Cubetto for preschoolers: C*omputer programming code to code*

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Abstract— **This article is derived from a study on the creation of strategies within children's computer programming An analysis of time used by children for the creation and execution of strategies was performed. Another analysis about the children´s errors made during the process was also achieved. Taking as a starting point the fact that computer programming is translated as a set of codes to work out a problem; it is necessary to mention that such codes are created under a specific programming language, which will perform a particular function on the computer. In this case, the codes execute a series of movements that will al-low infants to solve a problem, which has been stated through a child's story with the purpose that children aged 4 to 5 years old can create playful strategies for the fulfillment of objectives previously set. Through a descriptive and exploratory research, some bibliographic data were collected and a population group of second-level initial education students was directly ob-served. Such children learned to use the Cubetto robot to learn to codify their ideas by giving solution to a problem. It is concluded that the development of the systemic thinking at this level is of great importance since it facilitates the acquisition of new mental processes; in this case, the code-to-code programming strengthens the student's systemic process.**

Keywords—"Cubetto" Robot, computer programming, preschoolers, coding.

I. INTRODUCTION

"People learn to code and code to learn" Resnick (2012). [6] Within the initial education level, it is important the innovation and formation of new skills for children at early ages.

According to the new needs of these days, although it is true for the present, the world technological development has increased remarkably. That is to say, there is a great amount of technological gadgets and applications to be used in these tools; one of them is the Cubetto robot that has been designed for the learning of computer programming; such a programming skill is currently necessary, due to the wide variety of available programs. The consumerism of technological media in children at early ages has been encouraged. To avoid consumerism, children's creativity must be promoted, which means that kids must stop being consumers and start being builders; for this, it is important that students develop computer programing skills.

With the Cubetto robot, there is an opportunity for children to develop advanced cognitive processes such as systemic and creative thinking, collaborative work, and social communication. All these processes give kids the possibility to develop new skills that will be useful in the youngsters´ future formation.

II. DEVELOPMENT

A. Computer Programming

> Ferraris (2010, p.47) holds that programming is to tell a computer what to do, with the help of a set of instructions. When these instructions are used to solve the problem independently from the computer, they are called an algorithm. To use that algorithm in a specific computer, we must translate those instructions into a specific programming language. [3]

The computer programming is translated as a set of codes created to solve a problem; these codes are created under a specific programming language, which will play a function in the computer.

There are many programming languages since each one is designed to fulfill a specific objective; for example, to solve mathematical problems, games, invoices, generate letters or images, etc. Programming languages are designed under the systemic thinking, that is, they start from a global problem, which is divided into simpler problems that allow it to be

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solved in a simple way. In programming, it must be considered that when executing a code if an error appears, it is not a computer failure; it is a mistake in the programmed algorithms. (Ferraris, 2010). [3]

There are two ways to run a program on the computer, the first one is to enter the written program into the programming language; that is to say, the source code. It is necessary to have the computer translated it through the compiler to its internal language, which consists of a binary collection called an executable code. The compilation process takes time; however, the program is executed quickly.

And the second way consists of allowing a program called interpreter to be in charge of translating the instructions of the source code; that is to say, that in this process there is no an executable code. (Ferraris, 2010). [3]

With the development of new technologies and computer evolution, new programming languages have been created and adapted to the needs of the human being. Education is one of these needs, which throughout this new generation has been promoting the development of new competences; in this case, the development of computer programming skills within formal education.

B. Pre-school programming

Lovette (2016) cites Professor Jill Carrick from the Wyoming seminar. "The wonderful thing about coding is not to develop a skill of this century and in relation to university careers, it makes students to slow down their pace and think about solving problems in all fields." [4]

The programming process involves the development of integral skills in children, based on creativity, teamwork, social communication, and systemic thinking. These skills have been considered by Resnick (2012) as the most relevant in the development of the coding process in children at early ages. [6]

Within pre-school education, the development of skills and abilities is essential as a basis for learning in all areas of human development, for example, the creative thinking: De Bono & Castillo (1994) hold that "There is no doubt that creativity is the most important human resource of all. Without creativity, there would not be progress and we would be constantly repeating the same patterns. " [1]

The Systemic thinking: Within programming, the systematic thinking allows creating a whole starting from several parts with unique and different characteristics, which when getting together with each other can create a different whole.

The collaborative work: defined by Wilson (1995, p.27) as "a place where students should work together, helping each other, using a variety of informational tools and resources that allow the pursuit of learning objectives and activities for problem solving." [8]

The social communication: When using the ability of the collaborative work within the classroom, it can be emphasized that when a child shares experiences of his/her peer group about activities and norms cited by Romera, Ortega & Monks (2008), directly influences on his/her social communication called "Peer culture" [7]. It considers that when children are in contact with each other in a playful way, they can be the intellectual authors of new positive social norms that favor the development of social competence, in this way, the individual development of each member of the group is actively encouraged.

C. Cubetto

The idea of the creation of the Cubetto robot begins in 2013 with the company Primo Toys, created under the conception of being a language of ludic programming, which allows touching and perceiving with the senses the different functions it performs.

This devised was designed on the Montessori methodology and the concrete didactic material and it was inspired on the Turtle LOGO (one of the first programs created for programming at early ages).

Cubetto is characterized for being a program-learning tool without using screens (KICKSTARTER, n.d.). [2]

The concrete materials are the main need for education because they en-courage the use of the senses to explore them. Kickstarter holds that the Cubetto robot fulfills the function of didactic material to be explored by in-fants at early ages. This robot is made of wood, which according to Yacob (2016) wood has memory, besides being durable and very unlikely to be damaged; such features potentiate its free handling without restrictions in its use. [9]

The functionality of Cubetto can be understood from its parts, as can be seen in fig. 1 the set consists of: 1. Cubetto 2. Programming table, 3. 16 blocks (4 forward, 4 right, 4 left, 4 function) each coding block has an unambiguous and specific instruction, which allows to recognize and combine codes according to the order that Cubetto must comply with. 4. Cubetto World Map which expresses a path, a sequence and an adventure story for children. The programming is done by placing the coding blocks in the command lines of the programming table; in which you can create a main sequence and a subroutine, for the execution of the code programmed in the table there is an execute button to visualize the programming in the robot.

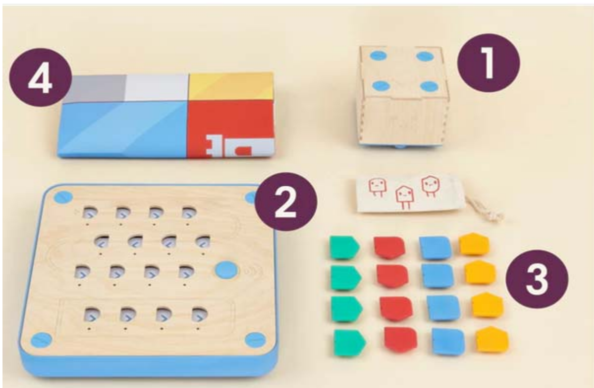

Figure 1. Elements of the Cubetto Robot

Cubetto promotes the learning of programming concepts, for example, **algorithms.** They are created by precise instructions by the blocks that when combined, they form a programming and a **collection**. The instructions created by algorithms are based on a sequential location creating a queue of physical programming and of **debugging**. Instructions are found in the programming table to correct errors in the specific blocks. This is a process of debugging, **recurrence**, and it creates a subroutine in a sequence of the function line and execute it by using a function block (Primo Toys, 2016). [5]

III. Methodology

For the descriptive study of Cubetto as a programming tool, techniques of direct observation and bibliographic data collection were applied, with the purpose of describing the scientific data collected through an observation card applied to 21 children from 4 to 5 years old. Pre-school who knew and used Cubetto for a period of one month.

The data collected show the functionality of Cubetto as a resource for learning programming. Parameters of creation of strategies to encode ideas raised by children have been observed; measuring time and number of errors committed during the coding process.

This gives the result that students visually and physically create the idea they wish to codify to meet the proposed objective, that is, through a story that involves this robot the fulfillment of an activity to be performed is established.

In the observed task of the present study, children were told to get from point A1 or so called Cubetto's house (fig. 2) to point D6 or letter B (figure 2). On the way, there are several obstacles they should avoid, especially at points A5 (castle), B6 (city), B2 (tree), C4 (mountains), D3 (letter Y), and F3 (ship), which can be seen in figure 2. When students run into obstacles in the map, they must create strategies that involve logical and systemic thinking.

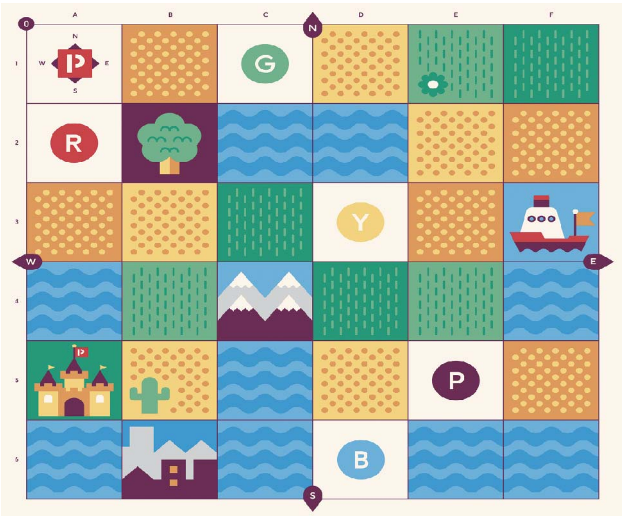

Figure 2. Cubetto map, objectives and obstacles.

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IV. Results

To start the observation, different logical strategies were proposed (Figure 3) and they could be used by children; besides, it should be considered the possibility that children could create a new strategy; with the purpose of facilitating the gathering of data in terms of strategy, time, errors, and the individual observation of their coding skills.

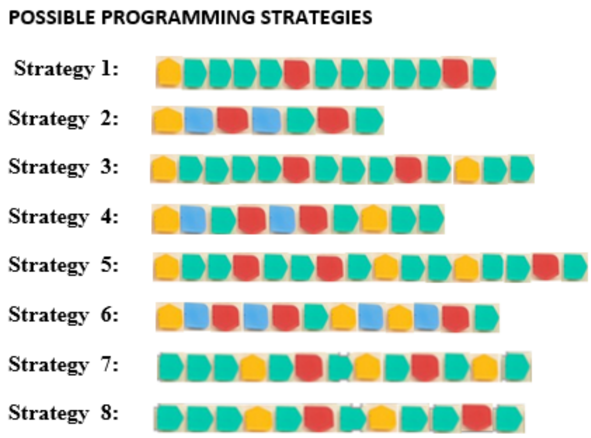

Figure 3. Possible programming strategies

The strategy most used by children is strategy 8 plotted in figure 4 with a 52% acceptance of the students, to start coding the children think with visual and tactile help the strategy they wish to use to complete the activity on the map.

Children are not aware of the strategies previously established by the re-searcher, so they are creators of their own strategy. After visualizing it mentally, they continue coding the idea in the programming table by using the coding blocks.

In figure 3, it is observed that in strategy 8 at the beginning there is a repetition of 3 blocks to advance forward and the following codes involve different turns; therefore, it is observed that students code continuous sequence lines when the codes are equal. For example, in this case they are 3 equal codes. The next programming line is done code-by-code, that is, a turn is programmed, which is executed, is observed, is corrected if necessary, and children continue creating different programming lines in which there is only one code in order to observe the movement step by step.

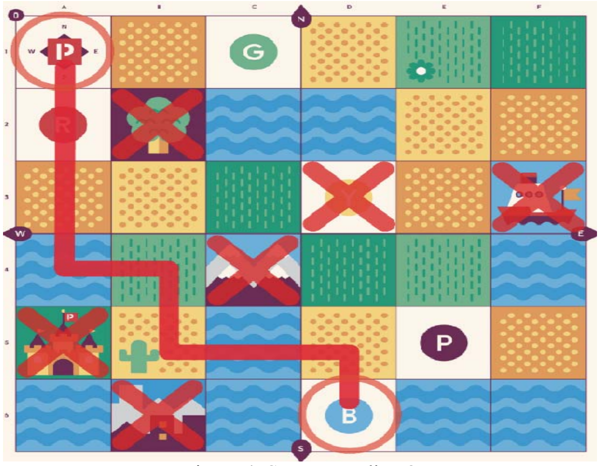

Figure 4. Strategy coding 8

The systemic thinking allows creating a whole formed of small parts with different characteristics, which together allow forming a complete unit; in this case, the programming code-by-code allows finding the solution to a unified problem that can be solved with a single programming line formed by codes that are revised one by one by the programmer.

Regarding time and errors made by students, a relationship between both data can be established. By observing figure 5, it can be seen that in a range of 2 to 6 minutes, students have been able to solve the proposed activity by committing O to 5 errors.

If strategy 8 is considered to have 11 codes compared to the maximum number of errors made by children, the reference among them is minimal. It is important to emphasize that the majority of students have completed the activity in 4 and 5 minutes with 1 and O errors respectively. That is to say, students have a logical reasoning of high potential, so they do not rush to solve the activity in less time; however, they do use the time properly to think before executing the code and in this way to make the least amount of possible errors. It is important to emphasize that within this time, the planning of the strategy and the execution of the same is considered. It requires more attention on the child's part, so he/she can notice the obstacles the map contains, so that Cubetto should avoid them and try to look for other ways.

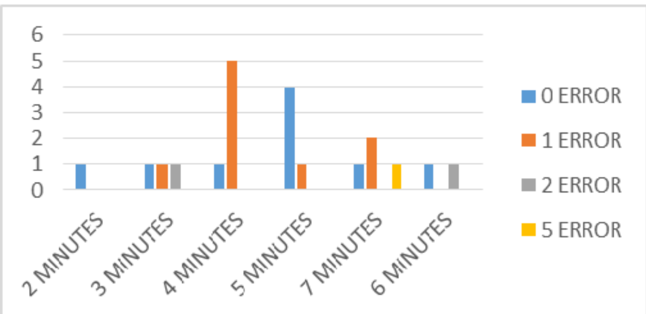

Figure 5. Relationship between time and errors

V. Conclusions

The learning of computer programming in preschoolers represents a new challenge and innovation for education. Students strengthen their cognitive skills and relate them to new areas of human development.

The coding of ideas requires different thinking skills, which are in development during the initial stage and it is important to motivate children to use these skills in new challenges.

Using the Cubetto robot, children who have participated in this study have potentiated skills already acquired within their educational training by using them in new situations that allow the formation of new concepts and mental processes.

With Cubetto, there is an opportunity for preschoolers to create strategies for the solution of programming problems that can be applied throughout all of their training. The main thing in this programming process is the opportunity that students have to carry out systemic processes, with which they can create small codes, which together can solve a problem or fulfill a goal. That is, in a code-by-code programming, children analyze each one of the movements made by the robot. They can make changes along the way and make fewer errors in the process.

Regarding the time it takes to perform code-to-code programming, it decreases in the sense that if the initial-level student performs a line of programming in sequence, there will be a high number of mistakes since at this stage the development of the Temporal-spatial location of an object in reference to the position of the body is reduced.

In the work with children at an early age, there were difficulties in terms of work coordination, since they worked in small groups with the purpose that all participants interacted with the tool; therefore, more time was required and several planned school activities were interrupted.

It is important that a child start programming with a code-by-code methodology and progress into the complexity of the programming lines as their spatial referencing skills improve.

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