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# Informatics and ICT as Learning Subjects in Primary and Secondary Education in Greece

**Anthi Gousiou**
Researcher, University of the Aegean, Greece, *goussiou@gmail.com*

**Nikolaos Grammenos**
PhD Candidate, National Technical University of Athens, Greece, *nikolaos.grammenos@gmail.com*

Informatics and Information & Communication Technology (ICT) have been closely intertwined with education for about 50 years worldwide and about 40 years in Greece. This article focuses on the content of the learning subjects of Informatics and ICT in Greek schools, which are included as independent subjects in all primary and secondary school grades, aiming at well-educated graduates to be able to use ICT in an effective, creative, and ethically correct way, and to be prepared to participate actively in the digitally enhanced society. To this end, a review was conducted to all current curricula of the primary and secondary education in Greece for the learnign subjects of Informatics and ICT to present the basic principles and content of the instruction of these two subjects, as well as the student's skills that the teaching of these subjects aims to develop. Informatics and ICT as learning subjects in Greek are being taught in all grades of primary and secondary education by specialized Informatics teachers. For the instruction of them, constructivist learning theories are proposed, and collaborative, project-based and game-based approaches are promoted. given the rapid advances in computer and communication science, it is imperative that ICT curricula are updated or reformed to meet the needs of the ever-changing landscape.

Keywords: informatics, information and communication technology, 21st-century skills, digital skills, greek educational system, computational thinking, curriculum

## INTRODUCTION

The rapid development of ICT (Information and Communication Technologies), along with the globalization and internationalization of national economies have reformed people's way of life, work, and learning (Anderson, 2008). As a result, new skills and competencies are needed, alongside the necessary cognitive skills, which are prerequisites, such as flexibility and adaptability to the ever-changing world (Carnevale, & Smith, 2013). To this end, educational systems need to equip students with the skills and competencies necessary for the preparation of tomorrow's citizens (Ananiadou & Claro, 2009; Rini et al., 2022).

Moreover, ICT undoubtedly constitutes one of the basic components of modern society and hasa decisive impact on every aspect of people's lives, such as management, economy, education, culture, and entertainment. Thus, everyone needs to adapt to the new social, cultural, and educational environment shaped by the rapid growth and spread of ICT, the huge volume and multiplicity of available digital information/data along with the ever-increasing production of new knowledge. ICT environments have radically changed the way people access, compile, analyze, represent, and present information, as well as collaborate and communicate with each other.

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ICT is a basic tool that has transformed both education and schools by supporting and enhancing learning, and by upgrading the educational procedure as well (Mikre, 2011). In this context, students need to develop new competencies and skills, in order not only to consume the available digital content but also to be able to use ICT in an effective, creative, and ethically correct way. At the same time, they need to be able to make connections, understand and analyze concepts, and create and share knowledge to be prepared to participate actively in the digitally enhanced society (Aminatun, Subali, Yuningsih, Dwiyani, Prihartina, & Meliana, 2022; Constantinou, & Ioannou, 2018); Starkey, 2011). Moreover, building computational literacy is one of the four success paths in STEM education, with one of the three goals of this pathway being "to make computational thinking an integral part of all education" (Li, Schoenfeld, diSessa, Graesser, Benson, English, & Duschl 2020).

Therefore, considering that the above skills need to be developed from an early age, the role of Informatics and ICT as learning subjects at school is very important (García-Peñalvo, & Cruz-Benito, 2016; Roussou, & Rangoussi, 2019). Moreover, taking into account the evolution of computer science and the emergence of concepts such as artificial intelligence, machine learning, big data, and related applications, the necessity of constantly updating the curricula of these subjects in order to equip students with appropriate knowledge and skills is highlighted.

To this end, considering the fact that the curricula of primary and secondary education are being reformed in Greece, the purpose of this article is to present Informatics and ICT as learning subjects in primary and secondary education schools in Greece and their future perspectives. In the next section the 21st-century skills and digital skills will be discussed and an overview of the Greek EducationnSystem will be presented. Then the results and discussion of the research will be presented along with the future perspectives. Finally, conclusions are drawn.

## LITERATURE REVIEW

### Essential Skills for Students

*21st-Century Skills*

21st-century skills are the abilities that people need to develop for them to participate and contribute actively to the knowledge society.

Several 21st-century skills frameworks (Figure 1) have been proposed and developed by education or employment-related institutions and it seems that some certain skills and competences are common to all of them (Chalkiadaki, 2018). Moreover, the educational community has proposed several models for the integration of 21st-century skills in education as well as the specific students' knowledge, skills and attitudes that are important for citizens in the 21st century (Anderson, 2008; BattelleforKids, 2019; Binkley et al., 2012; Kaufman, 2013; Voogt et al., 2013). The 21st-century skills encompass, among others, the ability to understand the power of images and sounds, to realize and use that power, to manipulate and transform digital media, to share and spread them, and to adapt them to new forms. The most popular 21st-century skills as regards learning and innovation are the known 4Cs, which are essential for everyone and include critical thinking, creativity, collaboration, and communication. Moreover, they are comprised of literacy skills, such as information, media, and technology literacy, and finally, life skills that include flexibility, leadership, initiative, productivity, and social skills (BattelleforKids, 2019; Kaufman, 2013; Supena et al., 2021; Voogt & Pareja Roblin, 2012; Wahyuddin, Ernawati, Satriani, & Nursakiah, 2022). The 21st-century skills could be categorized into four broad sets of skills that encompass all the above, namely personal skills, interpersonal and social skills, knowledge and information management and digital literacy (Chalkiadaki, 2018).


Figure 1
21st-century skills frameworks (Chalkiadaki, 2018)

However, the challenge for the educational community seems to be the integration of these competencies and skills in the curricula - as they are essential for every student – and, to this end, different approaches have been reported, in particular:

- Addition of the 21st-century skills into the existing curriculum as new subjects or as new content within traditional subjects.
- Integration of them as cross-curricular competencies that both underpin school subjects and emphasize the acquisition of wider key competencies.
- Inclusion of them in a new curriculum that is comprised of school subjects with transformed structure in a wider context of schools being considered as learning organizations (Voogt et al., 2013).

*Digital Skills for the 21st Century Active Citizens*

In the modern digital world, everyone needs to develop appropriate digital skills for a successful career, active participation in the knowledge society and well-being. Respectively for students, digital skills are necessary for their participation in the digital society as active citizens of the 21st century. To this end, European Commission has proposed the conceptual reference model for the Digital Competence Framework for Citizens (DigComp) including the specific areas of information and data

literacy, communication and collaboration, digital content creation, safety and problem-solving (Vuorikari et al., 2016; Vuorikari et al., 2022).

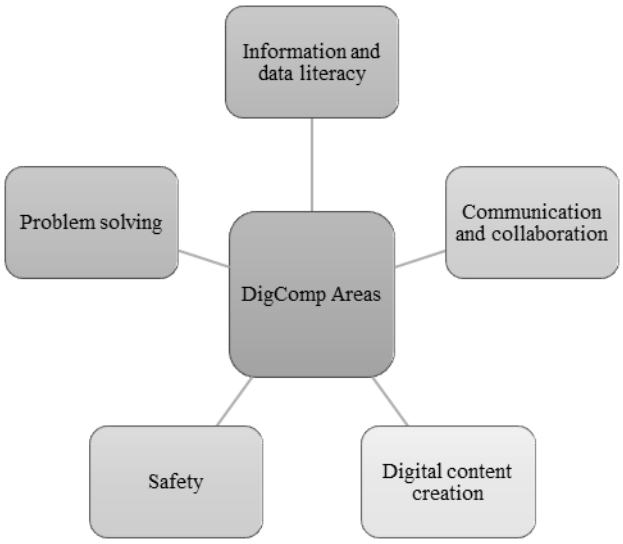


Figure 2
DigComp areas

DigComp constitutes both a "common language" for the competencies needed for employment, personal development, and social inclusion and a cornerstone for the development of new curricula and educational policies. Moreover, it evolves and now is labeled DigComp 2.2 with eight proficiency levels and examples of use in the learning and employment field (Vuorikari et al., 2022).

The Digital Education Action Plan (European Commission, 2022) also sets a common vision for high-quality, inclusive and accessible digital education in Europe and aims to support the adaptation of Member States' education and training systems to the digital age. Moreover, it specifies two strategic priorities and fourteen actions to support them. These priorities are:

- Priority 1: Fostering the development of a high-performing digital education ecosystem
- Priority 2: Enhancing digital skills and competencies for digital transformation.

**Overview of the Greek Education System**

The Greek education system consists of three levels: primary, secondary and tertiary education, with an additional post-secondary level providing vocational training. Primary education begins in kindergarten, which lasts two years, and continues in primary school, which lasts six years (ages 6 to 12). Secondary education includes two levels of three years each: the Lower Secondary School (or Gymnasium or Junior High School), where compulsory education is completed, after which pupils can attend either High School (or General Lyceum) as regards the General Education or Vocational High School (EPAL) as regards Vocational Education and Training (VET). Tertiary education is provided by Universities, Polytechnics, or Academies mainly for the military and the clergy. Undergraduate studies usually last 4 years (5 years polytechnics, agricultural school, and some technical/artistic schools and 6 years medical schools). Postgraduate studies (MSc and PhD level) are also provided by tertiary education institutions.

All levels of education are supervised by the Ministry of Education and Religious Affairs (MERA). MERA has central control over state schools, defines curricula, teaching instructions and syllabus, nominates teaching staff, and supervises funding.

As regards the evolution of learning subjects of Informatics and ICT in Greek schools, it is worth noting that the introduction of Computer Science in Greek secondary education started at the Technical-Vocational and Polytechnic High Schools during the period 1983-1985. Informatics first appeared as an independent learning subject in Greek Lower Secondary School curricula in 1992. Then, it was extended to the General Lyceum, in 1998. It was later extended to the primary education, with the introduction of an indicative curriculum and the equipping of some schools with computers (Komis, 2004).

Nowadays, the term ICT is used in the Primary education and Informatics (or Computer Science) is used in the Secondary education.

## METHOD

The present study is qualitative, consisting of a revew of the curricula of primary and secondary education of Informatics and ICT learning subjects along with the current Teaching Instructions of them. Through this analysis, data were gathered as regards the instructional approaches, the teaching methods, and the skills and competencies developed by involving thorough examination and interpretation of the aforementioned sources.

## FINDINGS

### Informatics and ICT as Learning Subjects in Greece: Instructional approaches, teaching methods, and competencies and skills

The integration of ICT and Informatics in Greek primary and secondary education took place with the formulation by the Pedagogical Institute[1] of the Unified Framework of Curricula (PI, 1997), which evolved into the Interdisciplinary Unified Framework of Curricula (PI, 2003).

Based on the above, the main goals of Informatics and ICT subjects are to develop knowledge-based learning abilities, critical thinking, collaboration and communication skills. In addition, computational thinking is part of the Informatics/ICT curriculum, while Robotics is gradually being introduced at the primary and lower secondary level. Informatics and ICT have a clear laboratory orientation and during instruction ICT School Lab is used. Moreover, Informatics and ICT are taught by specialised Computer Science teachers.

Every year, MERA provides specific instructions for the Informatics and ICT learning subjects that promote the exploitation of modern educational approaches and digital educational resources. Specifically, Informatics and ICT instructional approaches aim to reinforce exploratory learning, self-action and peer collaboration. Furthermore, it is recommended that teachers adopt active learning techniques and use authentic examples from the real world in their teaching, and it is also recommended that this is supported by the use of learning scenarios and learning objects. Specifically, the "Aesop" platform (http://aesop.iep.edu.gr/) is recommended to be used for the preparation and utilization of appropriate digital learning scenarios, which are based on the general principles of the subject's curriculum and emphasize teaching through the implementation of activities by students (Grammenos et al., 2017). At the same time, the utilization of the "Photodendro national educational

[1] Institution supervised by the Ministry of Education, Lifelong Learning and Religious Affairs (http://www.pi-schools.gr/).

content aggregator" (http://photodentro.edu.gr/aggregator/?lang=en) is promoted for the use of specific learning objects adjusted to the learners' age level (Megalou & Kaklamanis, 2014).

Overall, the learning subjects Informatics and ICT are laboratory-based and are approached through activities and authentic examples of interest to students, using appropriate techniques, such as brainstorming, case studies, and discovery through data mining. In addition, efforts are made to enhance differentiated teaching, and student creativity by promoting collaboration among students, with the teacher in the role of assistant and collaborator to achieve the curriculum objectives. Teachers and students can make use of, among other things, digital educational resources available from the Institute of Educational Policy (http://iep.edu.gr/en/), the Panhellenic School Network (https://www.sch.gr/english) and the Digital School (www.dschool.edu.gr).

Overall, the teaching of each subject is proposed to be based on the principles of constructivism and discovery learning. According to these principles, learning is not transmitted but is a process of personal active construction of knowledge based on student's prior knowledge, which should first be modified appropriately to eliminate previous misconceptions that may stand in the way of building new knowledge.

Next, the instruction of Informatics and ICT learning in primary and secondary education in Greece will be discussed.

**Preschool and Primary Education**

*Preschool Education – Kindergarten School (age:5-6)*

According to the Kindergarten School Curriculum (New School, 2014), ICT constitutes a dynamic tool that enhances the development of preschool pupils through learning in a playful or game-based way. In this context, it is recommended ICT be integrated into all cognitive contexts.

Specifically, kindergarten pupils are introduced to digital literacy, which includes knowledge, skills, attitudes, and values for ICT that are essential for their participation in the digital age. ICT provide pupils with opportunities and tools that enhance playing and create important and meaningful learning experiences for them, which are related to their interests and everyday life.

To this end, the use of ICT by kindergarten pupils contributes, gradually to:

- The development of cognitive skills (critical thinking, reasoning, metacognition) alongside collaboration, communication, problem-solving, coordination of movements, creative thinking, and self-assessment skills.
- The building of self-esteem and confidence.
- The development of self-action and taking initiative.

*Primary School (age:6-12)*

Since 2016, ICT is a compulsory learning subject (one hour/week) in every grade of elementary school (from 1st to 6th). ICT is also a cross-thematic tool for all subjects; thus, it is both a separate learning subject and a way of thinking that could be integrated into every learning subject of the curriculum (Greek Government Gazette, 2003).

The key objective of the ICT curriculum is ICT literacy, which is the ability to use digital technologies, communication tools and network services to access, manage, integrate, evaluate, create and communicate information, solve problems and participate in the knowledge society.

Thematic units for the three age groups (1st-2nd grade, 3rd-4th grade, 5th-6th grade) in primary schools are thoroughly defined, including hours of study (duration 25 hours in total), grouped under four specific dimensions (technological, cognitive, problem-solving, social skills):

- Learn, create and express myself with ICT
    - I learn and use the computer
    - I create and express myself with painting, multimedia and presentations
    - I create with a word processor
- Communicate and collaborate with ICT
    - I learn about the Internet
    - I communicate and collaborate
- Investigate, discover and solve ICT problems
    - I model with concept maps
    - I solve problems with spreadsheets
    - Programming the computer
    - Implementing work/research projects
- ICT as a social phenomenon
    - Building digital education and literacy

Consequently, the inclusion of ICT in primary school does not simply aim at students' familiarization with computers and specific software applications. It is noteworthy to mention that coding and programming have been introduced in the 5th and 6th grades, mainly in a playful way, to reinforce the development of computational thinking skills (Wing, 2006; Nouri, Zhang, Mannila, & Norén, 2020; Grover, & Pea, 2013), the basic principles of which have been taught in previous grades of primary school (MERA-ICT, 2022).

**Secondary Education**

*Lower Secondary School (Age: 12-15)*

In all grades of the Lower Secondary School (1st-3rd), Informatics is a compulsory learning subject (two hours/week for the 1st grade and one hour/week for the 2nd and 3rd grades). Its curriculum exploits the cross-curricular approach (Greek Government Gazette, 2003), while it is also composed of the same four dimensions as in primary school (technological, cognitive, problem solving and social skills). Specifically, different dimensions are elaborated for each grade:

- 1st Grade Lower Secondary School

- Informatics in the Modern World: Basic Concepts
- Use and create: I create using word processing software
- Searching for information, communicating and cooperating: I learn about the Internet and communicate
- Explore, discover, and solve problems: I program Computing Devices and Robotic Systems

- 2nd Grade Lower Secondary School

  - Informatics in the Modern World: Basic Concepts
  - Explore, discover, and solve problems: I program Computing Devices and Robotic Systems & I solve problems using spreadsheets
  - Searching for information, communicating and cooperating: I create and express myself with multimedia and presentations & I explore and collaborate using the Internet.

- 3rd Grade Lower Secondary School

  - Explore, design, and solve problems: I program Computing Devices and Robotic Systems
  - Create, present, communicate and collaborate: I create documents and collaborate in online environments & I create presentations

It is worth noting that special emphasis is given to ICT literacy as in primary school. Moreover, Informatics teachers are encouraged to exploit the project-based approach so that students be engaged and learn in a playful, innovative, and participative way the basic concepts of Computer Science. Finally, students in all grades of Lower Secondary school work on robotics and coding (MERA-Informatics, 2022).

*High School (Age: 15-18)*

Throughout High School, special emphasis is placed on the creation of digital applications in modern programming environments.

- 1st grade High School: "Computer Applications" is a compulsory learning subject (two hours/week) (MERA-1st GEL, 2022). In the context of this course, exploratory learning, self-action, and cooperative learning are reinforced. Moreover, alignment with active learning techniques and the use of authentic examples from the real world are suggested.
- 2nd grade High School: "Introduction to basic computer science principles" is a compulsory subject (two hours/week) (MERA-2nd GEL, 2022), which aims to introduce students to the fields and fundamental concepts of Computer Science and to develop their analytical and synthetic thinking. The content of this subject covers topics in both theoretical (problem, algorithm, programming) and applied Computer Science (Operating Systems, Information Systems, Networks and Artificial Intelligence).
- 3rd grade High School: "Informatics" is a course for the Specialization Group of “Economics and Informatics” (six hours/week) and it is tested, inter alia, at the national level in the Economics and Computer Science Orientation Group for the admission of students to higher education. This subject focuses on algorithms and the basic programming principles using a pseudo-language. In addition, the curriculum has recently been enriched and approaches additional topics on a theoretical level, such as object-oriented programming, and dynamic data structures (lists, trees, graphs, the divide-and-conquer method, debugging, etc.) to enhance the analytical, combinatorial, synthetic, algorithmic and generally computational thinking of students (MERA-3d GEL, 2022).

*Secondary Vocational Education (Age: 15-18)*

In all grades of secondary vocational education, the subject of Computer Science is taught according to the timetable indicated below.

- 1st grade of Vocational High School (EPAL): "Computer applications" a compulsory learning subject (two hours/week).
- 2nd grade of EPAL: "Introduction to basic computer science principles" is a compulsory subject (one hour/week) for all specializations. Moreover, the Informatics sector is composed of six specialization courses and twenty-two instruction hours/per week.
- 3rd grade: "Introduction to basic computer science principles" is a compulsory subject (one hour/week) for all specializations. Moreover, two Informatics specializations are provided: (i) "Computer Applications Technician", and (ii) "Computer and Network Technician". For each specialization, eight different learning subjects are instructed (23 hours/week).

According to the corresponding teaching guidelines of the MERA, the project method is proposed, in which students are given a task and work in groups. Within the group, the peer teaching method is used, in which students who have more knowledge/skills share them with others. In addition, it is proposed for the teachers use elements of gamification to involve and motivate students in the activities that will be implemented in the context of the course (MERA-EPAL, 2022).

*Post-Secondary Vocational Education (Age: 18-19)*

"Post-secondary year-Apprenticeship" of EPAL provides for the Informatics sector graduates of EPAL two specializations: "Computer Applications Technician" and "Computer and Network Technician". For each specialization, are provided with a laboratory course [one day (7 hours) a week in the school lab and a total year duration of 203 hours] and a supplementary training course [four days/week in a public or private company or organization]. Laboratory courses for both specializations are based on modern and recently developed curricula (Greek Government Gazette, 2018a; 2018b). It is noteworthy to be mentioned that the main objective of secondary and post-secondary vocational education is the appropriate training of students, according to the development and evolvement of computer science, to be employed in the ever-changing labour market of the sector.

*National Certificate of Informatics*

Since the school year 2018-19, the National Certificate of Informatics (KPp) has been established by MERA to support in-school certification of the basic Informatics skills (Word processing, Spreadsheets, Internet services) of the 3rd grade Lower Secondary students. The participant students have the opportunity to be prepared, within the school and free of charge, after the completion of the compulsory daily program. In July of 2022 was organized the first exams from the pilot implementation period of KPp (Greek Government Gazette, 2022).

## DISCUSSION

Taking into account the aforementioned issues, is seems that Informatics and ICT as learning subjects in Greek are being taught in all grades of primary and secondary education by specialized Informatics teachers. For the instruction of them, constructivist learning theories are proposed, and collaborative, project-based and game-based approaches are promoted. Moreover, it seems that there is a common thematic approach for primary and lower secondary education grouped under four specific dimensions (technological, cognitive, problem-solving, social skills) on which the instruction of Informatics and ICT is based. As regards High School, and vocational education and Apprenticeship, it seems that the main objective of secondary and post-secondary vocational education is the appropriate training of students, in line with the development and evolution of computer science, in order to equip them either to continue their education at tertiary level or to be employed in the ever-changing labour market of the sector. Another innovative initiative, which is evolving is the students' certification in terms of

basic Informatics skills. This is also another activity that will contribute to the acquisition of specific certified knowledge by students.

However, given the rapid advances in computer and communication science, it is imperative that ICT curricula are updated or reformed to meet the needs of the ever-changing landscape. European Union (EU) contributes in this topic by proposing guidelines for several issues related to Computer Science. Recently, taking into account the fact that the impact of Artificial Intelligence on education and training systems is undeniable, and will grow further in the future, EU suggested specific guidelines on the use of artificial intelligence and data in teaching and learning for educators to allow them to be more inclusive and pragmatic (European Union, 2022).

Another important issue that should also be taken into consideration is the COVID-19 pandemic, which changed the field of education and many other fields by promoting distance and digital teaching environments and approaches (Bayir, Dulay, & Tekel, 2022; El-Ashry, El-Din, Khairy, Soliman, Beram, & Nosier, 2022).

**Future Perspectives of Informatics and Ict Learning Subjects in School**

The Greek government has initiated reforms to modernize the existing educational system, with specific initiatives – among others, to modernize all learning subjects' curricula. Focusing on ICT and Informatics curricula reformation, modern scientific and pedagogical approaches need to be considered for high school graduates to acquire comprehensive Informatics/ICT literacy. At the same time, the efficient use of digital technology within education (teaching and learning procedure) is encouraged for all students to develop essential digital skills and competencies necessary to the rapidly evolving digitized world. To this end, taking into account the aforementioned issues, alongside the DigComp framework, and other frameworks for 21st-century learning, it is essential for the ICT and Informatics curricula to emphasize the following six dimensions:

1st. The acquisition of broader digital literacy:

- The investigation, critical thinking, modelling of solutions, composition skills, creativity, communication and collaboration skills.
- Developing capacities for the autonomous use of computational and network tools to solve problems.
- Formation of attitudes and values for students to realize the new social, economic and cultural environment that evolves in today's world.

2nd. The ICT Literacy: Active participation, collaboration and autonomous student development in Informatics and ICT subjects by exploiting various digital tools for the implementation of integrated digital projects.

3rd. The Utilization of Digital Technology: Connection between school knowledge and the skills and competencies of creative use of digital technology tools.

4th. Turn to Open Technologies and Resources: Change of the usual practice. Development of sharing practice. Learners as creators, not just digital content users.

5th. Algorithmic/Programming/Coding:

- Primary school: Programming in a playful way.
- Lower Secondary School: Investigation, discovery and problem-solving through coding and programming of computer devices and robotic systems.

- High School: Emphasis on modern programming environments and creation of applications.

6th. Developing Social Attitudes and Skills:

- Develop positive and profound participation skills in today's digital environment.
- Raise the awareness of modern digital culture, entrepreneurship, and e-citizenship, through information management and exploitation from network sources, electronic security, privacy, and information-technology ethics issues.

It should be noted that while the 21st century is mainly characterized by the technological and ICT evolution, globalization, and innovation and students need to develop relevant skills and competencies, at the same time, emphasis should be paid to maintaining a balance between the personal and social needs of individuals and the outcome-oriented development of skills mainly related to professional achievements, especially for the younger students (Chalkiadaki, 2018).

## CONCLUSION

This article focuses on the Informatics and ICT as learning subjects in Greece and highlights the fact that they are being taught in all grades of primary and secondary education by promoted constructivist, collaborative, project-based and game-based approaches. The contribution of Informatics and ICT in school is vital for the cultivation and development of digital competencies and skills that every digitally active citizen of the 21st century should have. To this end, the instruction of ICT and Informatics at school is essential at all levels of education, as it promotes skills and competencies, such as problem-solving, communication and collaboration along with creative, critical, analytical, and computational thinking skills that enhance the intellectual and social development of students. In terms of computational thinking skills, their development is an integral part that begins in early childhood - in a playful way - and continues as a lifelong learning process to enable students to use the knowledge and skills they acquire to solve real-world problems, design systems, and understand human behaviour based on the fundamental concepts of computer science. Moreover, it is equally important to introduce ICT horizontally in all learning subjects in primary and secondary education, not only in STEM subjects but also in subjects with humanistic and social content.

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