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Computational thinking with Scratch or App Inventor in primary education

Pensamiento computacional con Scratch o App Inventor en la educación primaria

María Carmen Martínez-Murciano[1], David Pérez-Jorge[1]

[1] Universidad de la Laguna, España

mcarmen730@hotmail.com , dpjorge@ull.edu.es

ABSTRACT. Computational thinking (CT) is increasingly encouraged in subjects such as technology and digitalisation, and robotics. The effect on the development of generic competencies is of interest. This study investigates the use and effect of Scratch and App Inventor on the development of skills and competencies associated with CP (self-efficacy, motivation, creativity, collaborative work, algorithmic thinking, communication and social interaction) in primary education. A systematic review of articles in English and Spanish was conducted using the PRISMA statement, in the Web of Science (WOS), Dialnet and SCOPUS databases, obtaining 425 papers, from which 10 were finally selected. The results showed that both Scratch and App Inventor favour the development of skills and competencies for learning in the context of primary education and that these are underused strategies that should be promoted from the first years of compulsory education.

RESUMEN. El pensamiento computacional (PC) se fomenta cada vez más, en asignaturas como tecnología y digitalización, y robótica, interesa el efecto sobre el desarrollo de competencias genéricas. Este estudio indaga sobre el uso y efecto de Scratch y App Inventor en el desarrollo de habilidades y competencias asociadas al PC (autoeficacia, motivación, creatividad, trabajo colaborativo, pensamiento algorítmico, comunicación e interacción social) en educación primaria. Se realizó una revisión sistemática de artículos en inglés y español utilizando la declaración PRISMA, en las bases de datos de Web of Science (WOS), Dialnet y SCOPUS, obteniendo 425 trabajos, de los que finalmente se seleccionaron 10. Los resultados mostraron que tanto Scratch como App Inventor favorecen el desarrollo de habilidades y competencias para el aprendizaje en el contexto de la educación primaria y que éstas son estrategias infrautilizadas que se deberían promover desde los primeros cursos de la educación obligatoria.

KEYWORDS: App Inventor, Scratch, Primary education, Motivation, Computational thinking.

PALABRAS CLAVE: App Inventor, Scratch, Educación primaria, Motivación, Pensamiento computacional.

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1. Introduction

It is no longer possible to continue teaching in the same way as in the 20th century. The evolution of learning tools and strategies and the new models of learning in relation to information processing require the development of new competencies focused on challenges and opportunities derived from challenges that allow students to solve real problems, facing them from a flexible model of thinking and promoting the development of creativity. This is a real challenge for the current education system, which has to rethink the curricular and methodological model for the inclusion, promotion and development of alternative competencies such as computational thinking (CT).

It is important to find motivating elements that awake students' interest in learning and make them come to school with enthusiasm (Pérez-Jorge, 2010). It is time to think that it is not always necessary to study in a physical place with a rigid and pre-established timetable. It is about seeing the possibilities of online learning as an opportunity for lifelong learning with a view to promoting alternative teaching models that allow the development of competencies and thinking skills.

The educational robotics content, introduced into the educational curriculum with the LOMLOE included in the subject "Technology and Digitalisation". This part of robotics offers content and develops competencies that allow students to design and build functional robots from basic levels. They are taught to program and use programming language (PL) from a very early age using simple language software based on visuals, algorithms and cloud platforms that facilitate learning. The need to use new technologies has become a permanent feature of educational centres, as they are a tool for innovation (Pérez-Jorge, et al., 2018), although it must be understood that, in itself, their use does not imply any innovation (Castro et al., 2018). This requires qualified and competent teachers for the development of educational innovations that have a significant impact on student learning.

This is the way in which Aparici (2011) indicated that beyond digital technology, the principles of pedagogy and educommunication, based on participation, self-management and dialogical communication, have survived to technological changes in recent years. Digital technologies without a clear educational purpose can have counterproductive effects. Failure to take up this challenge would continue to reproduce a model of little technological renewal. In this sense, teachers should broaden their knowledge of programming, software and hardware, which is necessary to encourage students to develop CT skills, a competence that appears in the 21st century, Wing (2006), which uses the basic concepts of computer science to solve problems, design systems and understand human behaviour.

Through this competence, the ability to use language, symbols and text interactively is developed, oral and written language skills, communication and mathematical skills are improved. The implications of achieving this competence are fundamental for students , individual and social development and future professional performance. In this sense, it highlights the importance of CT development and specifies the need to develop skills related to algorithms, modularity, control structures, representation, hardware/software, design process and debugging.

This requires specialised training for teachers Sevillano (2011) to enable them to master hardware and software, to know how to search, select, analyse, understand and manage the large amount of information that is produced nowadays, in order to know how to make a good selection of resources and materials. Developing a critical attitude helps people to distinguish between true and reliable sources and information, helps to develop a permanent attitude of questioning and analysis that favours adopting a more objective stance in the face of technological advances and innovation. It is necessary to innovate in order to achieve the development of creative and computational thinking in students and requires teachers to be able to adapt and make appropriate use of information and communication technologies (ICT) that also facilitate and promote inclusion, especially for disabled people (Martínez-Murciano & Pérez-Jorge, 2023).

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This study delves into the analysis of the progress and educational application of Scratch and App Inventor within Primary Education (PE). By examining the innovative experiences implemented in several PE schools, this research aims to evaluate the effectiveness of these tools in improving a wide range of skills and competencies. These include CT, self-Efficacy, motivation, creativity, collaborative work, algorithmic Thinking, communication, social skills, reflective thinking, problem Solving, concentration and mathematical competence. This effort aligns with the overall objective of investigating the use and impact of Scratch and App Inventor on the development of these specific skills and competencies in physical education.

Integral to this objective is the exploration of how these Visual Programming Languages (VPLs) are applied across various subjects within PE. The study's specific goals, derived from this broader aim, include:

1. Identifying the types of thinking and skills—particularly CT, self-efficacy, motivation, creativity, collaborative work, algorithmic thinking, communication, and Social Skills—developed through the use of Scratch and App Inventor by PE students.
2. Assessing the level of interest that the application of computer programming via Scratch and App Inventor generates in the research field.
3. Comparing the results obtained using Scratch and App Inventor, focusing on the mastery of programming skills and the development of Computational Thinking.

Through this integrated approach, not only does the study examine the current state of Scratch and App Inventor in PE, but it also aligns its analysis with specific, actionable objectives aimed at understanding and enhancing the educational experience in primary education.

2. Literature review

2.1. CT in the classroom

Computer programming was stopped being taught some years ago, but studies and evidence in recent years on its benefits for student learning have led to it being revived and it has now been introduced in different subjects. In 1967 an LP designed for teaching purposes called Logo was created, and in the late 1980s and early 1990s it was taught in many schools. With the emergence of simpler operating systems such as Windows and MacOS, this type of knowledge was no longer taught.

Almost all educational institutions incorporated computers when ICT arrived in schools, then netbooks, tablets and smartphones appeared; they were used for consultation and rarely for learning to program. Programming was an absent skill in the vast majority of curricular designs in Spain. Fortunately, it has gradually been realised that the use given so far was limited in terms of the real potential offered by the incorporation of ICT resources in schools Franchescin (2017) and the importance of incorporating practical programming skills has been highlighted. The CT can be used more broadly, to teach reasoning and work on other types of learning situations and in all areas of knowledge (Iglesias & Bordignon, 2019).

CT is the sum of other forms of thinking, it is a complex form of thinking in which mathematical thinking, algorithmic thinking and critical thinking are involved Rico et al. (2018).

Algorithmic thinking is a competence that is included in CT, it is used to solve a similar type of problems, in a periodic way whereby they are analysed, and the general solution is sought (Aparici et al., 2018). A study conducted in 2018 in the classrooms of the University Hospital of the Canary Islands (Tenerife) showed the benefits of using this thinking in hospitalised and long-term hospitalised children. The study concluded that the students are able to understand both the hardware and software of the Bot (robots), they learned to think and execute algorithms with the programming blocks. The students were able to program modularly and to make corrections to their mistakes.

2.2. Conseptualisation of Scratch

In the search for improvement in education, Resnick (2003) developed a creative workshop in order to promote a change in the learning process of students. To do so, he created the Scratch project with the intention of achieving, through this free software tool, that children learn to design, create interactive stories and animations, express themselves and use their creativity through technology and learning programming Salamanca and Badilla (2018).

Scratch is the most widely used visual programming language (VPL) in the classroom, and this is due to the fact that it can be used from infancy to postgraduate level. The stages in which it has been mostly used as a tool for learning are university and secondary education (Tejera-Martínez et al., 2020). Scratch is also a programming community that promotes CT and conflict resolution skills, creative teaching and learning, self-expression and collaborative work, and equality in computing. It was designed to enable children to learn through creation and exploration.

Scratch was originally designed for children between the ages of 8 and 16 but is now used at any age. Students are learning with Scratch at all levels of education and across different disciplines such as art, computer science, language, mathematics, social sciences, etc. Scratch (2022). This VPL is used in 200 countries and in 70 languages.

Most of the competencies described in Bers (2020) on the CT are developed by creating a project in ScratchJr. This language is based on programming blocks comprising concepts ranging from the basic sequencing of movement to control structures. Students can use Scratch to code and perform other types of activities such as creating and modifying characters in the paint editor, recording sounds and their own voice, and inserting photos of themselves that they take in the paint editor using the camera option. They can incorporate these multimedia elements into their projects and learn in a theoretical and practical way.

2.3. Conceptualisation of App Inventor

App Inventor, which is a programming environment created in 2010, uses blocks for programming and is used by students from 4 years old to higher education. It is used to create mobile applications, to support assignments and games. According to Mikolajczyk (2018) Massachusetts Institute of Technology (MIT) markers create mobile applications for automatic process measurement, system control and robot control. It allows in a visual and intuitive way to create functional applications for Android mobile phones, iPhones and Android tablets/IOS Massachusetts Institute of Technology (2022).

Children stimulate intelligence and creativity by inventing applications with their mobile phones, as in the case of Texas students who created an application that helped their visually impaired classmate, Huertas (2022), navigate and move through the school's hallways. Hello Navi, which is the name of the app they developed, contains different digital resources such as a compass, Voice-Over, optical braille readers, scanners and indoor navigation technology that help visually impaired students find their way around the school and other spaces.

3. Methodology

The programmes that promote CT in schools tend to focus on different areas, therefore, we looked for studies that address specific areas of Scratch and App Inventor and not only those that talk about CT in a generic way. Furthermore, the studies considered were estimated for the case of students and teachers, not considering those focused on other members of the educational community (principals, families...). The studies on these programmes had to provide benefits and/or limitations of their implementation in relation to the development of competencies related to CT. Therefore, at the beginning of this study, criteria were established for the inclusion and exclusion of documents in order to carry out an adequate selection of sources, see table 1.

Inclusion criteria	Exclusion criteria
• Studies in English and Spanish	• Studies in languages other than English and Spanish
• Papers written within the last 5 years	• Documents older than 5 years
• Papers focused on PE	• Documents from other educational stages.
• Research papers	• Reflective articles or reviews and summaries
• Studies sobre App Inventor y/o Scratch	• Articles that do not base their results on App Inventor and/or Scratch.
• Open Access articles	

Table 1. Inclusion and exclusion criteria considered. Source: Self-made.

3.1. Type of study

The methodology used in this study was of a mixed and interpretative nature, through a systematic review of the scientific literature on the research topic, following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement. Databases and articles on the scientific production developed in relation to the educational use of computational LP used in Scratch and App Inventor were analysed, focusing the interest of the study on the analysis of the competencies and skills developed.

The previous existence of studies on the subject justifies the time review that has been estimated in this work Olarte-Mejía and Ríos-Osorio (2015), through this study we intend to show in a synthetic way the new findings on the research topic.

The PRISMA statement is in itself a guide to the conceptual and methodological aspects considered during the development of systematic review studies Paramo (2020) It is a type of study that consists of accessing the scientific literature on a topic with the aim of constructing valid and objective conclusions that speak to the evidence on the topic (Urrutia and Bonfill, 2010 and Sanchez-Meca, 2010). It should be noted that this is not only a study that provides knowledge on the proposed topic, but also aims to be the starting point for future lines of research arising from reflection on the state of research in this field. Specifically, in this case, on how Scratch and App Inventor are applied in schools and their effects on the development of CT-related competencies in primary school pupils. The Prisma 2020, Page (2021) statement has been updated to utilise the benefits of the latest technological innovations such as harnessing natural language processing and using evolved terminology. The research question, which will guide the research process, is specifically: do studies on the use of VPL Scratch and the Inventor App show effects on the development of general and specific CT competencies of PE students?.

3.2. Review

To guarantee the rigour and the appropriateness of the topics, an initial process was carried out to identify the keywords most commonly used in the studies that address this line of work, analysing their relevance and appropriateness to the objective of our study. This process is specified in point 4.4 as it is considered useful for guiding future research work in this field. At the beginning, the search strategy was very general and showed too many documents that did not represent or fit the objective of this study.

Boolean OR and AND were used, specifically the combinations used for the search were: Scratch OR App Inventor AND Education. Specifically, the first terms were searched for, and the different Boolean markers were combined; the initial search was carried out for all educational stages. The final stage of interest was considered to be PE, mainly because it is the stage in which most studies on the subject had been carried out. The combination for the final search was: (Scratch OR "App Inventor") AND ("Primary Education" OR "Elementary School"). For the search in Spanish, we also used the same topics.

3.3. Resources

The resources used for the information search strategy during the study were three electronic databases from the search engine of the library of the National University of Distance Education and the University of La Laguna, from which documents from the Web of Science (WOS), Scopus and Dialnet were accessed. These databases were considered to be the main ones hosting research in the field of education.

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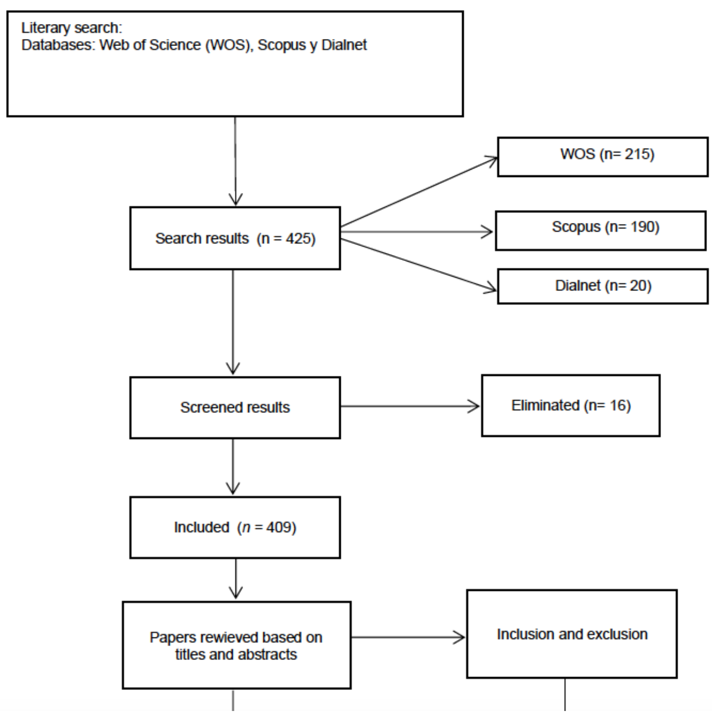
3.4. Process

The exhaustive search was started using the key words, after which the inclusion criteria were applied, eliminating those documents that did not meet them. Using the bibliographic manager Mendeley, duplicate documents were eliminated, after which the titles and abstracts of all the documents were read, selecting the papers that met the analysis criteria. From the selected texts, a complete reading was carried out and the final decision was taken on the selection or rejection of documents.

The information extracted was obtained through content analysis of the ten studies based on previously established criteria relevant to this study. The analysis refers to case studies described in research that has been carried out on the main features and formative effects of Scratch and App Inventor in PE classrooms. The starting selection of papers was as follows:

- 190 papers were found in Scopus for the combination (Scratch OR "App Inventor") AND ("Primary Education "OR "Elementary School").
- In Dialnet, 20 papers were found for (Scratch OR "App Inventor") AND ("Primary Education "OR "Elementary School").
- WOS found 215 results for (Scratch OR "App Inventor" AND "Primary Education "OR "Elementary School").

A total of 425 results were obtained. Inclusion and exclusion criteria were applied based on title and abstract and 366 articles were obtained that were either not Open Access or had been written prior to 2018 or in a language other than English or Spanish or were not published in scientific journals. Following this, duplicates were removed and a total of 16 were excluded. The remaining 43 full texts were read, and 33 papers were discarded: 8 papers that did not include primary school students. 2 papers that covered other educational stages, 3 papers focused on CT assessment (two of them were reviews), 3 papers focused on gamification (game creation or fairy tales), 7 papers referred to programme components or design, 10 articles dealing with other topics, kidney, food, farm, city officials, musical instrument, 19th and 20th century education, avoiding accidents in the elderly and swimming, 10 documents were chosen as suitable for the purpose of the study. This allowed the selection of 10 documents. The most detailed is shown (Figure 1):



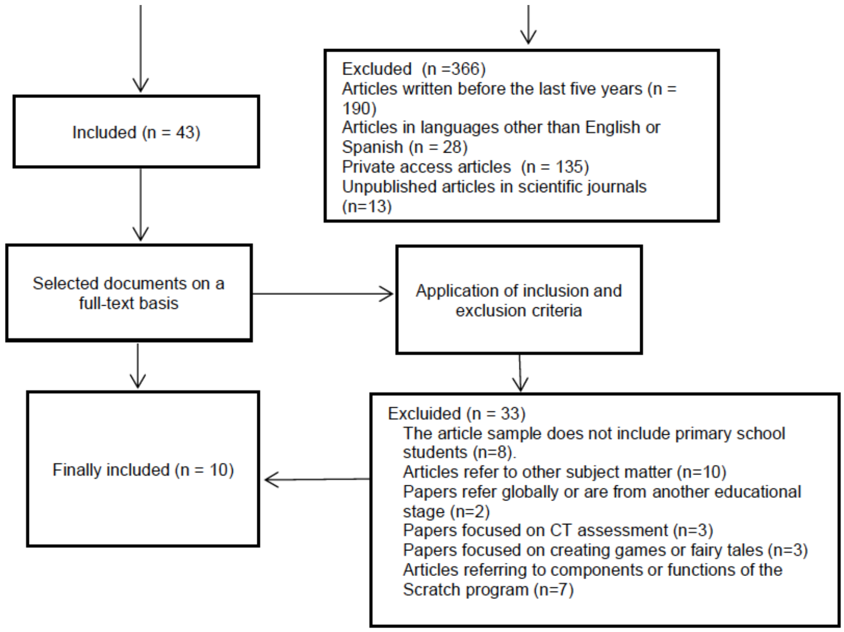


Figure 1. Document search flowchart. Source: Self-made.

4. Results

4.1. Characteristics of the studies included

The ten articles selected for the review were research studies published in English (7) and Spanish (3) between 2018 and 2022, which ensured up-to-date results on the use of the application of Scratch and App inventor software in PE. The studies were mainly conducted in European countries (Spain, Greece, England and Turkey) and also in Colombia, Korea and Ecuador.

Four studies used quantitative methodology (40%; N= 3), three used qualitative methodology (30% N= 3) and three were mixed studies (30 %; N = 3).

Some assessment instruments overlapped across the studies, with 7 being used in the 10 selected articles. These were questionnaires (40%; N=4), individual or paired interviews (40%; N=4), observation (10%; N=1), objective tests (30%; N=3), surveys (10%; N=1), learning guides (20%; N=2) and scales (10%, N=1) (Figure 2).

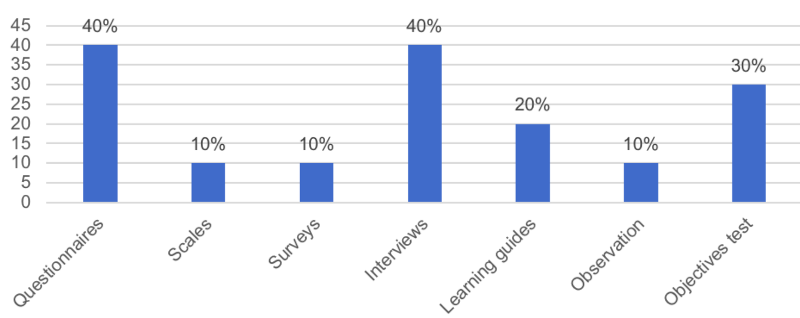


Figure 2. Instruments in selected studies. Source: Self-made.

As can be seen in Figure 2, the most frequently used instruments were questionnaires and interviews. The least used were scales, surveys and observation. In all studies, the samples selected were school students. Only one study also included teachers. In terms of results, it should be noted that most of the programmes met their stated objectives, only one failed to demonstrate any effect on improving motivation and self-efficacy.

Furthermore, all the studies focused on the PE stage. One focused on the 3rd grade of PE, one on the 4th grade of PE, three on the 5th grade of PE, two on the 6th grade of PE, three on both grades (5th and 6th). As can be seen from the distribution by educational stage, these studies mainly focused on the 5th and 6th grades. Nine studies used the Scratch language and one used App Inventor. All information can be found in Table 2, which also lists authorship, year of publication, purpose, sample, country, methodology with evaluation instrument and main results.

Authors and Year	Objectives	Sample	Country	Method	Results
Moreno-León et al. (2021)	Using Scratch in a mathematics programme to evaluate mathematical competence	3795 pupils in 5th grade of PE	Spain	Quantitative methodology with a battery of questions Becoma On.	Using ScratchMaths for learning mathematics develops students' mathematical competence and CT.
García-Perales & Palomares-Ruiz (2020).	Using Scratch in a mathematical project to assess the importance of learning to program	3795 pupils in 5th grade of PE	Spain	Quantitative methodology with a battery of assessment of mathematical competencies Becoma On. Google Docs. 30-item questionnaires.	It demonstrates the effectiveness of the Scratch programme in Programming for Mathematics and a slight increase in motivation to study the subject.
Ntourou et al. (2021)	To discover the effect of Scratch for Arduino (S4A), on self-efficacy and motivation towards the PC and students' views on electrical concepts.	33 pupils in 5th grade of PE	Greece	Quasi-experimental, mixed quantitative and qualitative method. With a questionnaire of closed questions and open-ended interviews.	Scratch helps in the learning of electrical concepts, visual programming helped in the acquisition of PC skills and collaborative work. It does not demonstrate the influence of motivation and self-efficacy.
Durango-Warnes & Ravelo-Méndez (2020)	To achieve through the use of Scratch in the Mathematics classroom to enhance meaningful learning.	30 pupils in 3rd of PE	Colombia	Research methodology	The use of Scratch in Mathematics was shown to stimulate creative and logical-mathematical thinking. The children were motivated to learn and to work collaboratively.
Ocaña et al. (2020)	To demonstrate that students with prior knowledge of Scratch will be able to improve their results if they use a friendly learning partner using p-code such as Alcody.	137 pupils in 5th and 6th year of PE	Ecuador	Qualitative with descriptive approach.	Motivated pupils, happy to program with a partner Bot that is able to solve their problems without a teacher, just with Alcody.
Benton et al. (2018)	To explore students' understanding of algorithms following their participation in a year of ScratchMaths (SM) designed to develop PC and mathematical skills	181 pupils in 6th of PE	England	Instruments: four learning guides.	There are differences between the criteria used by the pupils to evaluate the algorithms with respect to the different constructs. They need to understand and put into practice the concept of algorithms at an early age, They do so at the age of 5 in England.
Gökçe & Yenmez (2022)	To find out whether Scratch develops PC skills and reflective thinking oriented towards problem solving.	524 pupils in 5th and 6th of PE and 8 Mathematic teachers.	Turkey	Mixed methodology: quantitative and qualitative, with scales and forms.	Using Scratch in programming and mathematics in the software information technology course encourages CT and reflective thinking towards problem solving. It is advisable to train mathematic teachers in Scratch.
Puraivan et al. (2021)	To find out the relevance of introducing Bboot, App Matblook and Scratch technology in educational curricula.	16 pupils in 5th and 6th of PE	Spain	Descriptive quantitative methodology with satisfaction survey.	Technologies such as Scratch in deeply disadvantaged and
Dağyar, et al . (2020)	To reveal the students' opinions about Mobile Programming Education in Literature using App Inventor.	24 pupils in 4th of PE	Turkey	Qualitative methodology with interviews.	Disadvantaged contexts and with a high dropout rate are favoured to avoid school failure. Find motivation, CT, creative and mathematical thinking and collaborative work.
Chun et al. (2021)	To find out whether using Scratch in programming increases students' interest in programming.	16 pupils in 6th of PE	Korea	Qualitative methodology with interviews.	Educating in mobile programming with App Inventor improves students' social, scientific and creative thinking skills.

Table 2. Explanatory table of consultation documents. Source: Self-made.

4.2. Identification of study areas

The selected studies worked in different areas of PE education. The programmes mainly focused on the areas shown in Table 3 related to Scratch and/or App Inventor programmes in PE.

Authors *	1	2	3	4	5	6	7	8
Moreno-León et al.(2021)	YES	NO	NO	NO	YES	NO	NO	NO
García-Perales & Palomares-Ruiz (2020)	YES	NO	NO	NO	YES	NO	NO	NO
Ntourou et al. (2021)	YES	NO	YES	NO	NO	YES	YES	NO
Durango-Warnes & Ravelo-Méndez (2020)	NO	NO	NO	YES	YES	NO	YES	NO
Ocaña et al. (2020)	YES	NO	YES	NO	NO	NO	NO	NO
Benton et al. (2018)	YES	NO	NO	YES	YES	NO	NO	NO
Gökçe, S. & Yenmez (2022)	YES	YES	NO	NO	YES	NO	NO	NO
Puraivan et al. (2021)	YES	NO	YES	YES	YES	NO	NO	YES
Dağyar et al. (2020)	YES	NO	NO	NO	NO	NO	NO	NO
Chun et al. (2021)	YES	NO	NO	NO	NO	NO	NO	NO
Nº	9	1	3	3	6	1	2	1

Note: *1 Programing; 2 Communication and software technologies; 3 Robotic; 4 Logic; 5 Mathematics; 6 Electricity;7 Computer science 8. STEM

Table 3. Areas of study of Scratch and/or App Inventor. Source: Self-made.

The percentage of studies in our selection in which they appear were programming (90%; N= 9), mathematics (60%; N= 6), logic (30%; N= 3), robotics (30%; N= 3), computer science (20%; N= 2), communication and software technologies (10%; N= 1), electricity (10%; N= 1) and STEM (10%; N= 1). From this we can discern that programming and mathematics are the areas in which most studies were focused.

4.3. Identification of skills and competencies

The studies also seek to find out whether there is an effect of improving different competencies and skills as reflected in table 4.

Authors *	1	2	3	4	5	6	7	8	9	10	11
Moreno-León et al. (2021)	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	YES
García-Perales & Palomares-Ruiz (2020).	NO	NO	YES	NO	NO	NO	NO	NO	NO	NO	YES
Ntourou et al. (2021)	NO	YES	YES	YES	NO	NO	YES	NO	NO	NO	NO
Durango-Warnes & Ravelo-Méndez (2020)	NO	NO	YES	YES	NO	NO	YES	YES	NO	NO	NO
Ocaña et al.(2020)	NO	YES	YES	NO	NO	NO	NO	NO	NO	NO	NO
Benton et al. (2018)	NO	NO	NO	NO	NO	NO	YES	NO	NO	YES	NO
Gökçe & Yenmez (2022)	YES	NO	NO	NO	NO	YES	YES	YES	NO	NO	NO
Puraivan et al. (2021)	NO	NO	YES	YES	NO	YES	YES	YES	NO	YES	YES
Dağyar et al. (2020)	NO	YES	YES	YES	YES	NO	YES	YES	NO	NO	NO
Chun et al. (2021)	NO	NO	YES	NO	NO	NO	NO	NO	YES	NO	NO
Nº	1	3	7	4	1	2	7	4	1	2	3

Note*1 Reflective thinking; 2 Self-efficacy; 3 Motivation; Collaborative work; 5 Social skills; 6 Problem solving; 7 CT; 8 Creative thinking; 9 Concentration; 10 Algorithmic thinking; 11 Mathematics

Table 4. Skills and Competencies. Source: Self-made.

Some competencies and skills coincided in the studies, it can be seen that of the 10 articles selected, 7 found the relationship of Scratch and/or App Inventor with the improvement of motivation (70%; N= 7), in 7 with CT (70%; N= 7), in 4 with creative thinking (40%; N= 4), in 4 with collaborative work (40%; N= 4), in 3 with self-efficacy (30%; N= 3), in 3 with mathematical competence (30%; N= 3), in 2 with algorithmic thinking (20%; N= 2), in 2 with problem solving (20%; N= 2), in 1 with social skills (10%; N= 1), in 1 with reflective thinking (10%; N= 1) and in 1 with concentration (10%; N= 1).

On a general level, it is evident that studies have mainly focused on the introduction of PL with the intention of improving levels of motivation, CP, collaborative work and creative thinking.

VPL promotes CP (Moreno-León et al., 2021; Ntourou et al., 2021; Benton et al., 2018; Gökçe & Yenmez, 2022) and favours learning in the area of mathematics (Moreno-León et al., 2021; Benton et al., 2018). Similarly, evidence on learning programming with Scratch shows improvements in motivation (García-Perales & Palomares-Ruiz, 2020; Ntourou et al., 2021; Chun et al., 2021), meaningful learning Durango-Warnes and Ravelo-Méndez (2020) and collaborative work, especially in the area of mathematics García-Perales and Palomares-Ruiz (2020). Students with knowledge of Scratch improved their results by adding robotic tutoring, based on interaction through the P-Code application, in the form of an interactive avatar that automatically responded to the students' doubts and which they considered to be a friendly learning partner that motivated them (Ocaña et al., 2020).

Introducing Bboot technology (manipulable physical robot) for programming with Scratch and the use of the Matblook App in educational curricular content in PE motivates and favours collaborative work, creative thinking and CT Puraivan et al., (2021). The use of App Inventor improves the same skills and competencies in EP students Dağyar et al., (2020).

4.4. Achievements of using Scratch and App Inventor

Analysis of the programme results has confirmed that almost all of the research made sense and achieved the intended effect, see Table 5.

Authors	Effectiveness	Main difficulties
Moreno-León et al. (2021)	YES	-
García-Perales & Palomares-Ruiz (2020)	YES	-
Ntourou et al. (2021)	PARTLY	It does not demonstrate motivation and self-efficacy towards CT.
Durango-Warnes & Ravelo-Méndez (2020)	YES	-
Ocaña et al. (2020)	YES	-
Benton et al. (2018)	YES	-
Gökçe & Yenmez (2022)	YES	-
Puraivan et al. (2021)	YES	-
Dağyar et al. (2020)	YES	-
Chun et al. (2021)	YES	-

Table 5. Effectiveness of the use of Scratch and/or App Inventor in PE. Source: Self-made.

The study by Moreno-León et al. (2021) found that studying with the VPL ScrachMaths favours mathematical competence. The generalisation of CT experiences in the curriculum improves the quality of educational processes.

The study by García-Perales and Palomares-Ruiz (2020) concluded that better academic results in mathematics are obtained when using VPL Shortcomings in the didactic models used in the teaching of mathematics were evidenced, estimating the need to train teachers in the use of VPL (Scratch).

In the study by Ntourou et al., (2021) the influence of physical computing on motivation was not demonstrated and only partially achieved in self-efficacy, but it was shown that it helps in the learning of electricity concepts, the use of PV contributed to the development of CT skills. Students were engaged and developed a positive attitude towards science and collaborative work.

The study by Durango-Warnes and Ravelo-Méndez (2020) showed that the use of Scratch in mathematics stimulates creative and logical-mathematical thinking. The children's motivation to learn and willingness to work collaboratively were improved.

The study by Ocaña et al. (2020) confirmed that students were more focused on the task, engaged, motivated and happy and expressed a desire to continue learning programming. They were increasingly autonomous, solving problems with little or no prompting from the teacher. There was a significant

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improvement in students' grades along with high satisfaction. It showed that it is possible to teach with Scratch and the help of a robot like Alcody to tutor students in their progress.

The study by Benton et al., (2018) recognises the relevance of the role of algorithms in CP development.

The study by Gökçe and Yenmez (2022) found that the use of Scratch in programming and mathematics increases problem-oriented reflective thinking and CP.

The use of Scratch in groups of vulnerable students or students at risk of exclusion significantly reduces dropout rates and encourages students to stay in school Puraivan et al. (2021). Especially in the case of the study of robotics-related subjects where CT, creative thinking and collaborative work are encouraged.

The study by Dağyar et al., (2020) highlighted the positive sense of using App Inventor from PE for the benefits in the development of creative thinking and social skills.

VPL Scratch promotes concentration and fosters motivation and interest towards programming tasks Chun et al., (2021).

4.5. Limitations of the studies

The studies showed positive results in relation to the development of CP skills and competencies, however, some limitations were detected. Two studies had a small control group, two lacked a control group (in one of them the skill level was also unknown and the duration of the positive effect was not established). One study was based on only 16 hours of App Inventor training, and one study found contradictions in the data on self-efficacy.

As shown in the table below (Table 6):

Authors	Limitations	Main difficulties
Moreno-León et al. (2021)	YES	Small size of the control group
García-Perales & Palomares-Ruiz (2020)	YES	Small size of the control group
Ntourou et al. (2021)	YES	Contradictory self-efficacy data
Durango-Warnes & Ravelo-Méndez (2020)	YES	-
Ocaña et al. (2020)	YES	No control group
Benton et al. (2018)	NO	-
Gökçe & Yenmez (2022)	YES	The durability of the Scratch effect, lack of control group and skill level is not demonstrated.
Puraivan et al. (2021)	NO	-
Dağyar et al. (2020)	YES	16 hours of App training
Chun et al. (2021)	NO	The sample of only 16 participants

Table 6. Limitations of the studies. Source: Self-made.

5. Discussion

The results and advances mentioned in the introduction of this work, in relation to the topic and objective of this study, have confirmed that the majority of the research in the field of App Inventor and the VPL Scratch has been developed finding the desired competencies and skills.

The main objective of the work was to assess the effect of the use of Scratch and App Inventor on the development of CT skills and competencies of PE students. This review provides evidence that Scratch and App Inventor work for the development of specific programming skills. Although some studies are inconclusive

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regarding the benefits of using Scratch and App Inventor, most emphasise the positive effects in terms of developing specific CT skills and competencies. The studies reviewed reflected a preference for the use of VPL Scratch and/or App Inventor in PE classrooms. The number of studies conducted on Scratch has been numerous in recent years, however, on App Inventor the number has been smaller.

The dispersion of approaches and results on CT development makes this study necessary, which has focused its analysis and reflection on the lines of work and needs to be covered, from an educational point of view, in relation to the benefits of using CT in schools.

These tools and programmes should be used if CT is to be consolidated as a fundamental competence to be developed by pupils Wing (2006), especially in the case of PE pupils. The studies reviewed showed that; a) they have mostly focused on the students' mastery of competencies, few studies have assessed the mastery of VPL competencies in teachers; b) there is a lack of a clear and concise method to evaluate the effectiveness of the implementation of programmes such as Scratch and/or App Inventor in PE schools; c) the results obtained show positive effects on the improvement of competencies and skills in the use of VPL.

It is important to start working with and stimulating CP from the EP stage (Durango-Warnes & Ravelo-Méndez, 2020; Hijón-Neira et al., 2020). It is thought that this may be the reason why Scratch is beginning to be used more in some schools. Regarding the inclusion of programming in the Spanish education curriculum, there is also a free configuration subject for each autonomous community called "Technology and Digital Resources to improve learning", which includes programming concepts.

Its specific content is established for the EP curriculum, but each educational centre decides on the configuration of robotics within the academic programme; the studies selected have focused on the 4th, 5th and 6th years of EP; only one study (10%) of those selected raised doubts about the effect of introducing this type of content in the 3rd year of EP. The planning and inclusion in the programming of Scratch and/or App Inventor in different subjects of the school curriculum would give it a continuous and integrated nature that would favour the acquisition and consolidation of specific CT skills and competencies. Curricular designs and proposals should increasingly promote the use of ICT, focusing on the use of VPL to encourage students' CT development. The educational community should move away from the idea that mobile devices in the classroom cause student distraction and consider them an effective resource to motivate students to learn through video games or applications such as App Inventor.

We believe that teachers need to be trained in PLs such as Scratch and App Inventor in order to become experts in these languages and thus be able to support the implementation of programmes and teach students, since, as the studies analysed show, training and skills in this area are still scarce among teachers (García-Perales and Palomares-Ruiz, 2020). It is necessary to highlight the importance of training teachers in VP and the need to learn programming in schools; this training in programming is not only necessary but has been shown to be an important deficiency among teachers. Gökçe and Yenmez (2022) consider that teacher training plans should include computer science and PLV content. Only in this way will we be able to change beliefs regarding the educational possibilities of ICT use, thus breaking the myth that computer science does not go beyond hardware or software mastery and fostering an alternative view of computer science as a CT-promoting discipline. Best (2020) highlights the importance of changing the beliefs of teachers who believe that computer science does not go beyond hardware, in this sense it is necessary to promote a vision of computer science as a tool for the development of the CT, agreeing with Papadakis et al. (2017) on the importance of programming from PE.

The selected studies confirmed that both Scratch and App Inventor help to understand algorithms, which are crucial for CT development (Rico et al., 2018; Moreno-León et al., 2021; García-Perales & Palomares-Ruiz 2020; Benton et al., 2018; Puraivan et al., 2021). These authors indicated that algorithmic thinking is part of CT, González-González et al., (2018) highlighted the need to extend it to hospital classrooms. Also, Benton et al., (2018) and Gökçe, and Yenmez, (2022) show that ScratchMaths develops CT skills and favours mathematical thinking. Problem-oriented reflective thinking develops with these VPLs, does not vary by gender and has a positive effect on mathematics learning.

In general, programming with Scratch and/or App Inventor works, generates desirable skills and promotes meaningful learning in students. From the studies presented above, results have been extracted that coincide with the study conducted by Iglesias and Bordignon (2019). Also, Park and Shin (2019) indicated that, if students learn Scratch and App Inventor, they can improve their CT skills in general and find that both can be used in early childhood education and PE as they indicated (Scratch, 2022; Mikolajczyk et al., 2018). On the other hand, Dağyar et al., (2020) highlighted the advantages of learning mobile programming, a fact that was refuted by (Durango-Warnes; Ravelo-Méndez 2020; Ocaña et al., 2020), who also estimated the effect on motivation (Wing 2006) and on CT development. Hardly any scientific studies have been found focusing on App Inventor in PE, which was curious given that as a tool for the development of applications on mobile devices it can be attractive to students.

More papers have been found on Scratch, including systematic reviews and experiences focused on CT assessment, using Scratch in PE (Fagerlund et al., 2021; Mukasheva and Omirzakova, 2021; Allsop, 2019). The systematic review of this study on PE has also been carried out in university education by Pérez-Jorge and Martínez-Murciano (2022), finding that Scratch and App Inventor favour of autonomy, attention, motivation, CT development, critical and creative thinking, social interaction, communication and conflict resolution in university students. Both this study and the one carried out in university contexts have shown the benefits of Scratch and App Inventor tools, which is why it is necessary to carry out longitudinal studies to assess the effect and stability of competencies in students.

Competence development in both teachers and students has been a topic of educational interest, and studies by (Castro et al., 2018; Chun et al., 2021) highlighted the importance of fostering the development of creative thinking and the role of teachers in promoting it. The processes of support, monitoring and development of this thinking, in relation to those promoted through the use of VPL, are closely related and require processing of support, incentivisation and activation promoted from an individualised training model in which the processes of tutoring and support for students are fundamental (Chun et al., 2021). Teachers have always had a relevant role in student motivation (Pérez-Jorge, 2010), in this sense, the motivating teacher has to involve students in projects for the development of creative competence or alternative thinking. Puraivan et al., (2021) insist on the need to awaken interest in the development of this type of thinking in which the CT fits, Pérez-Jorge et al. (2020) affirms that competent teachers with a command of ICT competencies are required, in this sense it is considered that teaching to think implies knowing how to think and promoting thinking in students.

6. Conclusions

The findings obtained from the analysis of these documents support the objective proposed in this study. We expected to find that Scratch and App Inventor were being used in PE and that there were insufficient studies to demonstrate the effectiveness of their use in CT development. Pupils need to have theoretical and practical knowledge about them, and teachers need training to be able to teach pupils to develop this thinking as a fundamental learning strategy for the promotion of other fundamental competencies.

Thus, we consider:

- Scratch and App Inventor are used to design applications, program and learn in different disciplines such as mathematics, logic, literature, computer science, history, robotics and electricity from the third year of primary school onwards.
- Scratch and App Inventor stimulate and develop computational, algorithmic, mathematical and critical thinking in PE students. It also fosters reflective and critical thinking and social skills and competencies such as collaborative work and motivation.

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• Considering the benefits that both Scratch and App Inventor produce in learning, it is considered necessary to include them in the curriculum of initial and continuing teacher training plans.
• It is necessary to extend studies on the application and development of CP in the field of PE in order to find out how pupils develop the skills inherent to this type of thinking.
• CT related skills improve with the use of Scratch and App Inventor. The studies analysed show that Scratch and App Inventor improve computational thinking skills and the mastery and use of LP. In spite of the positive results detected, it is necessary to continue implementing the use of these resources in the classroom in order to have, in the future, new results that confirm the findings.

The main difficulties encountered when carrying out this study focused on the lack of research studies on the objective evaluation of the results of the application of these tools (Scratch and App Inventor). Besides, the studies found are largely theoretical in nature, which shows a lack of specific proposals that address cross-cutting work on CT as a fundamental competence for the development of other learning in PE. The experiences and studies developed in schools have focused on specific experiences or assumptions, the results of which cannot be generalised.

With a view to the development of future research or studies on the effect of Scratch and App Inventor on the development of CT, it is necessary to consider the need to specify curricular proposals that allow this type of thinking, the cross-cutting approach and its use to be developed in the different subjects, given the effects evidenced in the studies analysed. This is a challenge to be taken up by educational centres due to the intrinsic potential of their use, and the mediating effect of the competencies promoted by CT, the benefits of which could be extended to the rest of the subjects in the curriculum.

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