School of computational thinking and artificial intelligence 21/22

From teacher training to a change in methodology

Research findings

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School of computational thinking and artificial intelligence 21/22

From teacher training to a change in methodology

Introduction

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Spanish Institute of Educational Technology and Teacher Training (or 'INTEF' in Spanish). Ministry of Education and Vocational Training

Today's society is constantly facing changes, most significantly, the rapid digitization in which we have recently found ourselves. In order to fully take advantage of the enormous benefits these changes offer, we must move forward in terms of updating and adaptation processes. This is a common vision shared by the educational administrations and European institutions, who work hard to promote different areas of our society's modernization, including education.

To this end, the Digital Action Plan and Transformation of Digital Competence in the Educational System carried out by the Spanish Ministry of Education and Vocational Training has highlighted some of the essential elements needed in order to completely digitalize education: the availability of technological resources, the digital competence of schools, teachers and students, digital educational resources and advanced digital skills. In fact, this last point attends to the development of computational thinking and artificial intelligence and is, in this context, the foundation for the School of Computational Thinking and Artificial Intelligence. This project, which has been carried out in collaboration with different Spanish autonomous communities and cities, is aimed at offering teachers with educational resources and support and is based on research that analyzes the evidence of the possible benefits of these skills in the development and training of our students, which is something fundamental for education.

Recently, the European Commission published the 'Digital Education Action Plan 2021-2027', which includes the objective of "offering programming classes to all schools in Europe, and in particular, increasing their participation in the EU Code Week."

We can conclude that efforts should now be focused on helping young people reach their maximum full development in an equal opportunity environment, as they acquire the skills that will guarantee that they become fully functional in the global society of decades to come. To do this, not only must schools be equipped with the necessary technological resources, but teachers' competence must also be up to date according to today's teaching practice in order to respond to students' needs. We are in the process of training a new generation of students who will have to coexist, both personally and professionally, with these types of skills.

In light of the research results presented in this publication, we have no doubt that this type of project will continue to form part of educational administrations' agendas in order to improve teachers' and students' skills, especially due to the positive impact they have on the drive to digitally transform education.

PRESENTATION

DR. MAR CAMACHO

Computational thinking and artificial intelligence can pave the way for new approaches in current learning that includes the acquisition of new thinking skills, which is crucial for surviving in the 21st century. Some of these skills include logical thinking, problem solving, analytical capacity, creativity, critical thinking and the ability to learn how to learn; all of which are fundamental to working on computational thinking and found in the competency model proposed by the Amendment of the new Spanish Education Law ('LOMLOE' in Spanish). This law introduces some basic concepts related to computational thinking skills in the lower educational levels and artificial intelligence in higher levels.

These amendments, closely aligned with the most recent regulations issued by the leading international educational organizations (UNESCO 2021, European Commission 2021), infer that including these skills into the learning process must be a priority. The European Commission's Digital Education Action Plan 2021-2027 indicates the need for quality digital education as a key element in educational transformation. However, these proposals pose challenges, not only for students, but also for teaching staff and schools as a whole, who require training and support to duly implement skills linked to computational thinking and artificial intelligence.

The School of Computational Thinking and Artificial Intelligence (SCTAI) was created in 2018. It is an experimental project developed by INTEF (the Spanish Institute of Educational Technology and Teacher Training) in collaboration with different Spanish Autonomous Communities and Cities, along with *Acción Educativa Exterior* (AEE Educational Initiatives). Its objective is to explore the possibilities of introducing Computational Thinking and Artificial Intelligence in the classroom. Each year, the SCTAI project carries out three phases: 1) training, 2) classroom activities and 3) research.

Each school year, the proposal and topics of the project have varied and included different subjects, until this year, which is structured around five main areas.

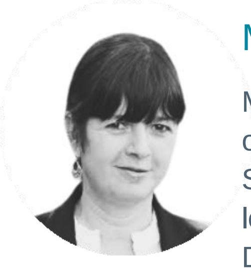
It should be noted that for the 2021-22 academic year, the available training has been increased, granularized and grouped into five modular areas: Unplugged Computational Thinking, Block Programming, and three Programming Languages: Python, Artificial Intelligence and Robotics.

Each area addresses different skills and abilities through different training blocks offered with different levels of difficulty, and, for the first time, participants are able to create their own personalized learning path which takes into account their interests and previous knowledge.

Unlike past editions, the third (research) phase of the 2021-22 SCTAI project focuses on teachers, a key element in the transformation of education and the driving force for change in schools. This research aims primarily at analyzing the impact of the training received in the acquisition and improvement of digital teaching competence, especially in terms of skills related to computational thinking and artificial intelligence, as well as examining the impact of said training on the teaching practice. The impacts analyzed, however, go much further, since the 4th annual SCTAI project has greatly impacted a number of aspects related to teaching: methodology changes, student competency and empowerment, school transformation, etc… Furthermore, it has also shown the need to point out, from an educational point of view, how present computational thinking and artificial intelligence are in our daily lives. In fact, this has been one of most important participant takeaways of this study.

It will become increasingly necessary to rely on spaces that analyze and discuss learning and the role of data, computational thinking and artificial intelligence in education. These spaces will be key to innovate and learn how to take advantage of the pedagogical and social improvement opportunities that artificial intelligence offers to education. We hope that the evidence found in this study can contribute to enriching this debate.

RESEARCH TEAM

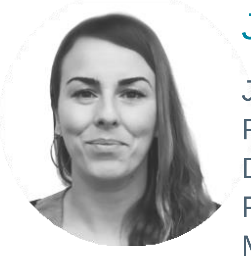


Mar Camacho

Mar Camacho is a professor and researcher at the Rovira i Virgili University's School of Education (Department of Pedagogy) and holds a PhD in Educational Technology. She has written a number of publications on the use of digital technologies in learning processes and other emerging technologies in Education. The former Director of Research of the 'Samsung Smart School' project (2015-18) has advised on the strategic planning (design, implementation, monitoring and assessment) of models based on Mobile Learning and skill acquisition, and has also collaborated with a variety of international organizations, including UNESCO and the United Nations' International Telecommunication Union (ITU). The UNESCO-Paris Visiting Scholar has also actively participated in seminars, round tables, and lectures at national and international conferences. In July of 2018, Camacho was appointed General Director of Innovation, Research and Digital Culture of the Government of Catalonia's Ministry of Education. Until June 2021, she was responsible for Innovation and Teacher Training, as she helped drive the implementation of the Digital Education Plan for Catalonia (2020-23), the STEAMcat Plan and a program focused on Training Centers. She also introduced a line of advanced innovation related to artificial intelligence and the acquisition of computational thinking skills in the educational field, which was the first time this field had been introduced in teacher training plans.

Janaina Minelli De Oliveira

Janaina Minelli De Oliveira has a BA in English Philology and master's degrees in Discourse Analysis, Scientific and Environmental Communication, and Translation and Intercultural Studies. She is also a Specialist in the European Higher Education Area and holds a PhD in Applied Linguistics. Currently, she is a Serra Húnter Associate Professor at the Rovira i Virgili University's Department of Pedagogy. Her research interests and numerous publications are related to the use of digital technologies and multimodal learning as enhancing elements of critical and democratic educational practice. Her scientific work establishes a dialogue between social semiotics and education, analyzing building processes of pedagogical positions through different representations, participation and interactive dynamics established in face-to-face and virtual learning environments.



Judith Balanyà

Judith Balanyà is specialized in Learning and Knowledge Technologies at Educational Resources Services and is an Associate Professor at the Rovira i Virgili University's Department of Pedagogy. She has a degree in Early Childhood Education and Pedagogy, a master of Educational Technology, E-learning and Knowledge Management, and is currently pursuing a doctoral degree in Educational Technology. Her scientific work is related to the design, implementation and assessment of educational activities with the use of mobile devices, as well as other emerging educational technologies.

CONTENT

COMPUTATIONAL THINKING AND ARTIFICIAL INTELLIGENCE, KEYS TO TOMORROW'S EDUCATION

KEYS TO TOMORROW'S EDUCATION

Computers, the Internet and technologies have become an integral part of our daily lives extraordinarily quickly, causing drastic changes in how we socialize, learn, work, communicate and entertain ourselves. Being able to cope with the tremendous evolution imposed by communication technologies is undoubtedly a highly desired skill in the workplace of a knowledge-driven society. The key to this trend is a more efficient use of technology that is aimed at problem solving and product development.

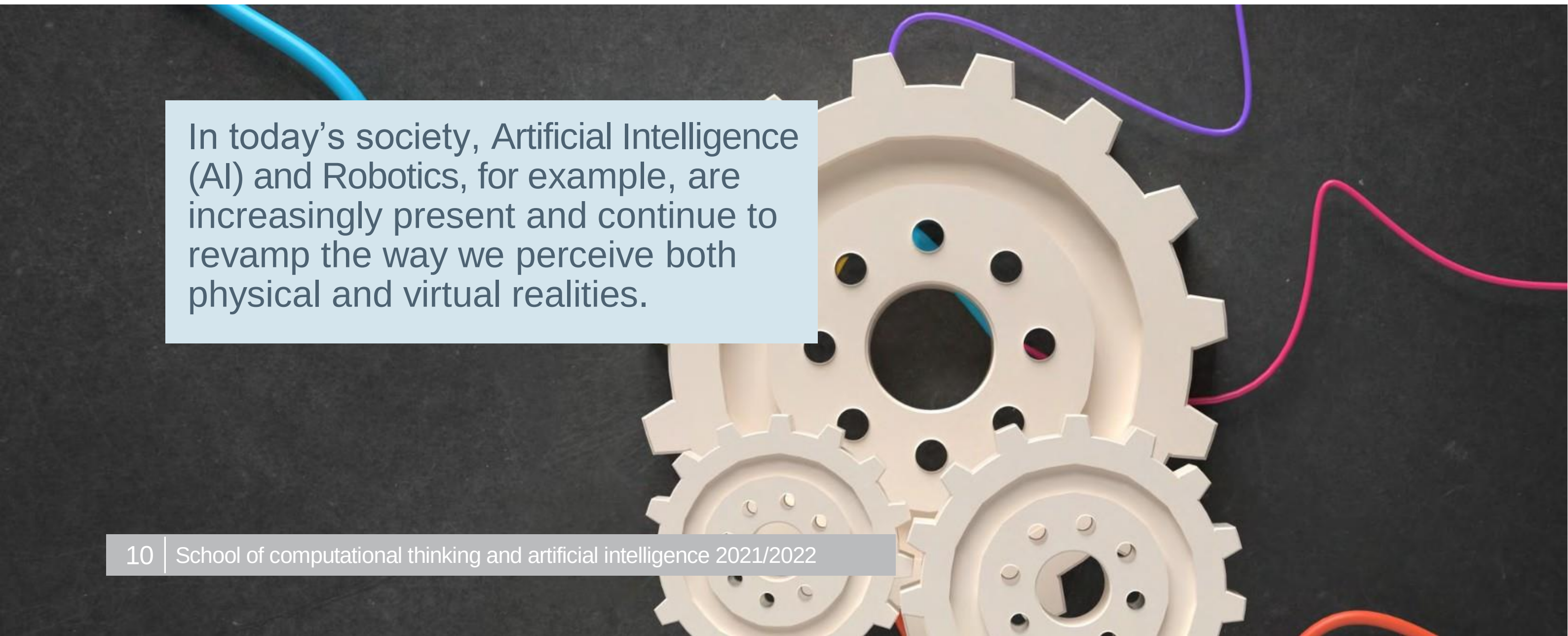
Currently, a wide variety of cutting-edge digital tools are being used interchangeably to manage information and communication, as well as to further our understanding and application of smart processes or technologies that are transforming and expanding our physical reality. Some of these tools include applications such as virtual simulators, virtual environments, video games, serious games, 3D printing, the Internet of Things, cloud computing, smart devices, home automation, blockchain, artificial intelligence and robotics. Some of these technologies are so leading-edge that we are still in the process of fully understanding all their possible practical and real applications.

When we look at the impact that computers and digital tools have had on the job market, we quickly realize the need for all citizens to be trained to use the new technology that is changing the way we work and live. Becoming more familiar with these tools will not only allow people to use computers, but also to ask questions about how algorithms affect our lives. Within this context, Computational Thinking (CT) is increasingly seen as a skill that is essential for everyone, not just for professionals or students of Computer Science or Engineering.

Computational thinking is a basic problem-solving skill, based on computer science concepts and techniques that include decomposition, pattern recognition, abstraction, and algorithms (Wing, 2008; 2011; Grover & Pea, 2013).

As science and technology develop progressively, a wide array of fields will gradual move towards automation and intelligence. The future of computational thinking is being furthered thanks to the promotion of activities that involve programming languages that are currently more accessible to children and young people.

This is due in part to the new tools, activities, platforms and communities offered online, such as Scratch, Alice and/or Code.org, which young people use to develop self-directed programming projects that lead to meaningful code learning through exchange and support of fellow community members. In turn, this has created an essential need to educate people so that they can keep up



In today's society, Artificial Intelligence (AI) and Robotics, for example, are increasingly present and continue to revamp the way we perceive both physical and virtual realities.

with the changes that arise from global innovations. Due to the widespread use of computers, people are paying more attention to computer education, in particular programming-related skills and knowledge, as they become an indispensable part of education (Lin & Chen, 2020).

Educational systems have evolved so drastically that today's systems have almost nothing in common with the earliest versions. This has not only led to a dynamic nature, but also to the need for continuous, permanent upgrades. Countries all over the world have already started updating their curricula to include computational thinking. For instance, Turkey, Austria, the Czech Republic, Denmark, Finland, France, Greece, Hungary, Italy, Lithuania, Poland, Portugal, and Switzerland have all started teaching computational thinking, either as an elective or compulsory, from kindergarten up to the end of secondary school (Bocconi et al., 2016; Vinnervik, 2020). Both the OECD and UNESCO see computational thinking as a necessary literacy skill for the citizens of tomorrow (Organization for Economic Cooperation and Development, 2018; Scott, 2015; World Economic Forum, 2015).

The National Research Council (NRC) has defined computational thinking as one of eight practices that must be integrated into science studies (NRC, 2012), while the European Commission has emphasized that it must be incorporated into compulsory education so that students may fully participate in the digital world (Bocconi et al., 2016).

The rapid change in skill requirements in all jobs has reiterated the urgency to instill our youth with computational thinking and code literacy skills so they are prepared for a future economy and society powered by complex computing technologies. A great deal of literature highlights the importance of effectively integrating computational thinking development into education (Berry, 2011; Bers et al., 2014; Lye and Koh, 2014; Ching et al., 2018). Hooshyar (2021), for example, suggests that educators could use computer game approaches to promote computational thinking in primary school students, therefore fostering both conceptual knowledge and skills in children, as well as more effectively helping students with less previous knowledge related to this area.

Rodríguez-García et al. (2020) insist that introducing AI in schools is essential to instigate more vocation in young people so that the growing number of projected STEM and AI jobs may be covered. The authors believe that computational thinking is an appropriate framework for introducing AI content into schools through both hands-on coding and disconnected activities.

> Cultivating creativity while promoting computational thinking is of the utmost importance.

Computational thinking considerably increases students' interest in continuous learning and motivation towards learning, therefore improving their overall academic performance (Lai et al, 2019). A controlled experiment of secondary school students conducted by Israel-Fishelson et al (2020) found a strong correlation between computational thinking and creativity, leading the authors to reinforce just how crucial cultivating creativity is while promoting computational thinking.

Educators who explore artificial intelligence and robotics have encountered a framework in computational thinking to introduce said content in today's schools. Robotics has been backed up by many researchers as an innovative learning tool that is capable of transforming education and supporting students in many learning contexts (Evripidou et al., 2020). Through the outputs that students create and the phenomena that is simulated, educational robotics promotes learning that is active and appealing. With robotics, students work on real-world applications of engineering and technology concepts, and the abstractness of science and mathematics is removed (Benitti & N. Spolaôr, 2017). According to Salas-Pilco (2020), artificial intelligence and robotics have become a catalyst for an early acquisition of fluency in science and technology.

Among the learning outcomes that students are expected to gain from educational activities related to robotics, we can include:

- **Problem-solving skills:** essential cognitive activities that help students solve a given problem
- **Self-efficacy:** considered to be one of the guiding elements of human activity as it allows a person to estimate what they can achieve using their specific abilities
- **Computational thinking:** studies on this subject have concluded that educational robotics is an effective educational tool that will help develop computational thinking skills
- **Creativity:** educational robotics is an innovative educational technology that has been shown to enhance student creativity
- **Motivation:** refers to an individual's choice to dedicate effort, participation and perseverance to a particular activity. It has been proven that educational robotics encourages and improves student motivation.
- **Collaboration:** enables people in the same working environment to complete a task or achieve a predefined goal. This is considered to be an essential communication and job skill for 21st century learners. Almost all STEM disciplines consider this to be the most important interpersonal attitude.

It is fascinating to see just how much robotics can influence student learning at an early age, both as a motivating factor and as an articulating element to promote social STEAM learning. Zapata-Cáceres & Martín-Barroso (2021) came up with a voluntary videogame based on intrinsic motivation that addresses basic computational concepts at early ages. Their findings have shown significant age and gender differences as the game was played, in terms of interests, abilities, achievements, and progress. The researchers observed that the concepts addressed were achievable between 3 and 6 years of age, with full mastery peaking at 4 years of age, regardless of gender, since both boys and girls persevered throughout the challenge and were intrinsically motivated to accomplish their goals.

Clearly, in order to take advantage of AI's pedagogical potential, it is necessary to identify and take advantage of all its benefits, while identifying and reducing potential risks. To do this, the following questions must be answered:

1. How can AI be used to improve education?
2. How can an ethical, inclusive and equitable use of AI in education be guaranteed?
3. How can education prepare people to live and work with AI? (UNESCO, 2021)

UNESCO is paving the way in their response to current global challenges through transformative learning by coordinating the Education 2030 Agenda. This program is part of a global movement to eradicate poverty by achieving the 17 Sustainable Development Goals (or 'SDG's). Education has its own specific goal (SDG 4), which aims at ensuring "inclusive, equitable and quality education and promoting lifelong learning opportunities for all."

According to UNESCO, Artificial Intelligence (or 'AI') has the ability to cope with some of the biggest challenges that the field of education faces today, to develop innovative teaching and learning practices and, finally, to help achieve the 4th SDG even faster (UNESCO, 2021). However, it also states that the connection between AI and education will inevitably play out in very different ways, depending on national and socio-economic circumstances. In fact, according to UNESCO, in order for AI to contribute to the 4th SDG, it will be necessary to provide low-cost models for AI technology development, to ensure that the interests of low- and middle-income countries are represented in key discussions and decisions, and to build bridges between the nations and countries where AI has been implemented the most.

> The goal of eliminating the need for human teachers reveals a fundamental misunderstanding of their essential social role in the learning process.

Despite its potential to empower teachers, the use of AI applications centered on teaching has so far received much less attention than AI apps centered on the learner, which, by definition, would replace the teacher.

The goal of eliminating the need for human teachers reveals a fundamental misunderstanding of their essential social role in the learning process. We are aware that teachers will need to acquire new skills in order to work effectively with AI, along with appropriate professional development to foster their human and social capacities (UNESCO, 2021).

DIGITAL TEACHING COMPETENCE AS A TRANSFORMATIVE AGENT IN LEARNING

DIGITAL TEACHING COMPETENCE

The 2022-2023 school year began with the challenge of a progressive implementation of the Amendment of the new Spanish Education Law ('LOMLOE' in Spanish), which took effect in January 2021 and is expected to gradually enter into force until the 2023-2024 academic year. This new Education Law intends not only to restore 2013's legal provisions, reversing changes that were promoted by Spain's Quality Education Improvement Act ('LOMCE' in Spanish), but also to promote a greater focus on the objectives set forth by the European Union and UNESCO for 2020-2030. The purpose of this new Law is to establish a renewed legal system that increases educational and training opportunities for the entire population, thus contributing to an improvement in student academic results, while satisfying the Spanish society's generalized demand for quality education for all. The firm belief that a good education is a country's main resource and greatest source of wealth for the society at large, has been increasingly accepted in today's societies, which have equipped themselves with progressively more highly-developed national educational systems to make their educational goals a reality.

In order to renew the educational system and thus meet today's social demands of offering quality education to all citizens, the Education Law proposes modifications to the school curriculum and a competency-based and transversal learning model.

Information and Communication Technologies are taking on an increasingly important role in this renewed legal framework, in which computational thinking has enhanced the intended educational transformation. It is apparent that computational thinking is extremely present in today's educational context and, as a result, in in-service teacher training. In fact, in this type of training there seems to be an increasing tendency to include competency standards that will provide indicators to help teachers assess their computational aptitude and current practice, while strengthening it with the development of computational thinking (Loureiro et al., 2022).

> The development of computational thinking from the earliest stages of schooling is one of the proposed changes in the new Education Law.

The development of computational thinking from the earliest stages of schooling is one of the proposed changes in the new Education Law, although the tasks in each stage must be dealt with uniquely and adapted to the corresponding age group.

For example, in Early Childhood Education, problem solving, analysis, creativity, critical thinking or the ability to learn how to learn are listed as some of the key competencies that teachers should encourage in their students.

In fact, Artificial Intelligence is growing right alongside a whole generation of children in this rapidly changing digital world, with the increase in virtual assistants like Siri or Google Assistant, as well as many other AI-enabled applications in a wide array of areas including healthcare, automobiles, education, social media, entertainment, and robotics (Yang, 2022).

For instance, in terms of STEM skills in Primary Education, the use of mathematical reasoning to solve problems in different contexts stands out. The digital competence area includes the creation of digital content and aspects related to programming, cybersecurity, privacy, problem solving and computational thinking. The goal set for the end of this educational stage is “an approach and development of projects as different prototypes or models are designed, manufactured and assessed to generate or use products that creatively and collaboratively solve a need or problem.” At the end of Primary Education, students must be able to “develop simple computer applications and creative and sustainable technological solutions to solve specific problems or creatively respond to challenges.” To do this, block programming and educational robotics need to be included in the classroom.

The educational transformation sought by the new Education Law will pose challenges not only for students, but also for teachers and schools as a whole, who will need to be trained and supported.

The development of a high-performing digital educational ecosystem that is capable of generating digital skills and abilities towards digital transformation requires, among other things, teachers and educators who feel confident and competent as they use digital technologies during the teaching and learning processes and in their pedagogical strategies that are implemented along with said processes.

Western countries have introduced educational policies that meet the demands of a digital society. The development of digital competence reference frameworks for the teaching profession is being included in this context, highlighting the development of computational thinking, which is a competence construct that is necessary to train citizens.

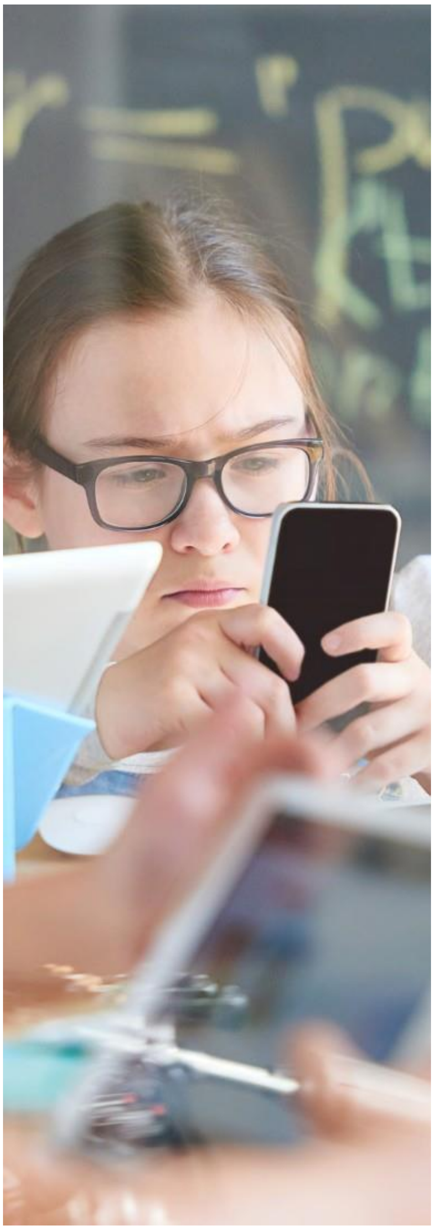
The educational transformation sought by the new Education Law will pose challenges not only for students, but also for teachers and schools as a whole.

Therefore, the Reference Framework for Digital Teaching Competence set forth by the Spanish Ministry of Education and Vocational Training that was approved in January 2022, adapts to the Spanish context of the Digital Competence of Educators (DigCompEdu) prepared by the Joint Research Center (JRC) and published by the European Commission (Redecker, 2017).

The DigCompEdu structure is divided into six areas, which include all the categories of the framework’s digital teaching competences; each focusing on different aspects of the professional activities of teachers.

- **Area 1:** Professional commitment. Digital technology use for communication; coordination, participation and collaboration within the school and with other external professionals; improvement of performance upon reflecting on each one’s practice; professional development; personal data protection; privacy and security; and digital well-being of students when carrying out their tasks.

- **Area 2:** Digital content. The search for, modification, creation and sharing of educational digital content.
- **Area 3:** Teaching and learning. The management and organization of the use of digital technologies in teaching and learning.
- **Area 4:** Assessment and feedback. The use of technologies and digital strategies to improve assessment, both related to student learning and the teaching-learning process itself.
- **Area 5:** Student empowerment. The use of digital technologies to improve inclusion, a focus on individual differences and the active engagement of students in their own learning.
- **Area 6:** Development of students' digital competence. Student training to creatively and responsibly use digital technologies for information, communication, a safe participation in the digital society, content creation, well-being, data privacy, problem solving and the development of their personal projects.



Essentially, the Reference Framework for Digital Teaching Competence assumes that along with literacy and calculation, digital technologies are the real objective of learning, and are part of the basic literacy of all citizens in both compulsory and adult education, while also constituting an essential element of academic and professional training in post-compulsory education. The underlying idea here is that teachers who are competent in their professional use of information and communication technologies will be able to deliver quality education and, ultimately, effectively guide the development of their students' ICT-related competence (UNESCO, 2021).

In this context, instructional design becomes pivotal in improving the motivation and effectiveness when acquiring computational thinking skills. As computational thinking is introduced as a new subject in the school curriculum in many countries, teachers must equip themselves with new knowledge of the subject and learn appropriate pedagogies to administer the new curriculum. However, Gabriele et al. (2018) have identified a gap between university training in Computer Science for Primary teachers and the needs of schools, the society and even educational policies.

Some teachers may feel that they cannot deliver such IT training effectively due to the insufficient knowledge they believe to have or the lack of infrastructure in some schools (Kert et al., 2019).

The most commonly mentioned challenges that teachers face related to computational thinking have to do with their own subject knowledge, students' lack of understanding of the content, technical issues, the differentiation to deal with different levels of ability and willingness, or students' problem-solving ability (Sentance & Csizmadia, 2017). Additionally, teachers in the poorest and most rural schools have limited opportunities when it comes to learning how to develop students' computational thinking skills (Kale et al., 2018). Training and curricular design have been described as the two core elements that have significantly contributed to a successful inclusion of computational thinking in schools (El-Hamamsy et al, 2020).

Teachers who try to stay away from technology because of lack of self-confidence or the fear of using technology, may be more open to using technology if we were able to create work environments with more enthusiastic teachers. Team building is key for schools as a whole to evolve. Having one sole teacher carry out their own, excellent activities is not the most desirable model. It is essential to innovate and push the boundaries of teaching paradigms even further so that the results may be lasting and reproducible, whether it be in the school itself or in other contexts. Only interested and self-confident teachers will be able to use robotics to teach programming and computational thinking in their classes. However, if the enthusiasm for innovation is shared, more teachers may feel up to this task.

> Teachers need to equip themselves with updated computational thinking knowledge.

Despite the fact that student teachers are generally poorly educated in computational thinking, STEM education integrated with computational thinking has been found to foster future teachers' professional development and their beliefs about their self-efficacy when teaching (Çiftçi & Topcu, 2022).

Günbatar (2029) found that in-service teachers feel that a common working environment and exchange of ideas provided within a professional scope can benefit cooperation, and therefore, computational thinking skills, as well. The findings of Hadad et al (2020) highlight the importance of strategies, such as dialogue in a learning community, peer facilitation, and collaboration for learning processes and outcomes in order to increase student engagement and self-regulation.

The authors also found that a relatively high level of intrinsic motivation and self-discipline is recommended, especially when developing new skills that strengthen existing professional skills.

It may also be relevant to consider the components of a solid and adequate computational knowledge base (Vinnervik, 2020). Vinnervik calls into question the reasonable level of professional knowledge and understanding of programming that a secondary school teacher, for example, needs to teach the subject.

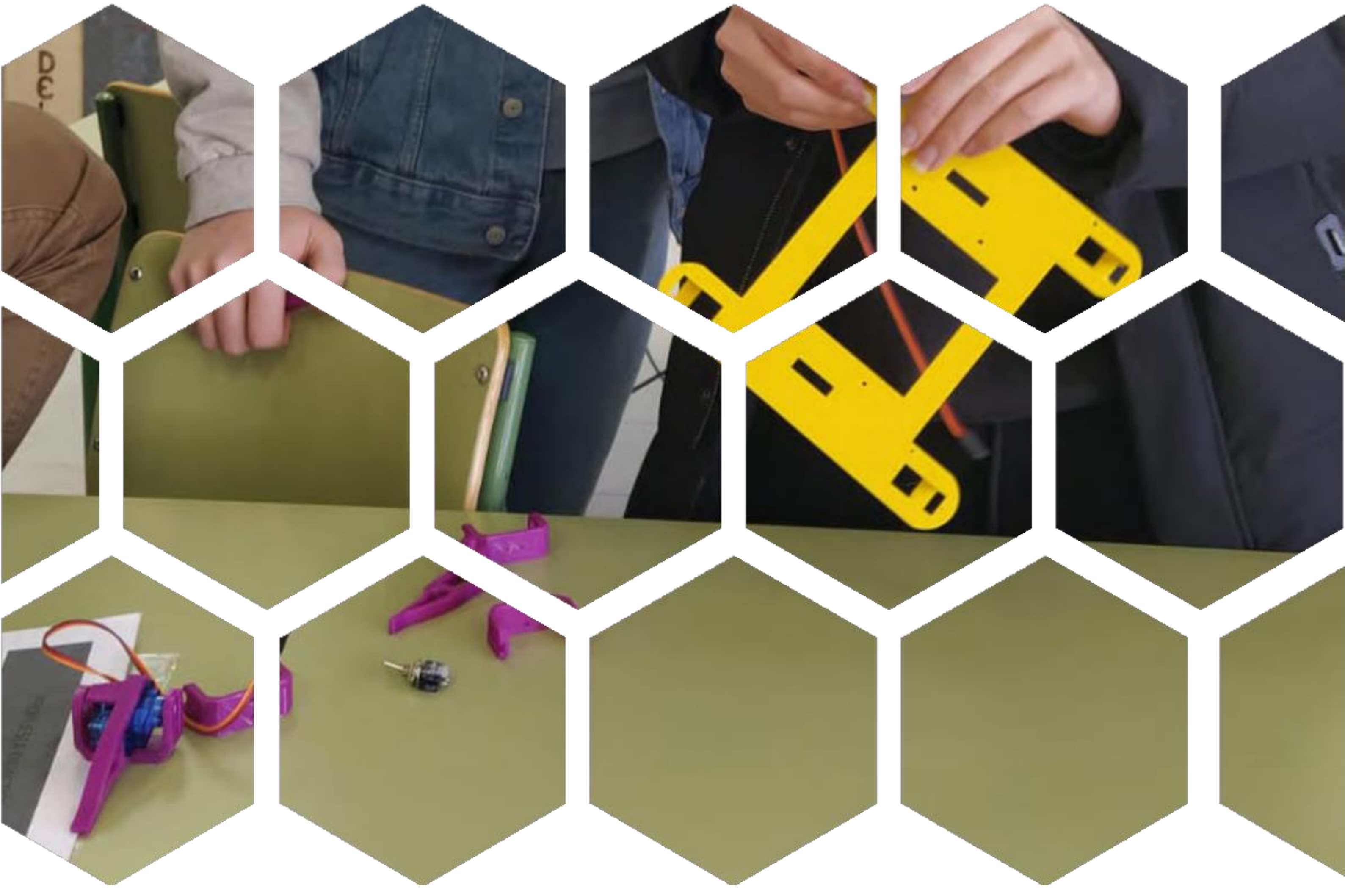
> It is essential that the desire to innovate and push the limits of teaching paradigms even further is carried out as a team.

Tsai et al. (2021) highlight the fact that although robotics education has become gradually more present in modern school curricula, assessment tools for robotics learning are still limited. Students can also use digital tools and AI to be more aware of their potential benefits and dangers.

Content should be developed that not only prepares students to be practitioners, but also to understand the moral, ethical, and philosophical impacts that cutting-edge digital tools can have on society (Rodríguez-García et al, 2020).

In conclusion, understanding and becoming familiar with AI's basic functions, along with developing skills that integrate computational thinking, will be organic elements of digital literacy for all citizens in today's increasingly intelligent society. We are living in exciting times, in which the boundaries between what is physical and what is virtual are constantly being redefined. The challenges posed by this era include the display of human beings' most creative, flexible and innovative skills and competences. All the social agents involved in the training of future generations must assume this responsibility with an unwavering commitment to quality education for all.

THE 2021-22 SCTAI PROJECT: PARTICIPATING AUTONOMOUS COMMUNITIES AND CITIES



THE 2021-22 SCTAI PROJECT

Since 2018, the experimental project ‘School of Computational Thinking and Artificial Intelligence’ (or SCTAI) has been carried out and developed by *INTEF* (the Spanish Institute of Educational Technology and Teacher Training), in collaboration with different Spanish Autonomous Communities and Cities, and *Acción Educativa Exterior*, or AEE (Educational Initiatives).

Its objective is to explore the possibilities of introducing Computational Thinking and Artificial Intelligence in the classroom.

This year’s edition of the project for the 2021/22 school year is structured into 3 essential phases:

- **Phase 1: Personalized online training.** This includes technical and pedagogical training through the SCTAI Virtual Campus (on Moodle) and a teaching proposal designed to be applied in the classroom.

This training content is structured into 5 areas of knowledge:

Disconnected Computational Thinking
Block Programming
Python (Programming Language)
Artificial Intelligence
Robotics

These 5 areas include a catalog of training blocks with different levels of difficulty, allowing teachers to build their own personalized learning path with their specific interests and prior knowledge in mind.

- **Phase 2: Implementation.** Development and implementation in the classroom of the teaching proposals designed during the previous phase (with support of mentors).
- **Phase 3: Research.** Research is carried out on the project’s impact in terms of digital teaching competence training and learning areas. Case studies are also developed by teachers with their students.

4th ANNUAL SCTAI

The timeline for the project phases is as follows:

- **Phase 1:** 21 October 2021 - 28 January 2022
- **Phase 2:** 9 February 2022 – 9 May 2022
- **Phase 3:** 21 October 2021 – 31 May 2022

PARTICIPATING AUTONOMOUS COMMUNITIES AND CITIES

A total of 682 teachers from Early Childhood Education up to Vocational Training have participated in the fourth edition of the School of Computational Thinking and Artificial Intelligence (SCTAI) project for the 2021/22 school year.

Teachers, mentors, training tutors (8), participating school leaders (6) and policy makers and technical officers of the Institute of Educational Technology and Teacher Training (INTEF), an organization belonging to Spain's Ministry of Education, have enabled and worked together on this research.

Figure 1 lists the different participating autonomous communities and cities.

Autonomous Communities:

1. Andalusia
2. Aragon
3. Asturias, Principality of
4. Balearic Islands
5. Basque Country
6. Canary Islands
7. Cantabria
8. Castile and León
9. Castile-La Mancha
10. Catalonia
11. Extremadura
12. Galicia
13. Madrid, Community of
14. Murcia, Region of
15. Navarra, Region of
16. Rioja
17. Valencian Community

Autonomous Cities:

- Ceuta
- Melilla
- External Schools

Fig. 1. Participating Autonomous Communities and Cities

RESEARCH

4.1. DESIGN

4.2. METHODOLOGY

4.3. TOOLS

4.4. PROCEDURE

4.5. FINDINGS

4.1. DESIGN

The most recent edition (2021-2022 school year) of the School of Computational Thinking and Artificial Intelligence (SCTAI) was set up by INTEF, with the collaboration of all the autonomous communities in Spain.

This project aimed at improving active teachers' computational thinking and artificial intelligence skills in all pre-university subjects and educational levels.

SCTAI's main contribution is related to developing problem-solving and communication abilities, whether they be related to disconnected activities (level I) or the advantages offered by computers (levels II and III). Artificial Intelligence is also used to analyze the environment with smart behavior (with a certain degree of autonomy).

Since 2018, this fourth edition maintains its basic three-phase structure: one for online training, another for the implementation of a teaching proposal in the classroom, and a last one that measures the project's impact.

The 2021-2022 SCTAI was aimed at primary and secondary teachers with different levels of competence in the field. They were asked to carry out training blocks in 5 different areas, from basic to advanced levels of difficulty, so that each participant could be trained in blocks that were adapted to their interests and previous knowledge. The training blocks were organized into the following topic areas: (1) Disconnected Computational Thinking, (2) Block Programming, (3) Python (Programming Language), (4) Robotics and (5) Artificial Intelligence.

This project, which is part of the course of action for the development of advanced digital skills within INTEF's Plan for Digital Action Plan and Transformation of Digital Competence in the Educational System (#DigEdu), is in line with the European Commission's recommendations, which considers Computational Thinking to be a fundamental competence for the 21st century; not only from the point of view of the obvious job opportunities that it offers to students who develop them from an early age, but also to be able to fully participate in an increasingly more digital society.

This research has been carried out during the 2021-22 school year. As part of a larger project, the School of Computational Thinking and Artificial Intelligence (SCTAI) was first conceived in 2017 and was promoted by the Spanish Ministry of Education's Institute of Educational Technology and Teacher Training (INTEF), with the objective of promoting student learning through the integration of technology in Spanish public classrooms.

During the 2021-22 academic year, interest related to monitoring and assessing the program results increased.

Therefore, the design of this study has been prompted by the Ministry's decision to assess the impact of the teacher training program, while monitoring the training received to determine the impact on teaching and learning practices.

The study's main objectives include:

G1	evaluating the impact of the 2021-22 SCTAI training program on participating teachers (GO1)
1	evaluating the training's impact on the following areas: furthering and improvement of Digital Competence (v1), impact on teaching practice-proposal design, and effectiveness in the classroom (v2) (EO1)
2	examining the satisfaction of those teachers who participated in the program (v3) (EO2)
3	examining the main causes for non-completion of the course or dropout (v4) (EO3)

4.2. METHODOLOGY

This study was carried out using a descriptive approach, aimed at understanding the reality in its natural context and a joint interpretation of situations by both participants and researchers. Nevertheless, a pluralist methodological framework was implemented that combined quantitative, qualitative and participatory techniques in a complementary way. According to the definition set forth by Creswell (2009), mixed methods research is a research design (or methodology) in which the researcher collects, analyzes, and mixes (integrates or connects) both qualitative and quantitative data in a single study. This method allows for a better understanding of the research approach.

These types of qualitative studies involve the use and collection of a wide variety of materials and evidence, from questionnaires to individual interviews or focus groups. The data collected is used to triangulate the information and identify and determine the subjects while establishing how reliable the data is.

4.3. TOOLS

1. Initial and final questionnaire:

The questionnaires were designed ad-hoc for this study and the questions drawn up were aimed at responding to the initial objectives. This questionnaire was provided at the beginning and at the end of the training activity and set out to evaluate the training's impact in the following areas: development and improvement of digital teaching competence and its impact on the teaching practice (v1), training contents (v2) and expectations regarding the training received.

Therefore, the initial questionnaire was given to a total of 682 participants (58% men and 42% women), while the final questionnaire was answered by a total of 462 teachers (55% men and 44% women).

The questionnaire contained the following dimensions:

- Dimension I: biodata
- Dimension II: digital teaching competence and its impact in the classroom
- Dimension III: acquisition of course content: (1) computational thinking, (2) block programming, (3) Python (programming language), (4) robotics and (5) artificial intelligence
- Dimension IV: expectations regarding the training received

2. Dropout questionnaire:

Per the Ministry's request and in order to find out the main causes of teacher dropout during the first phase of training, a questionnaire was distributed to the participants who did not continue with their training. Only 71 participants out of a total of 220 completed the questionnaire.

3. Focus groups:

A series of focus groups were carried out with different groups involved in the project. In total, three focus group sessions were held, each lasting between 40 and 60 minutes; one of them consisted of 12 teachers who had completed the entire program, the second group was made up of 6 mentors who had accompanied the participating teachers in the intervention development for the classroom phase, and finally, a third group included 3 policy makers and technical officers of the Spanish Institute of Educational Technology and Teacher Training (INTEF). The main aspects addressed by teachers and mentors included those related to methodology and how the training was perceived to have impact the teaching practice. Those representing the administration were asked about the program's impact and their expectations related to the future.

4. In-depth interview:

This previously organized and planned dialogue tool was used to interview a total of 9 teachers from three school that had been chosen due to their good practice. During one-hour school visits, the teachers were asked about their perception of the project and how it was carried out. These interviews were recorded, coded and analyzed. The main topics addressed in the interview were: (a) methodological and content aspects dealt with during the sessions and (b) perceived training impact.

The following table indicates the variables that were analyzed, according to the tool that was used:

Tool	Training Impact (Digital Teaching Competence)	Training Impact (on teaching practice)	Teaching Satisfaction & Expectations	Non-Completion Reasons (training)
Questionnaire 1 / initial & final	●	●	●	
Questionnaire 2 / dropouts				●
Focus group		●		
In-depth Interviews	●	●		

Table 1. Breakdown of variables with different data collection tools

4.4. PROCEDURE

The design of the study followed the subsequent phases:

Preliminary Phase:

During the first phase, the study's methodological design was carried out and the specific objectives, participants, tools and procedures for the gathering and analysis of information were determined. These activities were also sequenced and planned over time.

Diagnostic Phase:

Once the participants were selected, access and contact information was established, and the teachers participating in the training course were given an initial questionnaire.

Implementation Phase:

During this core phase of the study, the content of the educational plans and sequences was implemented, in-depth interviews were carried out in participating schools, and a series of focus groups were held: one for teachers, another for course mentors, and a final one addressed to the policy makers and technical officers of the Spanish Ministry of Education.

Final Phase:

During the last phase, teachers who had participated in all of the program's phases were asked to complete the questionnaire again for its subsequent analysis by the research team. This last step proved to be largely valuable for closure, as well as for a comparison of the results with previous findings, which helped to draw a series of conclusions and future recommendations.

4.5. FINDINGS

The School of Computational Thinking and Artificial Intelligence is an experimental project developed by INTEF, in collaboration with different Spanish Autonomous Communities and Cities and *Acción Educativa Exterior*, or AEE (Educational Initiatives), and has been celebrated each year since 2018. Its objective is to explore the possibilities of introducing Computational Thinking and Artificial Intelligence in the classroom.

Biodata

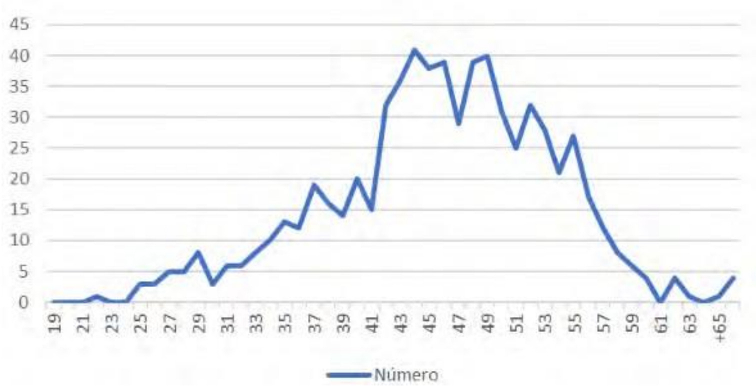
A total of 682 subjects participated in the initial questionnaire and 462 in the final questionnaire. The findings presented below are based on responses given by participants who participated in both the initial and final questionnaires, that is, by participants who completed all phases of the program, the training period and the classroom implementation period.

Gender and age

56% of the participants were male and 44% are female.

Regarding age, the 40-50 year old age group is the most prevalent among participants, as can be seen in Graph 2.

Figure 2. Breakdown of the participants by gender

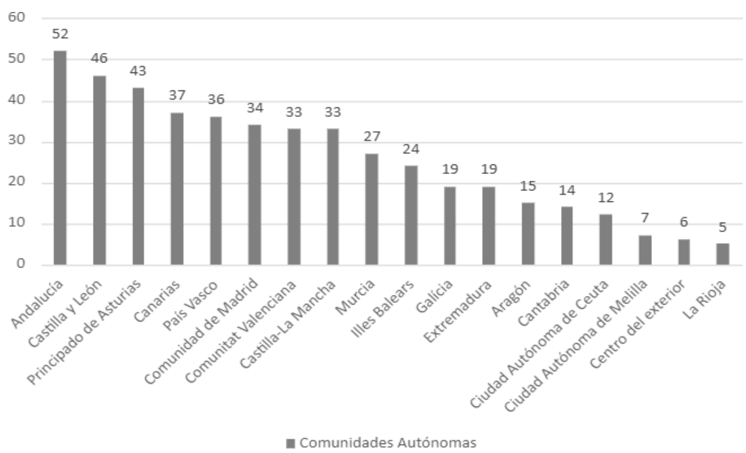


Graph 1. Age of the teachers who participated in the study

Participation according to Autonomous Communities

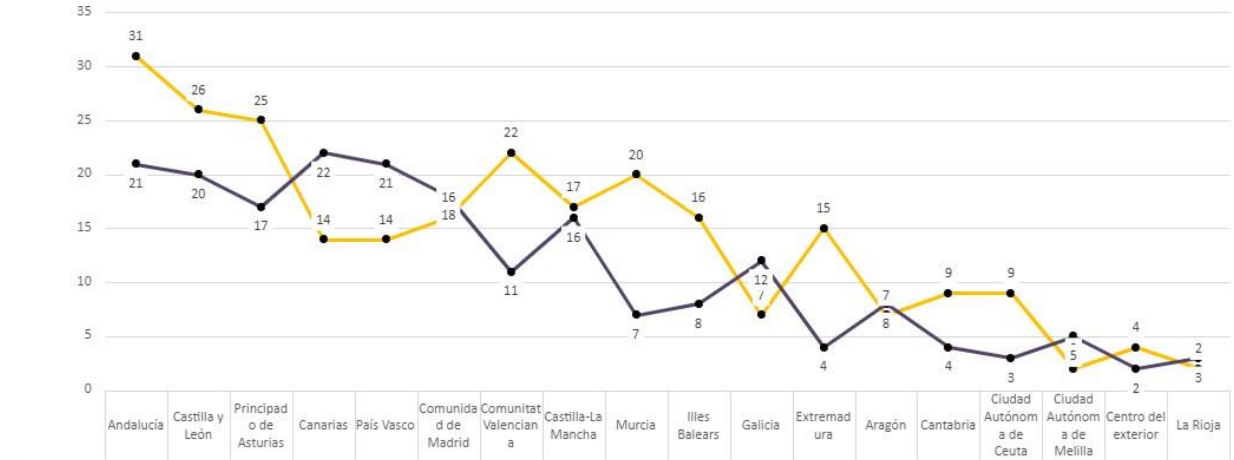
This Graph indicates a breakdown of teacher participation, according to Autonomous Communities. The findings indicate that Andalusia, Castille and León and the Principality of Asturias had the greatest participation.

The following graph also shows the participants' gender distribution in each Autonomous Community.



Graph 2. Teacher participation in each Autonomous Community

As per the Graph, female participation in the Canary Islands, the Basque Country, the Community of Madrid and Galicia was higher, while in communities such as Andalusia, Castile and León, the Principality of Asturias, Extremadura or the Valencian Community, male participation was higher.

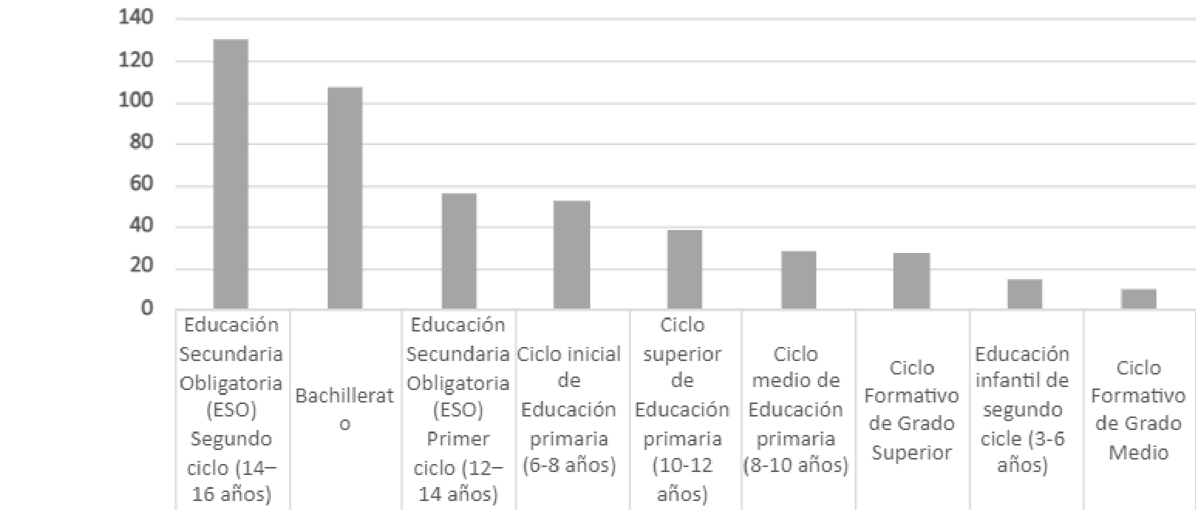


	Andalucía	Castilla y León	Principado de Asturias	Canarias	País Vasco	Comunidad de Madrid	Comunitat Valenciana	Castilla-La Mancha	Murcia	Illes Balears	Galicia	Extremadura	Aragón	Cantabria	Ciudad Autónoma de Ceuta	Ciudad Autónoma de Melilla	Centro del exterior	La Rioja
Masculino	31	26	25	14	14	16	22	17	20	16	7	15	7	9	9	2	4	2
Femenino	21	20	17	22	21	18	11	16	7	8	12	4	8	4	3	5	2	3

Graph 3. Gender participation in each Autonomous Community

Participation according to educational level

In terms of participant distribution according to educational level, a significantly high percentage of Early Childhood Education and Primary Education teachers should be noted.

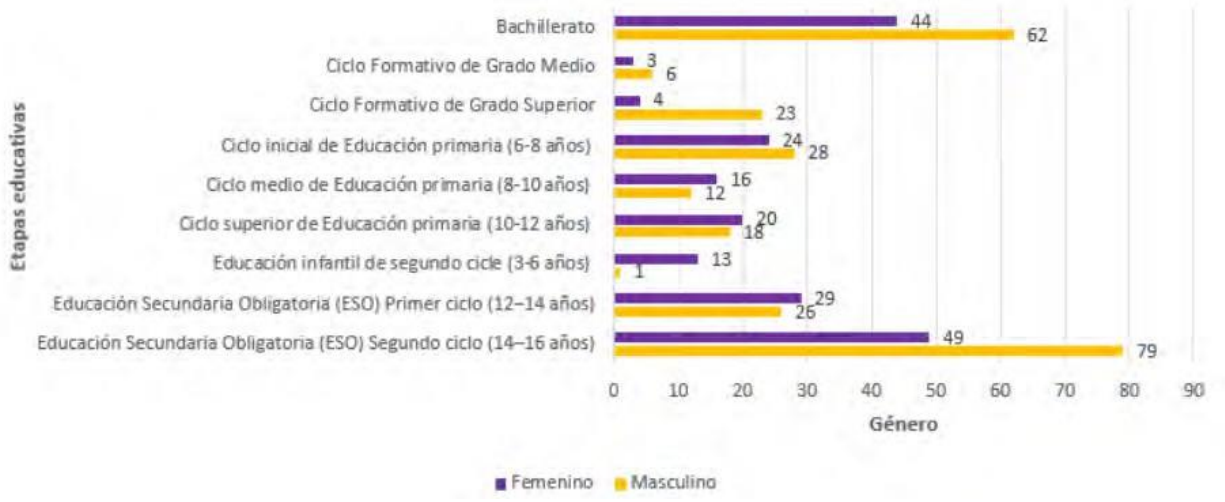


	Educación Secundaria Obligatoria (ESO) Segundo ciclo (14–16 años)	Bachillerato	Educación Secundaria Obligatoria (ESO) Primer ciclo (12–14 años)	Ciclo inicial de Educación primaria (6-8 años)	Ciclo superior de Educación primaria (10-12 años)	Ciclo medio de Educación primaria (8-10 años)	Ciclo Formativo de Grado Superior	Educación infantil de segundo cicle (3-6 años)	Ciclo Formativo de Grado Medio
Total docentes	130	107	56	52	38	28	27	14	10

Graph 4. Breakdown of program participation per educational level

Distribution of teachers according to gender and educational level

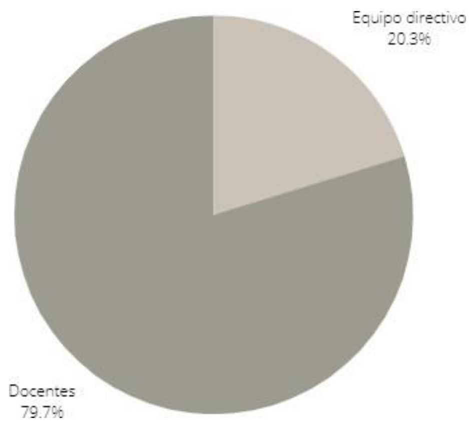
Regarding the distribution of teachers according to their gender and different educational levels, a clear difference can be seen between Early Childhood Educators, Primary Educators and teachers in the first cycle of Compulsory Secondary Education, where most teachers are female. However, in degree programs, Intermediate and Advanced Vocational Training, Junior High School and High School, the teaching staff is mostly male.



Graph 5. Distribution of participant gender in each educational level

Participation of school leaders

In terms of school leader participation during the fourth edition of the School of Computational Thinking and Artificial Intelligence, it should be noted that 20.3% of the participating teachers were school leaders, while the remaining 79.74% were not. This data may be relevant when promoting school-wide methodological changes, since school leaders are essential and should be used as leverage towards school change and transformation.



Graph 6. School leader participation in SCTAI 2021-22

DIMENSION 1:
DIGITAL TEACHING COMPETENCE

The questions related to digital teaching competence were divided among the following categories: professional commitment, which includes data protection, privacy, security and digital well-being (i) digital content (ii), teaching and learning, which includes self-directed learning (iii), assessment, which includes assessment strategies, analytics and learning evidence (iv), student empowerment, which includes personalization (v), and the development of students' digital competence, which includes content creation (vi).

Area 1. Professional Commitment

Data protection, privacy, security and digital well-being

DC1. I understand and apply the measures established by each Autonomous Community or school owners regarding personal data protection, privacy and the guarantee of digital rights of the entire educational community, with the counsel provided by other teachers in the school.

DC2. I independently and systematically comply with measures that protect personal data, privacy, security, digital rights and well-being when using digital technologies in my teaching activity.

DC3. I specify measures for data protection, privacy, digital rights and security, and collaborate in actions to achieve a positive coexistence when using digital technologies to meet the needs of my school. I identify new risks associated with the use of emerging digital technologies.

Area 2: Digital Content

DC4. I understand the pedagogical, educational and technical criteria (intellectual property, accessibility and suitability to student age and goal achievement) in order to choose quality content and apply efficient strategies for its search and cataloging in digital environments.

DC5. I choose the digital content so that different learning paths can be established, favoring electives, so that all students may achieve the proposed learning objectives.

Area 3. Teaching and learning

Self-directed Learning

DC6. I know and understand how to use digital technologies to improve self-directed learning.

DC7. I analyze different strategies to promote self-directed learning and reflect on their suitability for improving it.

DC8. I transform and develop new strategies and models to integrate digital technologies that improve self-directed learning in teaching practices.

Area 4. Assessment

Assessment strategies

DC9. I design new digital assessment methods in an innovative way, including personalizing the learning process based on students' results.

Analytics and learning evidence

DC10. I transform my teaching practice by using new data analysis and feedback systems.

Area 5. Student empowerment

DC11. I adapt technological accessibility solutions in all educational contexts and teaching-learning situations, allowing all students to be able to participate and progress in the same learning process.

Personalization

DC12. I am familiar with digital resources to detect needs, create personalized learning plans and track their results using ethical and pedagogical criteria.

DC13. I define new functionalities in digital resources and/or use existing ones in new ways to identify needs linked to specific learning objectives, to propose pedagogical strategies that respond to said needs or to follow-up, so that an assessment may be made concerning the learning impact in a variety of educational contexts.

Area 6. Development of students' digital competence

Content Creation

DC14. I am familiar with learning activities, tasks and assessments so that students can creatively adapt and create digital content in different formats.

The following table shows the findings:

Dimension 1: Digital Competence Perception	Pre-SCTAI training (n = 462) (M)	Post-SCTAI training (n = 462) (M)	Standard deviation (σ)	Variance (σ²)	Q1 (25% percentile)	Q3 (75% percentile)
1. I understand and apply the measures established by each Autonomous Community or school owners regarding personal data protection, privacy and the guarantee of digital rights of the entire educational community, with the counsel provided by other teachers in the school.	8	8	1.757	3.087	7	10
2. I independently and systematically comply with measures that protect personal data, privacy, security, digital rights and well-being when using digital technologies in my teaching activity.	9	9	1.414	2.000	8	10
3. I specify measures for data protection, privacy, digital rights and security, and collaborate in actions to achieve a positive coexistence when using digital technologies to meet the needs of my school. I identify new risks associated with the use of emerging digital technologies.	8	8	1.867	3.488	7	9
4. I understand the pedagogical, educational and technical criteria (intellectual property, accessibility and suitability to student age and goal achievement) in order to choose quality content and apply efficient strategies for its search and cataloging in digital environments.	8	8	1.502	2.257	7	9
5. I choose the digital content so that different learning paths can be established, favoring electives, so that all students may achieve the proposed learning objectives.	8	8	1.641	2.695	7	9
6. I know and understand how to use digital technologies to improve self-directed learning.	8	8	1.458	2.126	7	9
7. I analyze different strategies to promote self-directed learning and reflect on their suitability for improving it.	8	8	1.5038	2.261	7	9
8 I transform and develop new strategies and models to integrate digital technologies that improve self-directed learning in teaching practices.	8	8	1.548	2.396	7	9
9. I design new digital assessment methods in an innovative way, including personalizing the learning process based on students' results.	7	7	2.021	4.088	7	9
10. I transform my teaching practice by using new data analysis and feedback systems.	6	7	2.013	4.055	6	8
11. I adapt technological accessibility solutions in all educational contexts and teaching-learning situations, allowing all students to be able to participate and progress in the same learning process.	7	7	1.695	2.875	6	8

12. I am familiar with digital resources to detect needs, create personalized learning plans and track their results using ethical and pedagogical criteria.	7	7	1.944	3.780	6	8
13. I define new functionalities in digital resources and/or use existing ones in new ways to identify needs linked to specific learning objectives, to propose pedagogical strategies that respond to said needs or to follow-up, so that an assessment may be made concerning the learning impact in a variety of educational contexts.	7	7	1.904	3.628	6	8
14. I am familiar with learning activities, tasks and assessments so that students can creatively adapt and create digital content in different formats.	7	8	1.780	3.172	7	9

Table 2. Results of the digital teaching competence analysis

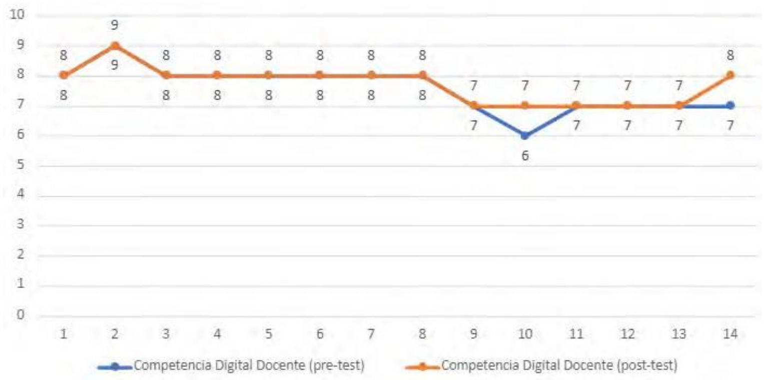
Regarding the results obtained, it is important to highlight the fact that in general, the participants considered that they have a high level of digital teaching competence, especially related to areas like data protection, privacy, security and digital well-being (professional commitment), digital content and teaching and learning. In the initial questionnaire, these areas all received an 8, while learning strategies and development of student digital competence received a 7. The average rating was 7.46.

As indicated in the following table, the data from the final questionnaire that was completed once the program ended shows that there was only a very minimal increase with respect to the following questions:

> I transform my teaching practice by using new data analysis and feedback systems.

> I am familiar with learning activities, tasks and assessments so that students can creatively adapt and create digital content in different formats.

The aforementioned questions show that teachers acknowledge that the training furthered their knowledge to transform their teaching practice based on the use of data and feedback. At the same time, they also value their improvement in their ability to empower their students in order for them to increase their digital competence, reflected in the creative creation of digital content in different formats. In this questionnaire, the average score was 7.66, showing a slight increase by only 0.20 points.



Graph 7. Comparative table–analysis of digital teaching competence

DIMENSION 2:

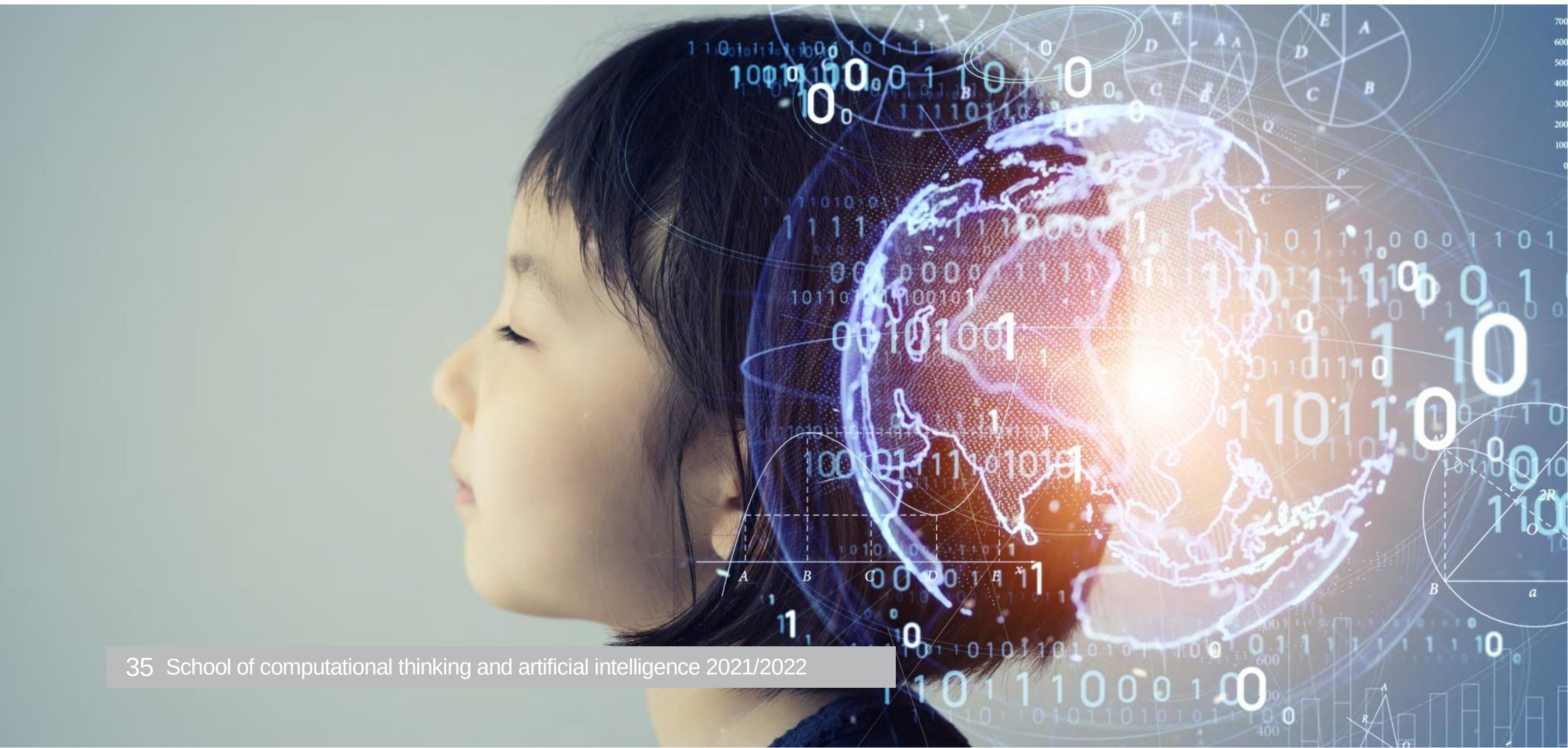
TRAINING PROVIDED BY THE SCHOOL OF COMPUTATIONAL THINKING AND ARTIFICIAL INTELLIGENCE (IV EDITION)

As previously mentioned, participating teachers were able to customize the training, consisting of 5 blocks related to computational thinking and artificial intelligence:

- **Block 1.** Learning based on disconnected computational thinking
- **Block 2.** Learning based on block programming
- **Block 3.** Learning based on programming with Python
- **Block 4.** Robotics
- **Block 5.** Learning based on artificial intelligence

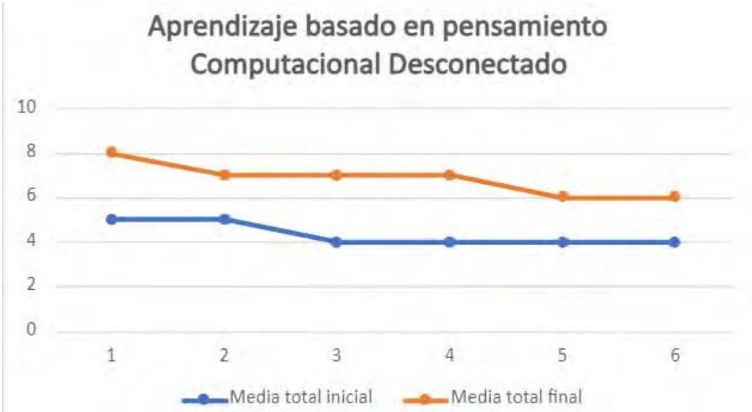
Each block contained the same questions related to each of the learning areas:

- I am familiar with and can identify the methodological principles of learning based on disconnected computational thinking / block programming / Python / robotics / artificial intelligence.
- I am familiar with learning activities so students may apply disconnected computational thinking / block programming / Python / robotics / artificial intelligence.
- I implement learning activities that encourage students to use disconnected computational thinking / block programming / Python / robotics / artificial intelligence.
- My lesson plans include learning activities that encourage the use of disconnected computational thinking / block programming / Python / robotics / artificial intelligence.
- I reflect on and create learning activities that enable students to apply disconnected computational thinking / block programming / Python / robotics / artificial intelligence.
- I research and formulate new learning activities based on programming with disconnected computational thinking / block programming / Python / robotics / artificial intelligence.



The ratings/indicators for each learning area or block (initial and final questionnaire) are as followed:

Block 1. Learning based on disconnected computational thinking



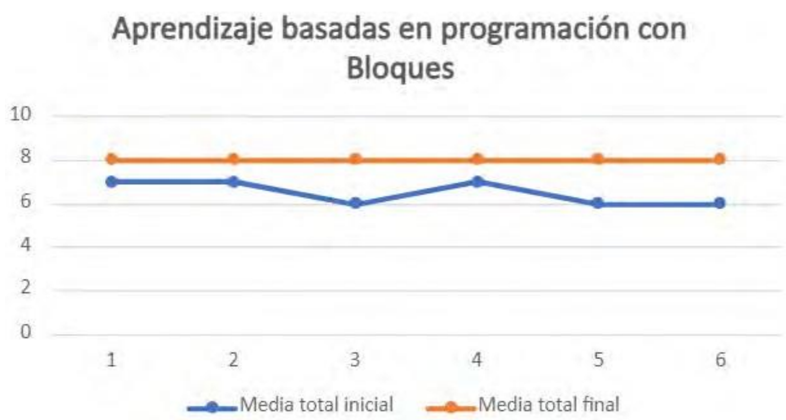
Graph 8. Training rating – Block 1

As can be seen, in this Block, the participants improved by 3 points in terms of the knowledge they acquired related to the following questions:

- I am familiar with and can identify the methodological principles of learning based on disconnected computational thinking. [5<8]
- I implement learning activities that encourage disconnected computational thinking. [4<7]
- My lesson plans include learning activities that encourage the use of disconnected computational thinking. [4<7]

Dimension 2: Disconnected Computational Thinking	Pre-SCTAI training (n = 462) (M)	Post-SCTAI training (n = 462) (M)
1. I am familiar with and can identify the methodological principles of learning based on disconnected computational thinking.	5	8
2. I am familiar with learning activities so students may apply disconnected computational thinking.	5	7
3. I implement learning activities that encourage students to use disconnected computational thinking.	4	7
4. My lesson plans include learning activities that encourage the use of disconnected computational thinking.	4	7
5. I reflect on and create learning activities that enable students to apply disconnected computational thinking.	4	6
6. I research and formulate new learning activities based on programming with disconnected computational thinking.	4	6

Table 3. Training rating – Block 1



Graph 9. Training Rating – Block 2

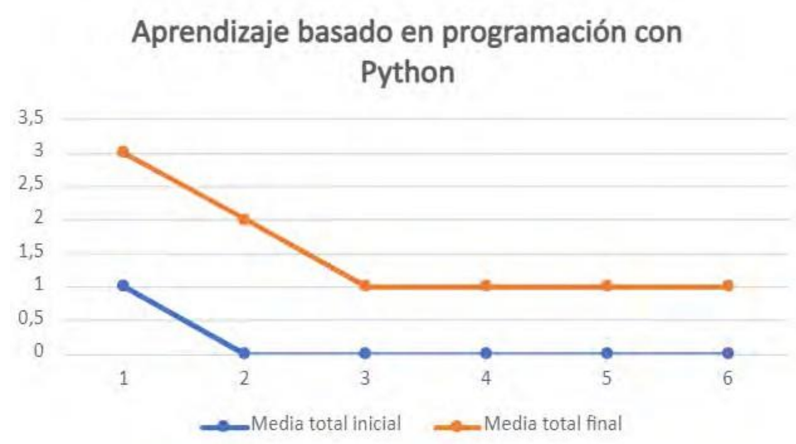
Block 2. Learning based on block programming

As can be seen, in the second Block, the participants improved by 2 points in terms of the knowledge they acquired related to the following questions:

- I implement learning activities that encourage block programming. [6<8]
- I keep in mind and create learning activities to enable students to apply block programming. [6<8]
- I research and formulate new learning activities based on programming with block programming. [6<8]

Block 2: Block Programming	Pre-SCTAI training (n = 462) (M)	Post-SCTAI training (n = 462) (M)
1. I am familiar with and can identify the methodological principles of learning based on block programming.	7	8
2. I am familiar with learning activities so students may apply block programming.	7	8
3. I implement learning activities that encourage students to use block programming.	6	8
4. My lesson plans include learning activities that encourage the use of block programming.	7	8
5. I reflect on and create learning activities that enable students to apply block programming.	6	8
6. I research and formulate new learning activities based on programming with block programming.	6	8

Table 4. Training Rating – Block 2



Graph 10. Training Rating – Block 3

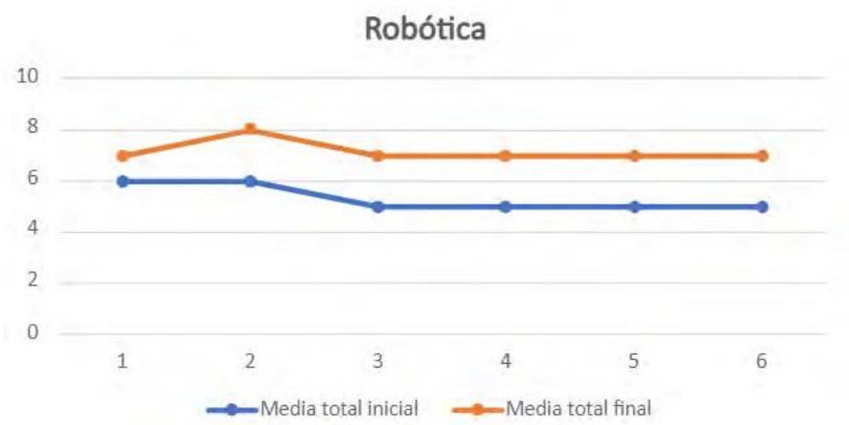
Block 3. Learning based on programming with Python

In the third Block dedicated to programming with Python, the participants improved by 2 points in terms of the knowledge they acquired related to the following questions: (it should be noted that in this block, the pre-training indicator was very low - 0 or 1 - while in other blocks, the pre-training indicator was 6 or 7).

- I am familiar with and can identify the methodological principles of learning based on Python programming. [1<3]
- I am familiar with learning activities so students may apply Python programming. [0<2]

Block 3. Programming with Python	Pre-SCTAI training (n = 462) (M)	Post-SCTAI training (n = 462) (M)
1. I am familiar with and can identify the methodological principles of learning based on Python programming	1	3
2. I am familiar with learning activities so students may apply Python programming.	0	2
3. I implement learning activities that encourage students to use Python programming.	0	1
4. My lesson plans include learning activities that encourage the use of Python programming.	0	1
5. I reflect on and create learning activities that enable students to apply Python programming.	0	1
6. I research and formulate new learning activities based on programming with Python.	0	1

Table 5. Training Rating – Block 3



Graph 11. Training Rating – Block 3

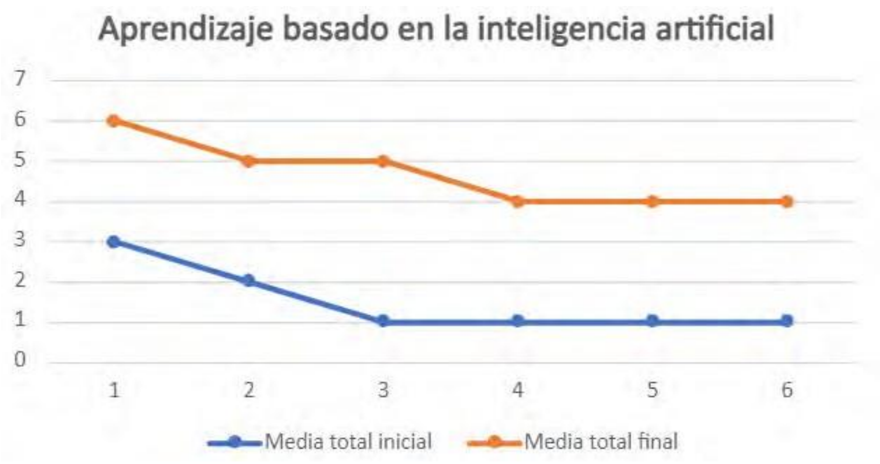
Block 4. Robotics

As can be seen, in this Block, the participants improved by 2 points in terms of the knowledge they acquired related to the following questions:

- I am familiar with and can identify the methodological principles of learning based on robotics. [6<7]
- I reflect on and create learning activities that enable students to apply robotics. [5<7]

Block 4. Robotics	Pre-SCTAI training (n = 462) (M)	Post-SCTAI training (n = 462) (M)
1. I am familiar with and can identify the methodological principles of learning based on robotics.	6	7
2. I am familiar with learning activities so students may apply robotics.	6	8
3. I implement learning activities that encourage students to use robotics.	5	7
4. My lesson plans include learning activities that encourage the use of robotics.		
5. I reflect on and create learning activities that enable students to apply robotics.	5	7
6. I research and formulate new learning activities based on robotics	5	7

Table 6. Training Rating – Block 4



Graph 12. Training Rating – Block 5

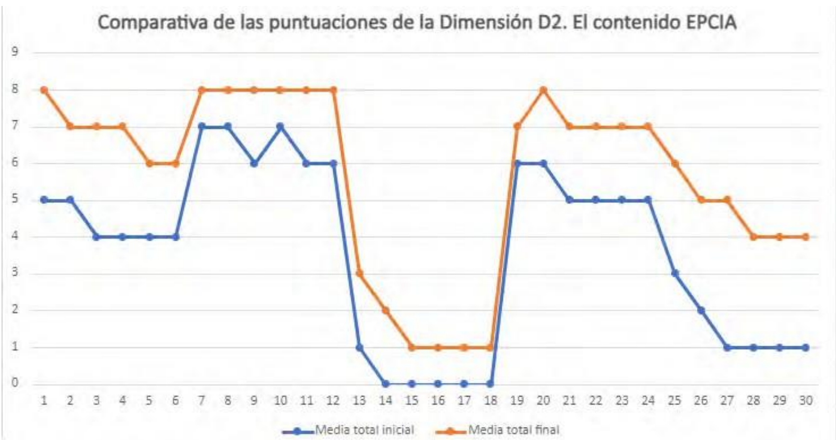
Block 5. Learning based on artificial intelligence

In the fifth Block, dedicated to learning based on artificial intelligence, the participants improved by 3 or 4 points in terms of the knowledge they acquired related to the following questions:

- I implement learning activities that encourage students to use artificial intelligence. [1<5]
- I reflect on and create learning activities that enable students to apply artificial intelligence. [1<4]

Block 5. Artificial Intelligence	Pre-SCTAI training (n = 462) (M)	Post-SCTAI training (n = 462) (M)
1. I am familiar with and can identify the methodological principles of learning based on artificial intelligence..	3	6
2. I am familiar with learning activities so students may apply artificial intelligence.	2	5
3. I implement learning activities that encourage students to use artificial intelligence.	1	5
4. My lesson plans include learning activities that encourage the use of artificial intelligence.	1	4
5. I reflect on and create learning activities that enable students to apply artificial intelligence.	1	4
6. I research and formulate new learning activities based on artificial intelligence.	1	4

Table 7. Training Rating – Block 5



Graph 13. Comparison of Training Ratings according to each Block

COMPARISONS OF TRAINING BLOCKS

If we make a comparison of the different blocks and the initial and final participant assessment of the results obtained, we can observe an improvement in each and every one of the blocks. Training Block 3, learning based on Python programming, was the block in which the participants started out with the least knowledge and in which the least improvement was made (0-1 points). In Block 1, learning based on disconnected computational thinking, scores improved by 3 points. In Block 2, learning based on block programming, there was an improvement of 1-2 points, although the initial indicator was 6 or 7. In Block 4, dedicated to robotics, the teachers showed an improvement of 2 points and, finally, in Block 5, learning based on artificial intelligence, a more substantial improvement of up to 3-4 points was evident, although the teachers started out with little knowledge. It should be noted that the questions with the highest improvement were clearly when the different blocks were applied in the classroom, as well as in educational programming. This means that the activities are not seen as isolated, but rather as having a continuum within the educational sequence of the subject.

DIMENSION 3:

TRAINING EXPECTATIONS

The third dimension aimed at analyzing the responses related to expectations of the program. On one hand, the questions were related to how much was learned after having participated in the different training phases of the 4th EPCIA (for the 2021-22 school year) and, on the other, the potential to transform the teaching practice by adding strategies and methodologies that facilitate the development of computational thinking and artificial intelligence, both in teachers and students. The following points were assessed:

1. I think I have learned new things for myself at the School of Computational Thinking and Artificial Intelligence (SCTAI).
2. At the SCTAI, I feel like I have learned different teaching methods and techniques that will help me innovate in my teaching practice.
3. I think I can come up with educational proposals based on the knowledge I have acquired at the SCTAI.
4. I think that I will be able to apply the educational proposal that I came up with thanks to what I have learned at the SCTAI.
5. I believe I will be supported by school leaders and policy makers when it comes to implementing what I have learned at the SCTAI.
6. I believe that I will have the necessary tangible resources at my place of work to implement the project that I have developed at the SCTAI.
7. I believe that my project will be positively welcomed by the students.
8. I believe that my project will have a positive impact on my students' learning.
9. I have shared knowledge and experiences with experts at the SCTAI.
10. I have shared knowledge and experiences with other co-workers at the SCTAI.
11. I believe that I have learned in a practical and dynamic way at the SCTAI.
12. Participating in the SCTAI has given me greater professional satisfaction.
13. I think that participating in the SCTAI has given me professional recognition.
14. I believe that I have benefitted professionally from my participation in the SCTAI.
15. I feel that my expectations regarding the SCTAI have been met.

TRAINING DROPOUT QUESTIONNAIRE

Training Expectations

As previously indicated, a total of 220 teachers dropped out of the program during its first phase. INTEF requested that a questionnaire be sent to the participants and the following information was obtained from the 71 responses:

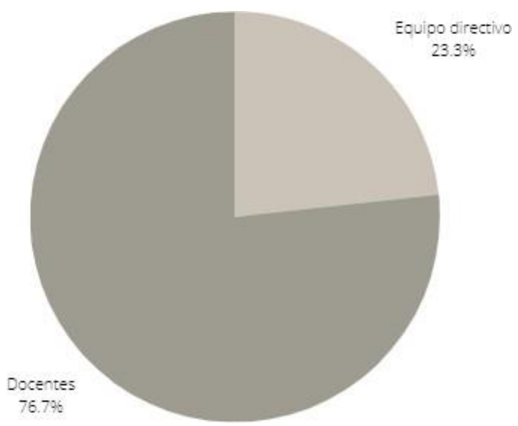
Figure 3. Breakdown of the participants by gender

Biodata

51.7% of the teachers who completed the questionnaire were men and 48.3% were women. 78% of the teachers who dropped out of the program teach at the following educational levels: Junior High School, High School, and Intermediate and Advanced Vocational Training. The remaining 21.6% are Early Childhood and Primary educators.

Graph 14. Distribution of participants by the educational level that they teach

76.7% are not school leaders. The remaining 23.3% are.



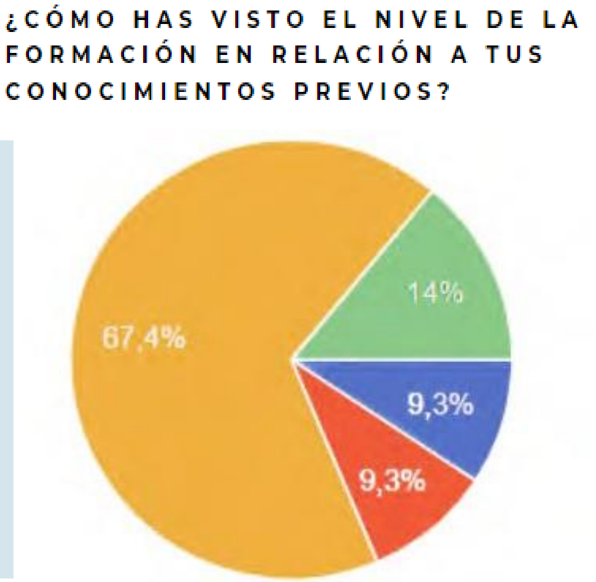
Graph 15. School leader participation in the 2021-22 SCTAI

Regarding the reasons for dropping out of the training, 61% of the teaching staff dropped out of the program during the training, while 21% never even started.

In terms of more specific reasons, the level of training compared to their previous knowledge does not seem to be a cause of dropout, since 73% of the participants indicated that the level taught was appropriate, 8.1% found it too easy, and only 18.9% found it to be too difficult or excessive.

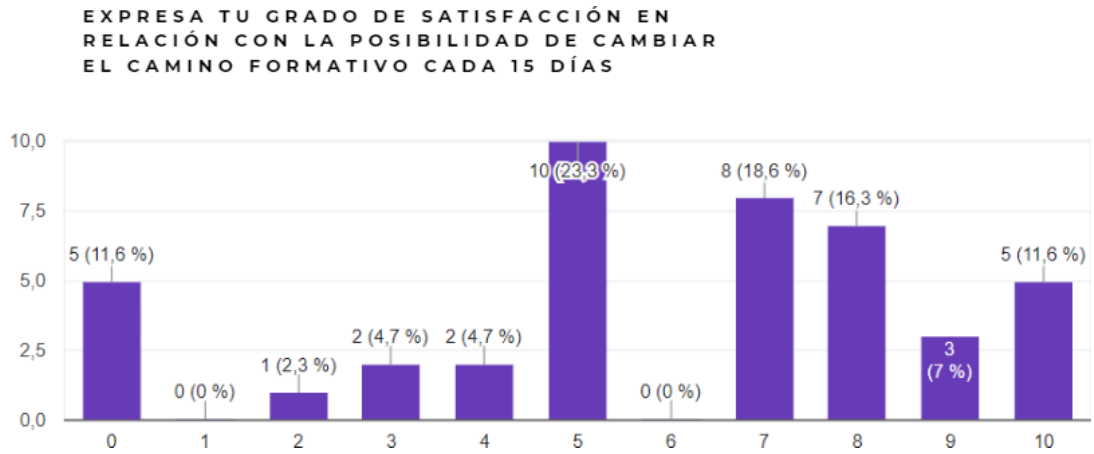
Therefore, other dropout reasons such as the following could be taken into account:

- Lack of time (23.3%)
- Lack of basic knowledge (11.6%)
- Excessively basic course content (2.3%)
- Unacceptable or poorly organized design (16.3%)
- Impossibility to complete the course (2.3%)
- Difficult interaction (11.6%)
- Personal circumstances (60.5%)



Graph 16. Level of training compared to the participants' previous knowledge

One of the positive aspects of the training is the program's flexibility when choosing the learning paths, as shown in the graph below:



Graph 17. Level of satisfaction related to learning path flexibility

IN-DEPTH INTERVIEWS

A total of 9 teachers participated in in-depth interviews that were carried out in person. These teachers had participated in both the training phase and the implementation phase of the program. Their schools were selected as having implemented good practice, and during the research team's visits, 45-minute in-depth interviews were carried out.

Below, the results obtained from the teacher (T) interviews can be found. These results are related to the study's objectives, especially according to teachers' perceptions in terms of the training content, as well as how they think it will affect their teaching practice.

The training: content and limitations

Regarding the reasons for dropping out of the training, 61% of the teachers dropped out of the program during the training, while 21% never even started. In terms of more specific reasons, the level of training compared to their previous knowledge does not seem to be a cause of dropout, since 73% of the participants indicated that the level taught was appropriate, 8.1% found it too easy, and only 18.9% found it too difficult or excessive.

First of all, it is worth highlighting how positively the interviewed teachers assessed the training received in terms of learning and content quality. The participants valued the support received and they have been able to reflect on the potential of computational thinking and its inclusion in the teaching and learning process. On the other hand, it was stressed that some curricular areas related to computational thinking were focused on, when they are often otherwise not featured.

T4 “Computational thinking helps you clarify ideas, directly set objectives and establish the most appropriate way to achieve them, regardless of whether you are trying to solve a math problem, teaching language arts or programming a robot.”

T3 “We have been exploring new things like data analysis, statistics and simulations. It may be intense, but this type of training has opened our eyes to many more possibilities.”

T9 “I started the training program because I wanted to start in the first year of Junior High School and I was interested in Python, which is more flexible. Regarding the contents, the training includes two aspects that interested me: statistical analysis and working with functions. My idea was to be able to work with my students on logarithms and scatter diagrams - parts of the curriculum that we often ignore.”

T8 “I found the materials useful. Except for the time spent, it has not been an excessive burden for me.”

The participants were positively surprised at the enormous potential that computational thinking and artificial intelligence can have in the classroom, the inclusion of the projects in different curricular areas and the peer collaboration that was forged:

T4 “Throughout the training, we combined science with other subjects, although my proposal was binary code with computers. We worked on contents related to mathematics, language, relating numbers and letters, as well as arts. It was very enriching.”

T5 “In the area of social sciences, it has helped me to work cooperatively and to carry out team projects."

Finally, the possibility to use the materials that were worked on during the training period in the classroom was one of the participating teachers’ main achievements:

T2: “It took us a long time to learn and prepare the materials, but it’s clear that we are going to use them in the future."

In terms of the limitations of the training, throughout the interviews there was a common feeling that the participants lacked time, as well as the possibility to self-regulate their own learning pace, which, in fact, was something acquired as the course progressed:

T6 “I have the feeling that everything is going really fast and being done very fast. I wish I had more time."

T7 “The deadlines are difficult to meet, but since we’re doing do so many things…”

T9 “A lot could be improved. At the beginning, it was very difficult for me to know how long it was going to take me to finish things, but then you start to see that you can do it.”

Opinions were gathered as to the difficulty of working on the contents in a non-isolated manner, which is to say, when links were established with other curricular areas:

T2 “It is difficult for me to work on computational thinking itself, and even more difficult to link it with the curricular content, but my colleagues have helped me.”

Teaching practice: methodological change and impact in the classroom

Regarding a methodological change, the participating teachers highlight an impact on the methodological change generated by the training received, as well as the transformative potential of computational thinking and artificial intelligence. Obviously, not only does this transformation affect the teaching process, but it also has a strong impact on the student learning process:

T2 “I have challenged myself to do things that I had put on hold for a long time. We generally work with textbook problems, but this type of work requires different solutions like real-life situations, which poses many challenges and has a positive student impact, leading them to use computational thinking as a tool.”

T3 “The students’ digital competence has improved a lot, as they are pushed to work together and develop products that integrate different digital tools. In fact, this is even more important than computational thinking itself, which, in the end, is just an excuse. It is all highly motivating and they are working on a lot of different things.”

T4 “In terms of assessment, they are the ones who sometimes clue you in. There are times when you don’t realize something, but they are able to detect it."

T6 “The training’s impact and implementation process is very evident in the students. Through the different tools used throughout the study, teachers repeatedly mention how the project has affected their students in terms of learning, increased motivation and self-esteem, as well as in terms of classroom participation.”

T14 “Regarding the achievement of learning objectives, they’re soaking up the social science content like sponges. They have learned a great deal.”

T9 “Without realizing it, with computational thinking, I was working with students who often have disruptive behaviors and attitudes in the classroom. With these more practical activities, they are more motivated and participative.”

Furthermore, this is an area with a wide variety of applications in our daily lives. The need to be aware of this potential was also pointed out by teachers:

T11 “Computational thinking helps them organize their whole life; all their knowledge, thoughts and feelings. It helps them channel the importance of things, to know how to separate what is essential from the rest.”

Finally, both teachers and tutors have highlighted the transversality of computational thinking, agreeing on the need to include computational thinking in all areas and educational levels. This introduction could start as soon as in Early Childhood Education or Primary School:

T2 “Computational thinking can be applied in all areas. If this content were introduced during Early Childhood Education, students would be excellent programmers by the time they reach High School.”

T22 “One of the problems related to computational thinking and AI is that in order to be applied, they must be used for isolated activities. This would make sense since the general consensus seems to be to start from a very young age (as soon as Kindergarten). However, if you start using it in the sixth grade, the activities are disconnected and more complex and worked on in a more isolated way.”

FOCUS GROUPS

Throughout the study, 4 focus groups were carried out aimed at gathering information related to the study’s objectives. Three groups of interest were addressed: (i) teachers who had participated in the training and the implementation phases, (ii) tutors who carried out the training and later accompanied the participants during the implementation phase of the projects, (iii) policy makers and technical officers from INTEF and public administrators who are versed in educational technology and responsible for drawing up policies based on evidence. A total of 27 people participated in the focus groups: 16 teachers, 8 tutors and 3 representatives of the educational administration. The sessions lasted one hour.

The focus groups were carried out virtually and, with the exception of the administrative representatives, all participants were randomly selected based on territorial and teacher distribution in all educational levels. The three groups were asked the same questions related to the study objectives, in order to obtain information from the different perspectives of teachers (T) and tutors (TT) regarding the content of the training received, as well as the perceived impact on their teaching practice. The tutors and representatives of the educational administration (R) were also asked about the possible participant dropout causes during the first phase of the training.

The following main results were obtained related to the following areas:

1. Training: content, limitations and dropout causes
2. Teaching practice: methodological change and impact in the classroom

Training: content, limitations and dropout causes

Content

The teachers participating in the focus group expressed their satisfaction regarding the course content and valued the support of the tutors throughout the training, as well as the implementation period of the project. They also stressed teacher collaboration when sharing knowledge:

T10 “Regarding the course content, I think that everything was quite good. Everything that is usually taught in computational thinking was covered and the tasks were relatable to the theory."

T7 “The experience was very satisfactory and it is very satisfying to see how colleagues with limited knowledge appreciate the support and collaboration from other colleagues who know more."

TT5 “With artificial intelligence, online resources can be used to complete the tasks and they really liked to see examples. I showed them an online tool that used artificial intelligence models to obtain information from a photo and they were amazed because they had no idea. It was a breakthrough for them because the tasks require a lot of effort, but it makes them think and get a lot of ideas.”

T17 “The material has been useful for me, because of all the examples. It went very well. It was more difficult for me to plan the educational proposal but my tutor helped me a lot. I was then able to move forward and understand what the students had to do. The tutor’s guidance helped me continue advancing.”

T12 “The mistake I made is that I liked so many activities from what we saw in the course that in the end I couldn't do them all in the time allotted. I was able to do 7 computational thinking activities."

Limitations

In terms of the training’s limitations, some teachers found the materials too complex, especially those who had no prior knowledge of the topic. The tutors highlighted the need to organize the modules in a scaled manner:

T7 “In the case of computer scientists, it was easy, but there was a lack of guidance. The forums were on fire. I think the materials were OK and I was encouraged to try something different thanks to the forums. The modules could be done well and they included a solid starting point.”

T14 “It might be a good idea to set up some type of ladder for computational thinking so it is clear what content and what knowledge we must have before going up to the next step. There is no point in starting with artificial intelligence if we don't know what a list is.”

Both tutors and teachers pointed out the difficulty and complexity of some of the courses, as well as the lack of resources that would make it easier to apply them in the classroom during the training, especially at the Primary School level. It was also stated on several occasions that some of the teaching staff demanded specific answers to specific problems without addressing a real and methodological change:

T12 “The AI courses were geared toward university levels and little was said about classroom methodology or implementation. Solutionism was sought and if we fall into that, everything we are doing will make no sense; we won’t achieve anything with that type of methodology. Scaled activities with well-founded bases should be proposed before moving on to more difficult challenges. We must make it clear that we won’t be going anywhere with just the answers.”

TT4 “In the end, with the more simple activities at the beginning, you can see an impact very quickly. When the content starts to get more complicated, you have to work much harder. People appreciated being guided by photos of the programming. The most complicated thing was how hard it was to find the answers: they wanted everything very detailed and easy to understand.”

T21 “In my case, I wanted to work with Siri, Cortana and things that 2nd Grade students have at home. With my 3rd graders, I decided to make video games. The information and the video tutorials were useful and the students found it very appealing. I feel like it was very geared towards High School and Junior High, but it can be reduced for Primary School levels.”

Finally, there is also a demand for more training related to computational thinking and artificial intelligence in the current curricula:

T16 “Another aspect that I would have liked to have seen both this year and last year is for the course to be more linked to prevailing regulations. In the Amendment of the new Spanish Education Law (‘LOMLOE’ in Spanish), content related to computational thinking is finally starting to appear in mathematics and natural and social sciences, and although there was some framework in the course, teachers need more examples and formal and regulatory aspects. This should be taken it into account for the future.”

Teachers’ involvement in the training was key. When the teaching staff was not involved, there was an impact in the classroom. Finally, COVID also left an obvious, albeit tangential, mark in terms of training impacts that we felt was important to mention:

TT5 “Students were not as prepared after COVID, making class work difficult. Also, there were teachers who were very focused on doing their jobs better, while others, not so much.”

Dropout

Regarding possible dropout causes, both tutors and teachers agree on the need to start this kind of training through the basic blocks, especially when there is no or very little prior knowledge:

TT2 “It is essential that all courses begin with the basics. Dropouts in these types of courses are usually due to the fact that the teacher doesn’t understand or hasn’t been informed well at the start of the course.”

Among the dropout reasons, we must also highlight teachers’ professional instability these days, the lack of knowledge when deciding on learning paths and the lack of school material:

TT5 “The situation has generated many changes in the workforce. People have lost their jobs because they were considered “a COVID position”, while others aren’t able to cope or haven’t chosen the correct path and have found themselves on a dead-end road since training is not always enough. Many others have given up due to the lack of material. There has been a shortage of motherboards and people aren’t able to obtain them and are therefore unable to implement what they have learned. Even though solutions have been sought, it has been almost impossible.”

TEACHING PRACTICE: METHODOLOGICAL CHANGE AND IMPACT IN THE CLASSROOM

Methodological change

As per the aforementioned in the in-depth interviews, the participating teachers stress the methodological change that the training has generated, as well as the transformative potential of computational thinking and artificial intelligence. Obviously, this transformation affects and impacts not only the teaching process, but also the students' learning process. The tutors also share this point of view and have pointed out different aspects that complement the teachers' views, from a standpoint of tutelage and support. The tutors' vision is very interesting and completely backed up by the teachers:

TT6 "The most important part for me is a methodological change. We should make an effort to raise awareness. This change is necessary to include computational thinking, robotics or artificial intelligence, because if we continue giving instructions like we did before or like our teachers gave us, there will be no change. There will simply be a trend, and the educational system is not going to be impregnated with what computational thinking is, leading to a loss in digital literacy."

TT2 "If we can't introduce active methodologies, give the students the lead and make everything more dynamic with computational thinking, AI or robotics activities will be almost impossible. As mentors, it's our job to do these things. Without a methodological change, we will simply be instructing."

TT4 "In Primary school, the project is what's important and its implementation is related to curricular content. In Secondary school, it's a little more complicated to change. Those who do the activity as a trial or experiment are left with something imply analytical. They lack emotion. In the end, in the final assessments, you can see who implements the project with or without emotion."

T4 "As a strategy, I usually give them a lot of freedom. I try to group them so that there is always someone who knows a little more about programming."

T12 "I let them work in pairs or balanced groups of 4, allowing students who have more work to be able to participate also. I would highlight that they help each other a lot."

T1 "We started out the proposals as a challenge to motivate them and they then work individually so that each one can do and contribute. Then, they work together. Students develop digital competence and learn how to learn."

As previously mentioned, both teachers and tutors highlight the improvement in students' skills as a result of the training's impact. This impact affects the way students learn, the organization of educational processes and the organization of the classes:

T13 "Students have improved their learning because the content is very motivating for them. When you're done, you talk to them about how information is stored in computers or how printers are able to understand information that you send them, etc... I think that it is very functional knowledge, which is more interesting for them and they are able to understand that it is something useful and from their world so they understand that it is important. This was even the case for students with learning difficulties."

T4 "This content can be closely linked to real life, which is much more motivating for children. You can create a code to communicate using numbers and letters and so on, and the fact that it is relatable to their lives, makes it much more interesting. If you don't include it in your teaching for a week, they ask you for it. I feel like they are really interested."

T13 "I think that if they are acquiring new programming language skills, it's too much at once."

T9 "The computational thinking activities help me work on self-esteem and to see how they work with each other."

The way that diversity is dealt with in the classroom is also transformed when including computational thinking activities:

T3 "Children with special educational needs who normally go unnoticed during these activities feel more involved in classroom activities."

Some of them even undergo a change in their habitual learning pace:

T7 "Students with reading-writing difficulties have worked together with other children. Students with learning difficulties, who were generally slower, have stood out and worked very quickly with computers. I have been pleasantly surprised and we have come across a gold mine that can be used to develop their abilities. The experience has been positive and satisfactory."

Student interest generated by classroom work on computational thinking and artificial intelligence is extremely relevant, especially when it comes to female students.

T15 "There was one particular female student's interest in working with programming languages that caught my attention."

T2 "It is important to encourage girls to be interested in programming. This year, girls are the most interested in programming. It's great."

T24 "With a female Ukrainian student, I quickly realized that language was not an issue. I usually communicate with her in English and she is a very good student, but after only two sessions with her, she automatically understood everything because of the numbers. Ultimately, I think that logical thinking, reasoning and insisting on the task are all that children really need. These types of activities are very useful for them."

The tutors also insist on how much learning has improved for both students and teachers. Not only does both student and teacher satisfaction stand out, but also their improved digital competence based on evidence:

TT3 “Digital teaching competence has definitely improved. Most teachers have decided to continue and acquire more resources so they can share their experience with their colleagues. They have seen that it can improve their teaching. One piece of evidence is that the implementation phase usually lasted longer than what was scheduled, which I think is interesting and demonstrates that it worked.”

TT7 “Another piece of evidence was what students told their participating teachers. The students are delighted. They come to class in a good mood and are enthusiastic. As a teacher, I think that this is so gratifying and helps to remind yourself to keep going. For me, that is important evidence.”

TT3 “If teachers want to make learning meaningful and at the same time respond to the needs of their students, in the end, this works. Plus, the feedback from the participants is positive. If they do the activities as planned and it goes well, it can be very rewarding.”

TT5 “What’s really interesting is that unknowingly, many more areas than we imagined at first have been developed. Clearly, these new dimensions have improved the new Digital Teaching Competence framework, and compared to the previous framework’s limitations, the new one offers more opportunities for improvement.”

TT1. “For me, the simple fact that a teacher wants to participate in training like this and that they finish it is a great advance. In my community, teacher training courses have already begun and I have completed 15 programming projects, which means that we are on the right track. This is all going to be a big change for the students; it’s more motivating and increases their desire to continue learning. In the end, what we are looking for is that the students increase their eagerness to learn and that what they learn will be useful for them.”

KEYS FOR THE FUTURE – ADMINISTRATIVE CHALLENGES WHEN DEALING WITH ARTIFICIAL INTELLIGENCE

The representatives of the educational administration who participated in the focus group stressed how important computational thinking will be in the future, as well as some major challenges that educational administrations will have to address. Regarding the implementation of computational thinking and artificial intelligence in education, they highlighted some interesting aspects:

R1 "It's a whole new world. What application can we obtain from artificial intelligence? We are facing enormous possibilities: an improvement in the learning process and the management of a huge amount of data that can help us to anticipate and personalize learning…"

R3 "It will be very important that both students and teachers know what artificial intelligence is and what it can be used for. After all, they already carry it around in their pockets: there's AI behind searching the internet, and sometimes they don't understand why ads pop up afterwards…"

Discussion also arose about the current situation in which educational administrations have found themselves regarding this field of knowledge and the main challenges they are facing, especially related to the processing and management of data and the educational value of AI.

R2 "The educational administrations are a little behind the times. We have few resources and little time to explore these possibilities."

R1 "The issue of data management for minors is very important. What will it be like? Will it be anonymous? It is becoming more and more crucial, especially with an increasing number of interconnected platforms… Anonymization will be a concern - and not only for education."

R1 "Everything that has to do with data is very interesting, even when thinking about citizenship, democracy, human rights... not only in terms of education. Everything must be linked and done correctly (by those responsible)."

Once again, the role of teachers demonstrates its transformative potential:

R2 "The role of teachers is very important. If teachers don't add value… It is essential to reflect on the true educational value of what we want to do with artificial intelligence in education: How will the data be used? How will we protect our students' identities?"

School of computational thinking and artificial intelligence 2021/2022

An assessment of the fourth School of Computational Thinking and Artificial Intelligence program led to a breakdown of its achievements, the possibility of customizing learning paths, an increase in the completion rate compared to previous years and the possibility of transferring the program to the autonomous communities for its subsequent deployment and monitoring:

R3 “The training was mainly focused on making sure each teacher could personalize their own learning path. In spite of the limitations at hand, we have been able to respond to this challenge. Organizing this type of ad-hoc training is a big effort on our part, due to the necessity of human resources and some developments in the platform in order to automate the processes.”

R2 “The completion rate is more positive than last year, which means that personalizing the course motivates you to finish.”

R1 “The aim is for each autonomous community to deploy this experimental project. Schools have been a source of good practices throughout these years. The associated research enables the findings to be supported, while promoting good practices. This is one of the very few studies on artificial intelligence in education that exists.”

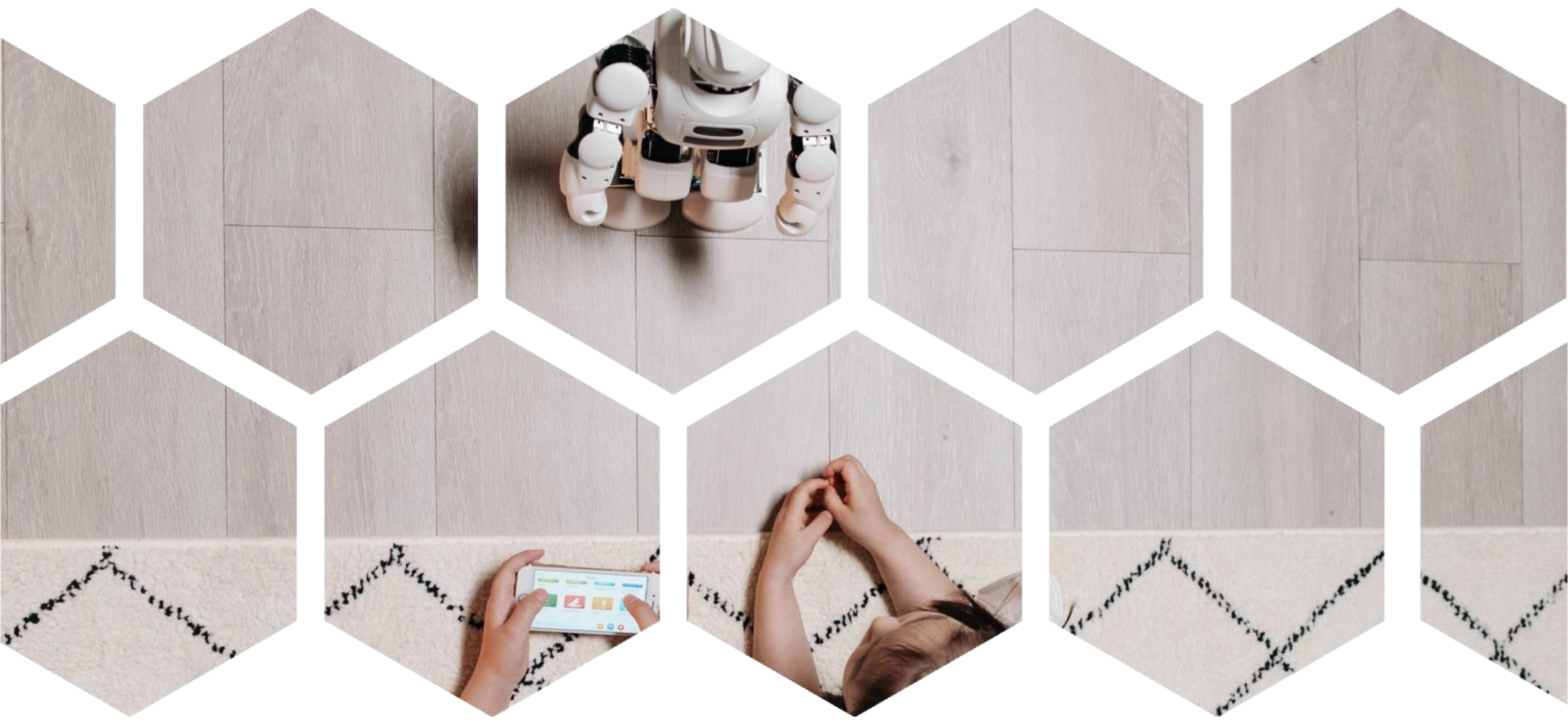
CONCLUSIONS AND KEY TAKEAWAYS

5.1. PERSONALIZATION AND SUPPORT, KEY TO PROFESSIONAL DEVELOPMENT FOR TEACHERS

5.2. TRAINING IN COMPUTATIONAL THINKING AND ARTIFICIAL INTELLIGENCE, KEY TO A TRANSFORMATION IN EDUCATION

5.3. IMPROVED SKILLS AND ITS IMPACT ON TEACHING

5.4. THE IMPACT OF COMPUTATIONAL THINKING AND ARTIFICIAL INTELLIGENCE ON EDUCATION



5.1. PERSONALIZATION AND SUPPORT, KEY TO PROFESSIONAL DEVELOPMENT FOR TEACHERS

In the first place, it is important to emphasize how highly the participants and tutors have assessed the training. Not only was the learning acquisition assessed positively, but also the quality of the content. The training has encouraged teachers to reflect on the transformative potential of computational thinking and artificial intelligence, and how to include them in the teaching and learning process.

The support offered by the tutors during the training was another highlight of the study. Given the ambitious nature of the program, the tutoring was very helpful for teachers who lacked previous knowledge. In addition, the collaboration and support provided by the most experienced colleagues during the course was appreciated.

The participants found the possibility to customize their learning paths to be very positive so they could establish bridges between the formative offer and the needs and interests of the teaching staff depending on their areas of knowledge, educational level and prior knowledge.

Finally, in terms of how well the fourth edition of the School of Computational Thinking and Artificial Intelligence was received by the educational administration, many points stood out, including this year's achievements, the participants' possibility to personalize their learning paths, the higher rate of completion compared to previous years, and the program's subsequent deployment and monitoring to the autonomous communities.

5.2. TRAINING IN COMPUTATIONAL THINKING AND ARTIFICIAL INTELLIGENCE, KEY TO A TRANSFORMATION IN EDUCATION

All those who participated in the study (teachers, tutors and representatives of educational administrations) highlighted the enormous potential of working on computational thinking and artificial intelligence using the design and implementation taught in classroom training and projects applied to different curricular areas. It should be noted that the training blocks linked specifically to disconnected computational thinking and artificial intelligence are the blocks in which the improvement was the greatest, while there was less improvement in the modules dedicated to block programming or robotics. Finally, regarding educational programming, the teachers thought it was positive that the activities were not seen as something isolated, but rather as a continuum within the didactic sequence of the subject at hand.

In terms of improving skills and competences, the teaching staff acknowledges an increase in their digital teaching competence, especially related to computational thinking, but also in terms of data protection, privacy, security and digital well-being (professional commitment), digital content and teaching and learning. Improvement was also noted in areas related to assessment strategies, the development of students' digital competence and the analytics and evidence of learning.

Teachers also stated that they received training on the ability to transform their teaching practice using data and feedback. Additionally, they value their newly-acquired knowledge to better empower their students and help them improve their computational thinking strategies and digital competence; a competence reflected in the creative creation of digital content in different formats.

Regarding the training’s limitations, some teachers found the materials to be too complex, especially those who had no prior basic knowledge of the subject at hand. The tutors, on the other hand, highlighted the need to organize the modules in a scaled and organized way, stating that there was a huge difference between untrained teachers and teachers who already possessed a solid knowledge base or were trained in computer sciences or engineering.

Both tutors and teachers pointed out the difficulty and complexity of some of the modules, especially those related to Python programming, for example. At times, this was attributed to the lack of instructions during the course that could have helped implement the training in the classroom, especially with Primary School levels or the impending computational thinking curricula. One of the minor pieces of criticism that often came from tutors was the fact that some of the participating teachers demanded specific solutions to specific problems without addressing a real and methodological change.

5.3. IMPROVED SKILLS AND ITS IMPACT ON TEACHING

One of the greatest contributions of this study concerns how training can impact the teaching practice. Both the tutors and the participating teachers agree on the methodological change that this training has generated, as well as the transformative potential of meaningfully introducing activities in the teaching practice related to the development of computational thinking and the move towards artificial intelligence.

Obviously, this transformation affects and strongly impacts the teaching process, as well as the learning process of students. The tutors also share this sentiment and point out how much unsolicited feedback they have received regarding the academic performance, attitude, participation and motivation of the participating students and teachers, which they believe to be extremely positive. One teacher pointed out an anecdote with a Ukrainian student who only spoke English, but was able to understand and carry out the activities satisfactorily, using only the “language of numbers”.

Additionally, both teachers and tutors have highlighted the improvement in students' skills and competences resulting from the training, not only affecting the way students learn and the organization of educational processes, but also forcing teachers to rethink their future teaching praxis.

In terms of any methodological changes, the participating teachers insist on the impact of the training received in terms of educational programming. They suggest that proposals with examples be included in future editions, as well as a close examination of the new curricula and the approach to acquire competences based on computational thinking and artificial intelligence.

As far as students are concerned, it is believed that they have improved their learning skills, especially in terms of digital skills and learning how to learn. Teachers have made some very interesting statements regarding a perceived improvement in classroom attitudes, increased motivation and interest, and above all, a growing interest of female students in the proposed activities. These findings suggest that there should be more activities directly aimed at female students in order to promote future STEM vocations. Regarding diversity, many teachers have highlighted that students with special needs have shown more interest and speed in carrying out these activities and when working with computers. This fact has contributed to cohesive class groups and has enabled an important reorganization of dynamics and methodologies.

5.4. THE IMPACT OF COMPUTATIONAL THINKING AND ARTIFICIAL INTELLIGENCE ON EDUCATION

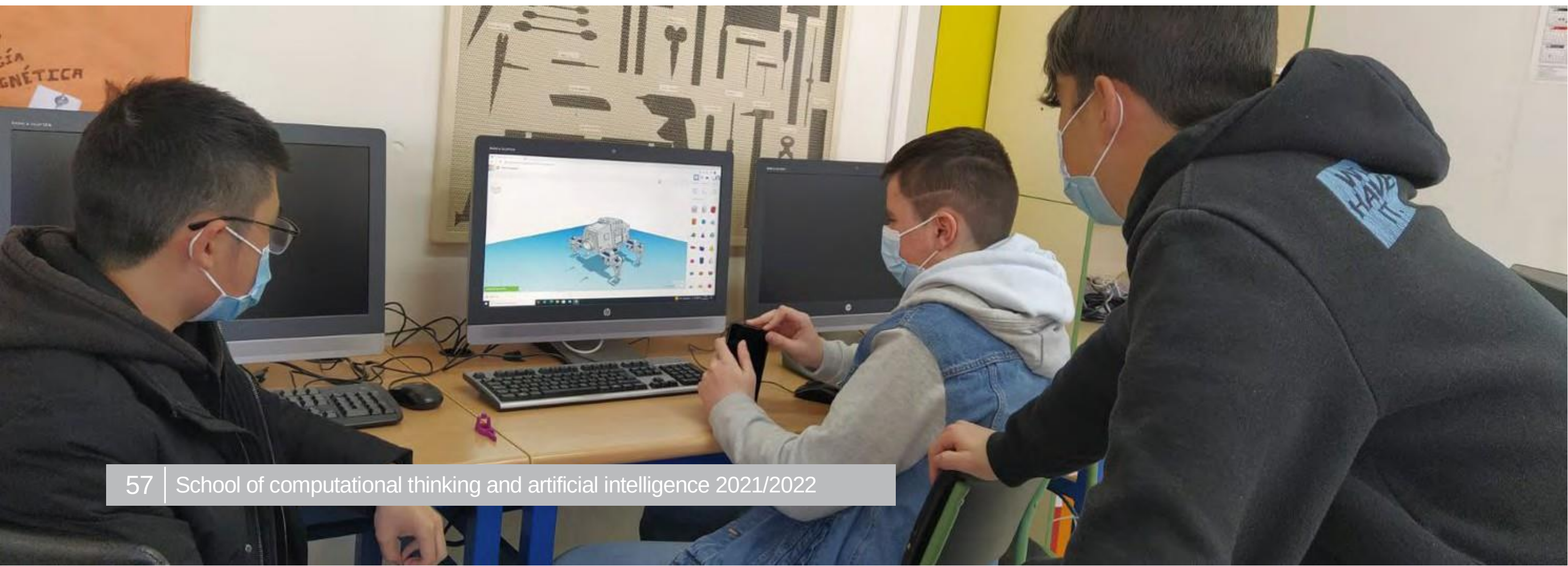
Until recently, the repercussions of the School of Computational Thinking and Artificial Intelligence training on teachers and students and the tutors' perceptions have been analyzed, however, other outcomes, including the impact on schools, have not been addressed. Therefore, the participating teachers have shared what they've learned with the teaching staff and school leaders of their respective schools, engaging other colleagues to collaborate and carry out projects together in mixed educational levels, groups and areas of expertise.

One great strength has been the transversality of computational thinking, leading to agreement on the need to incorporate computational thinking in all educational areas and levels.

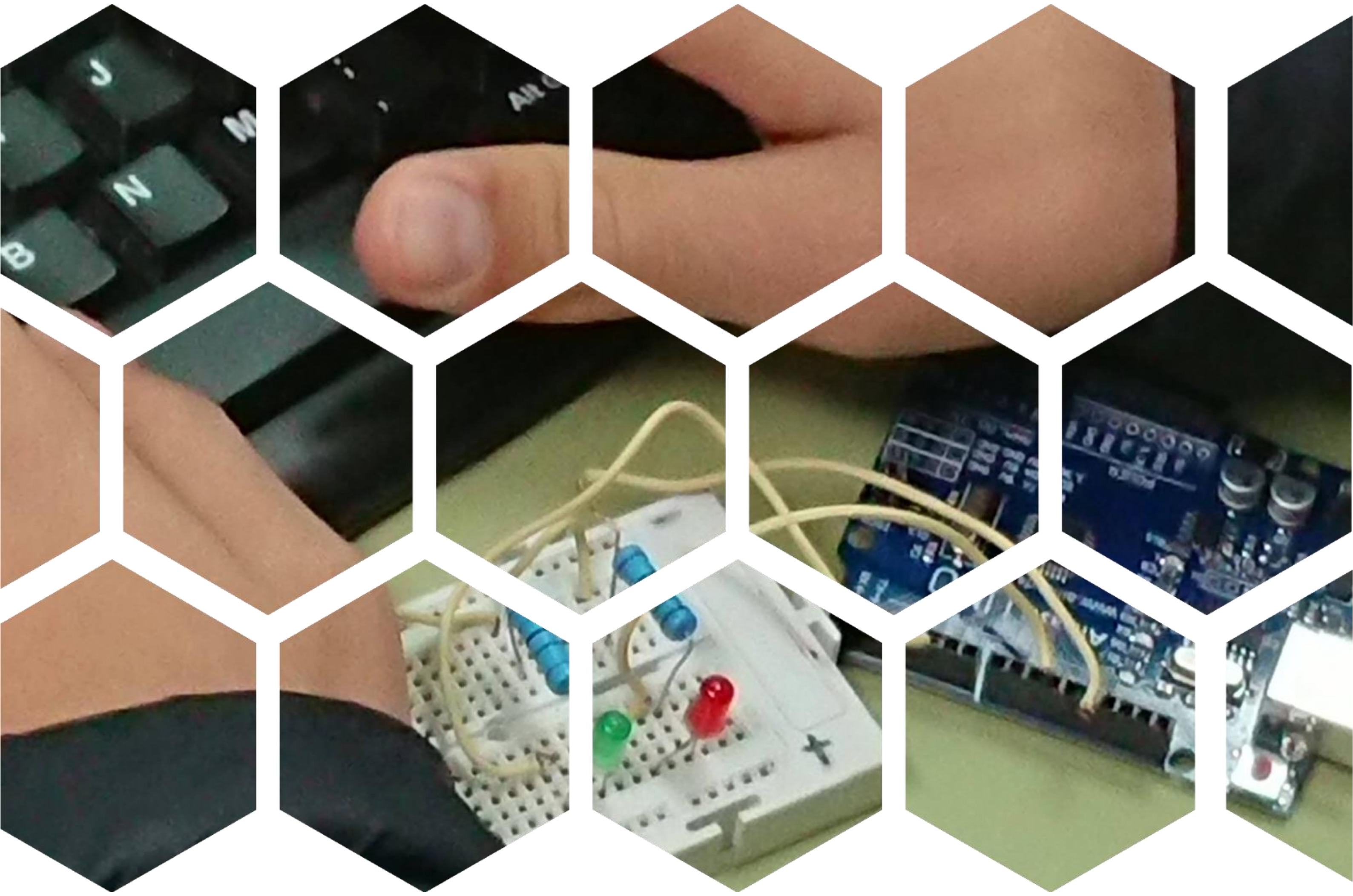
In this sense, it has been suggested that it be introduced in Early Childhood Education and Primary School, since, for a large number of teachers, implementing this type of education at higher stages (Junior High School or High School) is too late.

Finally, the implications of how computational thinking and artificial intelligence affect our lives was another important takeaway from the findings. Both teachers and tutors have highlighted this as another strong point, not only for their own learning, but also when sharing with their students how computational thinking and artificial intelligence can be connected and applied to our daily lives. The need to be aware of this potential was another point stressed by teachers and tutors, since strategies are being developed that help organize knowledge and thought, as well as emotions.

In conclusion, the educational administration representatives spoke about the impact that computational thinking and artificial intelligence will have on the future of education, as well as the main challenges that educational administrations will need to address. These include the role of data, the analysis of learning computational thinking and artificial intelligence and the roles they will play in education, learning personalization and other aspects related to ethics and cybersecurity.



21-22 SCTAI
BEST PRACTICES



06. 2021-22 SCTAI BEST PRACTICES

Robotic Missions	
TEACHER:	Eva Mª Amador Figueroa
SUBJECT:	Technology, programming and robotics
GRADE:	8th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/misiones-roboticas/
This educational proposal revolves around two units of the course: “Automatic machines and robots; mechanical and electrical elements of a robot” and “Programming of electronic systems”. This proposal is carried out in 10 sessions and the different tasks are presented as if it were a mission, which means teamwork and applying theory are required. Learning how to learn and problem solving is encouraged on a recurring basis. It explores and works with the VR-VEX simulator, LCD screens, Arduino and programs with Bitblog, among others!	

I can think, program, learn and share	
TEACHER:	Antonio Bernabéu Pellús
SUBJECT:	Language Arts, Mathematics, Social and Natural Sciences, block programming and robotics (transversely)
GRADE:	6th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/pienso-programo-aprendo-y-comparto/
This educational proposal aims to generate projects using Scratch and the construction of an mBot robot from scratch. During 9 sessions, students work on the content related to robotics and programming, while they develop creativity, problem solving, reflection and working in groups.	

The Time Machine: Egypt	
TEACHER:	Mª Inmaculada Burgos González
SUBJECT:	Mathematics and Social Sciences
GRADE:	1st Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/la-maquina-del-tiempo:-egipto/
The idea starts from a school-wide project called “The Time Machine”, in which each grade works on a different historical era: Prehistory, Ancient Age, Middle Ages, Modern and Contemporary. In this case, we travel to Egypt! The proposal addresses content related to Social Sciences and Mathematics, outer space, geometry and directionality – and all of the missions let you explore, create, build, play and dance!	

Videogame Development with Python and Pygame	
TEACHER:	Antoni Camps Camps
SUBJECT:	ICT II
GRADE:	12th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/desarrollo-de-videojuegos-con-python-y-pygame/
This proposal is carried out in 9 sessions. Students design and create video games using Python and Pygame. To do this, they learn to generate the constants and variables of the game; to create, position and move sprites (bitmaps used to create graphics); to use conditional expressions to define and establish different game states (playing, winning, losing…); and add text, music, and sounds.	

Pitches, catches and hits	
TEACHER:	Sergio Duarte
SUBJECT:	Physical Education
GRADE:	4th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/lanzamientos-recepciones-y-golpeos/
This proposal initiates students in disconnected computational thinking. Throughout the five sessions, the idea of a 'robot' is reflected on and the operation and usefulness of algorithms and sequencing are introduced as a fundamental procedure for solving problems. All of this is applied through physical activities designed for this purpose, as well as activities that involve reformulation and adaptation, including warm-up exercises that require an algorithmic transcription, and the popular game "Battleship".	

Programming with Python	
TEACHER:	Trinidad Echevarría
SUBJECT:	ICT II
GRADE:	12th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/programacion-con-python/
This 10-session proposal is aimed at designing a program that indicates in real time the need to protect the skin in different parts of the world, depending on each individual's phototype. During the sessions, the ozone layer is studied in terms of health and the food chain, while the causes, consequences, tools, etc. are addressed. In this way, ICT II is linked with Earth and Environmental Sciences from the Biology department. Languages and programs such as Python and Openweather are used, as well as APIs like Open UV for data searching and collection.	

Four-legged Robot	
TEACHER:	Olga Mª Fernández Nava
SUBJECT:	Industrial Technology (ICT elective)
GRADE:	11th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/robot-cuadrupedo/
This proposal is designed so that students come up with a technically viable and economically feasible solution to the construction of a quadruped robot that moves autonomously. To do this, students look for inspiration on Thingiverse, carry out design and 3D printing activities with Tinkercad, and program with Arduino. All of these technological processes requires teamwork and must be written out in a report that documents all the phases.	

Learning design and 3D printing	
TEACHER:	Laura Fernández
SUBJECT:	Technology
GRADE:	9th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/aprendiendo-diseno-e-impre-sion-3d/
The objective of this 8-session proposal is for students to develop a planned process that starts with the identification and formulation of a technical problem and finishes with the construction of a possible solution. To do so, graphic design programs are used to apply the students' knowledge of drawing, properties and technical materials, requiring both individual and team work. The evolution and techniques of 3D printing is reviewed while students use Genially to create a timeline, Canva to make an infographic, and TinkerCad to design a construction of their choice. Finally, they work with Cura Ultimaker to simulate the printing of their creation. All this is drawn up in a final report.	

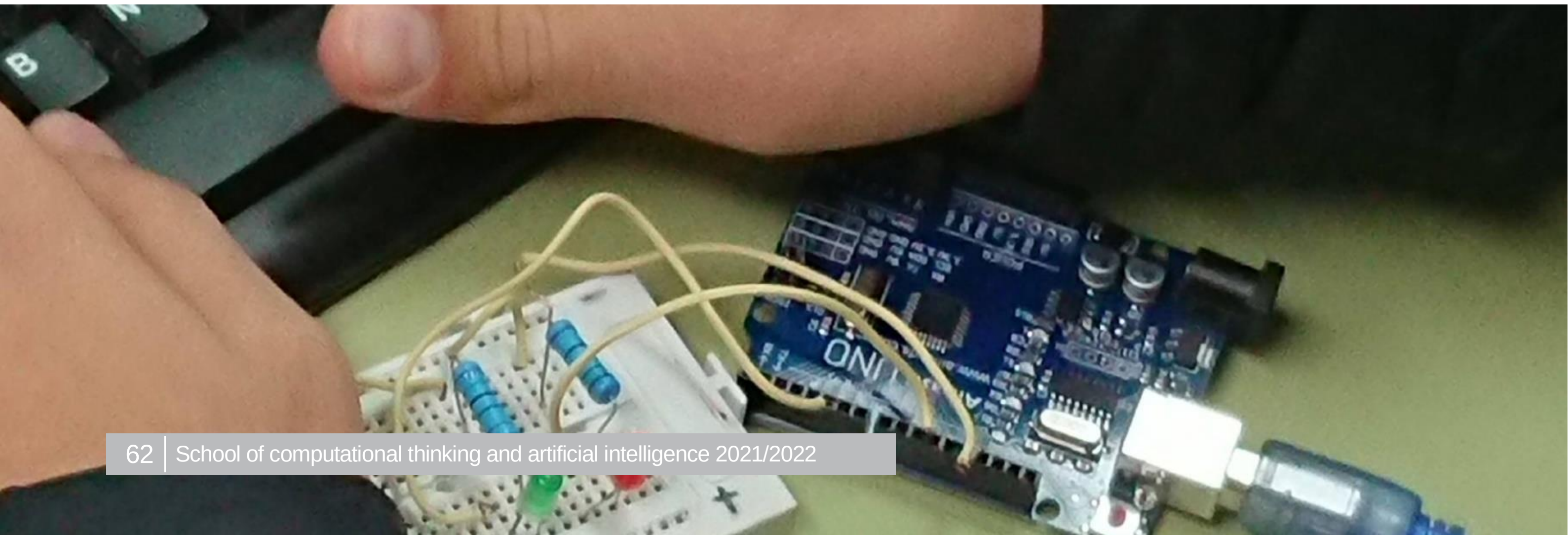
Opening "doors" to digital electronics (block programming with Scratch)	
TEACHER:	Eva García Reguero
SUBJECT:	Technology
GRADE:	10th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/abriendo-"puertas"-a-la-electro-nica-digital-programacion-por-bloques-con-scratch/
This proposal aims at introducing students to the basic concepts of programming and provides an initial contact with the world of digital electronics in a practical and enjoyable way. To do this, throughout 16 sessions, students develop a question-answer game using Scratch to see how much they know about logic gates. Previous work is required on circuits and logic gates with simulators such as crocodile and logic.ly and operations with Boolean algebra. This process is coupled with the design and creation of a digital tool for co-assessment and badges as an efficient motivating component.	

Applying artificial intelligence to ocean conservation	
TEACHER:	Victorio García
SUBJECT:	Natural Science
GRADE:	6th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/ai-en-la-conservacion-de-los-oceanos

The purpose of this proposal is to prepare a report for the "*Un Mar de Ciencias*" contest ('A maritime world of science'). The students study how artificial intelligence can help study ocean conservation and raise awareness about respectful habits towards living beings. Activities with different AI applications are proposed in which the fieldwork carried out by different marine scientists is investigated, data from different ocean habitats are recorded and the main species of cetaceans found in the Canary Islands are studied. Applications such as Google AI, AI for Oceans and the Teachable Machine tool are used to create a species classification program that will enhance the research work of scientists.

A super-space mission with Bee-bot the astronaut	
TEACHER:	Valvanera Jiménez
SUBJECT:	Framed in understanding your environment and transversely: Personal Autonomy, Communication and Performing
GRADE:	Kindergarten
WEBSITE:	https://code.intef.es/buenas_practicas_epc/una-mision-superespa-cial-con-la-bee-bot-astronauta/

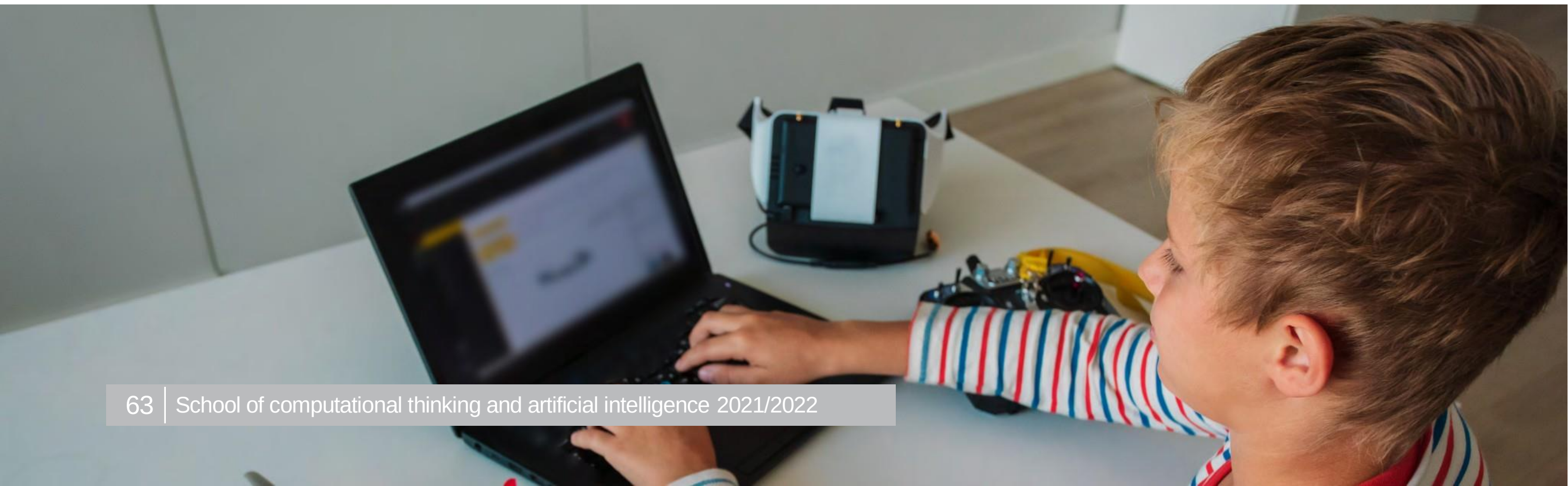
Integrated into a project about the Universe, this gamification proposal is divided into 6 challenges and is developed with a BeeBot floor robot and different boards and accessories. The narrative of the activity consists of helping NASA recover a piece of the James Webb Space Telescope. This piece is essential in order for the telescope to gather images and send them to Earth. The mission is managed by a virtual astronaut using the VOKI computer program and BeeBot, his assistant. Some of the programming objectives include developing simple programs with sequences of ordered instructions to solve simple tasks, understanding and verbalizing the expected results and identifying and correcting errors.



Let's Program!	
TEACHER:	José Antonio López
SUBJECT:	Technology
GRADE:	8th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/¿programamos?/
This proposal presents a progressive approach to computational thinking and artificial intelligence, beginning with disconnected programming activities that end up with the creation of a game using Scratch, thereby introducing students to block programming. Linguistic and numerical skills are developed, creativity is stimulated, problem solving is worked on and collaborative learning is encouraged.	

Think, connect, act	
TEACHER:	María Isabel Luengo Corbatón
SUBJECT:	Physical Education
GRADE:	2nd Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/piensa,-conecta-y-actua/
This proposal introduces students to disconnected computational thinking through activities that address Physical Education curricular content. During the 5 sessions, games are played that involve solving different codes or algorithms that work and improve students' body awareness and laterality.	

Programming and Robotics Workshop	
TEACHER:	Miguel Ángel Martínez
SUBJECT:	Social Science
GRADE:	6th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/taller-de-programacion-y-robotica/
In this 7-session workshop, Scratch is used to design and create an interactive cultural guided tour and nature trail of the town of Binissalem, Mallorca (Spain). This requires familiarization with the interface, as well as learning and applying programming processes that are structured based on the Flipped Classroom methodology.	



Machines that Learn	
TEACHER:	Alejandro Mendoza
SUBJECT:	ICT II
GRADE:	12th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/maquinas-que-aprenden/
This proposal is structured around artificial intelligence and its possible practical applications. Throughout the 15 sessions, 4 projects are carried out in which students create their own AI models using different programming tools such as Scratch, Machine Learning for Kids or Teachable Machine.	

Visual Programming. Introduction to Scratch	
TEACHER:	Eduardo Molina
SUBJECT:	ICT
GRADE:	10th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/programacion-visual-introduccion-a-scratch/
This proposal intends to introduce visual and block programming with Scratch in 12 sessions. The 15 dedicated programming activities will introduce basic concepts such as algorithms, flowcharts, movements, orientation and direction, loops and animations, among others.	

Robotics. Programming with TinkerCad simulators	
TEACHER:	Rosa Monasor Casas
SUBJECT:	Industrial Technology I and ICT I
GRADE:	11th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/programacion-con-tinkercad/
This STEAM project is structured around the creation of a video game programmed with Scratch that enables proper recycling and raises awareness in the educational community. In this way, environmental education is linked to the students' introduction to computational thinking. Throughout the 13 sessions, micro:bit and Makey-Makey boards are introduced and work is carried out using Arduino and TinkerCad to create basic and simple robotic circuits. Finally, the projects are not only presented to the rest of the classmates, but also to different grade levels at the school.	

Pikachu has been kidnapped!	
TEACHER:	Marta Moreno Arroyo
SUBJECT:	Art, Social Science and English (as a foreign language)
GRADE:	6th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/pikachu-has-been-kidnapped!!!/
This 6-session activity introduces students to Disconnected Computational Thinking using gamification and collaboration as a teaching method. These activities are framed in the following narrative: the famous cartoon character Pikachu has been kidnapped and students must overcome different challenges to rescue him.	

I can’t see it, so how can I "view" it?	
TEACHER:	Rut Paños Modrego
SUBJECT:	Physics and Chemistry
GRADE:	11th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/no-lo-veo-¿como-podria-“visualizarlo”?/
This 13-session proposal aims at designing a Scratch animation that makes it easier for classmates with impaired vision to access information. In addition to Scratch, applications such as Machine learning for kids, Genially and Padlet are used, and the learning process is gamified in such a way that certain pages can only be accessed with passwords that are obtained after overcoming the previous challenge.	

Micro:bit against Covid	
TEACHER:	Mª José Pareja Serrano
SUBJECT:	Robotics
GRADE:	6th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/micro:bit-contra-el-covid/
This STEAM-based proposal allows students to learn to block program different functions for their robots using Scratch, Makecode and micro:bit boards. In this case, 5 activities are carried out during 5 sessions in which programming is used to solve different problems posed by the recent pandemic. Some examples could include the creation of a thermometer that detects possible infected persons or a sensor that detects a violation of the required social distance.	

Q&A game about musical instrument instruments using Scratch	
TEACHER:	Julia Quintas Álvarez
SUBJECT:	Music
GRADE:	8th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/juego-de-preguntas-y-respuestas-sobre-familias-de-instrumentos-musicales-con-scratch/
This 2-session educational proposal is aimed at creating a game of questions and answers with Scratch that enables knowledge to be consolidated, related to the visual and auditory identification of musical instruments and the recognition of the role of technologies in the transmission, modernization and musical training. With this tool, you learn how to handle event programming, sequential, conditional, operator and variable categories, among other options offered by the interface.	

Micro Bit Robots & VEXcode Robots	
TEACHER:	Ana Isabel Santamaría Calderón
SUBJECT:	Arts
GRADE:	4th, 5th and 6th Grades
WEBSITE:	https://code.intef.es/buenas_practicas_epc/robots-micro-bit-&-robots-vexcode
This 12-session proposal is made up of a series of projects based on Educational Robotics. In a first project-based group, robots are built using recycled materials by transferring musical and audiovisual language to a Micro:bit card. Subsequently, in a second project-based group, a sketch of a robot is designed on a grid sheet that is later simulated in VEXcode and programmed using blocks.	

Robotics with Arduino	
TEACHER:	Miguel Señor Alonso
SUBJECT:	Computational thinking
GRADE:	9th Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/robotica-con-arduino
This educational unit proposes the construction of simple circuits using Arduino in TinkerCad, with a Shield board and prototyping boards, leds, microservos and sensors. All this will lead to the creation of a robot for which a JoveBot/mBot chassis model is printed in 3D, and line detection behavior is programmed.	

Robotics and heritage	
TEACHER:	Mª José Donaire Romero
SUBJECT:	Social Sciences, Mathematics and Language Arts
GRADE:	3^{rd}, 4^{th}, 5^{th} and 6^{th} Grades
WEBSITE:	https://code.intef.es/buenas_practicas_epc/robotica-y-patrimonio
This proposal consists of time traveling to local and provincial heritage sites throughout different moments of history. The time machine is programmed using block programming and Scratch (older students) and Makecode, Micro:bit boards and Maqueen robots (6^{th} Grade).	

Analysis of the impact of fireballs in the atmosphere	
TEACHER:	César Tomé Valle
SUBJECT:	Mathematics (for academic uses), ICTs, Physics and Chemistry, Biology and Geology and Geography
GRADE:	10^{th} Grade
WEBSITE:	https://code.intef.es/buenas_practicas_epc/analisis-del-impacto-de-boli-dos-en-la-atmosfera
This proposal aims at studying certain content related to fireballs in the atmosphere (eg. types, relationship between speed and energy, etc.) using statistics and probability (energy units, logarithmic scales, probability estimation, calculation of basic statistical parameters and representation and interpretation of elementary graphs), as well as computer programming (APIs, if-else decision structures, repetition structures, transformation of variables from string to float, creation of calculation functions, conversion of units of measurement, etc.).	

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School of computational thinking and artificial intelligence 21/22

From teacher training to a change in methodology

Research findings