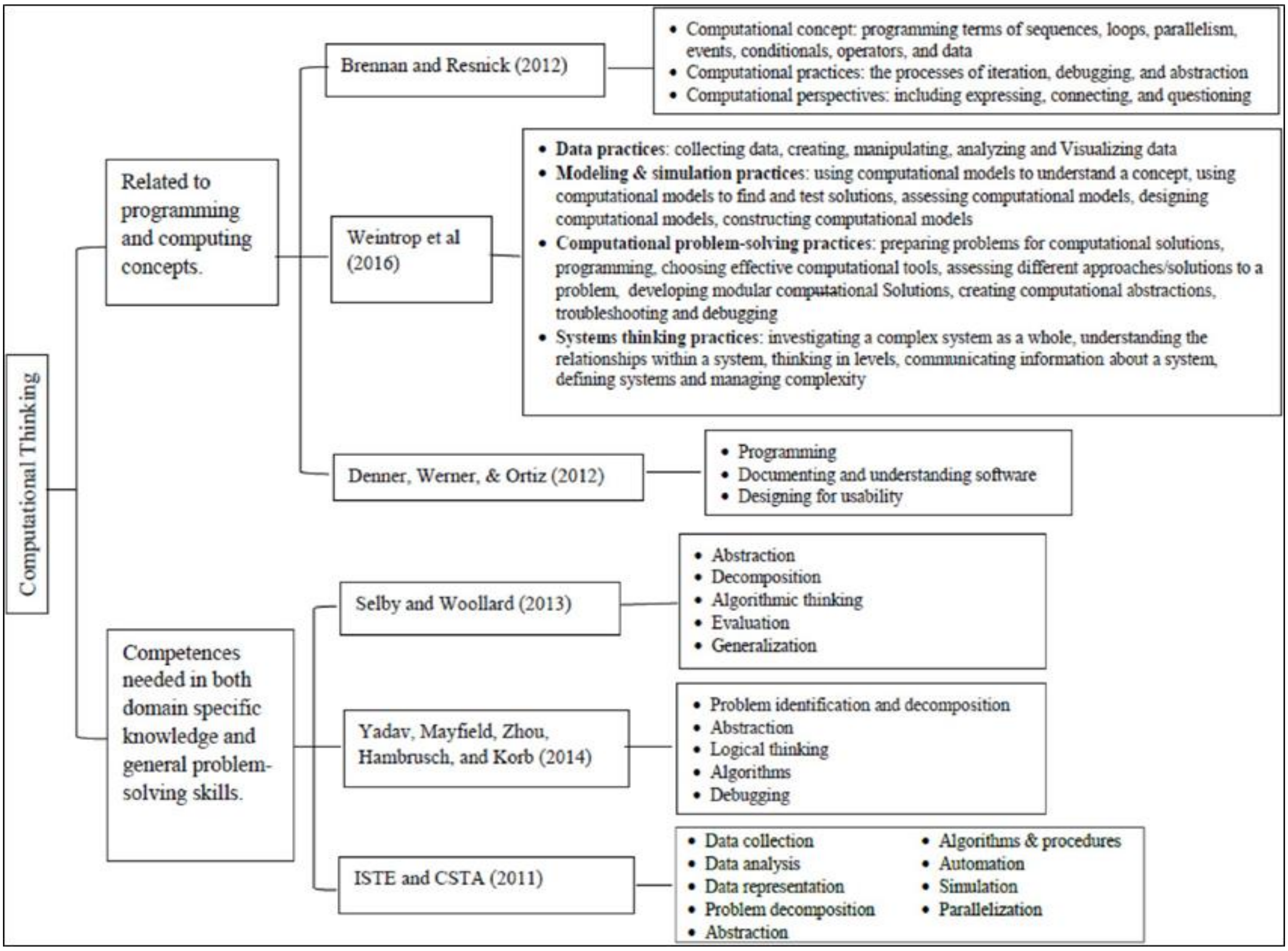

Figure 1. CT Definitions (X. Tang et al., 2020).

The synthesis of Figure 1 shows two approaches to defining CT. On the one hand, we observe a focus on concepts related to programming and computing and, on the other hand, a focus on the necessary skills in specific areas such as problem-solving. In this line, for the purpose of this study, understanding that the Chilean school curriculum is not developed with a competency-based approach, its analysis is suggested based on the first approach presented by X. Tang et al. (2020).

Using The Bee-Bot Robot in The Mathematics Class

The use of robots in educational contexts is known as Educational Robotics or Pedagogical Robotics (Moreno et al., 2012) and is recognized as an alternative to developing CT in schools. In this line, Bravo Sánchez and Forero Guzmán (2012), state that one of the great challenges of Educational Robotics is to demonstrate that students achieve the development of skills and understanding of computer science concepts through the use and robot manipulation. Likewise, it is observed that most of the research on robotics in schools has focused on high school students. However, recent works have shown that the field of Educational Robotics has a special potential from early childhood (Bers, 2008; Bers & Horn, 2010; Kazakoff et al., 2013) highlighting the Bee-Bot robot as one of the most used work programming in the range of 5 to 7 years of age (Forsström & Kaufmann, 2018).

The Bee-Bot allows children to manipulate their programming commands (forward, backward, pause, turn left and right by 90°, delete, and GO) and approaches a block programming language intuitively. To program it, you must press the commands or keys. The robot can memorize a sequence of up to forty movements when the user presses its commands. When the user wants to start a new sequence, he must press the delete key. If the user does not carry out this action, the new sequence is added to the ones he has previously memorized. In the robot you can program the actions of moving forward and backward 15 cm, turning to the right or left and you can program pauses in its movements with the "Pause" command. There are robots on the market like the Bee-Bot, such as the Mause robot and the Blue-Bot (see Figure 2). These robots differ in their shape, color, or complementary resources with which they are sold, but their programming language is the same. For this reason, the analysis proposed in this study is useful for the integration of any robot on the market that has a similar programming language.

Figure 2. Robots Available in The Market for Early Childhood.

The research conducted on the use of the Bee-Bot robot (or similar) in the teaching of mathematics shows two main approaches of interest: teacher training and types of tasks to work in the mathematics class. Regarding the first approach, data have been reported on the types of errors that future preschool teachers make when learning about and manipulating the Bee-Bot robot at a user level (Seckel, Vásquez et al., 2022), the reflections that emerge when the early childhood teachers plan didactic sequences with the use of the Bee-Bot in the math class (Seckel et al., 2022), the ideas of primary education teachers about the use of this resource in their math classes (Seckel et al., 2021) and the characterization of the Mathematical-Computational knowledge of teachers in initial training, when they design teaching (Sala-Sebastià et al., 2023). Regarding the second approach, data have been reported on: the development of logical-mathematical skills in early childhood education and first grade of primary education (Muñoz et al., 2020), the development of spatial thinking (Aranda et al., 2019; Palmér, 2017), the development of algebraic thinking (Alsina & Acosta Inchaustegui, 2018) and the development of mathematical skills (Diago Nebot et al., 2018; Pérez Buj & Diago Nebot, 2018). However, none of these studies emphasizes the computational concepts or practices (skills) that are developed when using the Bee-Bot and its articulation with the curricular aspects of the level to which the proposed robotic tasks or problems are directed.

On the other hand, the study by Seckel et al., (2023) stands out, who carry out a systematic review of the literature to raise didactic guidelines that allow the integration of the use of the Bee-Bot robot (or similar) in the mathematics class. This study suggests twelve orientations, of which we highlight four:

> 1) Didactic orientation 1: It is essential to consider the idea of the robotic problem for the design of mathematical tasks with the Bee-Bot robot (or similar). The answer to robotic problems is a sequence of actions that take the robot from an initial state to an intermediate state, to reach a final state.
>
> 2) Didactic Orientation 2: To introduce the use of the robot, three types of tasks must be considered (Unplugged tasks, Specific tasks, and Digital tasks).
>
> 3) Didactic Orientation 3: Two task design approaches should be considered. The first type is robotic problems that integrate mathematical and computational concepts, and the second type is robotic problems that reinforce mathematical concepts.
>
> 4) Didactic orientation 4: Task management should allow the enhancement of mathematical skills. (Seckel et al., 2023, pp. 14-16).

Methodology

Research Design

The study has followed a qualitative methodology (Sandín Esteban, 2000), with a case study method that focuses its interest on the mathematics study program in Chile, specifically, the first grade primary program, as it is the highest level. . for which the use of the Bee-bot robot is directed.

We highlight that the research considered the analysis of all the learning objectives of the curriculum that were related to mathematical content and skills, thirty in total. The data analysis methodology is explained in the following paragraphs.

Data Analysis

To conduct the process of articulation between the elements of the PC and the Chilean curricular program, the content analysis technique (Cáceres, 2008) was applied based on categories that we have selected for the study and that we substantiate below. The categories of analysis conducted are the computational concepts and practices necessary to develop the CT defined by Brennan and Resnick (2012). This research was developed within the scope of the *Media Lab*, which includes a broad interdisciplinary research agenda, such as, among others, social robotics and new models and tools for learning. In addition, by explicitly presenting the three dimensions of CT: computational concepts, computational practices, and computational perspectives, this research had a high impact in the international academic field, being cited in more than two thousand investigations that seek to understand, among others: the characteristics of CT based on a literature review (Lye & Koh, 2014; Shute et al., 2017) and empirical studies (Y. Tang et al., 2020); the CT in the early ages (Bers, 2020); CT and STEM projects (Domènech-Casal et al., 2019) and; the challenges and perspectives of teachers when working with Computer Science in primary and secondary schools (Sentance & Csizmadia, 2017).

The categories, and their respective subcategories, proposed by Brennan and Resnick (2012), with which the learning objectives related to the contents and skills of the first-grade mathematics study program were explored, are presented in Table 1.

Table 1. Computational Concepts and Practices

Categories	Subcategories
Concepts: represent the main ideas that are learned when developing CT.	Sequence: Series of instructions that follow one or another order. Loops: Blocks of code (sequence or program) that are repeated. Parallelization: Sequence of instructions that occur at the same time. Events: An action that causes something to happen. Conditionals: Statements that are only executed under certain situations. Operators: Support for mathematical, logical, and string expressions Data: Quantities, characters, or symbols that are the inputs and outputs of computer programs.
Computational practices: Activities typical of work in contexts and with the support of the Bee-Bot robot (or similar).	Incremental and iterative practices: adaptive processes in which a plan can be changed to achieve the goal in small steps. Test and debug: Recognize and correct errors in programs. Reuse and remix: Build on another people's work. Abstract and modularize the process of separating the details that are not necessary to focus on the things that are.

Source: Brennan and Resnick (2012).

Considering the concepts and practices described in Table 1, an analysis of the learning objectives of the contents (20 objectives in total) and skills (10 objectives in total) declared in the first-grade mathematics study program was conducted to define which of these concepts and practices are articulated. with the curriculum from the use of the Bee-Bot robot (or similar) at this level and subject. To do this page 41-42 of the curricular proposal (MINEDUC, 2012) was analyzed. Likewise, to ensure the validity of the qualitative data, the study considered the regulative criterion of dependency (Guba & Lincoln, 2002), which consists of a process of control of the interpretation of the data from the triangulation of the analysis conducted by the authors of this study. The coding of the data was carried out by three researchers and, to guarantee the reliability of the results, the coding went through a calibration process that considered sessions of: 1) individual coding by each researcher, 2) joint review of the codings and discussion of disagreements and 3) joint coding based on consensus. For coding, the following criteria had to be considered: 1) the learning objective allows working on a concept or computational practice and 2) the learning objective that is related to a concept or computational practice can be worked on with the use of the Bee-bot robot.

Results

After analyzing the curriculum with the categories described above, the computational concepts and practices were identified, which are articulated with the Chilean mathematics study program for the first grade of primary school with the use of the Bee-Bot robot (or similar), which is presented below. continuation.

Computational concepts

Regarding the articulation of the computational concepts with the mathematical contents present in the curriculum that can be practiced by using the Bee-Bot (or similar), the findings allow us to determine that only two of the seven concepts are articulated with mathematical contents (Sequence and Loops).

Table 2. Relationships Between Computational Concepts and Mathematical Content.

Subcategories	Analysis Units
Sequence	LO 1: "Count numbers from 0 to 100: 1 by 1, 2 by 2, 5 by 5, and 10 by 10, forwards and backwards, starting with any number less than 100" (MINEDUC, 2012, p. 44). LO 2: "Identify the order of the elements of a series, using ordinal numbers from first (1st) to tenth (10th)" (MINEDUC, 2012, p. 44).
Loops	LO 11: "Recognize, describe, create, and continue repetitive patterns (sounds, figures, rhythms) and numerical patterns up to 20, increasing and decreasing, using concrete, pictorial, and symbolic material, manually and/or through educational software" (MINEDUC, 2012, p. 45).
Parallelization's	No learning objectives (LO) can be related to this concept.

Table 2. Continued

Subcategories	Analysis Units
Events	No learning objectives (LO) can be related to this concept.
Conditionals	No learning objectives (LO) can be related to this concept.
Operators	No learning objectives (LO) can be related to this concept.
Data	No learning objectives (LO) can be related to this concept.

Source: Self-elaborated.

Regarding the "parallelization" concept, it is inferred that it is a more difficult computational concept that requires the simultaneous execution of various parts of a program on multiple processors, therefore, it is not possible to work with Bee-Bot (or similar). In the case of the "events" concept, although there is no LO that can be related to it, the robotic problems that are designed require the use of this concept by understanding that for the programming to be executed, the Go command must be pressed.

It is also not possible to relate the concept of "conditionals" to a learning objective since Bee-Bot (or similar) does not allow programming at this level. Regarding the "operators" concept, although it is not possible to work on this concept with the manipulation of the Bee-Bot (or similar), it could be worked through the application of one of the robot versions sold on the market (Blue-Bot) called Blue's Blocks.

Lastly, it is not possible to relate the concept of "data", to a learning objective, just like the concept of "events." However, the development of robotic problems involves using this concept to make it execute programming (right-left, forward-backward, pause). In this sense, although some of the mathematical contents of the curriculum are not related to computational concepts, they are key to understanding the programming language of the Bee-Bot robot (or similar) and its movement possibilities. These are:

- ✓ LO 13. Describe the position of objects and people about themselves and to other objects and people, using common language (such as right and left).
- ✓ LO 15. Identify and draw straight and curved lines.

Figure 3 presents a synthesis of the computational concepts and their articulation with the learning objectives referring to the contents of the Chilean mathematics curriculum for the first grade of primary school.

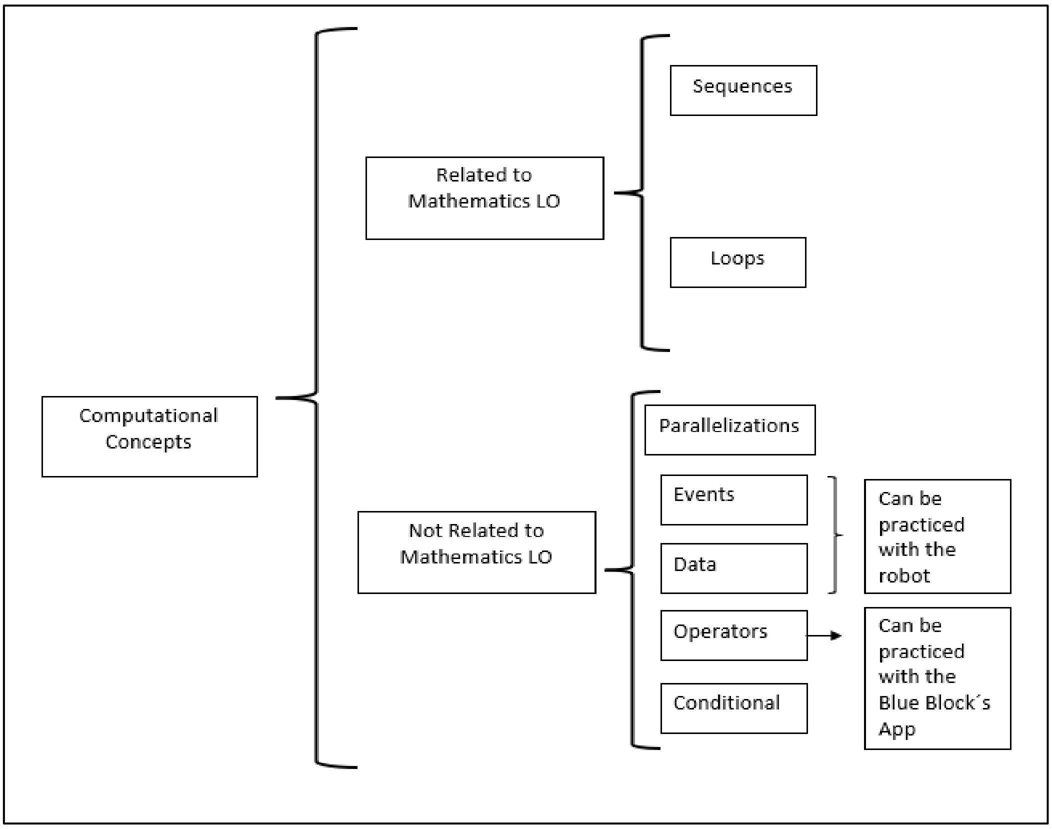

Figure 3. Computational Concepts Contemplated in the Contents' LO of the Mathematics Curriculum for the First Grade of Primary School

In summary, of the seven computational concepts proposed by Brennan and Resnick (2012), two of them are clearly articulated with the learning objectives related to the contents of the Chilean curriculum, that is, "sequences" and "loops". Although five of them are not directly articulated, the "events" and "data" can be developed from the use of Bee-Bot programming commands, and the "operators" can be worked through Blue's Blocks application.

Computational practices

The following table (Table 3) presents the links between computational practices and mathematical skills declared in the Chilean mathematics curriculum for the first grade of primary education.

Table 3. Relationship Between Computational Practices and Mathematical Abilities

Computational Practices	Mathematical Skills
Incremental	Problem-solving LO_a: Employ various strategies to solve problems. LO_c: Express a problem in your own words. Represent LO_i Choose and use concrete, pictorial and symbolic representations to represent statements.
Test and correct	Problem-solving LO_b: check statements, using concrete and graphic material. Sustain ideas and communicate. Lo_f: Explain your own solutions and the procedures used.
Re-use	Problem-solving LO_a: Employ various strategies to solve problems. LO_c: Express a problem in your own words. Sustain ideas and communicate. Lo_f: Explain your own solutions and the procedures used.
Abstraction	Model and solve problems LO_a: Employ various strategies to solve problems. LO_h: Express from pictorial representations and given explanations, daily actions, and situations in mathematical language. Sustain ideas and communicate. LO_e: Communicate the result of discoveries, relationships, patterns, and rules, among others, using mathematical expressions.

Source: self-elaborated.

The results of Table 3 show that the implementation of robotic problems with the use of the Bee-Bot robot (or similar) in the mathematics class allows for promoting the development of all the mathematical skills declared in the curriculum (solving problems, representing, communicating, and sustain ideas and modeling). In addition, all the computational practices declared by Brennan and Resnick (2012) can be promoted: incremental, test and correct, reuse, and abstraction. In particular, the problem-solving ability declared in the curriculum can be articulated with all the computational practices contemplated by Brennan and Resnick.

After identifying the concepts and computational practices that are articulated with the contents and skills of the Chilean mathematics curriculum of the first grade of primary school based on the use of the Bee-Bot robot, we consider it necessary to provide some examples that demonstrate this articulation in a practical way. En Alsina and Acosta (2018 p.230) shows an example of an activity that addresses the concepts of sequence and loop, and that is related to LO11 "recognize, describe, create and continue repetitive patterns (sounds, figures, rhythms) and numerical patterns up to 20, increasing and decreasing, using concrete, pictorial and symbolic material, manually and/or through educational software". At the same time, from the dialogue that we observe in the example, it is evident that the management of the activity allows for promoting the computational practice of testing and debugging, which is related to the mathematical ability to solve problems, specifically, with LO_f: "Explain your own solutions and the procedures used".

Discussion

The objective of this study was to identify the computational concepts and practices that are articulated with the contents and skills of the Chilean mathematics curriculum for the first grade of primary school based on the use of the Bee-Bot robot. For this, a content analysis of the curriculum was conducted, considering the computational concepts and practices proposed by Brennan and Resnick (2012) as categories of analysis. On the one hand, the results consider that some of the LOs of the curriculum contents are articulated with computational concepts, either using the Bee-Bot robot or using the Blue's Block application. On the other hand, all the computational practices are articulated with the LOs of the mathematical skills present in the said curriculum and both the practices and the skills can be developed with the use of the Bee-Bot. These results agree with what was stated by Hitschfeld et al. (2015), who highlight the possibility of integrating CT development in the subject of mathematics. In general, the results indicate that, although there is little articulation between the computational concepts present in the literature and the contents of the first year of elementary school proposed by the curriculum, there is a greater articulation between the computational practices and the skills present in the Chilean curriculum. Specifically, it is observed that through the design of robotic problems (Arlegui & Pina, 2016) mathematical contents of the thematic axis of "patterns and algebra" and "number and operations" can be addressed, which have a close relationship with two of the seven computational concepts under study, these are: Sequence and Loops. In this line, we highlight the work developed by Alsina and Acosta Inchaustegui (2018) as they exemplify the implementation of a robotic problem in which the articulation of these mathematical contents and computational concepts can be recognized. At the same time, after the curricular analysis, we recognize that literature shows various proposals for robotic problems in which the mathematical contents of the curriculum are addressed, the Bee-Bot robot (or similar) is used, but computational concepts are not promoted in its development (Aranda et al., 2019; Ferrada et al., 2021; Palmér, 2017). Despite this, these homework proposals provide the opportunity to promote mathematical practices and skills and also contribute to the development of both mathematical and computational thinking. A possible explanation for the limited link between mathematical and computational concepts observed in this study is related to the level of abstraction required by computational concepts such as Parallelization's and Conditionals, so it is possible to find these links in higher level study programs and with the use of a robot with a more complex programming language.

At the international level we observe cases such as England, Sweden, Argentina, among others, which have developed curricular proposals that describe in detail the digital literacy skills that they hope to achieve, within this, computational thinking (Vázquez Uscanga et al., 2019). However, other countries, such as Chile, have made progress in promoting the development of Computational Thinking from the first levels of schooling without developing a specific curricular proposal. Along these lines, the research provides guidance on how to explore the opportunities offered by a study program to integrate computational thinking through the use of a teaching resource, the Bee-bot robot.

In line with the above, it is important to consider some of the didactic guidelines provided in Seckel et al., (2023), since, when designing learning experiences, teachers must be clear about the focus of the task, that is, if the robotic problem allows the integration of mathematical and computational concepts, or if they reinforce mathematical concepts. This allows clarity on the learning that is expected to be achieved and how it is expected to be evaluated. In addition, although in both task approaches, it is necessary to promote the development of mathematical practices and skills, in the second approach their consideration is more urgent, otherwise the integration of thoughts would be non-existent or unintentional in pedagogical terms. On the other hand, given that a poor relationship between computational and mathematical concepts has been identified, it is necessary to consider a teaching itinerary that considers the types of tasks that are proposed in Seckel et al. With this, students can move from concrete programming (use of the Bee-Bot robot or similar) to digital programming (for example, through the use of the Blue's Block app), integrating other computational and mathematical concepts. For example, the concept "operators" in OA9 "Demonstrate that they understand the progressive addition and subtraction of numbers from 0 to 20..." (MINEDUC, 2012, p. 42).

In this way, the results highlight the possibility of developing CT from the first levels of schooling through the use of the Bee-Bot (or similar), as other authors point out (Bers, 2008; Bers & Horn, 2010; Fletcher & Lu, 2009; Guzdial, 2008; Hitschfeld et al., 2015; Kazakoff et al., 2013) an indication of this being the very structure of the Chilean mathematics curriculum, in particular, the one related to early ages.

Conclusion

In conclusion, the study shows that it is possible to integrate computational thinking through the use of the Bee-bot robot (or similar) in the subject of mathematics considering the Chilean national curriculum.

There are computational concepts that are closely related to mathematical concepts that children of the educational level studied are expected to learn (sequences and patterns). Mathematics skills are also related to the computational skills defined in this study. These findings allow projecting the design of types of tasks in which mathematical and computational concepts are developed in an integrated manner, and others that reinforce mathematical concepts using the robot. Regardless of the type of task designed for the class, the teacher's management in the classroom can promote the development of mathematical and computational skills in an integrated way.

In practical terms, the study carried out provides guidelines to develop the teaching and learning process in the Chilean context, becoming a resource in which teachers can support their work for the design of tasks. In investigative terms, the study provides methodological guidelines to extend the analysis in other educational contexts.

Finally, it is concluded that it is possible to develop the same curricular analysis taking as reference the mathematics curriculum of other educational levels and the study of other robots found in the market, which have a broader programming language. The latter would make it possible to project a teaching and learning trajectory and would facilitate the integration of computational thinking in the subject of mathematics.

Recommendations

It is suggested to consider this study as an advance in the search for relationships between TC and mathematical thinking from a curricular scope. From this starting point, it is recommended When analyzing the curriculum of other educational levels, new articulations could be found between the computational concepts and practices and the content and mathematical skills present in the different curricula.

A second recommendation is that when working with other types of educational robots, different results could be achieved, such as the articulation with more computational concepts.

A third line to work on in the future is to train Primary Education teachers for the introduction of the PC in mathematics classes, based on the design, implementation and reflection of didactic sequences with the use of the Bee-Bot (or similar) so that, from the use of this resource, they are competent to help students develop the contents and skills present in the curriculum through computational concepts and practices.

Limitations

Although the study presents important results that defend the incorporation of robotic problems for the development of CT at an early age, it is important to highlight that the research has some limitations. One of them is that the study is related to a very particular context: the Chilean mathematics curriculum for the first grade of primary school. The second is that only one type of educational robot is contemplated, the Bee-Bot (or similar).

Conflict of Interest

The authors declare no conflict of interest.

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Authorship Contribution Statement

Salinas: Concept and design, data acquisition, data analysis / interpretation. Seckel: Concept and design, data acquisition, data analysis / interpretation, drafting manuscript, asegurar la financiación. Breda: Drafting manuscript, asegurar la financiación. Espinoza: Revisión crítica del manuscrito.

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