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Computational thinking in early childhood education: an análisis through the *Computer Science Unplugged*

Pedro TADEU
Carlos BRIGAS

Datos de contacto:

Pedro Tadeu
CI&DEI-ESECD-IPG
ptadeu@ipg.pt

Carlos Brigas
CI&DEI-ESECD-IPG
brigas@ipg.pt

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ABSTRACT

There has been an increased determination to introduce coding and computational thinking early in education. So, programming has progressively grown and got an essential focus in European education following international trends. This idea of introducing computer programming into the classroom it's not recent; it came in 1960 by the investigations of Seymour Papert. The potentialities of teaching children's programming languages as an incubator of powerful ideas started in that decade, but it extended and continues to be used nowadays in a vast way. The programming was used to engage children in new ways of thinking, but much more critical than that, putting the student in a role to think about the thinking process. So with this context in mind, we aim to present a series of important ideas that rule the way that Computational Thinking could be applied inside of the Pre-School classroom. For that, we identify in this research the strategies and methodologies that allow teachers to implement these activities with children. Stating good practices and tools, pointing out some tips and ideas on designing projects in Pre-School Education that will allow the working of the computational thinking with the students of the XXI century.

KEYWORDS: Computational Thinking; Pre-School Education; New Methodologies.

El pensamiento computacional en educación infantil: una análisis a través del Computer Science Unplugged

RESUMEN

Ha habido una mayor determinación para introducir la codificación y el pensamiento computacional al principio de la educación. Por lo tanto, la programación ha crecido progresivamente y ha adquirido un enfoque esencial en la educación europea siguiendo las tendencias internacionales. Esta idea de introducir la programación informática en el aula no es reciente, surgió en 1960 por las investigaciones de Seymour Papert. Las potencialidades de enseñar lenguajes de programación infantiles como incubadora de ideas poderosas comenzaron en esa década, pero se extendieron y continúan utilizándose hoy en día de una manera mucho más vasta. La programación se utilizó como una herramienta para involucrar a los niños en nuevas formas de pensar, pero mucho más crítica que eso, poniendo al estudiante en un papel para pensar en el proceso de pensamiento. Entonces, con este contexto en mente, nuestro objetivo es presentar una serie de ideas importantes que rigen la forma en que el pensamiento computacional podría aplicarse dentro del aula de preescolar.

PALABRAS CLAVE: Pensamiento Computacional; Educación Infantil; Nuevas metodologías

Teaching requires innovation and knowledge of the latest tendencies

The change of the world takes us to a new and different level of knowledge, throughout the use of the necessary information regarding the Information, Communication Technologies (ICT), daily contact with technology, access to information linked to it, and we have a constant update of technological services and tools (Tadeu & Brigas, 2018). The new workers in the today's society should keep in mind that they will not have the same situation as their fathers; a three-stage approach to our working lives is ending: education, work and retirement (Tadeu & Brigas, 2018), combined with this change, society needs to take measures to readapt to the long lifetime of the population.

The change arrived, it is also true that pupils' learning is more lasting when they deal with real-life situations, so we need to create learning environments that utilise concrete materials and tools. ICT has potential in this sense. Students need to adapt to raise new soft skills and revolutionary ICT tools across most areas. These modifications should be integrated, meaning the importance of the changes in the society to be attained from the education side.

We know that the processes of pedagogical innovation are not inherent in the direct use of digital technologies, and sure it is not because of the availability of technological equipment that the education process will be different. On the other hand, some obsolete technology and dysfunctional connectivity services show that schools are not entirely prepared for the established necessary change, as stated in the study (CNE, 2018). In the same report, we have that in support of pedagogical innovation and educational modernisation that is sought to establish, in the national context and European, technologies are indeed an unmet requirement, showing that still there is a long way to walk, not only in Portugal but across Europe.

The role of the teacher also needs to change; not only could the facilities be a problem or the lack of technological equipment inside them, but the initial formation needs to adapt to the constant evolution. Within this use of technologies, there is inevitably a requirement for another type of teacher, someone that needs to be a driver of change, assuming high responsibility for the development of the so-called teacher professional, which requires an awareness of individual and collectively teacher professionality.

Today the know-how to act with and on technologies, to have the notion of digital competence is in itself know-how to acquire and that it needs to have specific space in the curriculum, which is therefore advocated by multiple international curricula and by the key competencies listed by the European Union (European Commission, 2018). So apart from the technology, the curriculum should act according to this necessity, making the teacher be on time with the modifications and progress daily to develop students' willingness to use the technology to solve problems inside the classroom.

The OECD report regarding innovation (Vincent-Lancrin et al., 2017) shows that among tertiary graduates of 19 European countries, the HEI shows a greater level of innovation over primary and secondary schooling, this should put us to think about the necessity of innovation regarding the first levels of teaching, by using the new technologies at our disposal. One of the positive aspects is that computers for learning lie in their power for simulations: they allow students to practice and become experts in specific tasks without the real-life consequences of failures (Vincent-Lancrin et al., 2017).

Teaching requires innovation and knowledge of the latest tendencies.

The NMC/CoSN Horizon Report: 2016 K-12 Edition (Becker et al., 2016) indicates the critical trends as significant challenges and the necessary technological developments that are very likely to impact changes in K-12 education across the world in the next five years.

Regarding the challenges for schools, creating more authentic learning opportunities and reconfiguring the roles of teachers are considered solvable. K-12 leaders are already addressing the former problem by partnering with local businesses to provide real-world experiences for students and expose them to different careers at a young age. The experts classify the trends in three ways: long-term, mid-term and short-term.

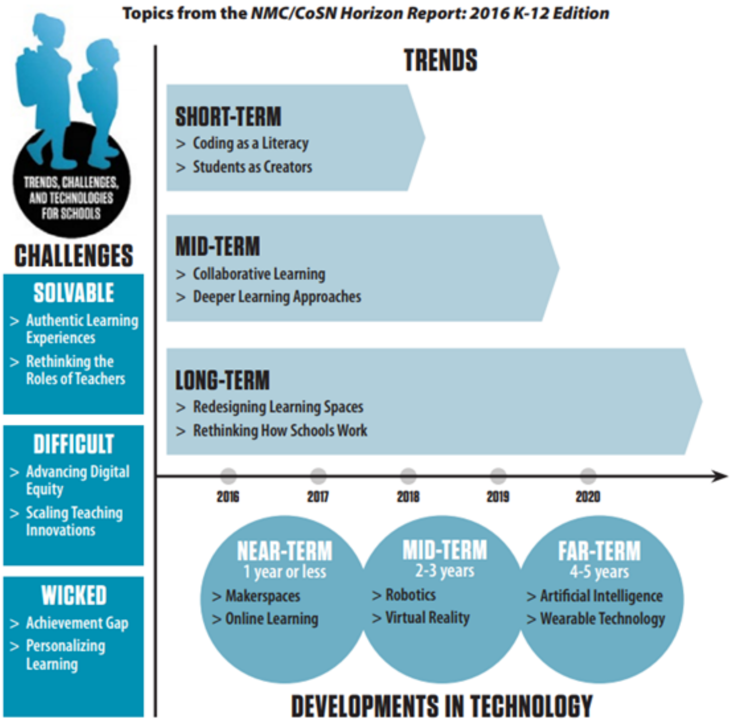
In the long-term, the same report refers to different points: the redesigning learning spaces to accommodate more immersive, hands-on activities and states how important it is to rethink how schools work to keep pace with the demands of the 21st-century workforce and equip students with future-focused skills (Becker et al., 2016).

In mid-term trends, two important areas to improve better educational environments are identified: promoting collaborative activities to students and giving the opportunity students to have deeper learning approaches.

In the short term, the improved activities involving code because coding as a literacy emerged as a new trend. Students need to learn coding and programming skills, which have proven to support problem-solving, creativity, and critical thinking skills. The design and implementation of student activities that improve creativity is an essential skill for the future of our students.

Figure 1

Trends for XXI century from (Becker et al., 2016)



Coding as a literacy

To the international trend, programming has become an increasingly growing focus in European Education. Introducing computer programming in the classroom dates back to the late 60s'. The training in a programming language provides an opportunity to engage in logical and abstract thinking, problem-solving and creative design. Seymour Papert identified the potentiality of teaching children programming languages as an incubator of powerful ideas (Papert, 2000). As a tool to engage children in new ways of thinking and thinking about thinking (Papert, 2005). Some research argues and presents pragmatic reasons for beginning Computational Thinking at this teaching level:

- Cross-curricular approaches - Computational thinking allows the creation of

transversal activities in different teaching areas;
- Promote gender equality – Several researchers point out that promoting computational thinking in learning environments in primary school is a very effective way to increase gender equality (Lapan et al., 2000, Turner et al., 2008, Graham & Latulipe, 2003);
- Motivation, confidence, pleasure - Design and participate in activities that involve Computational Thinking and, if implemented using technology such as PC, tablets, and smartphones, there is a straightforward satisfaction in learning itself, providing the pleasure of "enthusiasm" through innovative environments, which allows free choices. and practical outcomes; as Millwood points out, "such enthusiasm is usually fostered through play, where children are significantly responsible for choices and outcomes even when founded on imagination and fantasy" (Millwood, 2008);
- Collaboration - Computational thinking projects can be designed as teamwork which enables them to acquire the ability to consult, work and learn from others. It also can rely on play and, in particular, the delight of "coexistence" (Millwood, 2008);
- Creativity - Computational Thinking activities enable children to participate in rich environments, which can use arts, sciences and technology to solve problems or create new solutions.

Computational Thinking - soft skills for young people

The idea of introducing computer programming into the classroom it's not new since it came in 1960. The investigator Seymour Papert was the first to identify the potentialities of teaching children's programming languages as an incubator of powerful ideas. He had stated that programming was a tool to engage children in new ways of thinking, but much more critical than that, putting the student in a role to think about the thinking process.

Nowadays, the so-called soft skills are closely connected to the Computational Thinking capacity, which led to Computational Thinking being internationally recognised as a 21st-century skill needed to thrive in today's world. The future demands people that can work and think systematically. Besides, they should know how to analyse situations and work on different solutions. The educational system needs to embrace that challenge inside the classrooms to achieve that goal. So it is crucial to define and check for investigations on Computational Thinking. Adopting Computational Thinking and related concepts (such as algorithmic thinking and coding) in schools has led educational actors to promote activities that allow the development of these skills that are nowadays as fundamental for everyone as numeracy and literacy.

After Wing's work (Wing, 2006), there was an increase in the number of researches using Computational Thinking in education, in the first phase applied to secondary education. In a second phase, reached other education cycles, presenting a proliferation of initiatives and projects that aim to introduce Computational Thinking at earlier ages.

Authors such as Bocconi et al. (2016) referred to the need for children and students to start working with algorithmic problem solving and computational methods and tools in the educational system from kindergarten. Educational leaders have promoted initiatives that encourage the use of computational thinking. We see other approaches when analysing the various initiatives announced by different countries. Some have fostered projects involving schools, continuing education programs for teachers have been implemented, and international competitions.

So the importance of developing activities that involve Computational Thinking from an early age is a current topic, and some authors (Bers, 2019a; Sanford & Naidu, 2016) refer to the importance of introducing these concepts. These activities will allow the mastery of ideas associated with Computational Thinking from an early age, incorporating the benefits of thinking logically about real-life challenges. When we analyse how and in which areas the concepts related to Computational Thinking are used, we can check a wide diversity in the projects already developed. Still, most of them are related to STEM. The author Bers mentions that the impulse for teaching Computer Science in the United States grew together with the STEM education movement (Science, Technology, Engineering, Mathematics) (Bers, 2019b).

What effect of introducing Computational Thinking in Pre-School Education

Several studies show that children in preschool have capacities to design, build and program robots (Sullivan & Bers, 2016; Sullivan, Kazakoff, & Bers, 2013). Çakır and others (2021) point out the advantages of using computational thinking in preschool:

- develops language skills (Kory & Breazeal, 2014),
- cognitive/motor skills (Poletz et al., 2010),
- geometric thinking skills (Keren & Fridin, 2014),
- scientific process skills (Turan & Aydogdu, 2020),
- visual-spatial working memory, and robot programming abilities (Di Lieto et al., 2017)

Çakır and others (2021) promoted a project that had the primary objective “robotics and coding instruction contribute to problem-solving skills of preschoolers? 2. Do the robotics and coding instruction contribute to creative thinking abilities of preschoolers”. The results obtained showed that children who participated in robotics and coding instruction activities improved their creative thinking and problem-solving skills.

Some countries promote initiatives to promote the use of ICT inside the schools. For example, Singapore enables 2015 the project "Playmaker Programme" to give children competence in problem-solving and improving creativity. A total of 160 preschools participated in this project and gave them opportunities to use a great variety of technological tools that engage children with robotics and programming; some of these tools used are the BeeBot and KIBO robotics.

As part of the Playmaker Program project, Sullivan and Bers (2018) promoted a study entitled ‘‘Dances from around the world’. The project lasted seven weeks, covering five preschool centres, and in total, around 100 children participated.

At the end of the project, the children's knowledge of programming concepts was evaluated, and the results obtained showed that the children acquired the basic concepts of programming.

Palmér (2018) described a study in which programming was used to facilitate children learning of mathematics concepts. The results show that children developed their ability to mentally compare and connect movements in reality with maps and symbols. Palmér also states that the children broke down the tasks several times into subtasks, which is in line with the problem-solving process.

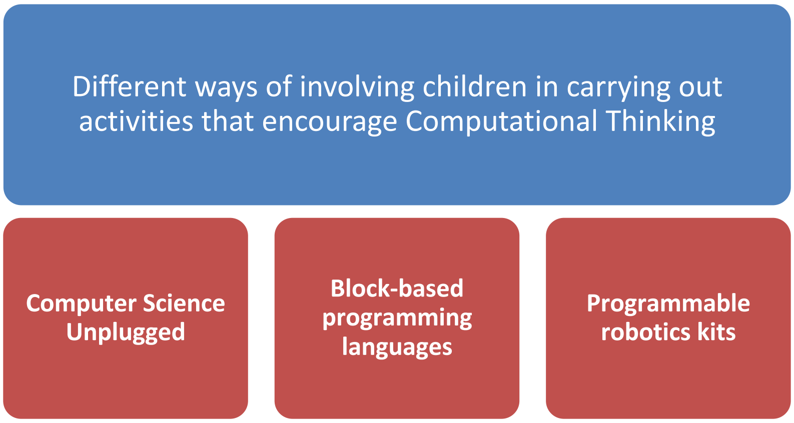
Strategies and tools for introducing Computational Thinking in Pre-School Education

In the last years, several projects (Keren & Fridin, 2014; Kory & Breazeal, 2014; Sullivan & Bers, 2016; Di Lieto et al., 2017; Sullivan et al., 2013; Turan & Aydogdu, 2020) have been developed showing that children in early childhood education can participate in Computational Thinking activities; they have the competencies to design, build, and program with robots or other block-based programming languages environments. These activities can be applied to different subjects (Mathematics, Mother Language, Science Nature…) and objectives, for example, language skills, cognitive skills, geometric and problem-solving skills, scientific process skills, visual-spatial working memory, mental calculation, oral communication, special needs, gender equality and others. Some studies state that these activities also promote equality inside the classroom. Promoting fair and just access to the students allows children to share their thinking processes.

Another aspect that we can find in the projects that have already been developed is the different ways of involving children in activities that encourage Computational Thinking.

Figure 2

CS Unplugged division



Some projects are based on Computer Science Unplugged (CS Unplugged). Through games and magic tricks, children are induced to think about computer science and engage in Computational Thinking without relying on computers and specifically learning a programming language. It is currently possible to find a vast diversity of materials that follow this perspective and allow children to be involved with Computational Thinking. An example of these materials is the Robot Turtles board game aimed at children over three years old.

Some projects developed are based on the use of Block-based programming languages. These projects are based on the use of block-based programming languages. Block-based programming languages represent instructions through icons or blocks, which simplifies the introduction of programming concepts (Mladenović et al., 2018). Block-based programming languages are prevalent in early childhood education because they do not require skills in reading /writing, and we can compare these activities to the construction of a puzzle. An example of such language is ScratchJr, a version of the Scratch application aimed at children between 5 and 7 years old in Pre-School/Kindergarten.

One of the most used methodologies for introducing Computational Thinking in these age groups is programmable robotics kits. Through these kits, children can be taught practically the basics of computer science. They exist a high diversity of robot kits that can be used in Computational Thinking activities: robot kits with a physical interface where children can define the execution of a sequence of movements; tangible blocks manipulate some kit robots; in this case, each block can be associated to a specific action; another type of robots kids is the hybrid system, in this case, children can use digital platforms to define the robot behaviour according to the desire goals.

Computer Science Unplugged activities in Pre-School Education

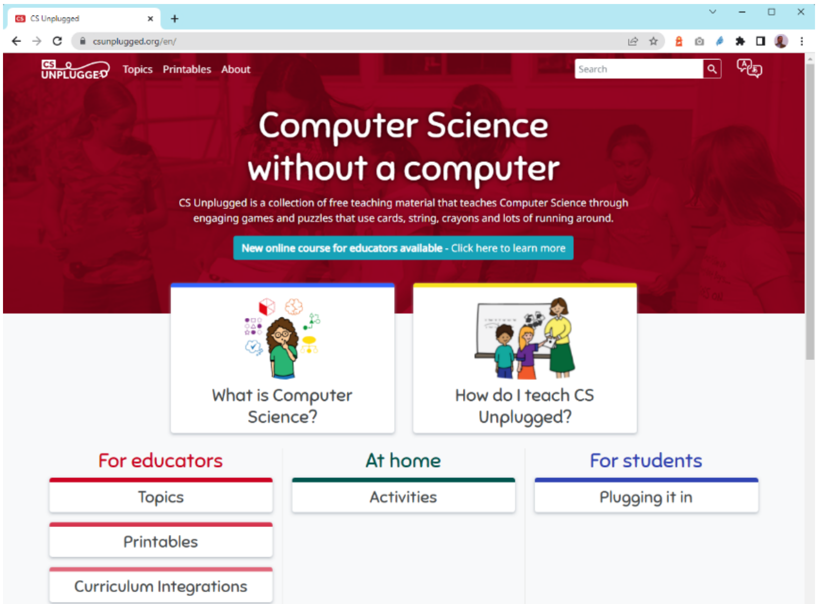
Activities that implement CT using an Unplugged strategy can be classified as a constructivist approach. Students have proposed challenges that have a set of rules. In solving these challenges, they autonomously discover ideas and manage to assimilate concepts related to CS.

A significant advantage of this approach lies in its independence from hardware or software resources. These advantages facilitate the implementation at any time or place, without the need for resources such as hardware or software, which will consistently implement activities more expensive.

Several platforms are available that have examples of CS unplugged activities that can be applied in early childhood education. On the Csunplugged.org (Figure 3) platform, several actions can be used for this age group.

Figure 3

Computer Science without a computer (https://www.csunplugged.org/en/)



The necessary resources and planning to carry out the tasks are provided for each activity. It is also listed how the execution of the activity develops computational thinking.

Figure 4

Rescue Mission – Activity (https://www.csunplugged.org/en/)

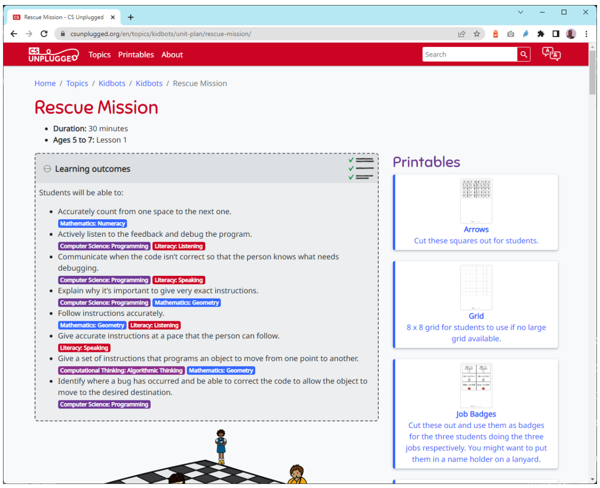
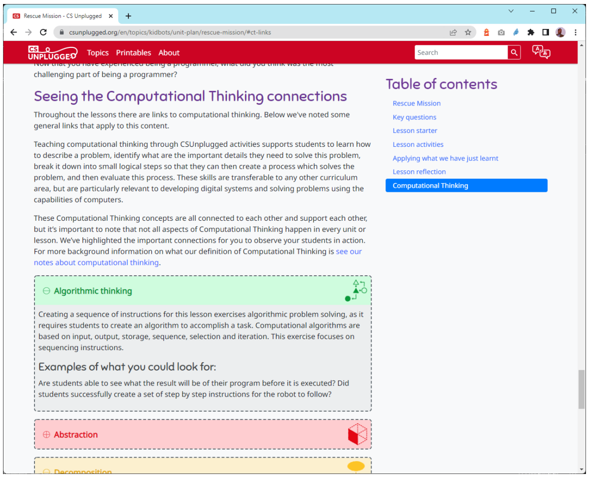


Figure 5

Rescue Mission – Computational Thinking Connections (https://www.csunplugged.org/en/)



Block-based programming languages activities in Pre-School Education

Activities involving Block-based programming allow children to define a set of instructions for building stories or systems. With this application, Block-based programming, children represent an instruction using predefined blocks and create relationships between them. Usually, the environment of these applications is visual and allows the use of drag and drop.

Activities involving block-based coding allow children to define a set of instructions for building stories or systems.

With this app, block-based coding, kids represent an instruction using predefined blocks and create relationships between them. Usually, the environment of these applications is visual and allows the use of drag and drop. In recent years, many initiatives that use block-based programming in early childhood education have grown.

This fact is due to the simplicity of the application environments, as they are based on visual elements they do not require reading or writing processes. This is important because it allows young children to explore computer science concepts such as algorithms and debugging fun and developmental.

For example, ScratchJr (Figure 6) is an application that allows children from the age of 5 to create their own stories using a block programming language. The creation of stories and programs is based on the joining of blocks, which will define characters' behaviour. The behaviours assigned to the characters will make it possible to add movements or audio.

The Kodable is an environment with specifications for children, parents, and teachers. The main objective of Kodable is to help children learn coding through interactive games and have self-guided activities. These activities start from beginners, where there is no necessary coding knowledge; at the last level, children can use an environment that enables children to write the code; in Kodable, the coding syntax is similar to JavaScrip.

Figure 6

Scratchjr Block-based programming languages. (https://scratchjr.org/)

Programmable robotics kits activities in Pre-School Education

Using robotics kits in early childhood education helps close gender and SES-based performance gaps in STEAM fields. In early childhood education, robotics is used to introduce STEM concepts playfully, encouraging them to explore and build concepts in Science, Technology, Engineering and Mathematics. Sullivan and Bers argue that Robotics and programming provide a fun and hands-on way to introduce young children to all aspects of STEM (Sullivan & Bers, 2018).

Several studies indicate that children over four years of age are capable of building and programming robots (Bers et al., 2002; Cejka et al., 2006; Sullivan et al., 2013; Sullivan & Bers, 2016)

The use of robots and the implementation of activities associated with their manipulation in an educational environment allows the development of motor skills, metacognitive skills, problem-solving and coordination reasoning; as in other age groups, these activities also develop a spirit of collaboration and teamwork (Lee et al., 2013; Bers et al., 2013).

An example of such a kit is the KIBO robot (Figure 7). It is a robot that was specifically designed for children between 4 and 7 years old to introduce activities in the area of STEAM in this age group. With Kibo Kit, children can build their robot, adding sensors and elements that customise the robot.

Figure 7

*KIBO 15 Kit (*https://www.shop.kinderlabrobotics.com/KIBO-15-Kit-KIBO15Kit.htm*)*

One of the characteristics that differentiate this robot is using tangible blocks to define the robot's behaviour. All robot behaviours are delimited by start and end blocks and, to be interpreted by robots, pass the barcode associated with each block on the front of the robot.

Another example of this kind of tool is the Bee-Bot robot (Figure 8). Bee-Bot is a robot that was developed to be used by young children.

Figure 8

Bee-Bot Family
(https://www.terrapinlogo.com/products/robots/bee/bee-bot-family.html)

It is a straightforward robot to operate, has a child-friendly layout, and can be used to introduce directional language and programming concepts to young children. Through a set of buttons placed on top of the robot (Figure 8), the child can enter a sequence of commands stored in the robot's memory. Each order can have movement indications, such as forward/backwards, left/right turn or a pause.

Figure 9

Directional keys - Bee-Bot Family
(https://www.terrapinlogo.com/products/robots/bee/bee-bot-family.html)

Another evolution of the Bee-Bot is the Blue-Bot, which is essentially the Bee-Bot robot but with a Bluetooth connection, which allows you to use a tablet to control the robot. From our point of view, this has a particularity which is the possibility of using the Tactile Reader programming device to control the Blue-Bot remotely. With the Tactile Reader, children can define the robot's behaviour using tokens representing robot commands and sequentially place these tokens. It allows the child to visualise a set of commands and their sequence, facilitating their interaction and manipulation.

Figure 10

TacTile Reader- Blue-Bot (TacTile Reader (terrapinlogo.com))

Future Work

We intend to use the three Computer Science Unplugged Divisions in a structured project to develop Computational Thinking in an enjoyable way to deliver to children in preschool for a short period.

The idea is to use the well-known LEGO bricks to develop a drag racing system that should be applied in groups inside a preschool classroom.

Children will have at their disposal a box (Figure 11) with specific LEGO bricks that they could use freely to test construction, the main goal is to build a small car that needs to cross several obstacles.

Figure 11

LEGO Box (https://roomcopenhagen.com/lego-box-with-handle/)

The way that children will build their vehicles will drive them into a new world of discovering, unplugging their ideas, testing their thoughts, and creating algorithms that necessary are connected to the computational thinking that we need to develop.

Figure 12

Drag Race (https://www.lego.com/en-pt/product/chevrolet-camaro-drag-race)

Creativity is totally connected to the way that they will find to create their race car; the necessary skills will be settled after testing again and again. This conjecture and testing set will help to get acquainted to the rules of problem-solving and the George Polya heuristics.

The first step of Polya's Process is to *Understand the Problem*, regarding this we could ask some questions:

- State the problem in our own words, changing to our own idea.
- Specify what is exactly being asked.
- Identify what we don't know.
- Figure out what is the more important aspects.
- Identify what is relevant, and what is irrelevant.

When we get familiar with the situation/problem, we need to find what is the data that we have at our disposal drawing a plan to carry out:

- Look for patterns.
- Think about similar problems that we have already studied before.
- Draw a picture, table, diagram or chart.
- When necessary, write an equation.
- Use checking.
- Work backwards.
- Identify sub-goals in the situation.

Carry out the plan in the third part of the process. It's important to keep a record of the steps when we are implementing the plan so that in the future we can take a look and see if any situation was already studied or analysed before.

After we try to draw conclusions from the situation obtained, we can take a look to what was the initial situation and look back with something that could be the solution to our initial problem.

So, this new future project will help children to develop their ideas, communicate their thoughts, express their feelings, raise their critical thinking, understand how a problem works, to try to find solutions to different situations.

Conclusions

The society where we live is flooded by technology; smartphones, intelligent faucets, automatic doors, AR and IOT are a few examples among a group of recent and entirely new technologies that were bought to us. But in the early years, children learn very little about how these things work, and the education system continues much in an ancient vision of the learning and studying concepts. If we want to keep our students up to date with society's latest trends and demands, we need to proceed in another direction towards a new teaching and learning process inside our schools.

We need to continue where Seymour Papert started and continue with different tryouts and experiences by using new and other tools, like the robots or the AR, to promote Computational Thinking at a significantly earlier stage, even if we don't use a wide range of technologies we need to develop the thoughts and create opportunities to all children.

Nowadays exist, several projects or initiatives to give the opportunities to young children to use interactive technologies and digital tools, such as block-based visual programming environments; programmable robotics kits have been introduced into the classrooms with the issue of children's use of computational thinking. The studies promoted in the last years say that young children can learn programming and engineering (Pre-School). This is possible when these children have access to various tools to develop appropriate skills that fit the XXI century and its demands.

The activities need to encourage open-ended play to integrate technical skills with expressive arts, math, literacy and cultural explorations; learning by doing is always present and has a specific and unique character. The transversality with all subjects, combined with the oral and written communication, and the cooperative work among children, make part of the package that should be addressed in Pre-School Education.

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Conflict of interest

The authors declare that they have no conflict of interest. Funders had no role in the study design; in the collection, analysis or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Authors' contributions

Conceptualization, CB; methodology, PT and CB; software, CB; validation, PT; formal analysis, PT and CB; research, PT and CB; resources, CB; data analysis, PT and CB; drafting of the original draft, CB; writing, proofreading and editing, PT and CB; supervision, PT; project management, PT and CB; acquisition of financing, PT and CB.

References

Becker, S., Freeman, A., Giesinger Hall, C., Cummins, M., & Yuhnke, B. (2016). *NMC/CoSN Horizon Report: 2016 K-12 Edition*. The New Media Consortium.

Bers, M. U. (2019a). Coding as another language: Why Computer Science in early childhood should not be STEM En C. Donohue (Ed.), *Exploring key issues in early childhood and technology: Evolving perspectives and innovative approaches*. Routledge. https://doi.org/10.4324/9780429457425-1

Bers, M. U. (2019b). Coding as another language: a pedagogical approach for teaching computer science in early childhood. *Journal of Computers in Education, 6*(4),499–528. https://doi.org/10.1007/s40692-019-00147-3

Bers, M. U. (2020). *Coding as a playground: Programming and computational thinking in the early childhood classroom*. Routledge

Bers, M., Ponte, I., Juelich, K., Viera, A., & Schenker, J. (2002). Teachers as designers: Integrating robotics in early childhood education. *Information Technology in Childhood Education*, 1, 123–145.

Bocconi, S., Chioccariello, A., Dettori, G., Ferrari, A., & Engelhardt, K. (2016). *Developing Computational Thinking in Compulsory Education - Implications for policy and practice*. JRC Research Reports.

Çakır, R., Korkmaz, Ö., İdil, Ö., & Erdoğmuş, F. U. (2021). The effect of robotic coding education on preschoolers' problem solving and creative thinking skills. *Thinking Skills and Creativity*, 40, 1871-1871.

Cejka, E., Rogers, C., & Portsmore, M. (2006). Kindergarten robotics: Using robotics to motivate math, science, and engineering literacy in elementary school. *International Journal of Engineering Education, 22*(4), 711–722.

CNE (2018) Estado da Educação 2018. Conselho. Nacional de Educação (CNE)

European Comission. (2018). Recommendation on Key Competences for Lifelong cil Recommendation of 22 May 2018 on key competences for lifelong learning. Official Journal of the European Union.

Graham, S., & Latulipe, C. (2003). CS girls rock: sparking interest in Computer Science and debunking the stereotypes. *ACM SIGCSE Bulletin, 35*(1), 322–326. https://doi.org/10.1145/792548.611998

Di Lieto, M. C., Inguaggiato, E., Castro, F. C., Cioni, G., Dell'Omo, M., Laschi, C., … Paolo, D. (2017). Educational Robotics intervention on Executive Functions in preschool children: A pilot study. *Computers in Human Behavior, 71*, 16–23. https://doi.org/10.1016/j.chb.2017.01.018

Kazakoff, E., & Bers, M. (2012). Programming in a robotics context in the kindergarten classroom: The impact on sequencing skills. *Journal of Educational Multimedia and Hypermedia, 21*(4), 371–391. Retrieved from https://ase.tufts.edu/DevTech/publications/JEMH.pdf.

Keren, G., & Fridin, M. (2014). Kindergarten Social Assistive Robot (KindSAR) for children's geometric thinking and metacognitive development in preschool education: A pilot study. *Computers in Human Behavior, 35*, 400–412. https://doi.org/10.1016/j.chb.2014.03.009

Kory, J., & Breazeal, C. (2014). Storytelling with robots: Learning companions for preschool children's language development. In The 23rd IEEE international symposium on robot and human interactive communication (pp. 643-648). IEEE

Lee, K., Sullivan, A., & Bers, M. U. (2013). Collaboration by design: Using robotics to foster socialinteraction in Kindergarten. *Computers in the Schools, 30*(3), 271–281. https://doi.org/10.1080/07380569.2013.805676

Lapan, R., Adams, A., Turner, S., & Hinkelman, J. (2000). Seventh graders' vocational interest and efficacy expectation patterns. *Journal of Career Development, 26*(3), 215-229.

Millwood, R. (2008). An Analysis of Delight. http://blog.richardmillwood.net/2008/05/15/an-analysis-of-delight/

Mladenović, M., Boljat, I., & Žanko, Ž. (2018). Comparing loops misconceptions in block-based and text-based programming languages at the K-12 level. *Education and Information Technologies, 23*(4), 1483-1500. https://doi.org/10.1007/s10639-017-9673-3

Papert, S. (2000). What's the big idea? Toward a pedagogy of idea power. *IBM Systems Journal, 39*(3.4), 720-729.

Papert, S. (2005). You can't think about thinking without thinking about thinking about something. *Contemporary Issues in Technology and Teacher Education, 5*(3/4), 366-367.

Palmér, H. (2017). Programming in preschool: with a focus on learning mathematics. *International Research in Early Childhood Education, 8*(1), 75–87. Retrieved from http://urn.kb.se/resolve?urn=urn:nbn:se:lnu:diva-70359

Poletz, L., Encarnaçao, P., Adams, K., & Cook, A. L. (2010). Robot skills and cognitive performance of preschool children. *Technology and Disability, 22*(3), 117–126. https://doi.org/10.3233/TAD-2010-0296.

Sanford, J. F., & Naidu, J. T. (2016). Computational thinking concepts for grade school. *Contemporary Issues in Education Research (CIER), 9*(1), 23–32.

Sullivan, A., & Bers, M. (2018). Dancing robots: integrating art, music, and robotics in Singapore's early childhood centers. *International Journal of Technology and Design Education*. 28. https://doi.org/10.1007/s10798-017-9397-0

Sullivan, A., & Bers, M. U. (2016). Robotics in the early childhood classroom: Learning outcomes from an 8-week robotics curriculum in pre-kindergarten through second grade. *International Journal of Technology and Design Education, 26*(1), 3–20. https://doi.org/10.1007/S10798-015-9304-5

Sullivan, A., Kazakoff, E. R., & Bers, M. U. (2013). The wheels on the bot go round and round: Robotics curriculum in pre-kindergarten. *Journal of Information Technology Education: Innovations in Practice, 12*, 203–219.

Tadeu, P., & Brigas, C. J. (2018). Using Online Programs to Centre Students in the Twenty-First Century. Handbook of Research on Student-Centered Strategies in Online Adult Learning Environments. Advances in Educational Technologies and Instructional Design (AETID) Book Series, 102-119.

Turan, S., & Aydogdu, F. (2020). Effect of coding and robotic education on pre-school children's skills of scientific process. *Education and Information Technologies, 25*(5), 4353–4363. https://doi.org/10.1007/s10639-020-10178-4

Turner, S. L., Conkel, J. L., Starkey, M., Landgraf, R., Lapan, R. T., Siewert, J. J., Reich, A., Trotter, M. J., Neumaier, E. R., & Huang, J.-P. (2008). Gender Differences in Holland Vocational Personality Types: Implications for School Counselors. *Professional School Counseling, 11*(5), 317–326.

Vincent-Lancins, S., Jacotin, G., Urgel, J., Kar, S., & González-Sancho, C. (2017), *Measuriling Innovation in Education: A Journey to the Future*. OECD Publishing.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM, 49*(3),33–35