A comparative analysis of primary Digital Education design and its implementation

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Abstract: *The article explores the importance of digital education in primary education, emphasising alignment with European standards, such as the DigComp 2.2 framework. Through a comparative analysis of curricula from various countries, it highlights best practices and gaps in integrating digital skills, such as programming, online security, and digital literacy. The study focuses on the experience of the Republic of Moldova, which has introduced digital education as a mandatory subject, providing a model for effectively integrating technology into the educational process from an early age.*

Keywords: digital education, curriculum, DigComp framework, primary education.

1. Introduction

Digital Education (DE) is essential in preparing individuals for an increasingly technology-dependent society. It not only facilitates the integration of digital competence (a key competence) into daily activities but also contributes to developing essential skills for lifelong learning, innovation, and active participation in the digital economy. In this context, the European DigComp 2.2 framework provides a clear and updated structure for identifying and developing the digital competencies needed by 21st-century citizens.

The implementation of primary digital education is vital for several reasons. Children at this educational stage are increasingly exposed to Digital Technologies (DT) at an early age, and schools have the responsibility to provide a structured and safe environment for them to develop age-appropriate digital skills. DE contributes to fostering critical thinking, adopting responsible digital behaviours, and preparing for creative use of technology. Moreover, by integrating DE into the curriculum, students acquire transversal skills such as online collaboration, problem-solving, and adaptability, which are fundamental for their future academic and professional success.

As with many other educational subjects, the importance given to digital skills at the primary level varies significantly from country to country. In some states, DE is not included as a distinct subject or is not taught at all. In other countries, technology use is integrated throughout the entire curriculum. There are national curricula where this subject is mandatory, while in others, it is only optional.

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Typically, in the primary cycle, IT is integrated into other subjects, and later Computer Science becomes a separate subject. The names of subjects that integrate IT topics vary considerably: “Information Technology” (Finland, Japan), “Technological Literacy” (USA, Massachusetts), "Computer and Information Sciences; Digital World" (Serbia), “Technology and Informatics” (Montenegro), “Computer Applications” (Singapore), or “Computer Science” (Italy).

These names reflect differences in priorities and approaches. Some emphasise technology and programming, while others focus more on the practical use of ICT (Sturman & Sizmur, 2011).

2. Methodology and results

In this study, the aim was to investigate the role of DE, analyse international initiatives and practices, and contribute to the development of the curriculum framework and educational resources for primary DE. The methodological stages of the research are detailed below:

- A documentary analysis was conducted on specialised literature, international educational policies, and relevant reports to understand the role and importance of digital education in a globalised society. The study focused on its impact on the development of key competencies and preparing citizens for the challenges of the digital economy;
- The research included an examination of international projects, policies, and relevant initiatives in the field of DE. Best practices and models implemented in various countries were identified to provide a comparative context for the development of the national curriculum;
- Curricula for DE from several countries were compared, focusing on structure, content, and targeted competencies. The curriculum analysis from the Republic of Moldova was detailed to explain how learning contents were identified and developed;
- The researchers developed and implemented content units and digital educational resources for the DE subject intended for the primary cycle. The process included analysing educational needs, defining specific competencies, and creating interactive resources, followed by their testing and adjustment within the school context in the Republic of Moldova;
- A detailed analysis of the educational contents of the DE subject was conducted in relation to the areas of the DigComp 2.2 framework. This approach aimed to ensure coherence between curricular objectives and European standards in DE, highlighting the correlations and differences between them.

2.1 The importance of primary Digital Education at the global level

As mentioned earlier, the importance given to digital skills at the primary level varies significantly from country to country. In some states, DE is not included as a distinct subject (mandatory or optional) or is not taught at all, and digital skills are developed through other subjects. For example, the Massachusetts school curriculum (Massachusetts Department of Elementary and Secondary Education, 2016) does not include a separate subject focusing exclusively on Information Technology (IT) or Computer Science, whereas the school curriculum in Finland (Finnish National Agency for Education, n.d.) includes separate optional subjects for IT and Computer Science. In Estonia (Riigiteataja, 2019), since 2011, the curriculum stipulates that each subject includes learning units for developing digital competencies. For instance, in studying the native language and foreign languages, digital communication tools are examined, while the Computer Science curriculum (an optional subject) focuses on virtual identity, internet safety, digital security, etc.

Both Serbia (Serbia, 2020) and Montenegro (Ministry of Education, 2020) offer separate courses (mandatory or optional). In Serbia, middle school students (aged 11-14) study the mandatory subject "Computer Science and Informatics" and can additionally choose other modules in the IT field (Programming, Interactive Graphics, and Graphic Design). Similarly, in Montenegro, word processing applications are studied as part of the optional subject "Informatics with Technology" starting from the 5th grade, while programming skills are covered later, starting from the 8th grade, through the mandatory subject "Introduction to Programming".

In some countries, such as Israel (Armoni & Gal-Ezer, 2014a), programming is taught from an early age. Other countries, such as Singapore, have made significant strides in integrating DE into the curriculum. For instance, in 2020, Singapore implemented a mandatory 10-hour programming program for students (Sturman & Sizmur, 2011).

South Korea is also a pioneer in this field. As early as 1987, the South Korean government launched a national plan for the computerisation of schools. Starting in 2015, South Korea included programming as a mandatory part of the curriculum from the primary level (Rha & Yoshida, 2005).

2.2 Initiatives for developing the curriculum framework for primary Digital Education

Many countries have integrated DE into their school curricula to prepare future generations for the challenges and opportunities of technology. Australia, South Africa, and the United Arab Emirates are just a few examples of countries that have adopted these initiatives. In 2016, Australia (Australian Curriculum, Assessment and Reporting Authority [ACARA], 2016) implemented the Australian

Curriculum for Digital Technologies, focusing on programming, data representation, and digital systems.

In Europe, DE has developed at different rates, depending on the country. The European Commission has been a key force in this process, leading programs aimed at promoting digital skills and digital literacy across the community. Over time, European countries have adopted these visions to include DE in their education systems. One of the key frameworks developed by the European Commission is the "Digital Competence Framework for Citizens" (DigComp), which was first published in 2013. This initiative paved the way for measuring and improving the digital competencies of every citizen. As a result, DigComp has become an important tool for educators in Europe, providing guidance on how to review and improve the teaching of digital skills.

Some European countries have a long history of teaching Computer Science in primary schools. For example, in Poland, Computer Science has been taught since the 1990s (Sysło & Kwiatkowska, 2015; Sysło, 2018), while in Slovakia, it was introduced in the early 2000s (Kabátová, Kalaš & Tomcsányiová, 2016). Other countries introduced Computer Science in primary school more recently.

Similar trends have occurred globally. In 2015, the U.S. Congress passed the "Every Student Succeeds Act", which includes Computer Science as one of the subjects that should be taught starting in primary school. In 2016, Israel introduced Computer Science from the 4th grade through to the last grade of secondary education (Armoni and Gal-Ezer, 2014a). Japan introduced Computer Science for primary schools in 2020 (Oda, Noborimoto & Horita, 2019).

Estonia introduced programming as a mandatory subject for primary school students as early as 2012, and other European countries, such as England, Finland, and Italy, followed suit. In England, children between the ages of 5 and 16 learn programming and fundamental computer science concepts, including internet safety.

Since 2014, Digital Education has been a mandatory subject in Denmark (Ministry of Children and Education, 2017). This is due to the fact that, in the 2014 school year, the Danish government introduced a new national curriculum that includes the module "Understanding Technology". It is mandatory for all students (aged 6 to 16). The module provides students with a deep understanding of technologies and how they impact society, thus preparing them for an increasingly digitalised world.

Since 2015, South Korea (Choi, 2021) has initiated several measures to improve digital education, including transforming Computer Science from an optional to a mandatory subject.

Digital education became essential for Italy starting in the 2019/2020 school year. In 2020, a new national curriculum was developed, which introduced a new subject: "Digital Citizenship and Digital Civic Education" ("Cittadinanza Digitale e Educazione Civica Digitale"). This subject focuses on developing essential skills for responsible citizenship in the digital environment.

In Greece (Ministry of Education and Religious Affairs, 2020), Computer Science is a separate, mandatory subject starting from the 1st grade throughout primary education. In Lithuania, the curriculum was updated to introduce Computer Science from the 1st grade at the primary level in the 2020/2021 school year, with mandatory implementation starting in 2023. In Bosnia and Herzegovina, it began being taught in primary schools in the 2019/2020 school year, and in Serbia, it was introduced starting with the 2020/2021 school year.

In Latvia (Skola 2030, 2020), the 2020–2021 curriculum reform includes the "Computing" course for grades 4–6.

In Liechtenstein, the subject "Media and Informatics" is integrated into general courses for grades 1–3 and is a separate subject in grades 4–5. In Slovakia, Bulgaria, North Macedonia, and Hungary, this subject is mandatory from the 3rd grade (Marrone et al., 2021).

In Finland (Finnish National Agency for Education, n.d.), primary digital education has been integrated into the curriculum since the 1990s, with an emphasis on digital literacy, computational thinking, and programming. The Finnish national curriculum was reorganized in 2016 to increase the focus on these areas.

In Romania (Ministry of Education of Romania, 2024), digital competencies are integrated into the primary education curriculum, not as a separate subject but by incorporating mandatory digital education topics into various subjects. According to the Strategy for the Digitalization of Education in Romania 2021-2027, starting with the 2021-2022 school year, such elements have been introduced into the primary school curriculum. On August 30, 2024, the Digital Competence Framework for Students was approved, establishing the necessary digital competencies for each educational cycle, including primary education. This framework aims to develop students' digital skills, adapted to their age and educational level.

Table 1 presents the names of subjects related to Digital Education, how they are taught, and the year of their implementation in the curricula of various countries.

Table 1. Integration of primary Digital Education into the national curriculum of different countries

Country	**Status**	**Year**	**Starting grade**	**Name of the subject**
Republic of Moldova	c	2018	1	Digital Education
United Arab Emirates	c	2017	1	Computer Science
England	c	2014	1	Computing
Finland	c	2016	1	ICT and Technology
Izrael	c	2016	4	Science and Technology
Singapore	c	2020	1	Computational Thinking and ICT
Japonia	c	2020	1	Tehnologie

South Korea	c	2015	3	Informatics
USA	c	2015	1	Computer Science/Computational Thinking
Australia	c	2016	1	Tehnologii digitale
Bulgaria	o		3	Computer modelling
Estonia	c	2012	1	Informatics
Greece	o	2019	1	ICT
Croatia	c		1	Informatics
Latvia	o		1	Computing
Lithuania	o	2023	1	Informatics
Hungary	o	2020/ 2021	1	Digital culture
Poland	o	2017/ 2018	1-3 4	Informatics education/Informatics
Romania	o	2024	1-4	Information and Data Literacy (in all disciplines)
Slovenia	c		4	Computer science
Slovakia	o		3	Informatics
Bosnia and Herzegovina	o		1	Informatics
Liechtenstein	o		4	Media and informatics
North Macedonia	o		3	Working with computers and programming basics
Serbia	o	2020/ 2021	1	Digital world

Status: c = compulsory; o = optional

2.3 Curricular analysis of primary Digital Education in the Republic of Moldova

Although significant progress has been made regarding the development of the curriculum framework for Digital Competence as a key competence, there is no common reference framework for the content of primary Digital Education (DE). At the European level, Digital Competence is described in the Digital Competence Framework for Citizens (DigComp) with 5 main areas and 21 skills. The latest version was published in March 2022 (Vuorikari, Kluzer & Punie, 2022). Although activities in Computer Science lessons contribute significantly to the development of Digital Competence, the objectives of this subject are still different. To support European countries' efforts in the development of Computer Science education, the Informatics for All coalition (Informatics for All coalition, 2022) published a reference framework in February 2022, the Informatics Reference Framework for School, which includes 10 domains considered fundamental in computer science education (Table 2).

Table 2. Fundamental domains in Computer Science education

Fundamental domains in Computer Science education	
D1. Data and information	D6. People–system interface
D2. Algoritmi	D7. Design and development
D3. Programming	D8. Modelling and simulation
D4. Computing systems	D9. Awareness and empowerment
D5. Networks	D10. Safety and security

Table 3 presents the results of the analysis of school curricula from different countries regarding computer science education for primary education level (in accordance with the 10 fundamental domains of the *Informatics Reference Framework for School*).

Table 3. Analysis of fundamental domains in Computer Science education worldwide

Country	**Fundamental domains in Computer Science education**									
	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10
South Korea	+	+	+	+	+				+	+
Singapore	+	+	+	+	+				+	+
Japonia	+	+	+	+	+				+	+
Australia	+	+	+	+	+				+	+
United Arab Emirates	+	+		+	+				+	+
Republic of Moldova	+	+	+	+	+				+	+
England	+	+	+	+	+				+	+
Finland	+	+	+	+	+				+	+
Bulgaria	+	+	+					+		+
Estonia			+							
Greece	+	+	+		+	+	+	+	+	
Croatia	+		+	+	+	+			+	+
Latvia			+		+					+
Lithuania										
Hungary		+	+			+				+
Poland	+		+	+	+		+			+
Romania	+				+		+			
Slovenia	+	+	+		+			+	+	+
Slovakia	+	+	+						+	+
Bosnia and Herzegovina	+									+
Liechtenstein	+	+	+	+	+				+	
North Macedonia		+	+	+						+
Serbia		+	+		+				+	+
Turkey							+			

The mentioned curriculum analysis shows that:

a) The educational systems in Moldova, Bulgaria, Czech Republic, Greece, France, Croatia, Poland, Slovakia, Switzerland, Liechtenstein, and Montenegro address topics related to *data and information* at the primary education level.

b) More than half of the countries in Table 2 have already designed learning topics related to *algorithms* in primary education (Croatia, Hungary, Macedonia, Moldova, etc.). In Croatia, primary school students learn to follow and present the sequence of steps to solve a simple task, while in Hungary, primary school students are taught to recognise, reproduce, and apply basic steps from daily activities, structure a daily algorithm in simple steps, understand the order of these steps, and determine the desired outcome of the algorithm.

c) In general, school curricula do not specify a particular *programming* language; some curricula mention block programming or visual programming and only rarely include programs like Scratch (e.g., in the 7th-grade computer science curriculum in North Macedonia). In Poland, informatics is taught at all three educational levels, including primary education. Primary school students create and write stories and simple solutions in visual programming environments, using sequential, conditional, iterative commands, and events. They develop programs that control robots or objects on the screen.

d) In some curricula for primary education (from Croatia, Poland, Slovenia, Liechtenstein, and North Macedonia), there are approaches related to the area of *computing systems*.

e) Many countries have developed learning topics related to *networks* at the primary education level (Greece, Croatia, Latvia, Poland, Slovenia, Liechtenstein, Serbia).

f) Only a few countries (Greece, Croatia, and Hungary) already include explicit learning objectives related to *human-machine interfaces* at the primary level, and only three countries (Greece, Poland, and Turkey) have learning outcomes related to design and development at the primary level.

g) *Modelling and simulation* is another area that the school computer science curricula do not frequently address. Only a few countries have explicit learning outcomes for this area in primary education (Bulgaria, Greece, Slovenia), and a few countries already have explicit learning outcomes related to the area of *Awareness and empowerment* at the primary education level (Greece, Croatia, Slovenia, Slovakia, Liechtenstein, Serbia).

h) Learning content corresponding to the domain of *Safety and security* is found in the majority of primary school curricula.

i) În România competențele digitale sunt integrate în curriculumul învățământului primar, însă nu printr-o disciplină separată, ci prin includerea unor subiecte obligatorii de Educație Digitală în diverse materii.

j) The education system in the Republic of Moldova addresses subjects related to most of the fundamental areas of Informatics at the primary level, which suggests an active integration of technologies and digital skills into the school curriculum from an early age (Ministry of Education, Culture and Research of the Republic of Moldova, 2018).

2.4 Primary Digital Education in the Republic of Moldova versus the areas of the DigComp 2.2 framework

Since 2018, primary digital education has become mandatory in the Republic of Moldova. The design and implementation activities for digital education have been supported by the government through joint initiatives with IT associations. The European Digital Competence Framework for Citizens (in 2018, DigComp 2.1, and from 2020, DigComp 2.2), conceptually developed by the European Union to support the development and assessment of citizens' digital competencies, describes 21 digital skills across 5 dimensions: A1. Information and data literacy; A2. Communication and collaboration; A3. Digital content creation; A4. Security; A5. Safety and problem solving.

Figure 1. Interactive digital learning resources for Digital Education (in Republic of Moldova)

As a result, together with the authors of this article, interactive digital learning resources were designed and developed (Figure 1, Ministry of Education and Research of the Republic of Moldova, n.d.), considering the DigComp 2.1 framework and the age-specific characteristics of the students (Table 4).

Table 4. Educational content of primary Digital Education versus DigComp 2.2 areas

Grade	Contents	Areas DigComp 2.2				
		A1	A2	A3	A4	A5
1	Digital world	+				
	Digital communication		+			
	Digital technology in everyday life				+	+
	Digital thinking			+		
2	Units of information	+				

	Writing and drawing digitally			+		
	Digital thinking			+		+
3	Creating and organizing folders and files	+				
	Writing and drawing digitall			+		
	The expanding digital world – networks and the internet		+		+	
	Digital thinking			+		+
4	Web pages	+				
	Rights and obligations in the digital world				+	
	Learning digitally					+
	Digital thinking			+		+

The national curriculum for primary Digital Education (from the Republic of Moldova) involves the formation and development of a wide range of digital skills in alignment with the 5 areas of the DigComp 2.2 framework (Figure 2).

The educational content of primary digital education developed by the authors has been created in accordance with this curriculum.

An important feature of the curriculum is the "Learning Digitally" module in the 4th grade, which focuses on the formation and development of ICT-assisted learning skills. Thus, the 4th-grade student should be able to utilise their educational achievements in the field of Digital Education to enhance their academic performance.

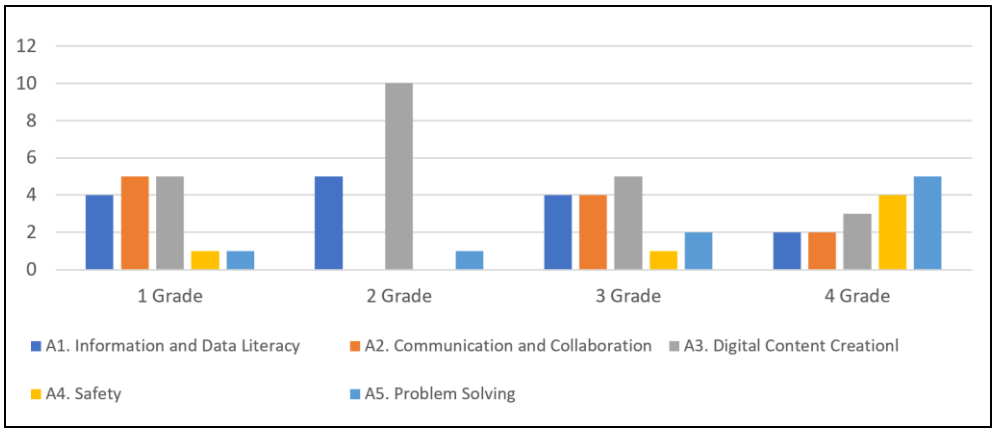

Figure 2. Number of hours of educational content per DigComp 2.2 areas

3. Conclusions

Digital education is becoming an integral and essential part of modern education systems. Countries that have adopted early approaches, either through the integration of primary digital education or by introducing programming as a mandatory subject, recognise the importance of developing digital competencies

from an early age. The Republic of Moldova has made remarkable progress in this direction, providing students with the opportunity to learn both the use and creation of digital content, preparing them for the professional demands of the future.

A comparative analysis of educational curricula from various European countries shows significant variation in how digital education is approached. While most countries include basic competencies such as information literacy, digital security, and online collaboration, there are notable differences in how programming, algorithms, and digital modelling are taught. Education systems in countries such as Greece, Poland, and Turkey have made significant strides in areas like technological solution design and human-machine interaction, although these fields remain less explored globally.

The Republic of Moldova, Bulgaria, the Czech Republic, Greece, France, Croatia, Poland, Slovakia, Switzerland, Liechtenstein, and Montenegro already have considerable progress in integrating topics related to data and information.

The curriculum for digital education in the Republic of Moldova aligns with European standards by covering all five dimensions of the DigComp 2.2 framework, providing students with the necessary competencies to become responsible users and creators of technology. However, the lack of continuity in the development of these competencies between primary and secondary education remains a challenge that deserves additional attention.

In conclusion, digital education can no longer be considered optional but a necessity to equip new generations with the skills demanded by an increasingly digitalised world.

REFERENCES

Armoni, M. & Gal-Ezer, J. (2014) High school computer science education paves the way for higher education: the Israeli case. *Computer Science Education*. 24, 101-122. doi: 10.1080/08993408.2014.936655.

Australian Curriculum, Assessment and Reporting Authority (ACARA) (2016) *Australian Curriculum for Digital Technologies*. Available at: https://www.australiancurriculum.edu.au/f-10-curriculum/technologies/digital-technologies/ [Accessed 4th January 2025].

Choi, D. (2021) *How South Korea implemented its computer science program*. Brookings. Available at: https://www.brookings.edu/wp-content/uploads/2021/10/How-S-Korea-implemented-its-CS-program_FINAL.pdf [Accessed: 5 January 2025].

Finnish National Agency for Education (n.d.) *National core curriculum for primary and lower secondary (basic) education*. Available at: https://www.oph.fi/

en/education-and-qualifications/national-core-curriculum-primary-and-lower-secondary-basic-education [Accessed: 3rd January 2025].

Informatics for All Coalition (2022) *Informatics Reference Framework for School*. Available at: https://www.informaticsforall.org/wp-content/uploads/2022/03/Informatics-Reference-Framework-for-School-release-February-2022.pdf [Accessed: 15th January 2025].

Kabátová, M., Kalaš, I. & Tomcsányiová, M. (2016) Programming in Slovak Primary Schools. *Olympiads in Informatics*. 10, 125-159. doi:10.15388/ioi.2016.09

Marrone, R., van Sebille, Y., Gabriel, F., Kovanovic, V. & de Laa, M. (2021) Digital technology in education systems around the world: Practices and policies. *Educational Technology International*. 6(1), 3-39. Available at: https://www.education.sa.gov.au/docs/ict/digital-strategy-microsite/c3l-digital-technologies-in-education-best-practices-report.pdf [Accessed: 4th January 2025].

Massachusetts Department of Elementary and Secondary Education (2016) *Massachusetts Curriculum Framework for Digital Literacy and Computer Science*.

Available at: http://masscan.edc.org/documents/publications/DLCS_MA_Curriculum_Framework-June_2016.pdf [Accessed 3 January 2025].

Ministry of Children and Education (2017). *Læreplan Informatik* B – hhx, htx. p. 2. [online] Available at: https://www.uvm.dk/gymnasiale-uddannelser/fag-og-laereplaner/laereplaner-2017/htx-laereplaner-2017 [Accessed 4 January 2025].

Ministry of Education (2020) *Curriculum for Gymnasium*. Available at: https://zzs.gov.me/ResourceManager/FileDownload.aspx?rId=438077&rType=2 [Accessed: 4th January 2025].

Ministry of Education and Religious Affairs (2020) *ICT Guidelines for Primary School*. Available at: http://www.iep.edu.gr/images/iep/epistimoniki_ypiresia/epist_grafeia/graf_ereynas_b/2020/τπε-φυσικη_αγωγη-2020-21.zip [Accessed: 5th January 2025].

Ministry of Education and Research of the Republic of Moldova. *Educația digitală*. Available at: https://ctice.gov.md/resurse/educatia-digitala/ [Accessed: 10th January 2025].

Ministry of Education of Romania (2024) *Framework of digital competencies for students.* Available at: https://legislatie.just.ro/Public/DetaliiDocumentAfis/289961 [Accessed: 20th February 2025].

Ministry of Education, Culture and Research of the Republic of Moldova (2018) *Curriculum pentru clasele primare*. Available at:

https://mecc.gov.md/sites/default/files/curriculum_scolar_clasele_i-iv_ro_2.pdf [Accessed: 20th February 2025].

Rha, I. & Yoshida, A. (2005) A comparative study on ICT policy in education in Korea and Japan. *Educational Technology International*. 6(1), 3-39. Available at: https://koreascience.kr/article/JAKO200514052804206.pdf [Accessed: 12th January 2025].

Riigiteataja (2019) *Framework requirements for teacher training*. Available at: https://www.riigiteataja.ee/akt/122082019010 [Accessed: 3rd January 2025].

Skola 2030 (2020) *Computers Grades 1–9. Sample of the subject programme*. p. 184. Available at: https://mape.skola2030.lv/resources/327 [Accessed: 12th January 2025].

Sturman, L. & Sizmur, J. (2011) *International Comparison of Computing in Schools*. September 2011. Available at:

https://www.computingatschool.org.uk/media/1u1jmkeb/internationalcomparisons-v5.pdf [accessed: 17th february 2025].

Sysło, M. M. (2018) A perspective from poland on the introduction of informatics into schools. In *UNESCO/IFIP TC3 meeting at occe coding, programming and the changing curriculum for computing in schools, Linz, Austria, 27 june 2018.* Available at: https://www.ifiptc3.org/working-groups/task-force-curriculum/ [Accessed: 17th february 2025].

Vuorikari, R., Kluzer, S. & Punie, Y., (2022) DigComp 2.2: The Digital Competence Framework for Citizens. *Publications Office of the European Union, Luxembourg*. Available at: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/digcomp-22-digital-competence-framework-citizens-new-examples-knowledge-skills-and-attitudes [Accessed 12th January 2025].