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Research Paper

Digital Competences in Europe

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ABSTRACT: *With this paper carried out on digital competences in Europe we want to highlight their importance, which they have in the educational processes of students, and for the strategic future of a country.*
The research was conducted by analyzing the education systems of primary and secondary schools, of European countries, and on surveys and databases on the digital skills and competences of students, teachers, workers and citizens.
Digital technologies have revolutionized our society, indeed we speak of "digital natives", children of "today" grow up and live with a "massive" use of these technologies.
European states have planned and adopted specific action plans for the development of digital competences and abilities.

KEYWORDS: *Digital Competences, Digital Skills, Europe, Digital Education, Digital Technologies.*

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I. INTRODUCTION

In recent years, one of the themes at the center of debates concerns the development and technological innovation, and the increasingly widespread use of digital programs that facilitate the performance of one's activities, from work to study. In this paper, special attention has been paid to the analysis of the level of digital competences possessed by students in European countries, at primary and secondary school level, and in order to understand more comprehensively the level of digital competences in Europe, an analysis of the level of digital competences possessed by teacher and European citizens has been conducted.

Our current society has been transformed by digital technologies, indeed we speak of a "digitalized society" it is no coincidence that those born in the 2000s have been defined as "digital natives", a period in which the use of digital technologies began to spread widely. In a digitalized society, teacher training represents an organizational, methodological and conceptual challenge.

European states recognize that their citizens need adequate digital competences, both for work and social aspects. In this regard, the European Union had already issued a first recommendation in 2006, in which it was pointed out that digital competences must be part of the key competences for lifelong learning. At these recommendations, have been followed over time, by others, and numerous initiatives have been undertaken, including the Digital Competence Framework for Citizens (DigComp). The framework of these competences is constantly updated, the latest edition dates back to 2022.

For European states, the development of digital competences represents an important challenge for the future, indeed they have decided to develop and implement specific intervention plans especially in schools to increase the level of these competences in their citizens.

II. LITERATURE REVIEW

Prensky (2001) stated that "digital natives" even if they grow up in the digital age do not become intrinsically competent and confident with digital technologies, but it is necessary to train them through an adequate path. Students must be supported in acquiring the right skills and informed of the dangers.

Wing (2006), defined computational thinking as a fundamental skill for everyone, and that it should be considered as the fourth basic skill, in addition to "reading, writing, and arithmetic".

The European Parliament's 2006 recommendation stated that " Digital competence involves the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet".

Klaus Schwab in 2016, defines this era as the "fourth industrial revolution", an era in which in society we find super portable computers available everywhere, intelligent robots, increased brain capacity thanks to neuro-technology.

Murphy et al. (2020), argue that students who are able to use digital technologies, are able to acquire greater skills than their peers who are not able to use them.

Digital teaching competence refers to the ability to integrate digital technology into teaching practices, sometimes also referred to as “digital pedagogies” or “digitally supported teaching methods,” and is more closely aligned with the “technological pedagogical knowledge” area of the TPACK framework. Integrating digital tools into teaching practice includes the use of various media, communication, and computational tools for teaching and learning activities, the development and use of digital assessments, appropriate management of digital environments, and supporting students’ critical, ethical, and creative use of ICT for learning (Starkey, 2020).

Tomczyk & Fedeli (2022), believe that digital skills must be part of the basic skills that modern teaching staff must possess.

Digital competence not only includes the ability to use hardware, specialized software, and websites, but also requires knowledge of the impact of new media on student behavior. This competence is a complex and evolving concept that has become essential in working with children and young people (Basilotta-Gómez-Pablos V. et Al. - 2022).

Grabiel (2023) said “We often make the wrong assumption that young people are naturally digitally savvy and computer literate. Of course, this is not always the case, particularly for those with less opportunities, coming from a disadvantaged background. If we want our youth to become active, responsible and engaged citizens, it is our duty to equip them with the necessary skills. Not only for their own personal developments, but also to secure their place on the labour market”.

Learning with digital technologies can reduce inequalities by facilitating the inclusion of students with special needs and adapting learning to different learning styles.

The OECD (2023) considers that the availability of appropriate hardware is a necessary condition for a digital transformation of education, which most countries are aware of and on which they focus their digital investments and strategies.

III. METHODOLOGY

This is a documental research, conducted by examining the educational systems of European countries, on three levels of education, primary school, lower secondary school, upper secondary school, corresponding to the ISCED 1, ISCED 2, and ISCED 3 levels, and on surveys and databases: OECD, PISA, PIAAC, TALIS, IEA, Eurostat.

The research investigates the digital competences of students, teachers, workers and European citizens.

With on the students investigation it has been detected:

- The European countries that provide adequate training for the acquisition of digital competences, through their curricular programs, data detected from the analysis of teaching programs;
- the competences for the Computer Information Literacy (CIL) area, data deriving from standardized tests, detected through databases;
- the competences for the Computational Thinking (CT) area, data deriving from standardized tests, detected through databases;
- use of the digital technologies, data deriving from surveys, detected through databases.

With the investigation conducted on teachers are been detected:

- The digital competences possessed by teachers to carry out teaching activities, data deriving from surveys, detected through databases.

With the investigation on European workers are been detected:

- Computer and software skills for their job, data deriving from surveys, detected through databases.

With the investigation on European citizens are been detected:

- The digital competences possessed by European citizens between 15 and 74 years of age, data deriving from surveys, detected through databases.

IV. DATA ANALYSIS AND RESULTS

4.1 EUROPEAN COUNTRIES THAT PROVIDE ADEQUATE TRAINING THROUGH THEIR CURRICULAR PROGRAMS

The results derived from the analysis of European school curricula on the learning levels of students clearly show that the knowledge and skills provided increase as one moves to the next levels of education, as it happens in all subjects. Furthermore, as one moves to the next levels of education, the number of topics covered also increases, thus favoring the acquisition of a greater amount of knowledge.

The programmes of the following countries were analysed: Albania, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, England, Estonia, Finland, France, Germany, Georgia, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye, Ukraine.

Through the analysis of educational programs, was verified, the number of countries providing training for the acquisition of digital competences, measured through learning objectives. Four areas were identified to carry out the evaluation:

- Coding
- Digital Literacy
- Systems and Networks
- Data Protection

Based on the objectives identified, for to have adequate digital competences, at primary school level the coding area, is trained in 16 countries, 28 in lower secondary school, and 37 in upper secondary school; while the digital literacy area, is trained in 13 countries in primary school, 26 in lower secondary school, and 31 in upper secondary school; while the systems and networks area, is trained in 8 countries in primary school, 17 in lower secondary school, and 26 in upper secondary school; the data protection area is trained in 6 countries in primary school, 13 in lower secondary school, and 16 in upper secondary school. The coding area and the digital literacy area, are the most trained, where starting from lower secondary school they are trained in more than half of the countries, followed by the systems and networks area, where starting from upper secondary school it is trained in more than half of the countries, while the data protection area is the least trained.

In the next figure we can visualize the data graphically.

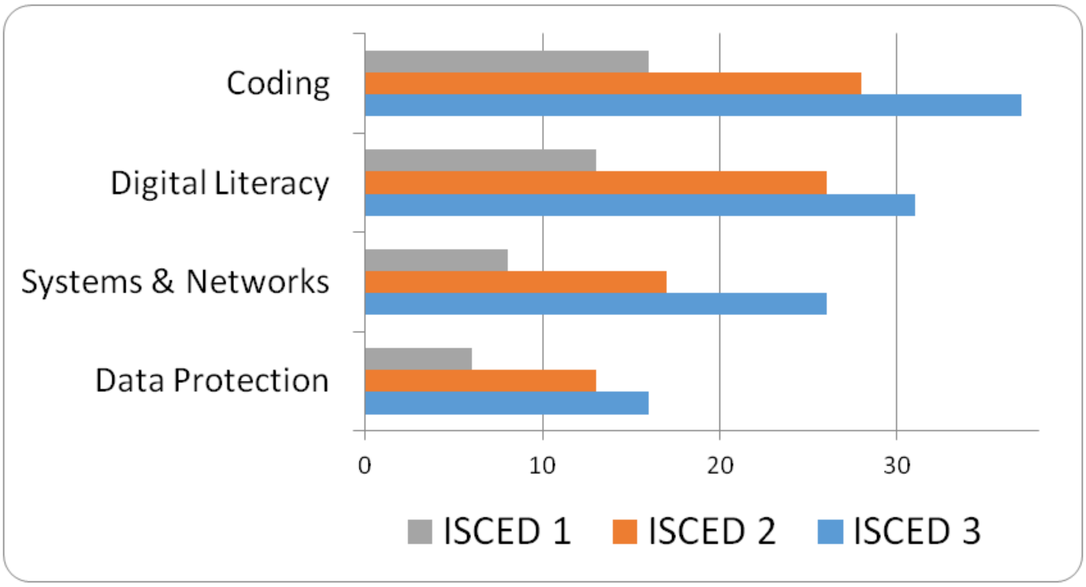

Figure 1: Digital competences of students in Europe.

4.2 Competences for the Computer Information Literacy area

Based on to the results of the standardized tests of the ICILS 2023 survey, for the Computer and Information Literacy (CIL) area in lower secondary school (students in the eighth grade of education, 13-14 years old), 55% of students reach at least level 2, value that represents the basic level that a lower secondary school student should possess, according to the developers of the ICILS 2023 survey, while 16% demonstrated that they can perform Computer and Information Literacy tasks, autonomously and independently. In figure 2 you can see the data in percentage by level of competence acquired; the data were calculated on the entire sample of students, and not as an average of the values of the individual states.

level	%
Undeveloped	17%
Basic/Functional	28%
Need Support	39%
Independence/Autonomy	15%
Precision	1%

Figure 2: Levels of CIL (ISCED 2)
source: Report ICILS 2023 - database IEA.

The levels scale was as follows:

- ➢ below level 1 (Undeveloped): up to 406 points;
- ➢ level 1 (Basic/Functional): from 407 to 492 points;
- ➢ level 2 (Need Support): from 493 to 576 points;
- ➢ level 3 (Independence/Autonomy): from 577 to 661;
- ➢ level 4 (Precision): over 662 points.

In Figure 3, you can see the European countries that participated in the ICILS 2023 survey for the CIL (Computer and Information Literacy) area with their scores.

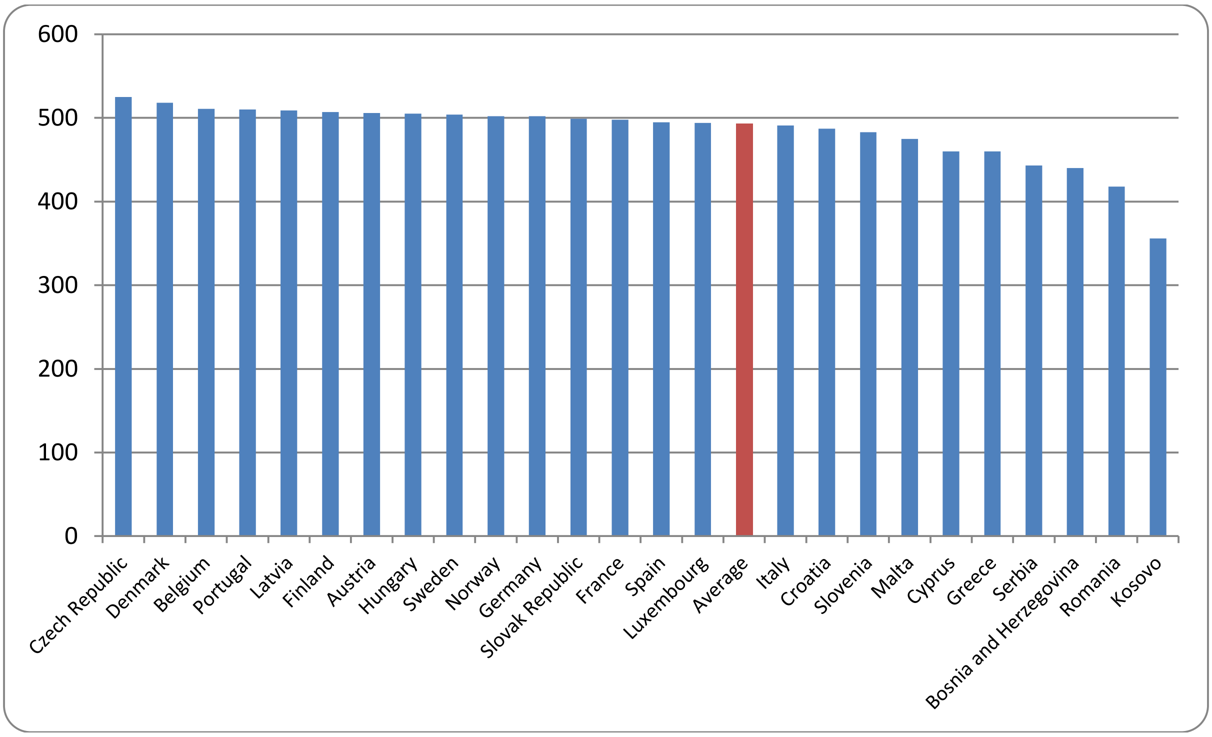

Figure 3: CIL scores for individual countries (ISCED 2) - source: Report ICILS 2023 - database IEA.
Note: The students in Norway were in their ninth grade of education.

The average value is 493 points, and was calculated on the total number of students, and not as an average of the values of the individual states. The data shows a significant difference in scores in the various countries. The range of variation is 169 points, and a standard deviation of 37 points. The Czech Republic and Denmark, show the best results with values between 5% and 10% more than the average; while Cyprus and Greece, show results between 5% and 10% less than the average; Serbia, Bosnia and Herzegovina and Romania, between 10% and 20% less than the average; the result of Kosovo is 28% lower than the average.

In nine countries: Bosnia and Herzegovina, Cyprus, Greece, Malta, Netherlands, Romania, Serbia, Slovakia, Slovenia, more than 50% of students did not reach level 2, in Kosovo more than 50% of students did not reach level 1.

Some states participated in the standardized tests of the ICILS survey for the CIL area in 2013, 2018 and 2023. For these states, we report the temporal evolution of the results obtained during this period.

	2013	2018	2023	Variation
Czech Republic	553		525	-5% (*)
Denmark	542	553	518	-4% (*)
Finland		531	507	-5% (#)
France		499	498	0% (#)
Germany	523	518	502	-4% (*)
Hungary	512		505	-1% (*)
Luxembourg		482	494	2% (#)
Portugal		516	510	-1% (#)
Slovak Republic	517		499	-3% (*)
Slovenia	511		483	-5% (*)

Figure 4: CIL scores (ISCED 2) for individual countries
source: Reports ICILS 2013-2018-2023.
Note: * Range 2013-2023.
Range 2018-2023.

From the analysis of the data, emerges a regression, in the scores obtained, with the exception of Luxembourg, the only state to increase its score, and France, which remains substantially stable in its score.

4.3 Competnces for the Computational Thinking (CT) area

The data derived from the ICILS 2023 standardized tests for the Computional Thinking (CT) area, show that in lower secondary school (students in the eighth grade of education, 13-14 years old) 67% of students have acquired at least level 2, which represents, according to the developers of the ICILS 2023 survey, the basic level that a lower secondary school student should have. In figure 5 can look the data in percentage by level of competence acquired.

level	%
Undeveloped	9%
Fundamental sequencing	24%
Structured problem solving	39%
Integrated problem solving	23%
Systems thinking	5%

Figure 5: Levels of CT (ISCED 2)
source: Report ICILS 2023 - database IEA.

The levels scale was composed as follows:

- below level 1 (Undeveloped): up to 330 points;
- level 1 (Fundamental sequencing): from 331 to 440 points;
- level 2 (Structured problem solving): from 441 to 550 points;
- level 3 (Integrated problem solving): from 551 to 660 points;
- level 4 (Systems thinking): over 661 points.

In Figure 6, can look the European countries that participated in the ICILS 2023 survey for the CT (Computional Thinking) area, with their scores.

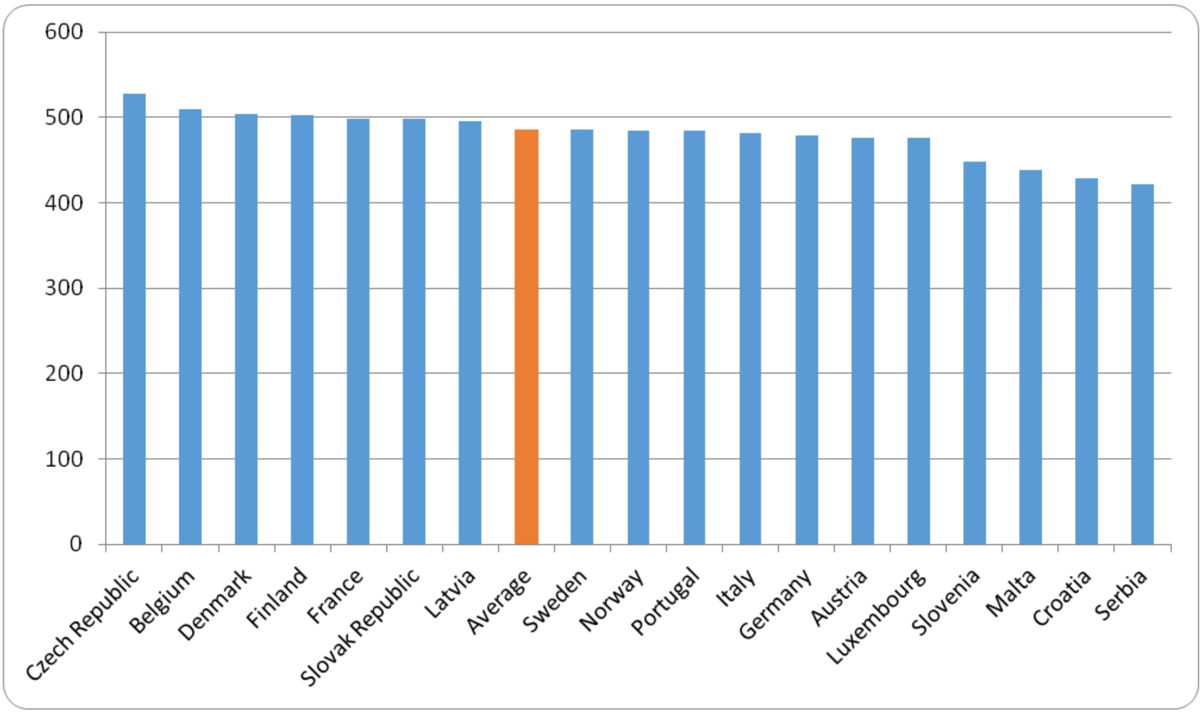

Figure 6: CT scores for individual countries (ISCED 2) - source: Report ICILS 2023 - database IEA.
Note: The students in Norway were in their ninth grade of education.

The average value is 486 points, and was calculated on the total number of students, and not as an average of the values of the individual states. The data shows a marked difference in scores in the various countries. The range of variation is 105 points, with a standard deviation of 28 points. Also in this area, the Czech Republic scores the best, with a score between 5% and 10% higher than the average; while Slovenia and Malta score between 5% and 10% lower than the average; Croatia and Serbia score between 10% and 15% lower than the average, and in these two states, more than 50% of the students did not reach the basic level.
Some states participated in the standardized tests of the ICILS survey for the CT area both in 2018 and in 2023. For these states we report the temporal evolution of the results obtained during this period.

	2018	2023	variation (%)
Denmark	527	504	-4%
Finland	508	502	-1%
France	501	499	0%
Germany	486	479	-1%
Luxembourg	460	476	3%
Portugal	482	484	0%

Figure 7: CT scores (ISCED 2) for individual countries
source: Reports ICILS 2018-2023.

From the analysis of the data, it emerges that the scores are substantially stable with the exception of Denmark (-4%) and Luxembourg (+3%).

4.4 Use of digital technologies

For the analysis of the use of digital technologies in lower secondary school, the sampled countries were: Albania, Austria, Belgium, Belarus, Bosnia and Herzegovina, Bulgaria, Cyprus, Croatia, Czech Republic, Denmark, England, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, Ireland, Iceland, Italy, Kosovo, Latvia, Lithuania, Luxembourg, Malta, Norway, Netherlands, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye, Ukraine. From the analysis of the surveys showed that 45% of European students use them regularly at school, while more than half, 55% use them for school activities outside of school, and 79% use them in leisure activities outside of school. There is enormous variability in the use of digital technologies for teaching activities during lessons between countries, with a range of 41% and a standard deviation of 14%. For the use of digital technologies outside of school for educational activities, the range of variation is 27% and the standard deviation is 11%. While the variability between countries is smaller in the use of digital technologies for leisure activities, the range of variation is 14% and the standard deviation is 5%. Slovenia with 13% is the country where lower secondary school students use digital technologies least for educational activities during class hours. Denmark with 27% is the country where lower secondary school students use digital technologies least for educational activities outside of school.

4.5 DIGITAL COMPETENCES POSSESSED BY TEACHERS TO CARRY OUT TEACHING ACTIVITIES

In Europe, during their training process to obtain the qualification, primary school teachers claim to have received adequate preparation for the use of digital technologies for teaching, at 50%, while those of lower secondary school at 60%, and those of upper secondary school at 56%. The detailed data of the individual countries are reported in figure 8.

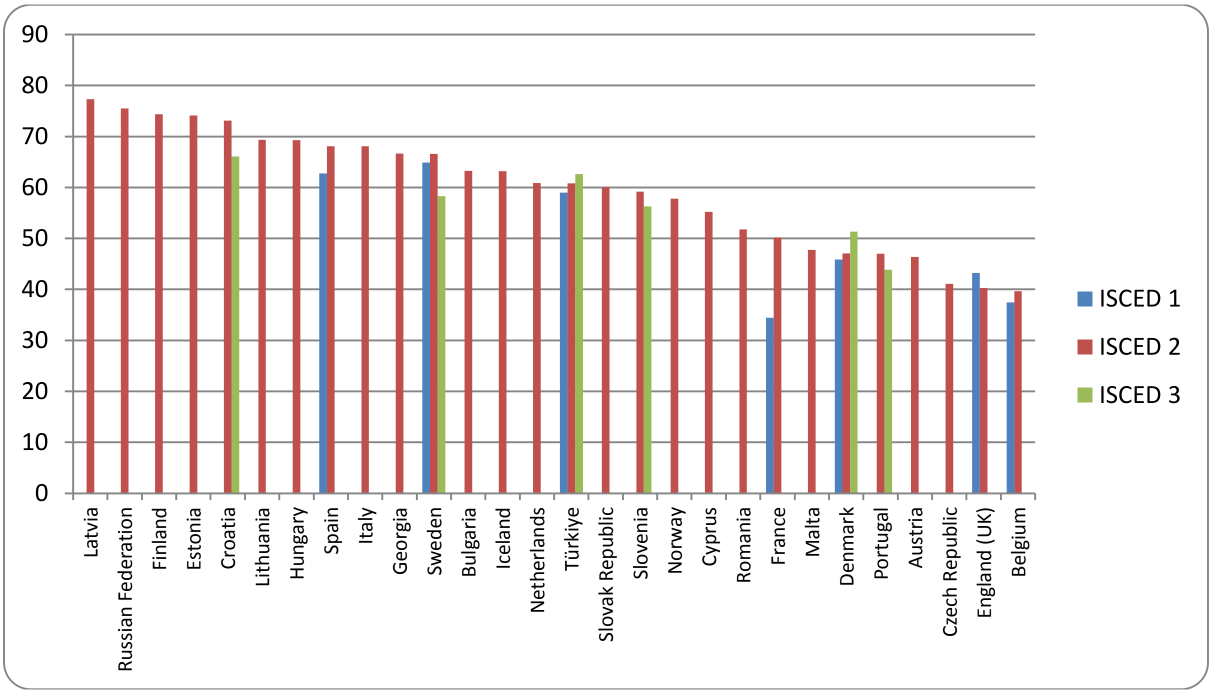

Figure 8: Training in the use of digital technologies for teaching. Source: TALIS.

Regarding the preparation of lower secondary school teachers, in the use of digital technologies during their lessons, the data analysis showed that teachers in Europe, on average, feel prepared at 51% (The data was calculated based on the total number of teachers who responded to the survey, rather than as an average for individual states). In figure 9, can look the data of the individual countries.

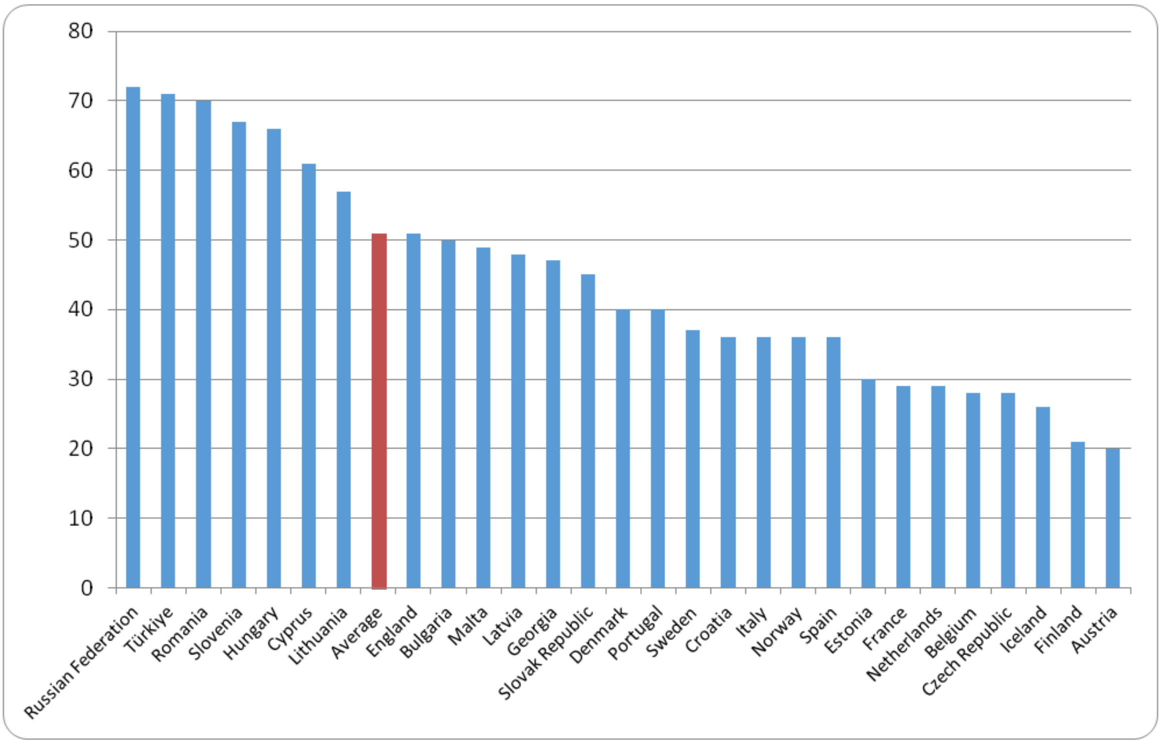

Figure 9: Teachers' digital competences for teaching. Source: TALIS.

4.6 Skills of workers in Computer and software for their job

Based on the data from the Survey Adult Skills 2023, in European countries that are part of the OECD (Croatia partner country), 3.6% (value calculated on the total number of workers who responded to the survey and not as an average of the values of the individual states) of workers reported having inadequate computer and software skills for their job.

In the next figure, can look the data for each countries.

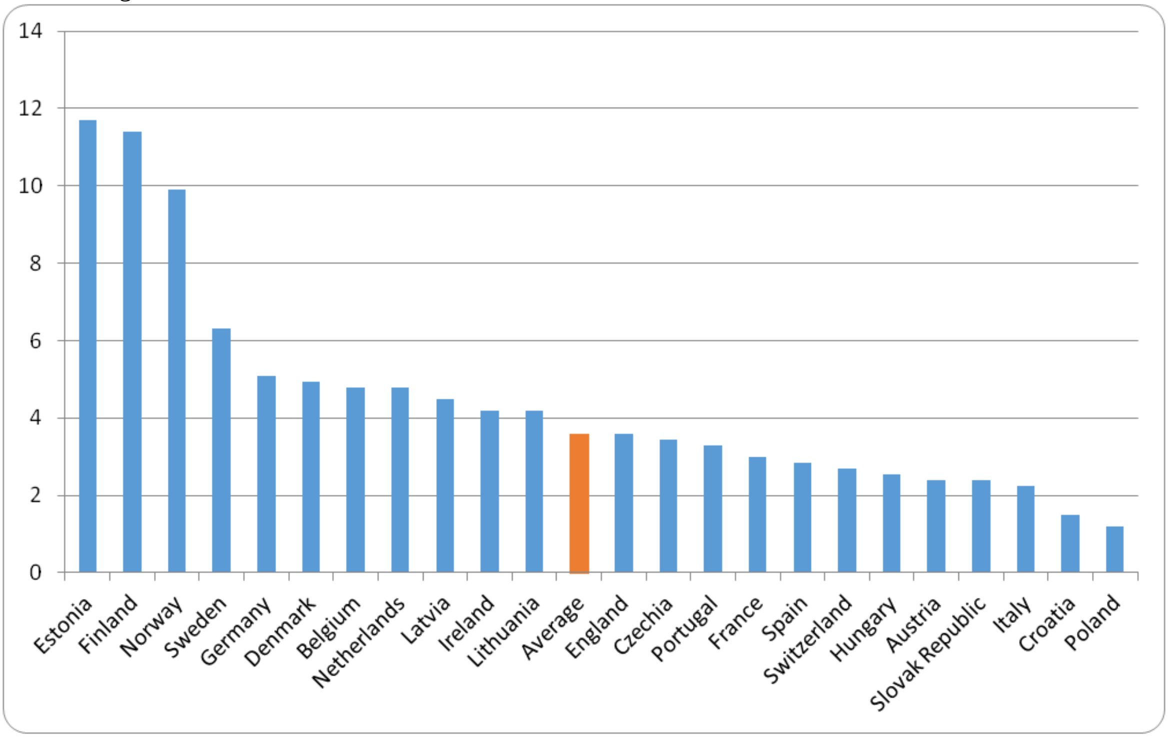

Figure 10: Workers reporting inadequate computer and software skills for their job - source: surveys of Adult Skills 2023 - OECD.

4.7 DIGITAL COMPETENCES POSSESSED BY EUROPEAN CITIZENS

Referring to Eurostat data, in 2023, 52% (value calculated on the entire sampled population, and not as an average of the individual countries) of European citizens aged 16 to 74 had at least basic digital competences, the average of the countries belonging to the European Union was 56%. There were significant disparities between European countries, with rates ranging from 83% in the Netherlands to 28% in Romania. The level of formal education had a significant impact on the acquisition of digital competences, the difference between highly educated European citizens (80%) and those with little or no formal education (34%), is 42 percentage points. The most significant differences were recorded in Ireland (74%), Portugal (66%) and Greece (63%); while the least significant differences were recorded in Estonia (12%) and Finland (14%).

Figure 11 shows the data for individual countries, which were sampled for this survey.

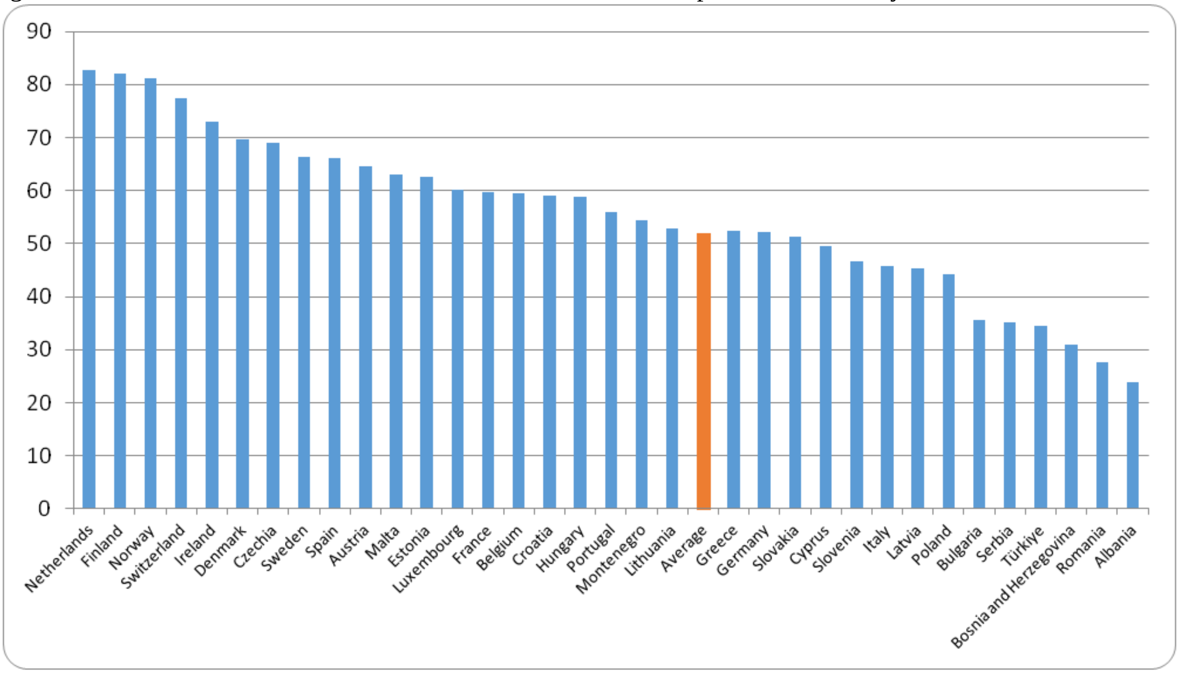

Figure 11: Digital Competences European citizens. Source: Eurostat.

V. DISCUSSION

New digital technologies have changed our society, and education systems are also affected; firstly because of the impact that digital technologies can have on the way lessons are delivered, secondly because education has a fundamental role to play in preparing young people in a world where technology is predominant. Students and citizens need to be supported in acquiring the right digital competences. The use of digital technologies has a great impact on the field of employability. For this reason, young people need to be well prepared to have the right competences to adapt to the digital workplace. Basic digital competences are a prerequisite for inclusion and participation in the labour market and society. Innovations and discoveries in different fields such as artificial intelligence, virtual worlds, robotics, quantum technology and 6G are triggering a wave of demand for a new generation of advanced digital competences.

Learning digital competences is gradually being introduced in European schools, not all countries recognize the same importance, for which the contents, and the hours of teaching in the curricular programs vary greatly, the way in which it is taught is also different: curricular subject, optional or transversally in other subjects. In more than half of European countries students begin to learn digital competences already during primary school, generally integrated into other compulsory subjects. In the other European countries the teaching of digital competences occurs at a later stage. The teaching of digital competences, at primary school level is provided with the exception of some countries by generalist teachers, that is teachers qualified to teach all or most subjects. While from secondary school onwards in most countries the teaching is entrusted to specialist teachers, that is teachers qualified to teach a subject or a group of similar subjects. Around half of European countries are currently reforming their curricula to increase the time dedicated to teaching digital competences, some of them with a particular focus on coding, computational thinking, cybersecurity, and artificial intelligence, in some countries these reforms foresee that digital competences are taught in a specific curricular subject, and no longer through transversal subjects.

The term digital competence refers to the set of knowledge and skills possessed by an individual in knowing how to manage and use appropriately the technologies of the digitalized society in any context. They are characterized by three dimensions: technological, cognitive, social.
Digital competences can be divided into two main levels depending on the level of knowledge required:

- Basic digital competences: these are the competences required for the effective application of systems and devices for Digital Technologies by citizens and which generally cover digital literacy.

- Specialized digital competences: these are the competences required by professionals in the digital sector, for research, development, design, strategic planning, management, production, consulting, marketing, sales, integration, installation, administration, maintenance, support and assistance to systems based on Digital Technologies.

The benefits that can derive from the development of digital competences are many, the labor market is one of these and is certainly among the most important, unfortunately among the competences required by the labor market there is a "gap" to be filled. The labor market requires high levels of competences for the use of digital technologies and many "new jobs" are based on specialized digital competences and skills.

A World Economic Forum study predicted that by 2030, 90% of jobs will require advanced digital competences.

Through digital education, European countries must address both the social and educational issues. Digital education from a social perspective must be inclusive, a digital divide between those without or with only basic digital comptences and others with high-level digital competences could aggravate existing gaps in society and further exclude some parts of the population. From an educational perspective, digital education must ensure that young people develop the necessary digital competences, but also know how to reap the benefits that technology itself offers. This skill ensures that young people can use digital technologies effectively and safely, from the risks that may arise, such as cyberbullying, internet addiction, or loss of privacy. These risks are major concerns for policy makers, security and protection of personal data has become a key issue in European policies for digital education.

In 2017, the Committee on European Computing Education confirmed a growing awareness, across Europe, of the importance of providing young students with the opportunity to obtain a solid education in digital competences. Learning digital competences is also important because of the essential role it plays in other sciences, particularly in STEM (Science, Technology, Engineering and Mathematics).

"The introduction of digital education into the school curriculum also requires the availability of appropriate teaching materials and pedagogical practices that teachers must be aware of and able to choose, depending on the needs and characteristics of their students. In particular, it is important that teaching methods and content are appropriate for the various levels of education and that they are delivered in a way that engages students, given the different ways of learning throughout their school progression" (Lister, 2016).

As of 2023, with the rapid evolution of Generative AI, education systems are facing a new challenge to harness the potential of this technology, addressing issues such as algorithmic bias, cheating, plagiarism, loss of knowledge, and concerns about privacy, data security, intellectual property violations, and sometimes even sustainability. The challenge is not easy, because beyond the complexities of understanding Generative AI, it is an emerging domain, making it essential for teachers to receive adequate training.

Through the Digital Decade Policy Programme 2030, the European Union has set the goal of developing basic and advanced digital skills and competences to drive the digital transformation, outlining the ambitious goals of ensuring that 80% of adults (in 2023 the average of EU citizens was 56%) possess at least basic digital skills and reach 20 million specialists employed in the digital technologies sector. The programme also promotes women's access to this sector and the increase in the number of graduates in Information and Communication Technologies (ICT) disciplines by 2030. This is a strategic approach through a medium-long term time frame that involves the world of school and training. The European Union's strategies to achieve the set objective are:

- Introduce STEM subjects (including the teaching of digital skills) in the early stages of the educational cycle to generate interest among young people, in line with the proposals long advanced for the introduction of computer science in primary schools;
- actively promote STEM subjects to attract more young people (especially women), for example by presenting visible role models to break down social barriers, conducting targeted awareness-raising campaigns;
- embed digital skills training in teacher education programmes and ensure continuous training for in-service teachers and school leaders to improve teachers' digital competence and confidence;
- promote vocational education as an attractive and relevant choice for the labour market, offering learning experiences adapted to industry needs;

- facilitate collaboration between universities to leverage expertise and resources and foster closer links between industry and academic institutions (for example, through adjunct professors, strategic partnerships and collaborative projects to provide students with more concrete opportunities for experience);
- respond to the fact that supply will not be sufficient to support the current pace of technological development by complementing formal education programmes with micro-credentials and learning initiatives such as short-term courses and online learning;
- encourage diversity in the ICT sector, for example by organising awareness-raising campaigns (e.g. in collaboration with National Digital Skills Coalitions), providing scholarships, internships, education and training opportunities (e.g. summer camps) and other support (e.g. study orientation events) for under-represented groups, in particular women.

The European Commission provides a self-assessment questionnaire, through which teachers can evaluate their digital competences, and the way they use digital tools and technologies in teaching activities. This tool called "SELFIE for Teachers", is available online, and is composed of 32 items. "SELFIE for Teachers" is based on the reference framework on digital competences for teachers (DigCompEdu) and is divided into six areas (Engagement and professional development, Digital resources, Teaching and learning practices, Assessment of learning, Enhancement of student potential, Promoting the development of students' digital skills), which focus on aspects of teachers' professional activity.

VI. CONCLUSIONS

In recent years, with the spread of digital technologies in society, the acquisition of digital competences has become increasingly important. The discipline "computer science" was initially studied almost exclusively at university level, today it is increasingly taught in all schools levels.

Students need to be supported in acquiring the right competences and informed of the dangers.

Employers need to have clear and precise information about the digital skill and competences possessed by workers, which is why their certification becomes essential.

European countries attach great importance to learning of the new digital technologies, and schools play a key role in developing active and competent citizenship. The European Union and other European countries invest a lot of money in developing digital competences. Becoming digitally competent is essential for young people to participate effectively in a digitalised society and economy; failing to develop these competences risks widening the digital divide and prolonging existing inequalities over time.

As with any other school subject, teaching digital competences requires trained staff, the lack of adequately trained teachers compromises the quality of teaching. To provide good quality teaching, teachers must have a broad knowledge of the subject and adequate pedagogical competences, unfortunately in Europe it is difficult to find teachers with high digital competences and skills, mainly because graduates in the IT and related sectors are attracted by the industrial sector that offers much more advantageous salaries.

For teachers, having good digital competences and skills can allow them to identify and (by implementing the appropriate strategies) resolve critical aspects related to student learning, increasing their performance.

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