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Analysis and Comparison of International Digital Competence Frameworks for Education

Joao Mattar [1,2,*], Cassio Cabral Santos [3] and Lucia Maria Cuque [1]

[1] Tecnologias da Inteligência e Design Digital—TIDD, Pontifícia Universidade Católica de São Paulo, São Paulo 01303-001, Brazil
[2] Mestrado em Ciências Humanas, Universidade Santo Amaro, São Paulo 04743-030, Brazil
[3] Instituto de Educação, Universidade de Lisboa, 1649-013 Lisboa, Portugal
* Correspondence: joaomattar@gmail.com

Abstract: Different frameworks are available for assessing and developing digital competences, which poses a choice challenge for potential users. This article aims to analyze and compare international digital competence frameworks for education. The study compares characteristics such as the frameworks' purpose, structure, competences, and levels, as well as indicators for instrument development. The results indicate that the objective, the theoretical background, and the target group define the framework characteristics. Most analyzed frameworks focus on teacher training. The comparison identified common competences: communication, collaboration, sharing, information and data, content, technical, teaching, learning, and ethics. All frameworks include profiles, objectives, descriptors, activities, examples, and cases of knowledge, skills, and attitudes. The article concludes that digital competence frameworks should be segmented by educational actors (students, teachers, and administrators) and levels (early childhood, primary, higher, and corporate) with corresponding assessment instruments.

Keywords: 21st-century skills; computer literacy; digital literacy; educational technology; evaluation; ICT; information literacy; media literacy; professional development; teacher training

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1. Introduction

A recommendation from the European Parliament and Council of the European Union [1,2] lists eight key competences for lifelong learning, one being digital competence. The 2030 Agenda for Sustainable Development [3] claims that the spread of Information and Communication Technologies (ICTs) has the potential to bridge the digital divide. The Agenda Goal 4 is to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all", along with technical skills. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) considers ICTs critical for achieving all 17 goals [4].

Even before the 2030 Agenda, however, several frameworks were elaborated to support ICT incorporation into education. Nevertheless, the problem is that many digital competence frameworks have different scopes (national, regional, and international), making it difficult for the researcher and practitioner to choose which one(s) to use.

This article analyzes and compares international digital competence frameworks for education. A digital competence framework is understood here, in a broad sense, as a structured conceptualization of intertwined competences and sub-competences aiming to develop and assess the digital literacy of a specific target group [5]. Education is also understood here in a broad sense: any process involving teaching and learning. The justification for this study is the need to make an updated comparison of frameworks with an international scope to guide researchers, practitioners, policymakers, and other persons interested in assessing or developing the digital competences of specific educational groups.

This study aims to answer the following questions: (1) What are the main similarities and differences between international digital competence frameworks for education? (2) What competences do these frameworks most mention? (3) What proficiency levels do these frameworks propose? (4) What indications for developing assessment instruments do these frameworks present?

The following section presents the results of a literature review on studies that compare digital competence frameworks. The third section explores the semantic field related to digital competence. The fourth section delineates the methodology employed in analyzing and comparing the frameworks. Then, the results are presented, followed by a discussion. The conclusion summarizes the study, highlights its contributions, reflects on its limitations, and points to possible future works.

2. Literature Review

This section presents the results of a literature review conducted to analyze articles that compare digital competence frameworks. A search was initially conducted on 29 December 2021, in Google Scholar. The search returned a total of 39 results. Then, the following selection criteria were applied:

(a) The text should be fully available for download.
(b) The comparison should include more than two frameworks (as we are not interested in one-to-one but in broader group comparisons).

Seven texts that effectively compared digital competence frameworks and complied with these selection criteria were included in the literature review and are summarized in this section.

Similar searches were also performed in Scopus and Web of Sciences databases. The Scopus search returned 130 results, and the Web of Science search returned 87 results, but none was included due to not complying with the selection criteria.

Rosado and Bélisle [6] compared ten frameworks developed for integrating ICT in education. As the study is dated 2006, the frameworks have no longer been updated or used. The comparison focused on the frameworks' characteristics, context, scope, intended audience, visions, objectives, basic components of digital educational practices, strategies, and evaluation (assessment procedures, indicators, and criteria), among other issues. The analysis highlighted the need for new visions of pedagogical models and changes related to incorporating ICT in education, that according to the authors, were insufficiently addressed by the documents.

Ferrari's report [5] analyzed 15 frameworks to support the proposal of a digital competence framework for citizens (later named DigComp). The objective of the comparison was to identify differences and similarities among the selected frameworks. Several criteria were used to compare the frameworks, such as literacy focus and approaches, target group, the vision of digital competence, main competences developed and its components, proficiency levels, and if and how competences are measured and assessed. The comparison pointed to the need to organize digital competences in areas and levels in a framework. Ferrari et al. [7] is a paper based on this report.

Cabero-Almenara et al. [8] used Spanish expert judges to evaluate and compare the most employed international digital competence frameworks for teachers. The evaluation included seven frameworks. The statistical analysis aimed to identify the most suitable framework for delivering a MOOC on Teacher Digital Literacy. The European Framework of Digital Competence for Teachers (DigCompEdu) was considered the most adequate to be used as theoretical support for this purpose, followed by the Common Spanish Framework of Digital Competence for Teachers (INTEF), based on DigCompEdu.

Tomczyk and Fedeli [9] systematically reviewed the five most influential and discussed digital literacy frameworks for teachers, focusing on their differences and similarities. The analysis (more than effectively a comparison) identified that these frameworks have clearly defined areas and levels of digital literacy and their measurement tools; self-declaration

(instead of practical activities) is used to measure digital literacy; and the group (teachers) defines the characteristics of the framework.

Yang et al. [10] reviewed and compared the characteristics of the six main current international frameworks on teachers' digital competence through a SWOT (Strengths–Weaknesses–Opportunities–Threats) analysis, focusing on its differences. The analysis identified different types of content, such as the purpose of the frameworks, competence areas, competences, learning domains (such as knowledge, skills, and attitudes), learning tasks (and how the tasks are to be performed), and the digital tools used for that purpose.

Finally, Bravo et al. [11] conducted a comparative analysis of eight 21st-century skills frameworks. The analysis identified differences and similarities of these frameworks based on three main comparative thematic blocks: definition, objectives and vision, and competencies and abilities. The comparison indicated that the frameworks have various specializations: evaluation and/or measurement, implementation, and learning guide. Some skills are mentioned in all frameworks (information, communication, collaboration, and technical), while others are mentioned in most documents (cultural and social, problem-solving, and critical thinking).

The result of the Bravo et al. [11] study is a meta-framework of digital literacy. The proposed meta-framework has 9 competences: 3 direct (information and data; communication and collaboration; and technical), and 6 transversals (problem-solving; global citizenship and multicultural awareness; interpersonal; future thinking; creative thinking; and critical thinking). It also has 6 dimensions (critical, cognitive, operative, social, emotional, and projective), 53 skills, and 9 learning profiles (creative thinker, innovative visionary, empowered learner, global citizen, knowledge constructor, collaborative communicator, conscious internaut, technological expert, and productive ideator).

It is possible to identify that some frameworks are considered in more than one study included in this literature review, independently of the version: TPACK [9,10], UNESCO's Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2 [10,11], ISTE standards [8–11], UNESCO ICT Competency Framework for Teachers [5,8–10], and the DigComp series—specifically DigComp and DigCompEdu [8–11].

Some criteria are used in more than one study for comparison: the frameworks' purposes, objectives, and visions; audience or target group; competences proposed; proficiency levels; and how competences are measured and assessed. The audience or target group defines the framework characteristics. The competences are usually organized in areas and levels, with some mentioned in most frameworks (information, communication, collaboration, and technical skills). This literature review also reinforces the need to update digital competence frameworks frequently; none of the documents mentioned by Rosado and Bélisle [6], for example, are currently in use today.

3. The Semantic Field of Digital Competence

The expression "digital competence" is part of an extensive semantic field composed of scattered, overlapping, and sometimes conflicting concepts, such as digital literacy, information literacy, media literacy, computer literacy, technology literacy, ICT literacy, data literacy, Internet literacy, digital citizenship, 21st-century skills, ICT skills, and digital skills. This section explores conceptual frontiers in this semantic field.

Initially, it is important to note that the review by Salman et al. [12] concludes that the words "competence" and "competency" are used interchangeably as synonyms without the need to make distinctions between two meanings. There is a common critique of the terms' association with economic interests, production, and employability, but an enriched perspective includes other social aspects, considering knowledge, attitudes, and skills (KAS) [5].

A pervasive term in this semantic field is "literacy". The word is historically associated with reading printed texts and handwriting. However, the development of technologies slowly changed its meaning, as we now also (or mainly?) read and write digital texts. Digital literacy then became associated with ICT and computer literacy. Today, however,

the focus is not only on ICT and computer skills for the use of tools, software, and hardware; other literacies are required, such as media literacy (understanding different media), Internet and information literacy (critical in searching and evaluating information), and communication using different tools and applications. In this techno-social approach, digital literacy must combine technical and critical thinking skills [5,11].

In this sense, UNICEF builds a work-in-progress definition for digital literacy focusing on children:

> Digital literacy is the set of knowledge, skills, attitudes, and values that enable children to confidently and autonomously play, learn, socialize, prepare for work and participate in civic action in digital environments. Children should be able to use and understand technology, search for and manage information, communicate, collaborate, create and share content, build knowledge and solve problems safely, critically and ethically, in a way that is appropriate for their age, local language and local culture. [13] (p. 32).

"Digital competence" is related to all these types of literacy, often used as a synonym for "digital literacy". Merging and summarizing the definitions of the 15 frameworks studied, Ferrari defines it this way:

> Digital Competence is the set of knowledge, skills, attitudes, abilities, strategies, and awareness that are required when using ICT and digital media to perform tasks; solve problems; communicate; manage information; collaborate; create and share content; and build knowledge effectively, efficiently, appropriately, critically, creatively, autonomously, flexibly, ethically, reflectively for work, leisure, participation, learning, and socialising. [5] (p. 29).

Ferrari prefers digital competence to digital literacy because of learning domains (knowledge, attitudes, and skills) spreading across several competence areas. On the one hand, choosing competences instead of literacy stresses the importance of attitudes:

> At present, the focus of Digital Competence is mainly on knowledge and skills, and attitudes seem to play a much secondary role. Moving towards competence instead of literacies requires taking into account attitudes, which are often left aside in certification and assessment discourses, but which are so intertwined with knowledge and skills to be often difficult to isolate. [5] (p. 19).

On the other hand, this notion of competence is broader than a tool-oriented perspective, covering much more than the technical or operational skills needed today for using digital tools:

> (. . .) skills are only part of the learning domains that are included in Digital Competence; and the ability to use specific tools or applications is just one of the several competence areas that need to be developed by users in order to function in a digital environment. [5] (p. 4).

In a more recent document, UNICEF [13] recognizes that the field is evolving from a focus on technical digital skills towards more comprehensive and holistic approaches that consider also cultural, cognitive, critical thinking, and ethical aspects. This shift is shared by international organizations, national governments, policy, and research.

A systematic review of the uses of the two concepts in higher education research [14] shows an earlier use of the term "digital literacy" when compared to the more recent use of "digital competence". Moreover, digital literacy is most often defined concerning research, while digital competence is most often defined concerning policy documents. The Council of the European Union considers the latter one of the key competences for lifelong learning, defining it again in a broader way:

> Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and

> collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking. [2] (p. 9).

A broader term is "digital citizenship", which UNICEF [13] prefers as an approach when working with children in the context of developing countries.

Another umbrella concept included in the digital competence semantic field (or which subsumes it) is "21st-century skills", which people need today to participate in society and the economy as citizens and workers [2,11]. Most of the competences and skills Bravo et al. [11] identify in the 21st-century skills studied frameworks are like those in digital competence frameworks. Nevertheless, one of the authors' objectives is to understand how digital competences articulate with 21st-century skills. One can conceptualize that adequately performing in the 21st century requires several skills, including (but not only) digital competences, even if we take the latter broadly, as discussed in this and the next section.

4. Materials and Methods

A previous section of this article described the methodology of the literature review. This section describes the methodology for analyzing and comparing the frameworks. A critical methodological decision was to identify and select the digital competence frameworks for the analysis and comparison. Some criteria were thus defined:

(a) The document should be a specialized and specific framework for digital competences.
(b) The framework should apply to education.
(c) The framework should have an international or regional scope.
(d) The framework should have a recent or updated version.

The first criterion requires the framework to be focused on digital competence, as discussed in the previous section, with accepted variations to digital literacy or ICT. Besides that, it should be classified as a specialized framework, according to Bravo et al. [11], when discussing 21st-century skills frameworks. Consequently, it should not be considered an articulated framework (where digital competences are transversal to the rest of the competences proposed) nor an autonomous framework (where digital competences have no integration with the rest of the competences proposed).

The second criterion requires that the framework is (or can be) applied to education, considered any teaching and learning process.

The framework scope should be regional (such as the ones produced by the European Commission) or international. National digital competence frameworks would open infinite possible category comparisons, introducing complex contextual issues.

Finally, the compared frameworks should have recent or updated versions. We observed the need to frequently update digital competence frameworks, mainly because of the development of new technologies. In this sense, a non-updated version indicates that a framework is no longer used.

The literature review identified frameworks analyzed in more than one study. All complied with these criteria: ISTE standards, TPACK, UNESCO ICT Competency Framework for Teachers, DigCompEdu, DigComp, and UNESCO's Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2.

Bravo et al. [11] classify the ISTE National Educational Technology Standards (NETS) as national. However, the new version does not include the word "National" anymore, and the Standards webpage (https://www.iste.org/iste-standards, accessed on 8 December 2022) carries the following information: "The standards have been adopted in all 50 U.S. states and many countries throughout the world". Moreover, the "International" Society of Technology in Education publishes it. Although initially elaborated in the United States and for the United States, we consider it now an international framework. One could argue that the ISTE Standards are not a framework for a simpler structure than the others.

Still, the document states: "The ISTE Standards serve as a framework for innovation and excellence in learning, teaching and leading" [15] (p. 2).

One could also argue that TPACK is not a framework, as it is elaborated in academic papers, not as a finished document as the others. However, these papers nominate it as a framework [16–19], and although it might also be considered more straightforward than the other frameworks, it complies with all the selection criteria.

The DigComp series includes a framework that is not mentioned in any of the texts in the literature review but complies with all the selection criteria and focuses on education: The European Framework for Digitally Competent Educational Organisations (DigCompOrg) [20].

One could question the educational aspect of another framework in the series, the Digital Competence Framework for Consumers (DigCompConsumers) [21]. However, we did not establish any limitations for formal education; informal teaching and learning processes are considered in our criteria. In this sense, DigCompConsumers educates consumers on how to behave in the digital marketplace, complying with all the other criteria.

Assessment and Teaching of 21 Century Skills (ATCS), OECD Future of Education and Skills 2030, and Partnership for 21st-century skills (P21), frameworks studied by Bravo et al. [11], have a regional or international scope. However, the authors themselves indicate that they do not comply with the first criterion: in ATCS and P21, there is no integration of the digital skills with the other skills, and in OECD, the digital skills are transversals to the others, not configuring a specialized digital competence framework.

The Digital Kids Asia-Pacific framework [22], developed by the UNESCO Asia and Pacific Regional Office in Bangkok, can be classified in a similar broader category, in which digital literacy is only one of the framework domains, together with digital safety and resilience (including children's health and well-being), digital participation and agency, digital emotional intelligence, and digital creativity and innovation. UNICEF analyzes these digital citizenship and digital intelligence frameworks, which should be used in specific contexts.

UNESCO's Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2 [4] identifies three commercial frameworks adopted for training courses and assessment in several countries: International Computer Drivers Licence (ICDL), Certiport Internet and Computing Core Certification (IC-3), and Microsoft Digital Literacy Standard Curriculum. National entities adopt these enterprise frameworks for human resource development, certification programs, and job qualification requirements. A focus on jobs and certification would not be an argument to exclude them from our research. However, these documents do not look like frameworks. There are no mentions of them in any of the texts included in the literature review nor in the other frameworks considered for analysis and comparison. They look more like support material for technology and computer skills courses and certifications based on the vendors' approaches or software. Digital skills are taken here in a narrower sense than digital literacies or competences, as discussed in the previous section. In addition to that, the UNESCO document [19] already maps the three against DigComp for elaborating the framework, so we did not include them in the comparisons.

No other framework mentioned in the studies included in the literature review or the documents chosen for analysis complied with the selection criteria. The research group did not know any other framework that complied with the criteria. Free searches on the Internet and other readings did not return additional results.

Then, we developed a Microsoft Word file for data extraction. The extraction files are available as Supplementary Material for this article. Later, we identified that the extraction structure was very similar to the "Model form for collecting information on cases" used by Bravo et al. [11].

Each author initially extracted data from some frameworks. Then, the group reviewed the extracted information, including the return to the documents, several times. The comparison then advanced to identify similarities and differences among the frameworks.

To identify the competencies most mentioned by the frameworks, a Microsoft Word file was prepared with the documents' areas and competences, and, when the competences were not nominated, included the descriptions, available as Supplementary Material for this article.

5. Results

5.1. Analysis

The International Society for Technology in Education (ISTE) publishes the ISTE Standards [15], formerly named the National Educational Technology Standards (NETS). Target groups segmented previous versions, but the current version (2021) is presented as a single 13-page document. It is used in the United States but also other countries. ISTE Standards is a framework for innovation and excellence in learning, teaching, and leading, aiming to transform systems and students' lives. It has four sections: Students, Educators, Educational Leaders, and Coaches, as well as a section on Computational Thinking. Neither the document nor its webpage (https://www.iste.org/iste-standards, accessed on 8 December 2022) describes its development methodology. There is no definition of digital competence or similar terms throughout the document.

For each target group, there are profiles, and for each profile, there are competences or descriptors (a total of 31). For students, for example, there are seven profiles: empowered learner, digital citizen, knowledge constructor, innovative designer, computational thinker, creative communicator, and global collaborator. One of the digital competences or descriptors of a student as an empowered learner is "articulate and set personal learning goals, develop strategies leveraging technology to achieve them and reflect on the learning process itself to improve learning outcomes" [20] (p. 3). Figure 1 presents the profiles of the four target groups.

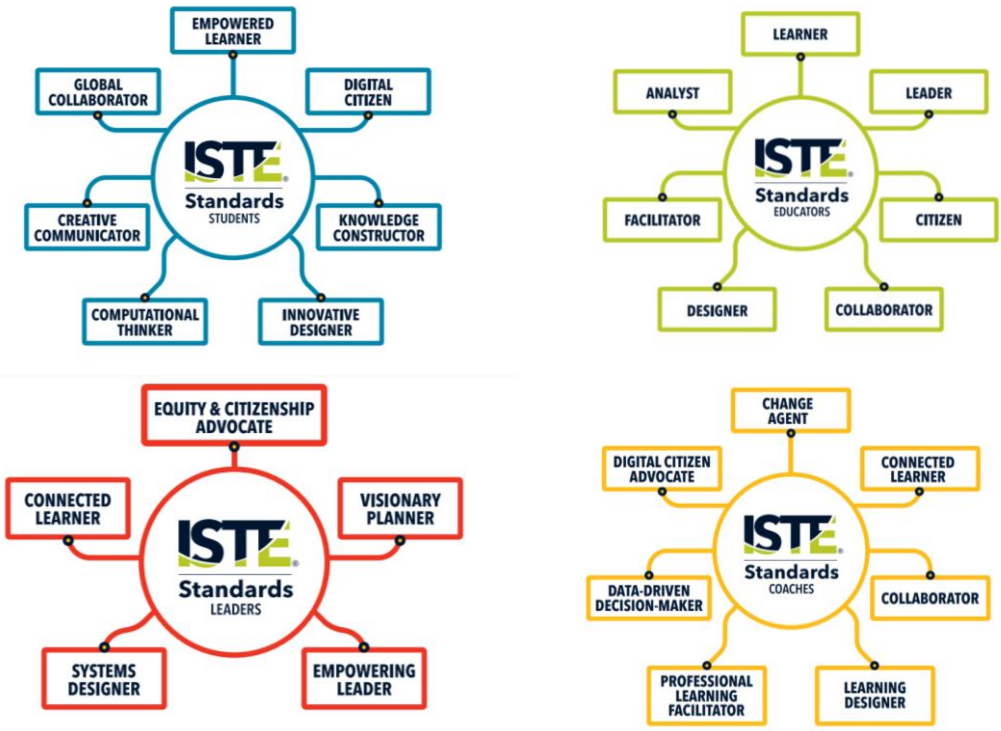

Figure 1. ISTE structure [15] (p. 3, 5, 7, 9).

Materials and information complete the document, such as pop-ups with explanations of text passages (available on the webpage); videos and additional materials as examples; guides for adopting, using it, and certification; and products seal-aligned with the Standards.

Technological Pedagogical Content Knowledge (TPACK, originally TPCK) is a conceptual framework for educational technology used worldwide. Differently from all the other frameworks analyzed in this section, it was not developed in a single document or report, but in a sequence of academic papers published since 2006 [16–19], as well as the support of a website (http://tpack.org/, accessed on 8 December 2022).

TPACK's purpose is to support teachers in integrating technology into their practices, emphasizing the connections and interactions between and among technology, pedagogy, and content. The authors conducted design experiments to develop the framework [16]. Figure 2 represents the last version of its structure.

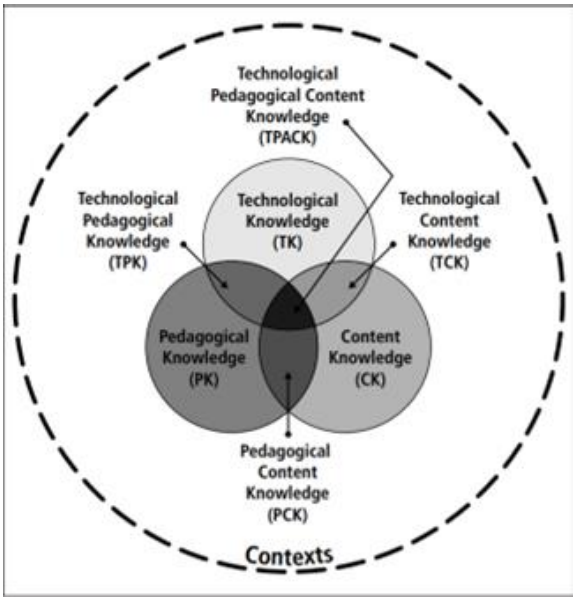

Figure 2. The TPACK framework and its knowledge components [19] (p. 15).

In addition to Content Knowledge (CK) and Pedagogical Knowledge (PK), Technological Knowledge (TK) involves a level of technical and computer literacy, the knowledge and skills required to operate current and adapt to new digital technologies. Nevertheless, teachers also need a broader understanding and proficiency in information technology related to information processing, communication, and problem-solving [16,17]; there is a mention of the ISTE Standards [16].

The TPACK framework suggests that the knowledge teachers need to develop can almost be seen as a new form of literacy—as a development of skills, competencies, and knowledge in practice that goes beyond specific knowledge of particular disciplines, technologies, and pedagogical techniques. This new form of literacy, however, emphasizes integration of these knowledge bases, going beyond standard definitions of literacy that often focus on instrumental competencies [17] (p. 10).

There are intersections in the framework: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK). Technological Pedagogical Content Knowledge (TPACK) "is an emergent form of knowledge that goes beyond all three components" [16] (p. 1028).

The selected articles on TPACK [16–19] present several application examples of the framework. There is also a mention of a survey instrument developed and administrated by the authors consisting of 35 items—33 Likert scale items and 2 short-answer questions [16]—and 141 other instruments based on the framework [18].

The UNESCO ICT Competency Framework for Teachers (ICT CFT) version 3.0 [23], a 68-page document published in 2018 taking into account the Agenda 2030 for Sustainable Development, was preceded by two previous versions: 2008 (3 volumes) and 2011. It is designed for teacher training on the use of information and communication technologies

(ICT) in education. Thus, its target audience is "teacher-training personnel, educational experts, policymakers, teacher support personnel and other professional development providers" [23] (p. 7). The document does not make explicit the framework's development methodology.

A specific chapter of the framework presents implementation examples, including influencing ICT in education policy creation and national teacher standards, providing assessment criteria to determine levels of teacher ICT competence, shaping teacher curriculum design, and designing teacher professional development courses. The examples range from Latin America and the Caribbean to Europe and North America, Africa and Pacific Region, and Arab States.

The ICT CFT structure includes six aspects of teachers' professional practice over three levels of teachers' pedagogical use of ICT, corresponding to 18 competences according to the document (Figure 3). The Glossary defines "competency" as "the skills, knowledge and understanding needed to do something successfully to a professional standard" [23] (p. 63).

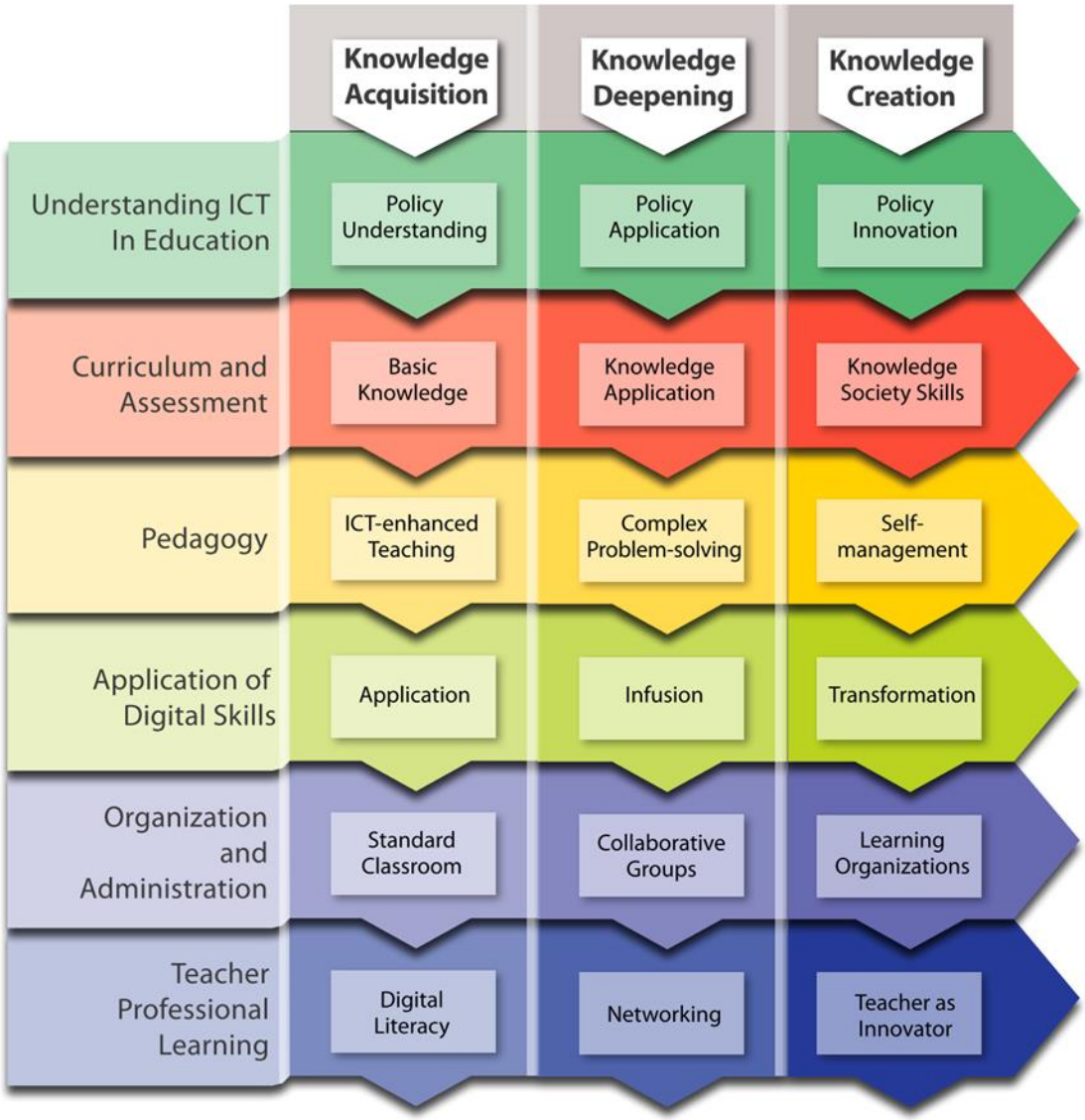

Figure 3. ICT CFT structure [23] (p. 10).

For each level, the framework describes the aspects concerning curricular goals for teacher training, teacher competency (Teachers can . . .), objectives (Teachers should be able to . . .), and example activities. Figure 4 presents one example.

Knowledge Acquisition

	CURRICULAR GOALS FOR TEACHER TRAINING	TEACHER COMPETENCY (Teachers can ...)	OBJECTIVES (Teachers should be able to ...)	EXAMPLE ACTIVITIES
ASPECT 1 *Understanding ICT in Education Policy*	**Policy Understanding.** Teachers make connections between policy and classroom practices.	Articulate how their classroom practices correspond to and support institutional and/or national policy.	**KA.1.a.** Identify how policy implementation is shaping classroom practice.	Discuss institutional and/or national policies and common classroom practices. Identify those practices that support policy. Teachers identify and analyse their own classroom practices in terms of how their teaching practices contribute to policy implementation.
			KA.1.b. Identify the principles of using ICT in education in a safe and accessible manner.	Investigate the benefits, and also drawbacks, of using ICT in education. Identify appropriate ICT use to support and enhance their productivity, teaching methods, class administration and continuing professional development.

Figure 4. ICT CFT Aspect 1 at the level of knowledge acquisition [23] (p. 28).

The document does not offer indications for instrument elaboration.

The European Framework for the Digital Competence of Educators—DigCompEdu [24] is a 95-page document published by the European Commission's Joint Research Centre (JRC) in 2017. It aims to promote the digital competences of educators (from early childhood to higher education) and innovation in education through continuous professional development. Thus, it is a general reference frame for developers of digital competence models and educational stakeholders responsible for designing, implementing, and evaluating policy initiatives, guidelines, curricula, and practices, used in European countries but also outside Europe. Digital competence is defined as "the confident, critical and creative use of ICT to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society" [24] (p. 90), a definition borrowed from the DigComp framework.

A separate article, "Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (Digcompedu)" [25], having the same DigCompEdu author (Redecker) as coauthor, describes the methodological approach for the development of the framework. It consisted of two major stages: mapping and analysis of existing frameworks, conceptual models, guidelines, and assessment tools used for the evaluation and development of educators' digital competences; and consultations to refine and validate the framework.

DigCompEdu has six areas divided into 22 connected competences (Figure 5).

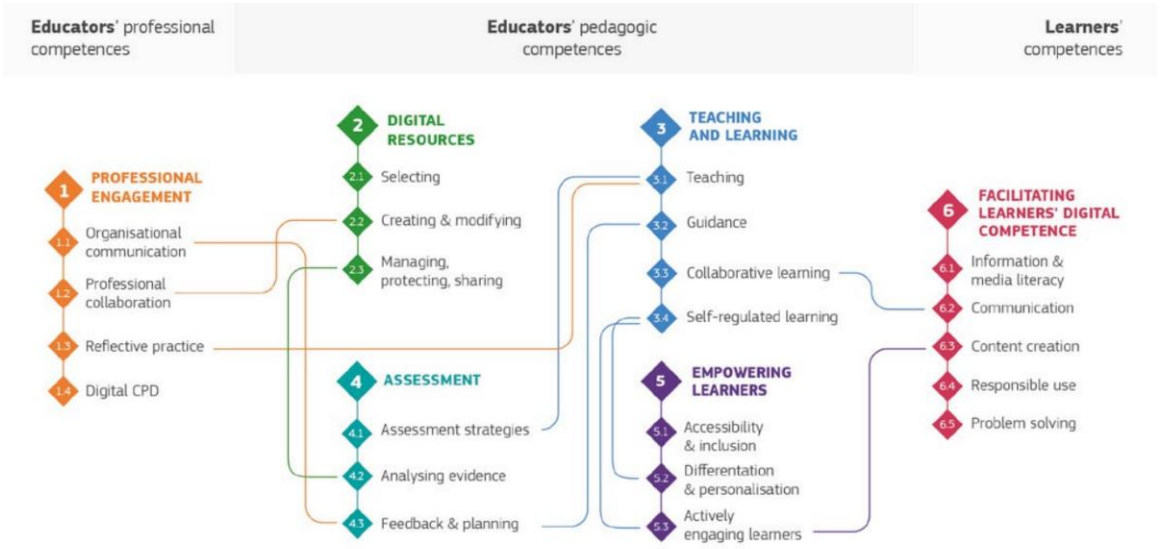

Figure 5. The DigCompEdu areas, competences, and connections [24] (p. 16).

Each competence is described along six cumulative proficiency levels (A1 to C2), like the Common European Framework of Reference for Languages (CEFR), inspired by the revised Bloom's taxonomy. For each level of each competence, there is a progression

and a proficiency statement. For the competence "organisational communication" level A1 (Newcomer), the progression statement is: "Making little use of digital technologies for communication," and the proficiency statement: "I rarely use digital technologies for communication". The framework also presents a set of activities for each competence. One example of an activity for the same competence is: "To use digital technologies to make additional learning resources and information available to learners (and parents)". DigCompEdu does not make any suggestions for instrument elaboration. However, the already mentioned article [25] describes the development of DigCompEdu Check-in, a self-assessment instrument.

The European Framework for Digitally-Competent Educational Organisations—Dig CompOrg [20] is a 77-page document published by the European Commission's Joint Research Centre (JRC) in 2015. It reflects the process of integrating digital technologies in educational organizations and institutions from different education sectors (primary, secondary and VET schools, and higher education institutions). Its primary purposes are to encourage educational organizations' self-reflection and self-assessment of digital competencies and to design and implement digital technologies programs and projects. Its development methodology included reviews and analysis of literature, frameworks, and questionnaires, besides consultation with experts.

The DigCompOrg framework has seven key elements and fifteen sub-elements, with the possibility of adding sector-specific elements, sub-elements, and descriptors (Figure 6). A total of 74 descriptors were developed for the sub-elements. For the Thematic Element "Leadership & Governance Practices" and the sub-element "Integration of Digital-age Learning is part of the overall mission, vision and strategy", the first descriptor is: "The potential of digital learning technologies is clearly flagged".

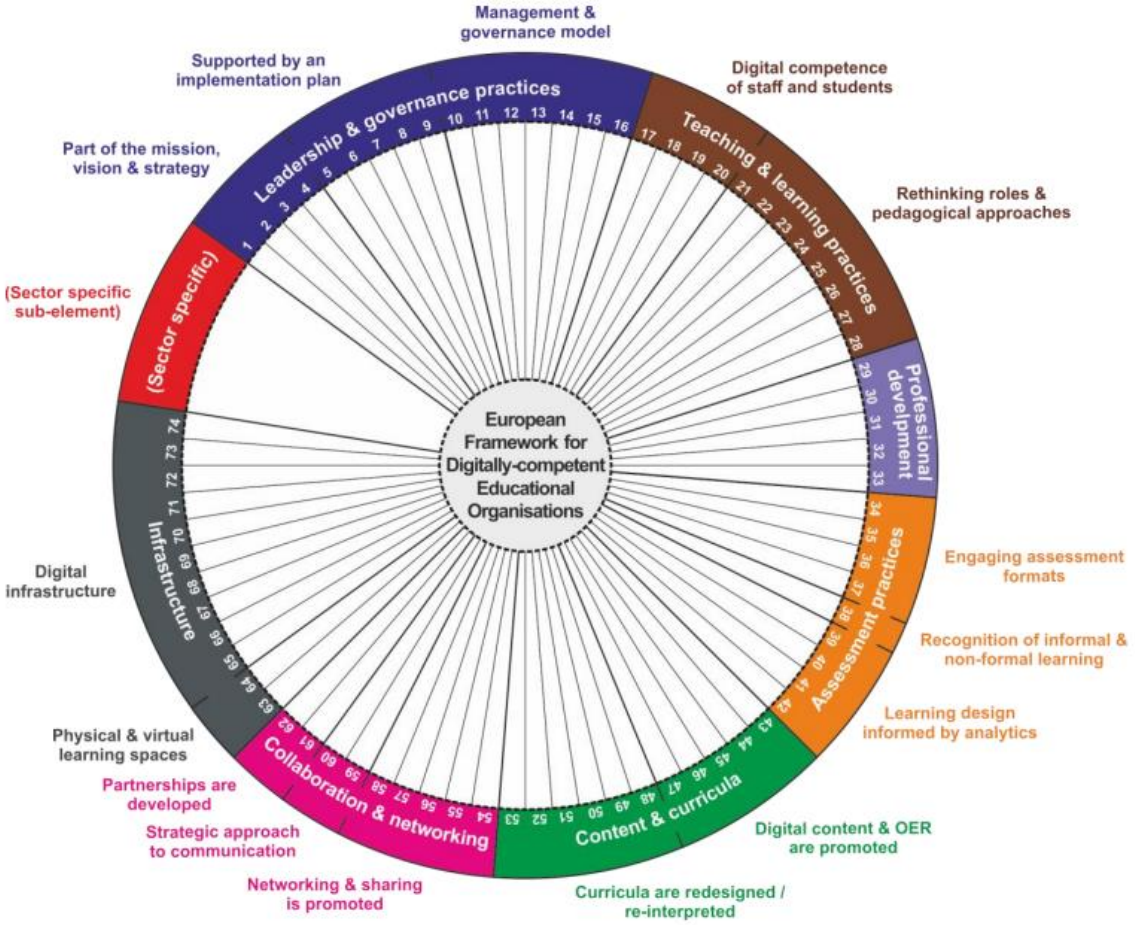

Figure 6. DigCompOrg key elements and sub-elements [20] (p. 18).

Digital competence is defined according to DigComp: "Digital Competence can be broadly defined as the confident, critical and creative use of ICT to achieve goals related to work, employability, learning, leisure, inclusion and/or participation in society" [20] (p. 39).

DigCompOrg can be used to guide an organization's process of self-assessment and self-reflection toward the integration of digital technologies; as a strategic planning tool for policymakers to design, implement, and evaluate programs, projects, and interventions for the integration of digital technologies; and as the basis for the development of sector-specific frameworks and self-assessment questionnaires; among other uses. The document does not carry indications for instrument development. However, SELFIE (Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies) [26] is a questionnaire developed based on DigCompOrg, used even outside the European Union.

DigComp 2.2: The Digital Competence Framework for Citizens [27] is a 134-page document published in 2022 by the European Commission's Joint Research Centre (JRC). Previous versions were published in 2013, 2016, and 2017. This updated version considers emerging technologies, such as Artificial Intelligence, Virtual and Augmented Reality, and the Internet of Things, as well as the green and sustainability aspects of interacting with digital technologies. The framework includes examples of knowledge, skills, and attitudes to help citizens engage with digital technologies. It also maps publications and references for DigComp. It aims to create a common understanding and vocabulary for digital competences related to policy formulation, instructional planning, development, and assessment. The framework can be adapted to specific contexts. The updating methodology involved consultations with stakeholders and a validation process, including UNESCO, UNICEF, and the World Bank.

DigComp 2.2 includes 21 competences grouped into five areas (Figure 7). The competences are distributed in eight levels of proficiency inspired by the European Qualification Framework (EQF), including descriptors, examples, and use cases. For the competence area "Information and Data Literacy", the competence "browsing, searching and filtering data, information and digital content", proficiency level "foundation", at a basic level and with guidance, I can: "identify my information needs, find data, information and content through a simple search in digital environments". An example of knowledge is: "knows that some online content in search result may not be open access or freely available and may require a fee or signing up for a service in order to access it". An employment scenario, "job seeking process", with help from an employment adviser: "I can identify, from a list, those job portals which can help me look for a job".

The definition of digital competence presented by the document is the one by the Council Recommendation on Key Competences for Lifelong Learning, in 2018, already mentioned:

> Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and for participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property related questions, problem solving and critical thinking. [27] (p. 3).

A specific section lists tools based on DigComp for self-reflection, monitoring, and certification of digital competence.

A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2 [4], part of the Digital Literacy Global Framework (DLGF) project, is a 146-page document published in 2018 by the UNESCO Institute for Statistics, aiming to be relevant to countries at all levels of development. Its objective is to develop a methodology for Sustainable Development Goal Thematic Indicator 4.4.2: "Percentage of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills". As it is based on DigComp 2.0, its focus is on citizens.

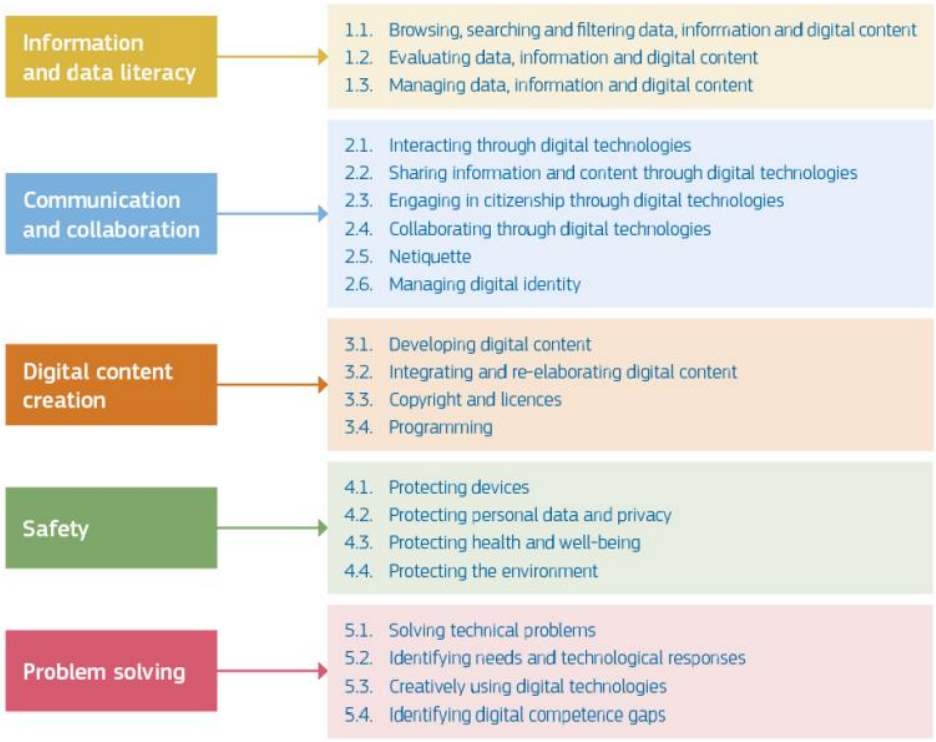

Figure 7. DigComp 2.2 conceptual reference model [27] (p. 4).

Its elaboration methodology involved a synthesis of existing digital literacy frameworks, an analysis of digital literacy competences focused on developing countries, and experts' consultations. DigComp 2.0 was selected as the reference framework for the project, but as it targeted economically advanced countries, DLGF has built on it. Its structure includes competence areas, competences, descriptions, and case examples. Descriptions include DigComp descriptors and keywords or phrases that emerge from coding other frameworks.

The document proposes the following definition:

> Digital literacy is the ability to access, manage, understand, integrate, communicate, evaluate and create information safely and appropriately through digital technologies for employment, decent jobs and entrepreneurship. It includes competences that are variously referred to as computer literacy, ICT literacy, information literacy and media literacy. [4] (p. 6).

It adds to DigComp 2.0 the following areas and competences.

Area 0. Devices and software operations

- 0.1 Physical operations of digital devices
- 0.2 Software operations in digital devices

This area and these two competences involve basic operations of devices and software, considered particularly important in low-income and developing countries.

Competence 5.5 Computational thinking

This competence, included in the Problem-Solving area, highlights the importance of problem-solving involving digital technology.

Area 6. Career-related competences

- 6.1 Operating specialized digital technologies for a particular field
- 6.2 Interpreting and manipulating data, information and digital content for a particular field

This area and these two competences are flexible to specific fields, contexts, and countries. DLGF collects digital literacy examples in countries outside of Europe in six sectors: agriculture, energy, finance, transportation, low-skilled and low-literate women in poor communities, and displaced populations (such as refugees). Unlike the other analyzed frameworks, it presents a pathway-mapping methodology for digital literacy development around case examples.

Finally, The Digital Competence Framework for Consumers [21] is a 35-page document published in 2016 by the European Commission's Joint Research Centre (JRC). DigComp-Consumers defines the competences that consumers need to adequately act in the digital marketplace, aiming to improve consumers' digital competences.

It is based on DigComp, consisting of 3 areas (pre-purchase, purchase, and post-purchase) and 14 competences (Figure 8), as well as competence descriptors and examples of knowledge, skills, and attitudes. For the Pre-purchase area and the competence "browsing, searching and filtering information on goods and services", one knowledge example is: "recognising that search engines are not neutral, and that search results and ranking of search results of goods and services are influenced by advertising and marketing".

Competence areas	Competences
1. Pre-purchase	1.1 Browsing, searching and filtering information on goods and services
	1.2 Evaluating and comparing information on goods and services
	1.3 Recognising and evaluating commercial communication and advertisement
	1.4 Managing digital identity and profile in the digital marketplace
	1.5 Considering responsible and sustainable consumption in digital markets
2. Purchase	2.1 Interacting in the digital marketplace to buy and sell
	2.2 Participating in collaborative economy platforms
	2.3 Managing payments and finances through digital means
	2.4 Understanding copyrights, licences, and contracts of digital goods and services
	2.5 Managing personal data and privacy
	2.6 Protecting health and safety
3. Post-purchase	3.1 Sharing information with other consumers in the digital marketplace
	3.2 Asserting consumer rights in the digital marketplace
	3.3 Identifying digital consumer competence gaps and limits

Figure 8. DigCompConsumers areas and competences [21] (p. 2).

The framework was developed, reviewed, and validated by including digital and consumer education experts, national consumer authorities, consumer research institutes and academics, and consumer associations. "Consumer digital competence is defined as the competence consumers need to function actively, safely and assertively in the digital marketplace" [21] (p. 4).

There are brief indications of use for policy formulation and support, and instructional planning and assessment. There are no indications for instrument elaboration based on the framework.

5.2. Comparison

This section compares the eight frameworks included for analysis considering the four questions proposed by the study and the information extracted.

The first question proposed by this study was: What are the main similarities and differences between international digital competence frameworks for education?

Table 1 provides general information about the frameworks.

The analysis identified several similarities. Except for ISTE [15], TPACK [16–19], and DigCompConsumers [21], the frameworks are long documents with dozens of pages. All the frameworks have target groups and audiences. Except for ISTE [15], all documents present a definition for digital competence or digital literacy. All frameworks present descriptors, examples, and/or cases of use. Some frameworks explain their elaboration methodology in the documents or a separate document.

The analysis also identified some differences and particularities. TPACK is presented through academic articles [16–19], while the other frameworks are presented in a report format. Students, as specific target groups, are only part of ISTE [15], because in DigCompOrg [20], students act as respondents to evaluate the organization's digital competence. DigCompOrg [20] is the only framework aiming at the digital competence of organizations with a 360-degree perspective (through the lens of teachers, students, and school managers). It is also the only framework that allows users to add elements, sub-elements, and descriptors according to the application context. Some frameworks count on the support of a website, such as ISTE [15] and TPACK [16–19]. DigCompEdu [24] presents the relationships among competences, even when classified in different areas, which is not explicit in the other frameworks. Emerging technologies, such as Artificial Intelligence, start to impact the elaboration and update of the frameworks, such as ICT CFT [23], DLGF [4], and DigComp2.2 [27].

The analysis and comparison identified another interesting relationship. DLGF [4] and ICT CFT [23] react to the Agenda for Sustainable Development Goals, and DLGF [4] builds on DigComp2.2 [27], adding new areas and competences. The proficiency levels on DigCompEdu [24] and DigComp2.2 [27], respectively, are based on the Common European Framework of Reference for Languages (CEFR) and the European Qualification Framework (EQF). A larger framework ecosystem was thus identified in the analysis and comparison exercise. DigComp2.2 [27] even presents references to its previous versions and instruments based on the framework as part of the document.

The second question proposed by this study was: What competences do these frameworks most mention?

TPACK [16–19] has knowledge domains (TK, TCK, TPK, and TPCK) that contain several competences which are not individualized in the framework structure. ISTE [15] builds profiles (such as, for students: empowered learner, digital citizen, knowledge constructor, innovative designer, computational thinker, creative communicator, and global collaborator), for which there is a general description followed by several descriptors of actions that the profile would be able to do. Competences can be identified spread through these descriptions and actions but without specific nominations and positions. DigCompOrg [20] uses the vocabulary of elements, sub-elements, and descriptors, and one can find digital competences throughout these three dimensions.

"Teacher competency" has a reserved position at the crossing of aspects (that could be considered a competence area) and levels in the ICT CFT framework [23], but without the previous naming of the competence and much more as a descriptor. For example, at the first level ("knowledge acquisition"), at the aspect "Understanding ICT in Education Policy", teachers can "Articulate how their classroom practices correspond to and support institutional and/or national policy".

The other frameworks present competences organized into areas with the following combinations of the number of competences in each area: DigCompEdu [24]: 4/3/4/3/3/5; DigComp 2.2 [27]: 3/6/4/4/4; DLGF [4]: 2/3/6/4/4/5/2; and DigCompConsumers [21]: 5/6/3.

Table 1. Basic information on the included frameworks for analysis and comparison.

Ref	Initials	Framework	Date	Pages	Authorship	Scope	Target
[15]	ISTE	ISTE Standards	2021	13	ISTE	International	Students, Educators, Educational Leaders, and Coaches
[16–19]	TPACK	Technological Pedagogical Content Knowledge	2006, 2008, 2009, 2013	77 (38 + 16 + 16 + 7)	Mishra, Koehler, & Cain	International	Teachers
[23]	ICT CFT	UNESCO ICT Competency Framework for Teachers	2018	68	UNESCO	International	Teachers
[24]	DigCompEdu	European Framework for the Digital Competence of Educators	2017	95	JRC	Regional (EU)	Educators
[20]	DigCompOrg	European Framework for Digitally Competent Educational Organisations	2015	77	JRC	Regional (EU)	Educational Organizations
[27]	DigComp 2.2	Digital Competence Framework for Citizens	2022	134	JRC	Regional (EU)	Citizens
[4]	DLGF	Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2	2018	146	UNESCO	International	Citizens
[21]	DigCompConsumers	Digital Competence Framework for Consumers	2016	35	JRC	Regional (EU)	Consumers

The comparison identified several competences that at least half of the frameworks list.

Collaboration appears in the following frameworks: ISTE (global collaborator student, collaborator educator and coach, and collaborating around computing), DigCompEdu (professional collaboration, collaborative learning, and digital communication and collaboration), DigCompOrg (collaboration and networking), DigComp 2.2 and DLGF (collaborating through digital technologies), and DigCompConsumers (interacting in the digital marketplace to buy and sell, and participating in collaborative economy platforms).

Information and data explicitly appear in the following frameworks: ISTE (data-driven decision-maker coach); DigCompEdu, DigComp 2.2, and DLGF (information and media literacy); and DigCompConsumers (browsing, searching, filtering, evaluating, and comparing information on goods and services).

Communication appears in the following frameworks: ISTE (creative communicator student), DigCompEdu (organizational communication and digital communication and collaboration), DigComp 2.2 and DLGF (communication and collaboration), and DigCompConsumers (recognizing and evaluating commercial communication and advertisement).

Technical competences or skills appear in the following frameworks: TPACK (technological knowledge, technological content knowledge, technological pedagogical knowledge, and technological pedagogical content knowledge), ICT CFT (application of digital skills), DigCompEdu (facilitating learners' digital competence), DigComp 2.2 (creatively using digital technologies), and DLGF (devices and software operation, and creatively using digital technologies).

Sharing appears in the following frameworks: DigCompEdu (managing, protecting and sharing digital resources), DigComp 2.2 and DLGF (sharing through digital technologies), and DigCompConsumers (sharing information with other consumers in the digital marketplace).

Content, in different ways, appears in the following frameworks: TPACK (technological content knowledge and technological pedagogical content knowledge); DigCompEdu (digital resources and digital content creation); DigCompOrg (content and curricula); and DigComp 2.2 and DLGF (browsing, searching, filtering, evaluating, managing, and creating digital content).

Teaching and pedagogy appear in the following frameworks: TPACK (technological pedagogical knowledge and technological pedagogical content knowledge), ICT CFT (pedagogy), DigCompEdu (teaching), and DigCompOrg (teaching and learning practices).

Learning, including professional development, appears in the following frameworks: ISTE (empowered learner student, educator learner, leader and coach connected learners, and computational thinking learner), ICT CFT (teacher professional learning and digital continuous professional development), DigCompEdu (collaborative learning and self-regulated learning, and actively engaging learners), and DigCompOrg (teaching and learning practices, and professional development).

A broad category of ethics appears in the following frameworks: DigCompEdu (responsible use); DigComp 2.2 and DLGF (copyright and licenses, and safety); and DigCompConsumers (considering responsible and sustainable consumption in digital markets; understanding copyrights, licenses, and contracts of digital goods and services; and protecting health and safety).

This study's third question was: What proficiency levels do these frameworks propose?

ISTE [15], TPACK [16–19], and DigCompOrg [20] do not propose proficiency levels for digital competences. DLGF [4] and DigCompConsumers [21] suggest that proficiency levels be developed according to the examples, cases, targeted stakeholders, purpose, sector, and context. Only three frameworks propose proficiency levels:

(a) ICT CFT—three levels: Knowledge Acquisition/Knowledge Deepening/Knowledge Creation [23].
(b) DigCompEdu—six levels: Newcomer (A1)/Explorer (A2)/Integrator (B1)/Expert (B2)/Leader (C1)/Pioneer (C2) [24].

(c) DigComp2.2—eight levels: Foundation (2)/Intermediate (2)/Advanced (2)/Highly Specialized 2 [27].

This study's fourth and final question was: (4) What indications for developing assessment instruments do these frameworks present?

Some frameworks, such as ISTE [15] and ICT CFT [23], do not even mention instruments or questionnaires for assessing digital competence or literacy. Moreover, DigComp-Consumers states, "The knowledge and skills items, for example, could be used for drafting survey questionnaires" [21] (p. 21).

However, in the case of two other frameworks that do not mention instruments, the personal or corporate authors have produced separate documents or questionnaires. DigCompEdu CheckIn [25], a self-assessment tool based on DigCompEdu [24], was designed and developed by the European Commission but is now discontinued, replaced by a new revised and updated version of the CheckIn Higher Education tool and the new SELFIEforTEACHERS [28]. SELFIE (Self-reflection on Effective Learning by Fostering the use of Innovative Educational technologies) [26] is a tool developed by the European Commission based on DigCompOrg [20]. There are now suggested optional questions on blended learning and a SELFIE for work-based learning (WBL) for Vocational Education and Training (VET) schools and companies.

Other documents present instruments based on the frameworks. TPACK's articles mention a survey instrument with 35 items (33 Likert scale and 2 short-answer questions) [16] and 141 other instruments based on the framework [18]. Furthermore, DigComp 2.2 lists tools based on DigComp for self-reflection, monitoring, and certification of digital competence [27], including DigCompSat, designed and developed by the European Commission [29].

Finally, DGBL [4] proposes an alternative strategy to handle digital literacy assessment: a pathway mapping methodology around case examples, which assume a broader dimension than individualized competences and their assessment through questionnaires.

6. Discussion

This section discusses and interprets the results from the perspective of the studies included in the literature review, the theoretical background adopted by the article, and the research questions.

The three main competences elements are knowledge, attitudes, and skills (KAS), although other elements are being added to the equation, such as values and awareness. Ferrari claims that "attitudes should be taken into account in the development of a Digital Competence framework" [7] (p. 44), and TPACK [17] considers technological pedagogical content knowledge a new form of literacy.

The digital competence semantic field is complex. The expression "digital literacy" seems to be used previously for "digital competence" and is more often related to research. In contrast, digital competence is more related to policy documents [14], although, many times, the terms are used as synonyms. The expression "21st-century skills" covers more competences than digital [2,11].

This article considers a digital competence framework as a theoretical structure of linked competences to assess and develop the digital competence of specific target groups [5]. These competences can be explicitly mentioned as sections of the designed framework or distributed in descriptors, examples, and cases.

The analysis and comparison exercise identified a framework ecosystem. Considering the complexity of the documents included in the analysis, it seems like a survival strategy based on other similar and solid documents elaborated by regional international organizations.

The fact of existing different frameworks for assessing and developing digital competences poses a challenge for those interested in its use. One alternative is to analyze and compare frameworks, this article's objective and contribution. Another alternative is to build a framework, facing the challenge of the already mentioned complexity. A third option is to build a meta-framework, as Bravo et al. [11].

Frameworks can be more application or tool oriented, especially when focusing on certification and employability [5]. The evaluation/measurement or implementation objective defines the framework [11]. The theoretical background also directly influences the definitions of digital competence adopted by the framework. Furthermore, the audience or target group also defines the framework characteristics, as digital competence differs depending on the professional groups due to the specific elements of the field [9].

However, sometimes the target groups and audiences of the frameworks are different. As a framework considering teachers as its target group generally focuses on teacher training, its target audience is not educators but professional development providers and policymakers. The ISTE Standards [15] have a specific section for coaches—teachers who teach teachers. DigCompOrg [20], in its turn, has the organization itself as a target.

Another interesting issue is the framework format. The ones included for analysis and comparison in this article are long documents—except the ISTE Standards [15] with specific characteristics—carrying much information. It seems to be a group job of solid international organizations, such as the European Union OECD, UN, UNESCO, UNICEF, and World Bank—except TPACK, which developed in a series of academic papers [16–19]. The final product is usually a report—except, again, TPACK. A website is a useful companion, as it can be updated dynamically.

Some frameworks describe their development methodology on the document itself or in a separate document, while others do not. However, one can identify a common methodological cycle: literature review, frameworks review, instruments review, consultations, validation with experts, and pre-test. Some cases involve an analysis of the digital competences for a specific target group or context.

Digital competence frameworks need constant updates as technologies continuously evolve. Emerging technologies, such as virtual and augmented reality, artificial intelligence, robotization, IoT (the Internet of Things), and big data, have influenced new framework versions [4,23,27]. In addition to that, new questions surrounding the use of technology appear all the time.

Yang et al. [10] attempted to review the indicators defined in each framework they selected to compare but found that each document has its structure and dimension, which poses difficulties for the comparison: "For example, we faced problems such as in similar areas, indicators in one framework are suitable for several areas of another framework, or areas that are mentioned in one framework but have no place in another" [10] (p. 54). The authors then decided to compare the frameworks' characteristics, not their dimensions and indicators. However, understanding each framework's logic is essential for a comparative exercise of the competences they mention. The analyzed frameworks do not follow the same logic, so the competences are distributed in different positions of their structures.

Although Ferrari's comparison among 15 frameworks [7] concluded the need to organize digital competences in areas and levels in a framework, this study only identified this structure in half of the analyzed frameworks. ICT CFT [23] has aspects of teachers' professional practice (what other frameworks analyzed in this section would probably consider areas or competences); TPACK [16–19] has knowledge domains; ISTE [15] has profiles; and DigCompOrg [20] has elements and sub-elements.

Corroborating the results of the article by Bravo et al. [11], the following competences stand out in the analyzed frameworks in this study: information and data, communication, collaboration, and technical, in addition to sharing (which appears together with communication in Ferrari [5]). However, this study also identified a group of related competences that appear at least in half of the frameworks: content (Ferrari [5] identified an area of creating of content and knowledge); teaching and pedagogy; and learning (including professional development). It is critical to explicitly identify the relationships among the competences in a framework, as in DigCompEdu [24].

This study also identified a broader category we named ethics (including responsible and sustainable use, copyright and licenses, and protecting health and safety); similarly,

Ferrari [5] identifies an area of ethics and responsibility. DigComp2.2 considers "the green and sustainability aspects of interacting with digital technologies" [27] (p. 1).

Figure 9 presents the competences identified in this study as the result of the analysis and comparison of the frameworks, organized logically and representing the relationship between ethics and the other competences.

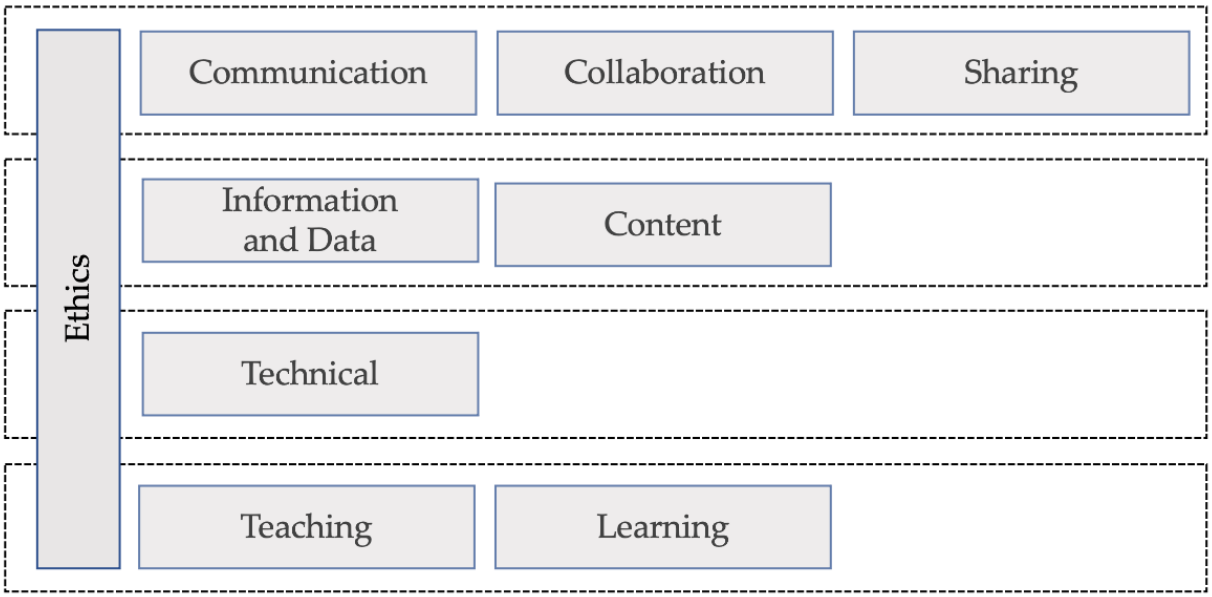

Figure 9. Competences identified in the analysis and comparison of the frameworks.

Bravo et al. [11] identified an area of evaluation and problem-solving, considering that problem-solving is mentioned in most documents they analyzed and classifying it as transversal in the proposed meta-framework. DigComp considers it the most transversal of all competences: "In the framework it is a stand-alone competence area, but on the other hand elements of problem solving can be found in all of the competence areas" [30] (p. 11). This study did not identify a justification for classifying it as a competence like the previous ones.

Technologies must be critically used: digital literacy must include critical thinking skills [5,11], and citizens must be reflexive and critical [31]. However, this study did not identify critical thinking as a general area or competence in the analyzed frameworks. We position it as problem-solving and corroborate the Bravo et al. [11] meta-framework as a transversal competence.

We should recall that we were not interested in articulated frameworks (where digital competences are transversal to the rest of the competences proposed) nor in autonomous frameworks (where digital competences have no integration with the rest of the competences proposed), but in specialized digital competence frameworks, according to the classification by Bravo et al. [11]. Consequently, we argue for differentiation between a digital competence framework and a broader 21st-century skills framework. Thus, resilience and digital emotional intelligence [22] are not considered digital competences in this study, and support material for technology and computer skills training courses are not considered digital competence frameworks. UNICEF [13] also positions digital literacy as part of the broader skills for learning, including, besides digital skills, foundational skills (literacy and numeracy), transferable skills (21st-century skills, soft skills, or socio-emotional skills, including problem-solving), and job-specific skills.

As well as areas and competences—with the vocabulary variations already discussed—the analyzed frameworks include profiles, goals and objectives, descriptors, activities, examples, and/or cases of knowledge, skills, and attitudes.

While Ferrari [7] concludes that two-thirds of the collected frameworks propose a division into levels, DLGF [4] concludes that most reviewed frameworks do not specify proficiency levels. Three frameworks analyzed in this study do not propose proficiency levels, two suggest that proficiency levels should be developed according to specific elements, and only three propose proficiency levels.

Ferrari [7] also identified that most frameworks propose three levels: basic, intermediate, and advanced, and that was DigComp 1.0 [31] structure. Nevertheless, he mentions that the eCompetence framework (eCF) has five levels, but none of its 36 competences are graded into five levels. DigComp 2.1 [32] expanded the proficiency levels from three to eight, creating a complexity operationalization challenge. Centeno et al. [33] discuss that most implementers needed help managing this 8-level scale.

The target group age influences proficiency levels definition, as "different age groups have different needs" [7] (p. 38). In "ICT framework for schools in Ireland", Ferrari [7] identifies that levels are related to the year of study, considering that "cognitive development increases with age" [7] (p. 38). Moreover, "levels might vary between competence areas and that any learner should be allowed and encouraged to work at different levels according to each competence area" [7] (p. 44).

This study identified that only ISTE [15] considers students as a framework target group, but it is only a two pages document. DigCompEdu [24] is concerned only with the educator empowering learners and facilitating learners' digital competence, while in DigCompOrg [20], the students contribute to assessing the organization's digital competence. Students are equated to citizens, so DigComp 2.2 [27] is considered its natural framework. However, there is a need to develop a framework that takes students as its target group.

In addition to students, another actor deserves attention. As the European competence movement is based on lifelong learning, digital competences frameworks for the elderly are needed [34]. A framework also must cover different social and economic realities and countries at all development levels; this drives DLGF [4]. DigCompOrg [20] teaches a way of evaluating digital competence at 360 degrees, considering that teachers, students, and school managers contribute to the evaluation.

The frameworks analyzed in this article address competences related to the use of technologies in the classroom, face-to-face, not considering specifically distance education or blended learning. However, it does not seem acceptable that frameworks that propose to list and discuss the digital competences necessary for today's educators completely ignore what occurs in the field of blended and online learning. Thus, there is a need to review the frameworks taking into consideration specific competences related to the theory and practice of blended learning and distance education.

An education challenge is how to teach the competences presented in the analyzed frameworks. According to Centeno et al. [34], teaching digital competences, together with other skills (e.g., social, creativity, or entrepreneurship), using a project-based approach has proven more effective in learning time and motivation than teaching digital competences in isolation. This would point to the need for more evidence and good practices concerning pedagogical approaches that combine different competences and frameworks.

Finally, two analyzed documents [15,23] do not mention instruments for assessing digital competence, while DigCompConsumers [21] states that the knowledge and skills items can be used for drafting survey questionnaires. Two frameworks [20,24] provide separate papers on instrument development or the questionnaire. Two other documents present instruments based on the frameworks [16,27,30]. Furthermore, DGBL [4] proposes a pathway mapping methodology around case examples for digital competence assessment. Mapping and listing instruments or strategies based on the frameworks and suggesting ways of building such instruments and strategies are critical contributions that a digital competence framework can give to its stakeholders.

7. Conclusions

This article aimed to analyze and compare international digital competence frameworks for education. The review of the literature that compares digital competence frameworks is one of this article's contributions. Application to education is another contribution because studies such as the one conducted by Bravo et al. [11], which is the most updated and similar to this one, do not focus on education.

Another contribution is the discussion of the semantic field of digital competence, which identified other common expressions, such as digital literacy. As UNICEF [13] recognizes, the field is evolving from an instrumental and operational focus on technical skills to more holistic approaches that consider aspects such as critical thinking and ethics. However, this study reinforced the differences proposed by UNICEF [13] between digital, transferable, and job-specific skills. Nevertheless, comparisons between narrower digital competence and broader 21st-century skills frameworks are suggestions for future research.

The comparison identified common competences in the frameworks: communication, collaboration, and sharing; information and data, and content; technical; teaching and learning; and ethics. Figure 9 organizes these competences logically and can be used as a reference for educational digital competence frameworks and assessment instruments. All analyzed frameworks include profiles; goals and/or objectives; descriptors; activities; examples; and/or cases of knowledge, skills, and attitudes. Proficiency levels can be used, but without the need to apply the whole range of levels to all the assessed competences.

This article thus contributed ideas for developing and implementing digital competence frameworks, which should be segmented by educational actors (students, teachers, and administrators) and educational levels (early childhood, primary, higher, and corporate education), with corresponding assessment instruments. This study also highlighted DigCompOrg [20], practically ignored by the literature, which targets organizations and proposes a 360-degree evaluation strategy, including the perspectives of teachers, students, and managers.

UNICEF [13] recognizes that a limitation of their study is that the literature review is not exhaustive of all existing digital literacy frameworks, programs, and policies and was based only on reports and documentation in English. This article focused on frameworks but studying programs and policies would certainly enrich its perspective and results, as any attempt to increase its coverage and include as many languages as possible.

A limitation of this study is that the search for competences in the frameworks referred to the explicit areas and competences. Sometimes, the competences are not named but distributed in descriptors or other framework dimensions. Even when nominated, the competences may be distributed in other dimensions; it is worth an analysis with a more systematized coding and categorization process.

Future research might include searching other databases and using other search strings. It might also consider the inclusion of national frameworks for analysis and comparison using the same methodology, a closer look at enterprise and children's digital competences frameworks, and a reflection on the usage of the frameworks for low and middle-income countries.

This study also identified that the analyzed frameworks ignore blended learning and distance education. An interesting work would be to expand the frameworks to include aspects of these pervasive teaching and learning modalities or to develop new frameworks that focus on blended learning and/or distance education.

Finally, this study also identified students as the target group of only a section of the ISTE framework [16]. Considering students as citizens and using DigComp 2.2 [27] does not disqualify the need for frameworks that focus on the digital competence of students, which constitutes fruitful future research.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/educsci12120932/s1, Extraction files and a Microsoft Word file with the analyzed and compared frameworks' areas, competences, and descriptions.

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