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On Current and Critical Issues in Curriculum, Learning and Assessment

Computational Thinking, Artificial Intelligence and Education in Latin America

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IBE-UNESCO Director	Yao Ydo
Coordination and Production Team	Lili Ji, Renato Opertti, Ruben Cruz, Perrine Arsendeau,and Yi Yang
Authors	Emiliano Pereiro, Mariana Montaldo, Victor Koleszar, and Alar Urruticoechea

Table of Contents

Table of Contents

Computational Thinking, Artificial Intelligence and Education in Latin America

Introduction

In the last few years we have been witnessing a tremendous growth in the use of digital technologies, digital products and digital platforms. In fact, digital technologies have been adopted faster than any other technology in history. This has created a new type of worker, the digital workers, who are able to use digital tools, methods and processes, but not only the economy has become digital also the exercise of citizenship has become digitalized, today our world is hybrid. To understand the world that the 4th industrial revolution is introducing in our societies, it is essential to provide our citizens with literacy in Computational Thinking and AI. The introduction of technology such as artificial intelligence into our educational systems is essentially a human issue.

In the last two years the disruption caused by Covid 19 has increased governments and international organizations' interest in exploring solutions in which technology appears as an ally to overcome difficulties such as isolation, school closure and lack of resources in many regions. Platforms, digital learning and access to devices and internet have always been issues that called for action but the search for new technologies and methodologies to improve education are in the center of the discussion worldwide. Within that discussion, it seems that all of a sudden the introduction of AI in Education settings is so important that it could even determine students success in academic life. Even though this issue is relatively new in Latin America, many countries are launching initiatives and researching different ways in which AI could benefit students' life, teachers' decision making and personalization of learning.

This document aims to provide a glance at Latin American reality about this pressing issue, and also to reflect around some critical questions: What experiences can we draw on in Latin American context to build knowledge around this topic? What are the key aspects for developing projects around this topic that could provide students with meaningful learning? Are teachers ready? What are their thoughts and beliefs about AI in education? What are the implications of this AI disruption in Education?

Framework: Key concepts that guide this paper

1. Computational Thinking

One of the pioneers in using coding in education was Seymour Papert. In the 80s, Papert integrated Logo with the learning theories of Jean Piaget, The Logo Programming Language[1] was developed by Seymour Papert at the MIT[2]. Logo was an early attempt to demonstrate the power of computer programming to children.

In the early 1970s Papert's research had two main goals: first, to determine what educational process would best facilitate the development of creative problem-solving skills in children, and, second, to determine how children could be helped to learn coding. "The child, even at preschool ages, is in control: The child programs the computer. And in teaching the computer how to think, children embark on an exploration about how they themselves think." (Papert, 1980, p. 19).

The idea of Computational Thinking (CT) is not new, but in the past few years a definition from Wing triggered a new movement around this issue in many educational communities. As a result CT is a hot topic now, and several countries have recently introduced CT and Computer Sciences (CS) to the primary school curriculum (Bocconi et al., 2016; Brown et al., 2014; Duncan et al., 2017). CT has been used as a framework for developing a range of contents and skills, from computer literacy to computer science, including STEAM[3], coding, robotics, or general problem solving (National Research Council, 2010).

Wing (2006) first defined CT as "the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent." Then over time, the author gives some more clues about the concept aiming to clarify it. In this initial definition of the concept Wing refers to Seymour Papert in the sense that the teaching of coding is not an objective in itself, but rather a means for students to generate cognitive skills to solve complex problems with the method used in computer science, being able to think like a computer scientist will have benefits regardless of the profession they work in. "The modern (and long) wave of the expression "computational thinking" started with a seminal essay by Wing, who argues that learning to think like a computer scientist would be a benefit for everyone, in whatever profession involves (Lodi & Martini, 2021).

But this learning, in addition to its effects on this more general cognitive line, will also have effects on well-defined technical skills, for example, in the understanding and appropriation of programming languages In the information age, everyone should understand the basics of coding in order to be able to understand the world of algorithms that surround us and influence our daily perception. "CT becomes a lens and a set of categories for understanding the algorithmic fabric of today's world" (Lodi & Martini, 2021).

Perhaps due to ambiguity, but also other reasons like advances in technology, and other converging ideas in the past years courses and resources have been increased. In this scenario coexist the use of CT to refer to computational literacy, digital literacy, problem solving and/or computer science in K-12 education.

[1] https://el.media.mit.edu/logo-foundation/what_is_logo/logo_programming.html
[2] https://www.mit.edu/
[3] Science Technology Engineering Arts Mathematics

Many efforts have been made to unify CT concepts and practices (College Board, 2020; Csizmadia et al., 2015; IEST & CESTA, 2011; Juškevičienė & Dagienė, 2018; K-12 Computer Science Framework, 2016; Raabe et al., 2018). In our view a very good attempt at synthesis is: “Computational thinking refers to an individual’s ability to recognize aspects of real-world problems which are appropriate for computational formulation and to evaluate and develop algorithmic solutions to those problems so that the solutions could be operationalized with a computer” (Fraillon et al., 2019).

There are already calls to extend the CT framework to cover some aspects of AI (Brummelen et al., 2019; Malyn-Smith et al., 2018), for example including *classification*, *prediction* and *generation* concepts; *training, validating and testing* to practices; and *evaluation* to perspective; in the CT Framework defined by Brennan and Resnick (2012). In our view the Fraillon et al. (2019) definition also allows incorporating these aspects. CT framework it’s a big opportunity to introduce and understand the basic principles of AI in such a way that it’s integrated with programming learning and problem solving.

2. Artificial Intelligence

AI (Artificial intelligence) is a field of Computer Science that has had a strong development in the last years, among other causes, due to the massive accumulation of data and the increase in the computational power of machines.

The term artificial intelligence however dates back to the 50's. Alan Turing (1950) is the first to refer to AI in his paper "Computing Machinery and intelligence", and it is at Dartmouth University where the first AI department is created (Holmes et al., 2019). Although the discipline began in the mid-twentieth century, today is the most effervescent historical moment of this field. There are at least two large companies[4] that are working towards achieving a general artificial intelligence, this refers to being able to emulate a human intelligence with all its complexity.

But what are we talking about when we talk about artificial intelligence? It is also quite complex to arrive at a concrete definition given the wide reach of this term and the interwoven relations with other terms such as machine learning, natural language processing and learning analytics. As a framework to this paper we will briefly define these terms and their extent.

We align with the definition by MIT that understands AI as the possibility of “machines that can learn, reason, and act for themselves. They can make their own decisions when faced with new situations, in the same way that humans and animals can” (Hao, 2018).

Under the framework of AI are included different fields with their own specificities. Machine Learning, computer vision, graphs, speech recognition, natural language processing, neural networks, among others. Beyond these fields, there are different dimensions of AI and Education, which include: (i) Learning with AI (teachers, students, etc facing AI), learning about AI (related to how AI works, its technologies, its techniques and how to create it) and preparing for AI (living with AI, human values and the limits of AI). (Holmes et al., 2019).

In this section we will define three subfields of AI that were identified in the experiences in the use of AI in education in Latin America. Machine Learning, Natural Process Language and learning analytics.

Machine learning is a field of computer science that uses statistical techniques to give computers the ability to “learn” without being explicitly programmed. The idea behind it is that you can build a model that will learn what data is important for making decisions based on historical data. The model will learn

[4] https://deepmind.com/ https://openai.com/

what data is important for making decisions based on historical data. The model will apply the learned knowledge to new data and make informed decisions based on this data. What is it used for? The most popular application of learning uses supervised learning, where a model is trained on a set of labeled data and then tries to predict an output or label that has not been seen before. This approach has been used to solve a variety of problems, such as classifying email as spam or non-spam. Analysing images and videos and classifying them according to content. Automatically generating captions for images and videos. Classifying data such as credit card transactions, recommendations for products and services, and so on. Finding trends in historical data. Predicting future values based on training data.

The field of machine learning is extremely broad and continues to grow and evolve. There is a lot of exciting research and exciting applications of the techniques available these days. What types of machine learning are there? There are a variety of different machine learning algorithms, but they can be classified into three categories: Supervised learning, Unsupervised learning and Semi-supervised learning.

In supervised learning, machine learning algorithms are trained on labeled training data. In other words, the training data has been labeled by a human expert to indicate which examples are positive and which examples are negative. For example, a supervised learning algorithm may be trained on a set of labeled images of a certain disease to determine whether a new image is a positive example of the disease or a negative example of the disease. Supervised learning is often used to create a classifier that can be used to determine whether new examples are positive or negative examples of the concept in question.

In unsupervised learning, machine learning algorithms are trained on unlabeled data. For example, an unsupervised learning algorithm may be trained on a set of labeled images of various objects. However, the images of the objects may not be labeled with the actual identities of the objects in the images.

A semi-supervised learning algorithm is trained on both labeled and unlabeled data. For example, the algorithm may be trained on both labeled images of objects and unlabeled images of objects. Deep learning is a subset of machine learning that involves training artificial neural networks. The training involves simultaneously training many neural networks on different levels of abstraction. For example, one neural network may be trained to identify the outlines of objects in an image. Another neural network may be trained to identify various features of the object. In that sense, machine learning is the process that makes that learning possible, connected to algorithms and their possibility of interpreting and processing available data. According to Chen et al (2020) “the core of machine learning is knowledge discovery, the process of parsing based on a sampling data set known as ‘‘training data’’, generating meaningful patterns and a structured knowledge”.

Natural Language Processing (NLP) is a form of AI that gives machines the ability to understand human language. Natural language refers to the human languages that include English, Spanish, German, French, Mandarin, Quechua, etc. NPL models help machines understand human speech and generate language.

Today, NLP is being used for voice recognition, natural language generation, chatbots, question answering, neural Machine Translation, etc. We are seeing more and more companies using NLP to power their chatbots, voice assistants, and text analysis with this technology. NLP is being used in many other areas including education, healthcare, entertainment, search engines, security, smart homes, etc.

NPL helps machines to generate human language in the same way as humans do. For example, when you type in a text message, your phone will try to predict what you are typing; this allows you to type faster and can also be used to write text messages, generate reports, generate speech, etc. Two of the most important developments in this area are chatbots and automatic translators, which are achieving better results year by year (Wu et al., 2016).

Finally, **learning analytics** is the set of metrics, criteria and processes involved in the collection, interpretation and analysis of that data coming from technology users related to learning outcomes, in this case students and the education community. A learning analytics system allows educational institutions to collect, analyze and interpret learning data to support activities such as student learning, teacher professional development, or school improvement, also can provide insights into student engagement, learning outcomes, and the effectiveness of instruction. This information can be used to help improve student learning outcomes, inform instruction, identify students at risk of dropping out, and better understand how students learn.

AI status in Latin América

Our research shows that this issue is quite new in the region, discussions are slowly taking leading places in education systems but there haven't been significant advances in policy making or curriculum design. However, there are plenty of current experiences that aim to provide the building blocks to this process that with the pandemic of COVID 19 has gained strength and relevance for governments.

Currently the more frequent experiences regarding AI in Education evolve around the use of platforms with different purposes and basic computer science notions embedded in Computational Thinking and programming initiatives directed to students.

Regarding the use of platforms as education resource, according to IDB (2020) there are three categories: adaptive platforms to learn a discipline, that typically provide sets of activities according to student's level and areas of improvement; Collaborative work platforms (LMS for example) with algorithms that can analyse or process natural language and focus on student's interactions and Gaming platforms that provide real time data on learning through gaming, using for example natural language processing.

What are the impacts of all this technology set up in classroom settings? Are there any studies or evidence that support their contribution to learning? We selected three initiatives that have run studies and gained evidence about their impact, current status and limitations.

For the analysis we selected four main categories to address: the experience/tool, the role of AI, evidence or results, large scale implementation possibilities and lessons learnt. For the analysis, the experiences of three countries in the region that are implementing computer science activities in their educational system were selected. Uruguay, Argentina and Brazil.

Three Regional Experiences

Uruguay

Plan Ceibal[5] is a state agency created in 2007 by the Uruguayan government to include technology in the education system. At the beginning, the program had the task of deploying technological infrastructure in schools. Today, all students from 1st grade of primary school to 3rd grade of high school have a device (tablet or laptop) provided by Ceibal. Additionally, all public schools have a wifi

[5] www.ceibal.edu.uy/en/institucional

internet connection and 100% of urban public schools have videoconferencing equipment installed.

Among the initiatives related to computer science in Uruguay, three lines stand out: the Robotics and programming olympiad, the international Bebras challenge and the Computational Thinking program.

Once a year Plan Ceibal organizes the Robotic and programming olympiad, where hundreds of students from all over the country participate with technology projects applied to solve problems of different topics. Last year for example the main theme was sports and health.

Bebras is an international challenge to promote computational thinking, born in Lithuania in 2004 and today more than 70 countries are participating. Uruguay joined the initiative in 2020 and in November 2021 will apply the second edition of the challenge. Last edition more than 4000 students and their teachers participated in this challenge.

Computational Thinking Program

Since 2017, Plan Ceibal has impulsed a large scale intervention program in computational thinking in primary education[6]. The program called Computational Thinking involves one more teacher, who connects remotely to a video conference equipment, and who works in a pedagogical team with the classroom teacher once a week in interdisciplinary projects. That is, specific contents of computational thinking are addressed with mathematics, science, language, physical education, etc. The work in this program is completely voluntary and participation in the program has grown exponentially. In 2021 the program has almost 2000 groups, 36,000 students and 1500 classroom teachers distributed in almost 60% of the total number of public urban schools in the country. The program mainly uses Scratch[7] for its pedagogical approach. Scratch is an educational programming language for all ages. It allows one to work with images, graphics, objects, sounds, images, video, text, expressions, algorithms, loops, events, etc., that can be combined in many ways. Scratch is a block-based programming language. These blocks allow a user to create a program using a graphical user interface, rather than a text-based programming language, so it's more simple. Scratch was developed for Mitchel Resnick at the MIT Media Lab as a project of the Lifelong Kindergarten group[8]. It's a great way to learn coding and express creativity at the same time. This tool is user friendly for teachers and students and it is free, which allows massive use.

The aim of the program is for students to develop the fundamental contents of computer science and learn new approaches to problem solving and expression. Lined with different international frameworks, the dimensions proposed by the program are: communication and collaboration; computing, society and equity; computational problems; data and abstractions; algorithms, programs and devices. The figure 1 shows the framework used by Ceibal for its Computational Thinking program.

[6] www.ceibal.edu.uy/pensamientocomputacional
[7] https://scratch.mit.edu/
[8] http://lifelongkindergarten.net/

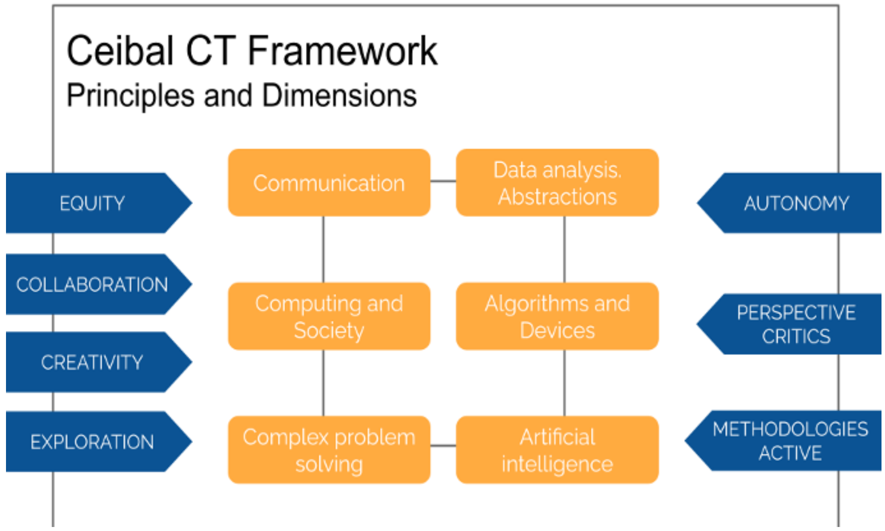

Fig 1. Plan Ceibal CT Framework

In this framework, some of the project's topics that are being worked on address the basic notions of Artificial Intelligence, ethical dilemmas and social impacts, as well as the work process with supervised machine learning.

AI project: teaching machines to learn

We developed a project to address artificial intelligence, which is currently in the pilot test phase with a training group of 60 teachers. This proposal called *Artificial intelligence: teaching machines to learn*, involves a training phase and another implementation phase with middle school students. This pilot is being implemented in the region of Rivera, on the border with Brazil and in schools participating in a national pilot called Centros Espinola[9]. The training phase consists of a 20-hour course, aimed at computer teachers. The proposal tries to involve teachers on the subject of machine learning, working in the generation of an AI model with a Teachable Machine and the design and programming of an application that includes this AI block with Poseblocks. This tour covers the main concepts of ML, the work cycle (Fig 2) and the 5 main ideas of AI4K12 (Touretzky et al., 2019): Perception. Representation and reasoning. Learning. Natural interaction. Social impact.

[9] www.anep.edu.uy/15-d/centros-educativos-mar-esp-nola

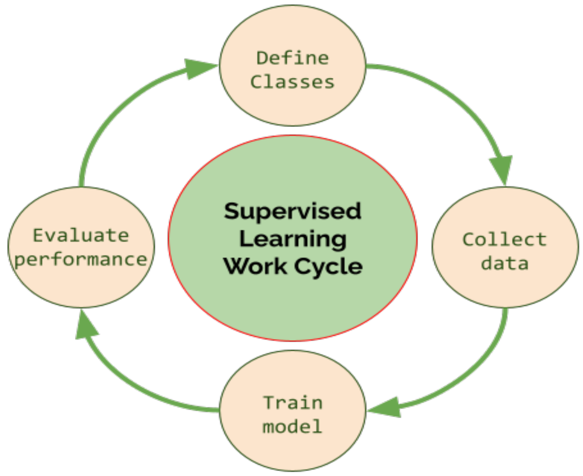

Fig 2. Machine Learning Work cycle

After the training phase, teachers work with students in a similar way as they were trained: working in a project that involves an AI module developed with Teachable Machine. The construction of this application or video game is a programming challenge, which adds to the additional difficulty of having to integrate a specific artificial intelligence module. In this project the teachers also have the opportunity to work with other subject teachers, in order to add some other specific content, in such a way that the pedagogical proposal serves to present the desired subject matter. The didactic sequence (See Fig 3) is designed to be implemented in a pedagogical partnership, a computer science teacher with a colleague from another subject area. The project will be scaffolded by a certain structure, but is also a product of the students' creativity and will allow them a first approach to understand what we mean when we say that computers learn or have intelligence.

Fig 3. Project stages synthesis

The role of AI

The idea behind this experience is to show the students the potential of Machine Learning and to make it easy for them to explore the field. The course starts with an introduction to Machine Learning and Google's Teachable Machine. It quickly dives into a hands-on section where students can experiment with different types of data and see how a Machine Learning model can provide interesting insights from that data. The focus is on approaching the subject of Artificial Intelligence in a practical and conceptual way, including social and ethics aspects. In this module, students will learn the basic concepts of machine learning and about the different types of data, and the ways to process that data.

Large scale implementation possibilities

This artificial intelligence proposal is designed for 40-hour (training and implementation), addressed to teachers, and the didactic sequence for students is based on free tools. To carry out this program massively it is necessary to have a team of trained teachers, the course has a completely online version with synchronous instances, in this way it is possible to scale the intervention with a basic budget.

The artificial intelligence pilot in Uruguay is being implemented at the time of this writing, so we do not yet have results or lessons learned to present.

PAM

Since 2013, Plan Ceibal has been working in cooperation with the educational system with PAM[10] (Spanish acronym for adaptive mathematics platform). The platform has more than 100,000 mathematics exercises and is available for teachers and students of primary and secondary education. The platform is a complement to traditional teaching, its use is voluntary for teachers and students, being more effective when both use it together.

The platform is a tool that allows gamification of learning and personalization of learning. For example, by using this platform, students can earn stars and coins for completing their homework. The platform also helps teachers with the creation of new content to be used in class and to be shared with other educators. This tool adapts to the learning pace of each student and offers individualized supervision by the teacher. It covers from 3rd grade of Primary to 4th grade of High School. PAM provides tools for defining lessons, presenting new topics, setting goals, preparing tests or exams, and sending homework assignments to groups or individuals. The tasks are organized in "books" or series of activities; as they are performed by the student, the platform provides additional help through related theoretical materials, the demonstration of other ways to solve them, and the suggestion of new activities of resolution and the suggestion of new activities in areas that require more training. An example of a task is shown in figure 4.

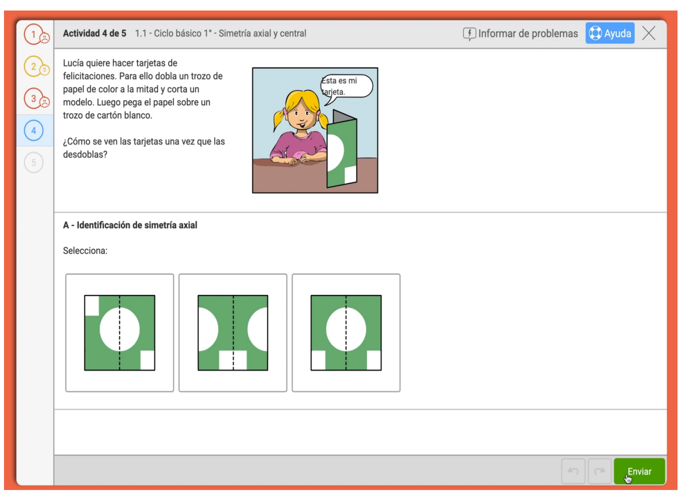

Fig 4. PAM Task

[10] www.ceibal.edu.uy/pam

PAM can also be used to keep track of their progress and help them assess their skills. It is possible for the teacher to obtain reports on the performance of his students in order to identify areas for improvement. Teachers can use the information to identify the students who fell behind and who require more attention and practice. Teachers can access different reports on their students' performance:

The *weekly report*[11] allows to visualize the activity report of a class within a period of time. It presents different data for each of the students enrolled in the course. The information presented in this report is on the following topics: Coins and stars earned; Exercise series started; Exercise series completed; Maximum achievement reached; Average achievement attained; Content. An example of a weekly report is shown in the following figure.

Informe de actividad de clase

Período: 16.02.2015 al 22.02.2015

Ceibal

alulab29

Libro	Capítulo	Contenido	Comenzadas	Finalizadas	Máximo logro alcanzado	Logro promedio	Monedas obtenidas	Estrellas obtenidas	Tiempo
Primaria 5° - Operaciones	1 - 1 - 5	Sumar números menores a 100 (las casillas suman más de 10)	1	1	100 %	100 %	3	1	ca. 3 min
Primaria 5° - Operaciones	1 - 1 - 4	Resolver problemas con números faltantes en restas con números menores a 100 (sin dificultades en cada casilla)	1	1	90 %	90 %	3	0	ca. 3 min
Primaria 5° - Operaciones	1 - 1 - 1	Sumar números naturales (sin llegar a 10 en cada casilla numérica)	1	1	95 %	95 %	3	0	ca. 2 min

Fig 5. PAM weekly report

The *General report* presents annual statistics disaggregated by groups, content, learning objectives and chapters for each student, where it is possible to visualize the different percentages in each area. An example of a general report is shown in the following figure

Primaria 3° - Ángulos

Objetivo de aprendizaje	Capítulo	Alu31	Alu32	Alu33
Medir ángulos	1 - 1	80	100	100
Clasificar ángulos según su medida	1 - 2	50	58	83
Estimar la medida de un ángulo	1 - 4	62	50	62

Referencia

- El mejor resultado está debajo del 60%.
- El mejor resultado está sobre el 60%.
- No hay resultados aún.

Fig 6. PAM general report

The role of AI

The role of AI in this platform is focused on personalizing the student learning experience and reporting data for teachers.

Personalizing learning based on the particular needs of each student is a priority for educators, the

[11] www.ceibal.edu.uy/storage/app/media/manuales-plataformas/20170815_ManualPAM_e2.0.pdf

platform's AI enables a level of differentiation that is impossible for teachers who have to manage 30 students in each class. PAM helps educators make better decisions about how to allocate resources to students based on their needs. The platform's AI also provides real-time data to teachers about each student's performance, allowing them to spend more time with students who are struggling with specific concepts or having difficulty keeping up with the pace of the class. AI also allows teachers to deliver personalized lessons to their students using a range of customized media and content.

Evidence and results

In 2017 Plan Ceibal commissioned a results evaluation of the platform, this study was conducted by the Center for Economic Research, CINVE. The objective of the study was to identify the effect of the use of the PAM on learning gains in mathematics based on longitudinal data from a sample of elementary school students. The use of PAM for teaching mathematics was associated with significant differences in students' mean scores, relative to the control group. The results showed a positive effect of 0.20 standard deviations in the learning gains. (Perera & Aboal, 2017b).

For this study, the researchers used test data from the Third Regional Comparative and Explanatory Study (TERCE), an international assessment coordinated by UNESCO's Latin American Laboratory for Assessment of the Quality of Education (LLECE).

The researchers published another paper about this evaluation, the second version of which analyzes the effects of PAM use by gender and socioeconomic level. The results of this analysis indicate that the impact of PAM use is better at lower educational levels and that there is no statistically significant differential effect of PAM use among students by gender. This report presents evidence that the use of technology helps in this case to reduce the learning gap in mathematics between the highest and lowest levels (Perera & Aboal, 2017a).

Argentina

In terms of digital education policies, in 2000 Argentina launched the Educ.ar[12] initiative, which is still in operation today, in which the government proposed to create digital educational content and training for teachers.

In 2006, the National Education Law N°. 26.206 was enacted, establishing the objective of developing competencies for handling the new languages produced by information and communication technologies (ICTs), as well as their integration into the curricular content essential for inclusion in the information society[13].

In 2010, the Conectar igualdad program was launched at the national level, a 1:1 model for the provision of devices, and some provincial governments also had policies for the distribution of devices, such as La Rioja, San Luis and the City of Buenos Aires. In 2013, the Program.ar initiative was created to promote computer science in schools. In 2018, the Federal Education Council approved the priority learning core on digital education, programming and robotics. In 2020, the National Ministry of Education created the Juana Manso federal program.

[12] www.educ.ar

[13] www.educ.ar/sitios/educar/resources/150123/nap-de-educacion-digital-programacion-y-robotica/download

Conectar Igualdad

In 2010 Argentina approved presidential decree 459/2010, that establishes the creation of the *Conectar Igualdad* program for the incorporation of new technologies for the learning of students and teachers. The objective of the program was to provide a netbook to each student and teacher of secondary public education, by 2015 there were more than five million netbooks distributed throughout the country (Cotik & Monteverde, 2016). Some provinces or municipalities began to adhere to the One Laptop per Child Plan; they do it individually as it does not fall within the plans adopted by the national executive.

NAP (priority learning core)

All these plans did not have a curricular normative support until 2018, when the Priority Learning Cores project for Digital Education, Programming and Robotics was approved, to integrate programming and robotics into compulsory education (Gobierno de Argentina, 2019). The objective of NAP is to facilitate the integration of access and mastery of ICTs in the curricular contents essential for the inclusion of the digital society (Ministerio de Educación, Cultura, Ciencia y Tecnología. Presidencia de la Nación & Consejo Federal de Educación, 2018). The NAPs establish the conceptual bases to be promoted in kindergarten, primary and secondary education.

Educ.ar and Juana Manso

To achieve this, Educ.ar, the state-owned company of the National Ministry of Education, a benchmark for digital transformation in access to knowledge, which integrates technology inside and outside the classroom in search of inclusive and quality education, created the Juana Manso Federal Plan[14] in 2020. This plan provides technology to the educational system through connectivity programs, equipment, teacher training proposals in ICTs and a free virtual educational platform. In 2020, a total of 121,839 devices were delivered, including computers and tablets. A total of 20,454 devices were also recycled (Gobierno de Argentina, 2021).

Sadosky Foundation and Program.ar

Another relevant actor in this context is Sadosky foundation[15]. In 2013, the foundation created the Program.AR initiative to promote the inclusion of Computer Science in argentine schools. The Initiative advises governments and public agencies in the design of regulations, curricular adaptations and training paths, provides continuous and initial training in Computer Science Didactics, develops didactic materials and digital platforms for teaching CS and conducts scientific research on different aspects of CS in Schools (Program.ar, 2021). The figure 7 shows examples and the main characters used in all proposals.

[14] https://juanamanso.edu.ar
[15] www.fundacionsadosky.org.ar

Fig. 7. Examples of Program.AR activities

Among the materials provided by the initiative are four manuals (*Ciencias de la computación para el aula*[16]), with didactic sequences and worksheets for students, designed for primary and secondary school teachers, which are free. It also offers teacher training in didactics for teaching CS together with the specific contents of the area where it is implemented, the timing of the training offered varies between 60 and 2800 hours and focuses on inquiry-based learning. For this initiative, CT is a concept that refers to the school teaching of computational sciences, being a discipline and not general competencies that require computation to be carried out. They also emphasize that not all problems can be solved by means of CT, defining a computational problem as one in which the elements are abstractions that are described by means of a computational model. Finally, they consider that computation can improve cognitive skills in search of an improvement in student's performance (Bonello & Schapachnik, 2020).

Chatbot project[17]

As briefly defined in this chapter, Argentina has 20 years of experience in educational policies linked to technology, with different infrastructure and digital content programs. Also the country began a stage of teacher training in technology and in 2018 approved a federal regulation on digital education, programming and robotics. Within this framework, a project on the development of a chatbot for high school students in the city of Cordoba has arisen.

In Argentina, around 4000 Computer Science students graduate annually, a rather small number when compared to the 10000 that graduate in Law or the 15000 in Economics and taking into account that the hiring of Computer Science graduates doubles the value of the graduates (Alonso & Molino, 2016; Observatorio Permanente de la Industria del Software y Servicios Informáticos, 2016). This situation may be due to the lack of early education in computer science. In Argentina, in particular, existing education is focused on user training and not on computer science contents that would make the student a technological creator and/or co-creator.

For this reason, the idea of the need for the inclusion of Computer Science starting in secondary and/or primary education gains strength, so that students can, on the one hand, have tools for decision

[16] https://program.ar/material-didactico/
[17] Benotti et al., 2018

making about their educational future and on the other hand, have tools to be included in this increasingly technological world. There are several initiatives that aim to motivate students to immerse themselves in Computer Science, in Argentina specifically there is an online programming contest using the Alice tool (Cooper et al., 2003).

Chatbot was developed with the aim of promoting and introducing Computer Science concepts. Unlike the other initiatives, in this one, which is part of the Dale Aceptar (DA) contest promoted by the Sadosky Foundation, animations, games or physical robots are not programmed, but chatbots are programmed. A chatbot is a bot that is programmed to hold conversations with humans and other robotic devices, using a natural language such as English, French, German or Spanish among others. The Chatbot tool includes a formative and automatic evaluation that provides automatic feedback, appropriate to the level of the task being performed. One of the objectives of this contest was to address the low female participation in these types of activities. The other objective was to increase the completion rate of projects.

In the Dale Aceptar contest participants could use Chatbot (with or without formative evaluation), Alice or both to carry out one of the contest proposals: animation, game and alibi. The majority decided to participate with the Alice tool.

Comparing product quality by gender, it was observed that both men and women obtained similar scores for character modeling, with women having greater difficulty in developing generic rules than men. Finally, making a comparison between the scores of the quality of the women's products, they obtained higher scores in the mastery of high-level computer concepts than in low-level ones.

As for the percentage of women's participation, almost twice as many women used the Chatbot (23%) compared to those who used Alice (12%). This proportion is maintained for the completion rate of the activities for all participants (women and men). From here Benotti et al. (2018) proposed to conduct two investigations. The first one aims to evaluate Chatbot in a classical classroom context to see the level of involvement of poor context students and girls with no previous interest in Computer Science. The results indicated that the attitude of the students reported by tutors and assistants was one of engagement, interest, and fun. The second research evaluated Chatbot with an online course that included the use of Alice and in a pilot course of 15 face-to-face classes in two high schools. In both courses, girls' engagement was higher when using Chatbot. In the online course, the completion rate was five times higher with the use of Chatbot compared to Alice.

Evidence and results

Nearly 9600 students participated in the *Dale Aceptar* 2013 edition, with ages between 11 and 20 years, and almost 1500 used Chatbot. Also a pilot study was conducted in three public schools in Cordoba Argentina, using Chatbot with and without automatic feedback for 15 sessions. The results showed that girls who performed the activities with automatic feedback showed more interest than boys in the tasks performed without it. Similarly, it was found that the tasks performed with feedback were significantly easier than without.

Lessons learned

Comparing gender, it was observed that on most engagement indicators (participation, task completion, interest, willingness to learn more, and self-report interest) girls had higher levels of engagement than boys. Chatbot had 5 times higher homework completion rate than Alice in the Online modality.

The more interest and willingness to learn observed in the classroom could be due to good lesson design and highly motivated tutors in charge of the lessons. The observed differences in motivation between girls and boys cannot be attributed to good teaching. Qualitatively, it was shown that the students were having fun.

Finally, if the engagement towards Chatbot could be attributed to it being an "incomplete" tool, one could envision a strategy for girls that starts with using a more structured but "incomplete" tool and, once they are in a state of "wanting to learn more" move them to more powerful and less structured platforms.

Brazil

In the study of the Computational Thinking section of Brazil, the Brazilian Computer Society[18] (SBC) and the Center of Innovation for Brazilian Education[19] (CIEB) appear as promoters of Computational Thinking inclusion in Brazilian education.

From 2017 to 2019 the SBC with a commission appointed by the Education Council worked on the development of a document intended to be a formative framework in Computing for Basic Education. They establish the competencies and skills that make up Computing in Basic Education, from early childhood education to high school. As can be seen in Figure 8, these competencies and skills are separated into three axes: 1. Computational Thinking, 2. Digital World, and 3. Digital Culture.

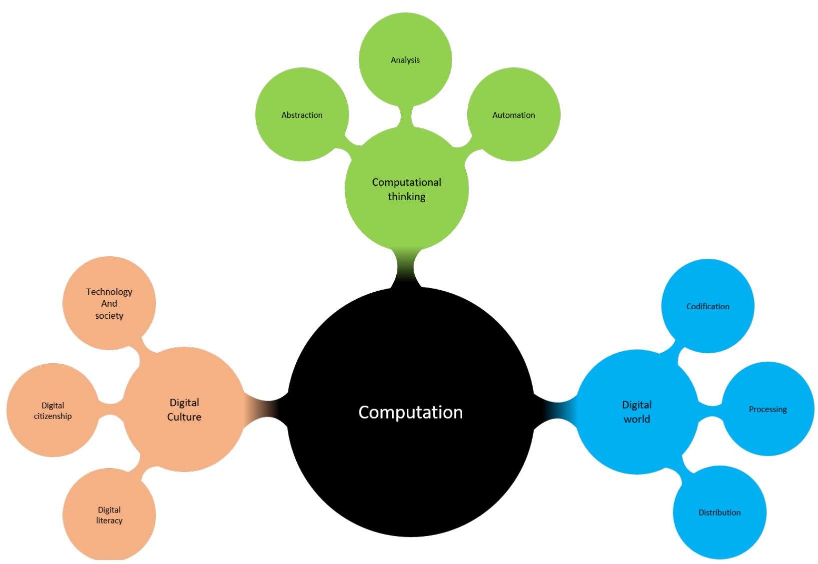

Fig 8. SBC computation competencies and skills

On the other hand, the CIEB, a non-profit organization created in 2016, supports public education networks by providing support to formulate public policies, develop concepts, prototype tools and articulation of agents specific to the Brazilian basic education system, Early Childhood and Primary education. This support seeks to achieve a systematic transformation in the learning processes, seeking greater educational quality through the effective use of digital technologies. The organization is convinced that technology can generate quality, equity and contemporaneity in education (Raabe et al., 2018). To include computational science in the educational system, CIEB generated a reference curriculum for basic education. This is organized in three axes: 1. Digital culture, 2. computational thinking, and 3. digital technology. These axes are subdivided into concepts, through which the

[18] www.sbc.org.br
[19] https://cieb.net.br

development of one or more competencies is proposed (see Figure 9). It is also a practical guide that proposes pedagogical practices, evaluations and materials that can be used in daily activities.

Fig 9. CIEB outline reference curriculum

The benchmark curriculum was developed taking into account the level of development that children should have acquired according to the National Common Core Curriculum. In order to use the reference curriculum, the teacher must be familiar with the use of digital information and ICTs.

In this line, there are several researches on computational thinking and programming in the K-12 framework for Brazil. Most of the research focuses on describing personal experiences, focusing on what and how the implementation of educational practices has been carried out (Santos et al., 2018). Some experiences involve the development of applications, games and free educational robotics (see Table 1), where they conclude that the concepts worked on go beyond the area of computer science, because they are transversal concepts used in an increasingly technological social context. They also think that through these activities it is easier to capture the attention of children, even those children who would not have enrolled in a classic programming class (Da Silva et al., 2020).

These authors believe it necessary to create a center for popularization of computational thinking and education (N2PCE) under the TPACK framework (see figure 10) (Mishra & Koehler, 2006). This framework articulates content, pedagogical practices and technology to provide a training process that integrates the educational current needs. Thus, the student converts in the centre of the process teaching-learning, generating a significant learning that starts from reflexive instances, where it is work important aspects such as critical thinking and reasoning (Jonassen, 2000), thus providing the student of tools to know how to learn, among other skills.

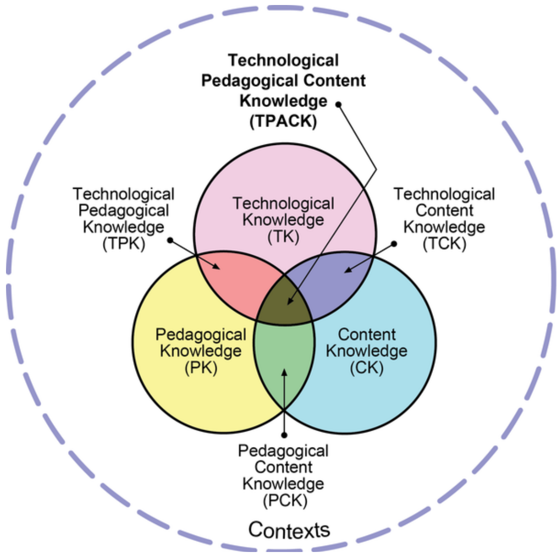

Fig 10.

There are also several researches that focus on exploring methodologies and tools for teaching computational thinking among which we can highlight: the collective game, the Methodology for Teaching Computational Thinking for Children (MEPeCoC, for Spanish acronym), digital literacy course, etc.

The collective game can be considered a useful tool for teaching Computational Thinking, as the game has a positive impact on motivation, on the teaching-learning process and on the acquisition of Computational Thinking skills and concepts (Gresse von Wangenheim et al., 2019). The authors propose collaborative board games, due to the low cost of their creation, lasting less than 15 minutes. The game works on the basic concepts of algorithms and programming, such as: Decomposing the steps needed to solve a problem in a precise sequence of instructions. and recognizing that an algorithm is a set of step-by-step instructions to complete tasks. The results show that the collective game is a good tool to teach/learn the basic concepts of Computational Thinking.

The MEPeCoC methodology aims to introduce computational thinking through the teaching of programming, it has three types of activities: connected, disconnected and project development activities (Berto et al., 2019). In the connected activities, programming is used as a tool, since it allows the representation of a solution for a given situation and/or problem in algorithmic language. Disconnected activities are carried out without the aid of computers; resources such as paper, pencil, blackboard, etc. are used to present the reasoning used to arrive at the solution to the problem. Disconnected activities favor the teaching of Computational Thinking concepts, being a good formative evaluation tool (Zaina et al., 2004). This methodology includes the process of developing a project that requires group work, the division into parts of the problem, the division of tasks, this development requires a greater temporization than the other two activities, this will be the way to consolidate the knowledge acquired in the connected and unconnected activities, (Berto et al., 2019). The development of the project will also serve as a cohesion tool between the concepts learned separately in the two previous activities and will also stimulate curiosity and creativity, motivating them through collaborative work.

Finally, the use of the MEPeCoC methodology in the classroom helps to introduce computer science concepts gradually, allowing a higher level of understanding of the concepts by the students, even when they do not have previous knowledge.

Digital literacy consists of giving tools to access internet content in a critical way, being able to analyze, evaluate and produce them. For which it is necessary to train in digital technology, digital culture and computational thinking (Ministério da Educação, 2018). Using digital literacy courses (16 hours, divided into 8 classes) and conducting an experiment with two groups, one as a control group, it was found that children who had digital literacy classes obtained a significant improvement in STEM skills, computational thinking skills, familiarization with the digital environment and the ability to perform logical activities autonomously, even for students with no access to technologies. These significant differences were not found in the control group (dos Santos et al., 2016).

All these experiences seek to foster the acquisition of the necessary skills for the inclusion of children in an increasingly technological world and emphasize the need to invest in technology within the educational system, since in this way the existing digital divide between different socioeconomic levels will be reduced by giving universal access to technology and working on the concepts necessary to function in an increasingly technological world.
Brazil is a country that is almost a continent and its educational system is complex. In the context described where many more actors are involved, a very interesting proposal has emerged to work on machine learning in high school students produced by a university group.

Machine Learning para Todos (Machine learning for all)

Some countries have included some elements of artificial intelligence in K-12 programs. However, it must be considered that most of the resources are available in English and contextualized or customized for the northern countries. Hence the relevance of this experience: a Machine Learning course in Portuguese, developed by a University of Santa Catarina group aimed at teachers and middle school students, as a part of Computação na escola[20] program (Gresse von Wangenheim et al., 2020).

They developed an introductory course to teach basic machine learning concepts, considering fundamentals of neural networks, limitations and ethical concerns, lined with the K-12 Guidelines for AI (Touretzky et al., 2019). Their goal is that students understand machine learning potential and limits, and from that to empower them becoming creators of intelligent solutions.

It is an interactive course, available online in Brazilian Portuguese[21], and the authors say that it can be used as an extracurricular course or even as an interdisciplinary project as part of science classes. It can also be applied in a face-to-face mode.

The course was designed for middle school students without any prior experience on Machine Learning, but they do have some basic knowledge related to algorithms and programming.

The distance course intersperses presentations, guides, tutorials with quizzes and other assessment instruments in a simplified way as part of interactive presentations. All teaching materials are available to be reused for non-commercial purposes

The course is organized and address the next topics: General notions and relevance of ML is about ML application in everyday life; Fundamental concepts introduce core concepts and ideas such as neural network learning and data management; Make your first ML model proposes to build an ML model with Google Teachable Machine[22], and the students have to prepare the images dataset, train the model, analyze performance in order to adjust the dataset and improve the model's performance. Additional

[20] https://cursos.computacaonaescola.ufsc.br/
[21] http://cursos.computacaonaescola.ufsc.br/cursos/curso-mlparatodos/
[22] https://teachablemachine.withgoogle.com/

activity can be added to make an app, using App Inventor[23]; Content review and ML process refers to the review of the main phases of the ML process; Lastly, Ethical issues and societal impact of ML includes a discussion and reflection to these topics.

The role of AI

In this case, the focus is on approaching the subject of Artificial Intelligence in a practical and conceptual way. The use of the Google Teachable Machine makes it possible to easily exemplify, train a model with data selected by the students and discuss the ML programming process.

Evidence and results

According to the authors, nearly 150 students have already completed the online course. The majority of the students indicated that they found the course easy and fun. Also commented at the end that they understood what Machine Learning is and the majority indicated that they think that they are now able to develop a ML model for image classification, yet recognizing that developing a ML model may not be easy.

Due to covid-19 they have postponed a large application of the course as part of school classes on the secondary educational stage (middle and high school) in school and federal institutes of technology in Santa Catarina/Brazil.

Large scale implementation possibilities

Like other experiences, in the case of Brazil this type of online-proposal opens up the possibility of reaching the entire extensive territory of the country, to the extent that local actors get involved.

One of the ideas that drives proposals such as the one described is the lack of qualified teachers in computing education in the region. In the Brazilian case computer labs are generally coordinated by an educational technology teacher (with background in pedagogy and some studies in the technological field) (Gresse von Wangenheim et al., 2021). This type of course can leverage the work of these teachers, by providing tools for work in the classroom.

Recommendations and final conclusions

In the three countries analyzed, the presence of a digital ecosystem stands out, with its different particularities. We have found that these countries are developing device delivery programs, digital education curriculum, teacher training in technologies, school regulations regarding programming and robotics education and specific programs for teaching Computational Thinking and Computer Science in classrooms.

In the three countries we found incipient proposals in artificial intelligence for educational systems, we can theorize that the work in digital education generates the necessary conditions for the incorporation of AI in educational projects. To learn with AI, learn about AI and prepare for AI, teachers must play and have a central role. The process by which both tools and platforms are incorporated and used and the way these topics are integrated into the curriculum depend to a large extent on the empowerment of teachers, and therefore the real impact of AI in education. Working on computational thinking, computer science, robotics and programming has a transitional effect towards the incorporation of AI, that it is the next stage in the development of these competencies, and it can serve as a milestone to follow this path.

[23] https://appinventor.mit.edu/

We observed specific pedagogical proposals for students to work on artificial intelligence concepts in the classroom (physical, virtual or hybrid), but we also observed an experience of using a platform that uses artificial intelligence to personalize teaching and to analyze student data.

Hybrid education combines and integrates face-to-face and distance learning methods. (UNESCO;2021) the power of AI can provide a learning context in which both students and teachers can optimize the learning experience. In a hybrid model, face-to-face and online components are combined to provide a learning experience that differs from a traditional classroom environment or a purely online or distance learning environment. Hybrid courses typically offer a combination of synchronous and asynchronous communication opportunities. This means that the course will include scheduled assignments that are presented online as well as asynchronous assignments that are completed at other times. The use of AI has a lot of potential for this model. Hybrid education is a key element of 21st century education.

The development of artificial intelligence in education can have a great impact on the teaching,learning and evaluation process. AI can help to solve some problems that have been difficult to solve with traditional methods (e.g. take attendance, complete and analyze spreadsheets, personalized messages for students, among others). The use of AI in education can be a way to reach these goals:

• To improve and personalize the learning process and the knowledge of the student, increasing learning motivation and increasing learning efficiency.

•AI can provide teachers with benefits in terms of time, for example, by providing students with more individualized feedback.

•AI applications can help diagnose and detect the problems that students face and offer them solutions.

• To provide students with technical and conceptual elements to understand and reflect on the changes that Artificial Intelligence will bring in the near future.

• To exercise digital citizenship in the 21st century

• To help reduce the gender and socioeconomic gaps in IT career choices

The development of artificial intelligence in education requires education providers to have the ability to leverage the benefits that AI can offer. This includes being able to scale the technology to make it available to more students, and develop a scalable solution. This will allow educators to use the technology in a streamlined way. To do this, it is necessary to use research, development and innovation programs in AI for education to promote the development of this skill in education and create a culture of AI use in education systems, as well as develop the necessary infrastructure for the use of AI. The development of AI in education is a challenge for universities, research centers, ministries and companies working in this field. This infrastructure and development must be available at different levels of the education system, from the basic education level to the higher education level. This infrastructure and development should be available at different levels of the education system, from the basic education level to the higher education level.

The introduction of educational proposals that integrate artificial intelligence into school curricula must be accompanied by a process of work along the lines of Computational Thinking and Computer Science in the classroom, it must be part of this digital ecosystem. This process should start from the earliest years with unplugged activities up to the last years of secondary education with more specific and technical contents. These skills can be worked as a specific subject or in an interdisciplinary way with other areas of knowledge. Algorithms and artificial intelligence already interact with us on a daily basis, at the dawn of the 4th industrial revolution, a literacy in this subject is necessary to understand the world around us. Artificial Intelligence is not the solution to all problems but it is a tool that will support teachers and students in educational systems

Artificial Intelligence is not the solution to all educational and social problems, but it is a tool that can support teachers and students in educational systems, and also can empower them to take more active and engaging roles.

Available resources
In this section we reference different resources (tools, curriculum, training, etc.) that can be used to teach or exemplify elements of artificial intelligence

A. Teachable Machine (Google). Teachable Machine is a Web-based tool that makes it possible to create machine learning models in a fast, simple and accessible way for everyone.

B. Dancing with AI (MIT Media Lab). Dancing with AI is a week-long workshop curriculum in which students conceptualize, design, build, and reflect on interactive physical-movement-based multimedia experiences.

C. Learning ML (Universidad Rey Juan Carlos, Madrid, España). LearningML is an educational platform for learning content on Artificial Intelligence and fostering Computational Thinking.

D. Machine Learning for Kids (Dale Lane using IBM Watson Developer Cloud APIs.). This tool provides an introduction to machine learning through hands-on experiences to train machine learning systems and build things with them.

E. Cognimates (started at MIT Media Lab). An AI education platform for building games, programming robots & training AI models.

F. Scratch Lab Face Sensing (MIT). Face Sensing blocks as a new experimental extension. With these blocks, you can create projects that respond to your eyes, nose, and other parts of your face.

G. MIT App Inventor (Google & MIT Media Lab). App Inventor is an intuitive, visual programming environment that allows everyone – even children – to build fully functional apps for Android and iOS smartphones and tablets.

H. Ecraft2learn (University of Oxford). Extensions to the Snap! programming language to enable children (and non-expert programmers) to build AI programs.

I. CS Unplugged (University of Canterbury, Google & Microsoft). Is a collection of free teaching material that teaches Computer Science through engaging games and puzzles that use cards, string, crayons and lots of running around

J. Digital technologies hub (Education services Australia). Resources to help teachers, students and families to learn about Digital Technologies

K. Ceibal PC. Plan Ceibal's computational thinking website

L. Program.AR (Sadosky) Consulting, training and free educational material

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