Meta-framework of digital literacy: a comparative analysis of 21st-century skills frameworks

Meta-marco de la alfabetización digital: análisis comparado de marcos de competencias del Siglo XXI

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ABSTRACT
Introduction: Faced with an imminent digital era marked by globalization and technological innovation, different organizations raised the importance of innovating education with the so-called 21st-century competencies. The need for new skills to participate in digital culture is highlighted in the different proposals, where digital competence is fundamental to live, work and participate in Knowledge Society. **Methodology**: This work aims to generate an integrated proposal of digital literacy through a comparative analysis of digital competence in eight frameworks of 21st-century skills (ATCS, enGauge, Naep, Nets, OECD, P21, UNESCO, European Union), which they are studied in three main thematic blocks: a) definition, b) objectives and vision, c) competencies and abilities. **Results**: Digital literacy encompasses a holistic approach, nurtured by different literacies, from which a meta-framework with nine competencies is built: three direct competencies, 1) information and data, 2) communication and collaboration, and 3) technical; five transversal competencies, 4) problem solving, 5) global citizenship and multicultural awareness, 6) interpersonal, 7) future thinking, 8) creative thinking and 9) critical thinking; and 53 cognitive, critical, technical, social, emotional and projective digital skills. **Conclusions**: Multidimensional digital literacy consolidates the techno-social perspective for empowerment and technological appropriation, which exceeds the operational use of tools and guarantees the broad, meaningful, and innovative use of technology for the construction of an equitable society, decent employment, social participation, among other purposes that are connected with the Sustainable Development Goals.

KEYWORDS: 21st-century skills; digital literacy; digital competence; ICT; education; digital divide; Sustainable Development Goals (SDGs).

RESUMEN
Introducción: Ante una inminente era digital marcada por la globalización y la innovación tecnológica, diferentes organismos plantearon la importancia de innovar la educación con las denominadas competencias del siglo XXI. La necesidad de nuevas habilidades para participar de la cultura digital es destacada en diferentes propuestas, donde la competencia digital es clave y fundamental para vivir, trabajar y participar en la sociedad del conocimiento. **Metodología:** Este trabajo tiene por objetivo generar una propuesta integrada de la alfabetización digital mediante un análisis comparado de la competencia digital en ocho marcos de competencias del siglo XXI (ATCS, enGauge, Naep, Nets, OECD, P21, Unesco, Unión Europea), los cuales son estudiados en tres grandes bloques temáticos: a) definición, b) objetivos y visión y c) competencias y habilidades. **Resultados:** La alfabetización digital abarca un enfoque holístico, nutrido por diferentes alfabetizaciones, desde el cual se construye un meta-marco con nueve competencias: tres competencias directas, 1)información y datos, 2) comunicación y colaboración y 3) técnica; cinco competencias transversales, 4) resolución de problemas, 5) ciudadanía global y conciencia multicultural, 6) interpersonal, 7) pensamiento de futuro, 8) pensamiento creativo y 9) pensamiento crítico; y 53 habilidades digitales cognitivas, críticas, técnicas, sociales, emocionales y proyectivas. **Conclusiones:** La alfabetización digital multidimensional consolida la perspectiva tecno-social para el empoderamiento y apropiación tecnológica, que supera el uso operativo de las herramientas y promueve el uso amplio, significativo e innovador de la tecnología para la construcción de una sociedad equitativa, el empleo digno, la participación social, entre otros propósitos conectados con la Agenda 2030 para el Desarrollo Sostenible.

PALABRAS CLAVE: competencias del siglo XXI; alfabetización digital; competencia digital; TIC; educación; brecha digital; Objetivos de Desarrollo Sostenible (ODS).

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Translation by **Paula González** (Universidad Católica Andrés Bello, Venezuela)

1. Introduction

The digitization of the world has been taking place since 1968 when Licklider and Taylor - directors of the ARPA research - conceived the ARPANET military experiment that preceded the internet, which two decades later united hundreds of people from different geographical spaces in the first virtual communities (Reindgold, 1996). Although the initial role of the user was more passive, it has evolved towards a more active role as a prosumer in a participatory culture (Toffler, 1980; Jenkins, 2005), in which it exercises different roles according to the interaction circumstances (Lang et al., 2020).

Although the internet has expanded access to knowledge and participation, the debates begin to reflect on the state of the public sphere and the new phenomena and realities such as "memecracy" and its impact on social discourses (Fernández-Villanueva and Bayarri Toscano, 2020); post-truth and the challenges for communication, public opinion, and democracy (Carballo, López-Escobar and McCombs, 2018); lifelogging (life blog) and reconfiguration of the self (Selke, 2016; Franganillo, 2020); misinformation and its multiple forms and risks (Salaverría et al., 2020); cybersecurity, wellness, and health care (Coventry and Branley, 2018); and many others that are transforming life, culture, and public space.

This changing environment, sometimes harmful, shows that technology evolves faster than the capacity for social and regulatory response (Moreno, 2019; Pedrioli, 2020). Consequently, faced with a volatile, uncertain, complex, and ambiguous «V.U.C.A world» (Kingsinger and Walch, 2012), new digital skills are necessary and, above all, a system that can engage their development by creating the right conditions (Meshcheryakova, Shalnev, and Filatova, 2020) for active, critical, and meaningful participation in digital culture.

At the beginning of the new millennium, in the face of an imminent digital age and as society changed, various organizations and governments around the world began to renew educational paradigms with different proposals for reference *frameworks* of the so-called 21st-century skills, where digital skill is key (Ananiadou and Claro, 2009; Voogt and Roblin, 2012).

The phrase "21st-century skills" refers to an umbrella concept that encompasses a series of learnings that people need for their full participation in this era as effective workers and citizens (Dede, 2016). For Unesco (2017), these skills contribute to the realization of the 2030 Agenda, and all children, adolescents, and adults must develop them to access decent jobs and for full participation in society that contributes to sustainable development and global citizenry. In the different 21st-century skills proposals, emphasis is placed on the effective and critical use of ICT in the face of present and future challenges and it is emphasized that "without the skills of the 21st-century, students prepare to succeed in yesterday's world, not tomorrow's" (NCRL & Metiri Group, 2003: 4).

The holistic vision of the term competence is underlined in several proposals and encompasses the development of skills, values, and attitudes (Ala-Mutka, Punie, and Redecker, 2007; OECD, 2019) that allow managing complexity, adaptation to change, and the use of ICT in an "effective, efficient, appropriate, critical, creative, autonomous, flexible, ethical, thoughtful way for work, leisure, participation, learning, socialization, consumption, and empowerment" (Ferrari, 2012: 5).

Digital literacy implies a fusion of cognitive, critical, technical, social skills, among others (Van Laar et al., 2017; Ferrés, Masanet, and Mateus, 2018), which empowers people in exchange, collaboration, and participation through ICT (Reig, 2016). In this sense, global trends, such as artificial intelligence or space technologies, make us reflect on the urgent development of an integral vision of the educational system that goes beyond the instrumental vision of technology. Berger and Frey (2017: 13) reinforce the need for a multidimensional skill approach in the face of challenges in the work sector and technological innovation, emphasizing that:

> Technology is unlikely to replace workers whose jobs require social and emotional skills… artificial intelligence is unlikely to replace those workers whose jobs require creativity. Similarly, artificial intelligence is unlikely to replace workers whose jobs require complex social interactions. Therefore, to adapt to advances in technology, workers will also need to acquire social skills…

The term competence has a close relationship with employability and the workforce; however, its meaning has been enriched in the debate from multiple actors (governments, academic unions, social groups, etc.). For many this term is limited to economic interests, given its relationship to the so-called "human capital", that is to say, to the "competent" person as a means of production. However, other positions connect this term with the so-called *empowerment*, linked to the capacity for citizen action and a long data of social studies. From this last approach, as highlighted by Moya and Tiana (2010), in the context of the project of the Spanish Ministry of Education COMBAS for the curricular development of basic competencies, having a competence is "being able" to do and decide something, "to possess a knowledge" that empowers a person.

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Although multiple approaches to competencies have been developed, such as functional, behavioral, or constructivist (Trujillo-Segoviano, 2014), this article focuses on the appropriation of knowledge for citizen empowerment, without losing the value it implies for the work future and professional success (García-Perez, García-Garnica, & Olmedo-Moreno, 2021) and recognizing the broad semantic field of the term competence (authority, competition, training, qualification, sufficiency, among others).

The pandemic caused by COVID-19 in 2020 has accelerated digitization in various areas of life such as work, education, the productive sector, or social life and has highlighted the importance of establishing guidelines and protocols that allow inclusion and participation in the digital world. However, preliminary research before the global health emergency has pointed out the difficulties and gaps in achieving digital and social equity (Van-Deursen, 2010; Van-Deursen & Van-Dijk, 2014), but also the multiple benefits and impacts of digital literacy for development, democracy, human rights, and more (New Media Consortium, 2017; Pangrazio & Sefton-Green, 2021).

This research collects the institutional visions of 21st-century competencies from eight organizations of different scope (national, regional, and international): ATCS, enGauge, Naep, Nets, OECD, P21, UNESCO, European Union. For this, a comparative analysis of the documents is carried out in three thematic blocks: a) definition, b) objectives and vision, and c) competencies and skills.

The study includes three contributions, the first is aimed at understanding how digital competence is articulated with 21st-century skills, which will allow future researchers to consider this in their implementation models and competence assessment. The second, understanding that there are multiple literacies integrated and addressed in each framework, this integrated work will allow a more nurtured vision to be recorded. And finally, the third, given that this analysis of digital skill has not been done in these eight studied proposals, although it has been done in some of them (Chu et al., 2017; Pérez-Escoda, García-Ruiz, & Aguaded, 2019), this allows contributing with a meta-framework enriched by all these visions. Additionally, it should be noted that reaching a level of detail of competencies and skills favors the understanding of the multidimensional scope of digital literacy.

2. Objectives and research questions

Digital literacy has been nurtured from different approaches embodied in reference frameworks with different visions. The objective of this research is to generate an integrated proposal of digital literacy and its competencies from the comparative analysis of eight proposals of reference frameworks of 21st-century skills. For this, four research questions are posed:

1. What role does digital skill play in the 21st-century skill frameworks?
2. How is digital literacy defined in the 21st-century skill frameworks?
3. What common elements exist in the vision and objectives of the 21st-century reference skill frameworks?
4. How are the different digital literacy skills proposals articulated in the 21st-century skill frameworks?

The main contribution of this research is to strengthen the construction of a holistic vision of digital literacy for techno-social empowerment, based on a proposed meta-framework that puts these institutional visions together.

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3. Methodology

The research is part of a comparative study of eight proposals for 21st-century skills frameworks from different organizations. It is based on the hypothesis that although the focus on digital literacy and its competencies may be different in each proposal, they share a multiplicity of relationships that enrich each other. This study seeks, on the one hand, to collect the visions of the first twenty years of the new millennium and, on the other, to generate a proposal to contribute to an integrated vision. Eight cases have been selected for the study and three thematic axes of analysis described below have been proposed.

3.1. Selection of analysis cases

Eight proposals from different organizations are integrated for the analysis: ATCS, enGauge, Naep, Nets, OECD, P21, UNESCO, European Union (Table 1). The eight selected cases have been established based on a preliminary study by Voogt and Roblin (2012) on 21st-century competencies and their implications for educational policy. Based on this determination, a search and selection of the latest versions of documents of the cases were carried out (cut-off date: August 2020). In total, 70 main and procedural documents were reviewed (Annex 1).

These cases enrich the analysis due to their different characteristics at the scope level (3 national, 2 regional, 3 international), origin (government, private company/organization, and international organizations), and approaches (emphasis on certain literacies). Finally, it should be noted that these cases cover 20 years, from the enGauge proposal conceived in 2000 and published in 2002, to the OECD proposal published between 2019 and 2020, which allows generating a timeline and projection of digital literacy concerning the 21st-century skills.

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Table 1. *21st-century skills frameworks compared in the study.*

Nº	Base document title	Acronym	Organization / Entity	Scope	Nº documents reviewed	Literacy focus
1	Assessment and Teaching of 21 Century Skills	ATCS	International project sponsored by Cisco, Intel, and Microsoft.	International	9	Computer and Information Literacy Digital Literacy*
2	enGauge 21st-century Skills: Literacy in the Digital Age	enGauge	North Central Regional Educational Laboratory (NCREL) and Metiri Group. Document produced with funds from the US Department of Education.	National	1	Literacy in the digital age
3	Technological Literacy and Engineering Framework for 2018. National Assessment of Educational Progress.	NAEP	Developed by WesEd, requested by the US Government.	National	4	Technology and engineering literacy
4	National Educational Technology Standards	NETS	International Society for Technology in Education (ISTE)	National	12	Literacy in the digital age
5	OECD Future of Education and Skills 2030	OECD	Organization for Economic Cooperation and Development	Regional	23	Digital literacy
6	Partnership for 21st-century skills	P21	US Government and private organizations (Apple Computer Inc, Cisco Systems, Dell Computer Corporation, National Education Association, etc)	International	7	Information literacy Media literacy ICT literacy
7	A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2	Unesco	United Nations Educational, Scientific and Cultural Organization, UNESCO	International	6	Digital literacy
8	Digital Competence for lifelong Learning	EU	European Union	Regional	8	Digital literacy

Source: Self-made based on analyzed 21st-century skill frameworks. * More than one title is expressed in the analyzed framework to refer to the skill

3.2. Comparative analysis

Comparative studies favor the understanding of realities from empirical generalization since they allow "to highlight the peculiarity of known phenomena and to systematize the information, distinguishing the differences with similar phenomena or cases" (Gómez Días de León and León de la Garza, 2014). This research is committed to a comparative strategy of different systems, which seeks to research the analogies between contrasting systems (different *frameworks* of different organizations and scopes) to know the relationships between variables and analyze the associations at the intra-systemic level (Villaroel, 2001).

The analysis carried out is framed in three large comparative thematic blocks: 1) definition of digital literacy, 2) objectives and vision, 3) skills and abilities. The stated elements constitute the analysis unit of the study. From this, two levels of analysis are established: on the one hand, the differences and similarities of the studied *frameworks* are identified, on the other hand, the articulation of the proposals is analyzed based on the consistency of the definitions of digital literacy and immersed competencies.

For the systematization of the information, a database is generated with the different proposals for definitions of digital literacy, its skills and abilities, and an exploratory case file is drawn up (Annex 2), tools with which the comparison is established in the three thematic blocks.

4. Results

The results are presented in four sections that are connected, in turn, with the research questions. The first section focuses on the role of digital competence in the frameworks of 21st-century skills (Q1); the second, in the definition of digital literacy that converges from the multiple contributions (Q2); the third, focused on the objectives and vision of the frameworks (Q3), and, lastly, the fourth is focused on the relationships found between frameworks regarding the skills (Q4)

4.1. Digital skill: a key skill in the skill frameworks of the 21st-century

The different frameworks of 21st-century skills, proposed as part of educational agendas, contemplate a repertoire of skills to face a world in permanent change, accelerated by the digital revolution and technological innovation.

The role of digital competence as a core competence is underlined by some *frameworks* (UNESCO, OECD, enGauge, European Union) that emphasize its importance for the development of other skills. In the analysis, three structures of the studied documents are identified, which show the emphasis and how digital competence is articulated with the rest of the skills. In image (1) the articulation structures are represented, where the letters (A, B, C) represent other skills, and their relationship with digital competence is shown. The categories are described below:

1. Specialized *framework*: Refers to proposals that have a broad framework of 21st-century skills where digital literacy is included, but also develop a specialized and specific framework for digital skill. This is the case of the proposals of the European Union, UNESCO, and NAEP.
2. Articulated *framework:* These are frameworks that propose their skill proposal, where digital skill is included and transversal in the rest of the skills. In this category are the cases of enGauge, OECD, and NETS.

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3. Autonomous *framework*: These reference frameworks present a sum of skills where digital skill is raised independently without any explicit integration to the rest of the skill. In this group are the proposals of P21 and ATCS.

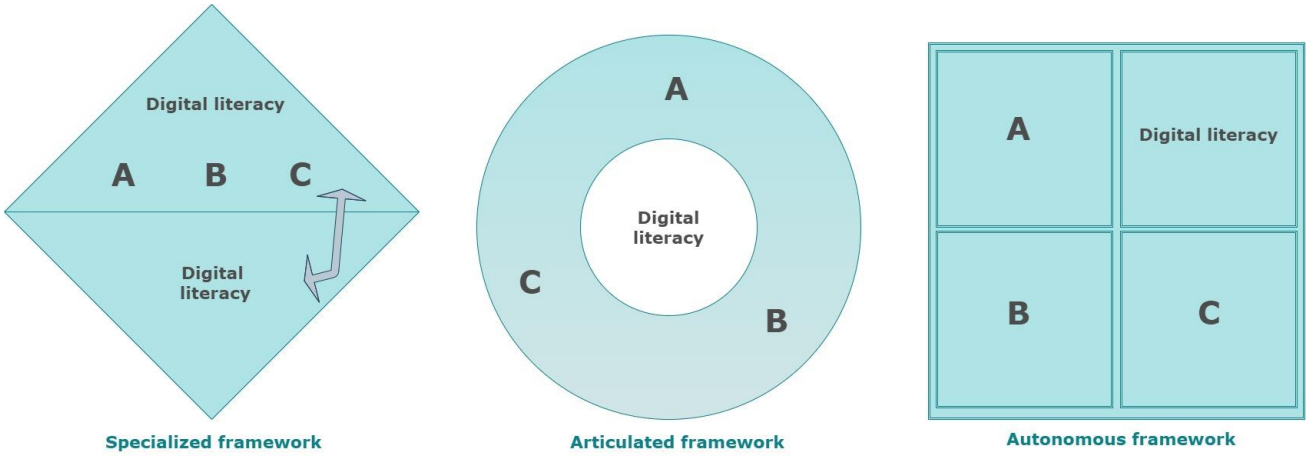

Image 1: *Articulation of digital competence in the competence frameworks of the 21st-century*
Source: Self-made

Articulated and specialized *frameworks* are more detailed than standalone ones. These categories show not only the deepening of the subject in the documents but also the importance and centrality of digital competence in the context of 21st-century skills.

At a general level, digital competence plays a key role because it has a direct interaction with many other 21st-century skills, promoting them through the active and critical use of ICT. In other words, although digital competence is a part of the skills of the 21st-century, its role is central and transversal because it allows the acquisition of other key skills. This also raises the challenge and reflection of the mainstreaming of digital competence in educational curricula.

4.2. Digital literacy: a convergent concept that drives human and economic development

In the most up-to-date 21st-century skills frameworks, which correspond to the European Union, Unesco, and OECD proposals, published in 2012, 2018, and 2019 respectively, there is a consensus on the use of the term "digital literacy". They refer to a sum of digital skills and abilities that arise from different disciplines. Furthermore, they highlight that the term digital literacy integrates the approaches of media literacy, information literacy, technological literacy, and ICT literacy.

The common elements of the definitions are identified in the what and for what of digital literacy. Although not all reference frames share the same name to refer to this digital literacy, the meeting point is in the for what (Table 2). In this sense, we find two visions: one focused on economic development and the other on human development based on capabilities.

On the one hand, the proposals emphasize that digital literacy is necessary to have a job (obtain a job or develop an enterprise), be functional in a digital environment, and be successful in the 21st-century; on the other, they speak of empowerment both at a personal and social level, as well as a vision of effective and active citizens and the construction of social and intellectual capital. Both visions complement each other and, above all, go beyond the instrumental approach of technology, aligning with social objectives focused on access and quality of education, eradication of poverty, reduction of inequities, decent work and economic growth, health and well-being, among others.

These meeting points magnify the value of digital literacy for the development of society and the fulfillment of development goals.

Table 2. *Definitions of literacies in the analyzed frameworks*

Framework	What?	For what?	Literacy focus
ATCS	The term "ICT literacy" brings together a wide range of skills, such as network learning, information literacy, digital competence, and technological knowledge. Each of them contributes to learning to learn by developing enabling skills. Firstly, functioning as a consumer in networks involves obtaining, managing, and using information and knowledge from experts and shared digital resources to benefit private and professional life. Secondly, functioning as a producer in networks implies creating, developing, organizing, and reorganizing information/knowledge to contribute to shared digital resources. Thirdly, developing and sustaining social capital through networks implies using, developing, moderating, leading, and intermediating the connectivity within and between individuals and social groups to organize collaborative actions, build communities, maintain awareness of opportunities and integrate diverse perspectives at the community, social, and global level. Fourthly, developing and maintaining intellectual capital through networks involves understanding how tools, media, and social networks operate and using appropriate techniques through these resources to build collective intelligence and integrate new knowledge.	Functioning as a consumer and producer in networks. Participating in the development of social capital through networks. Participating in intellectual capital (collective intelligence) in networks	ICT literacy Computer and information literacy Digital literacy
enGauge	Skills needed to negotiate the complexities of life also change	To achieve success in the 21st-century	Literacy in the digital age
NAEP	"Technology and engineering literacy" can be defined equally broadly as the ability to use, understand, and evaluate technology, as well as to understand the technological principles and strategies necessary to develop solutions and achieve goals (…) technological literacy includes knowledge, critical thinking skills and abilities, and decision making.	To develop solutions and achieve goals.	Technology and Engineering Literacy
NETS	No general definition is provided, but a definition of each skill.	N/A	Literacy in the digital age
P21	Variety of functional and critical thinking skills related to information, media, and technology.	Effective citizens and workers of the 21st-century	Information literacy, media literacy, ICT literacy
Unesco	Digital literacy is the ability to access, manage, understand, integrate, communicate, evaluate, and create information safely and appropriately through digital technologies for employment, decent work, and entrepreneurship.	Employment, decent work, and entrepreneurship	Digital literacy
EU	Digital competence implies the safe and critical use of Information Society Technology (IST) Digital competence is the set of knowledge, skills, attitudes (including skills, strategies, values, and awareness) that are required when ICT and digital media are used to perform tasks; solve problems; communicate; manage information; collaborate; create and share content; and build knowledge in an effective, efficient, appropriate,	For work, leisure, participation, learning, socialising, consuming, and empowerment	Digital literacy

	critical, creative, autonomous, flexible, ethical, thoughtful way for work, leisure, participation, learning, socialization, consumption, and empowerment.		
OECD	The concept of digital competence is mobile and multifaceted, covering many areas and literacies, it is at the convergence of multiple fields. Being digitally competent today implies the ability to understand the media (as most media have been/are being digitized), seek information and be critical about what is retrieved (given the wide acceptance of the Internet), and be able to communicate with others, using a variety of digital tools and applications (mobile, Internet). Being digitally literate requires the ability to read, interpret, give meaning, and communicate through digital texts and sources from a variety of online media. It also requires the ability to critically evaluate and filter information that is so easy to produce, access, and make public. Data literacy requires not only being able to work with mathematical formulas in a workbook, but also being proficient in browsing, interpreting, and computing diverse data in daily life and professional contexts, and communicating with data. Digital literacy is based on the same fundamental skills as "traditional" literacy, but digital literacy is applied in digital contexts and is based on new digital tools and skills.	For everyday life and professional contexts. To be functional in a digital environment.	Digital literacy. Data literacy.

Source: Self-made and translated based on frameworks: ATCS, enGauge, Naep, Nets, OECD, P21, Unesco, EU.

Digital literacy is a convergent concept of various literacies, which implies, more than a technical approach, a techno-social and critical vision. It makes it easier to work, live, and participate in the digital age, which drives human and economic development. This analysis leads us to understand digital literacy as a set of competencies, knowledge, skills, and attitudes that allow the safe and critical use of ICT to consume, produce, and participate in the digital ecosystem. Thus, digital literacy includes the same fundamental skills as traditional literacy, that is, it implies the ability to read, interpret, give meaning, and communicate, but through different codes, formats, and digital contexts.

4.3. Goals and visions found in social and work empowerment

The educational and institutional horizon of each 21st-century skills proposal is essential to understand the construction of visions about the education of the future. The documents are aimed at various actors in the learning ecosystem: education professionals, decision-makers, public-policy makers, educational authorities, among others. The main objective is to rethink education, innovate teaching and learning, create a conceptual umbrella that allows a common understanding to debate what students, citizens, and workers need in the digital age. An alignment with the expectations of the private sector, service providers, and business communities is also identified, which have a close relationship with the future of work or with the coverage of educational needs.

For their part, apprentices are, to a lesser extent, recipients of these documents, although they are considered fundamental actors, since they determine the knowledge, skills, attitudes, and values they will need to prosper and shape the world.

An approach towards formal and informal environments of digital literacy is identified in five of the eight proposals (Unesco, EU, OECD, enGauge, P21), that is, lifelong learning that goes beyond the classroom. In most of these cases, not only early childhood learning is considered, but also the participation of citizens of all ages. The other proposals focus on the formal educational environment (NETS, NAEP, and ATCS).

Regarding the objectives related to educational processes, such as the implementation and assessment of digital competence, the frameworks have various specializations. On the one hand, some develop the evaluation and/or measurement approach (Unesco, NAEP, and ATCS), while others focus on the implementation of the competence (EU, NETS, enGauge, P21). On the other hand, the OECD proposal establishes a learning guide that establishes an aspirational vision of education. This framework is not intended to be a curriculum for implementation or assessment, but rather a guide to the competencies people need to thrive in the future.

At a general level, two types of objectives of the proposals are distinguished: operational (measure indicators or common framework to operate education) and social (identify challenges to improve education, guide educators, common well-being, and equity). The *frameworks* develop one or both objectives. For example, in the case of Unesco, the main operational objective of the proposal is to provide indicators for the measurement of objective 4.1.1 (right to education) of the 2030 Agenda for Sustainable Development, in turn, this *framework* also pursues an alignment with other development objectives (decent work and equity), connected with socio-economic purposes (equity and poverty reduction).

Regarding the visions, the proposals aim to anticipate the future and be better prepared, for individual and collective well-being, social and citizen empowerment, guarantee equity, reduce social gaps, guarantee active, full, and critical citizen participation, better-informed decision making, ensure participation in the economy and culture. The most shared vision among the proposals is to be prepared for innovative jobs and the development of workforce skills.

4.4. Digital literacy skills: towards a techno-social approach and an integrated framework

Digital literacy in the 21st-century reference frameworks, encompasses various competencies and approaches, some more technical and others more techno-social. The enGauge and OECD frameworks are the broadest, that is, they contemplate a greater number of competencies and have a greater diversity of integrated knowledge areas.

Table (3) shows the compendium of competencies identified in each frame of reference. It is important to underline that there is no uniform structure regarding the level at which a literacy approach (broader concept) and competencies (specific skills, attitudes, and values) is presented. The table also indicates the direct (D) or transversal (T) role of the skills in the *frameworks*.

Table 3. *Digital skills identified in the studied 21st-century skill frameworks*

Framework	Competence general categorization	Role	Competence / Subcategory
ATCS	ICT literacy Computer and information literacy Digital literacy *	D	ICT literacy
enGauge	Literacy in the digital age	D	Basic literacy
		D	Scientific literacy
		D	Economic literacy
		D	Technological literacy
		D	Visual literacy
		D	Information literacy
		D	Multicultural literacy
		D	Global awareness
		T	Inventive thinking: adaptability and managing complexity, curiosity, creativity, risk-taking, higher-order thinking, and sound reasoning
		T	Effective communication: teaming and collaboration, interpersonal skills, personal responsibility, social and civic responsibility, interactive communication
		T	High productivity: Prioritizing, planning, and managing for results, effective use of real-world tools, ability to produce relevant and high-quality products
Unesco	Digital literacy	D	Device and software operation
		D	Information and data literacy
		D	Communication and collaboration
		D	Creation of digital content
		D	Safety
		D	Problem-solving
		D	Career-related competencies
Unión Europea	Digital literacy	D	Information and data
		D	Communication and collaboration
		D	Content creation
		T	Safety
		T	Problem-solving
NETS	Literacy in the digital age	D	Empowered learner
		D	Digital citizen
		D	Knowledge constructor
		D	Innovative designer
		D	Computational Thinker
		D	Creative communicator
		D	Global collaborator
P21	Information literacy Media literacy Technology literacy	D	Information literacy
		D	Media literacy
		D	ICT literacy
NAEP	Technology and Engineering Literacy	D	Technology and Society
		D	Design and Systems
		D	Information and Communication Technologies

OECD		D/T	Core foundations/foundational Literacies: - Basic: Literacy and numeracy - Digital literacy, ICT literacy - Data literacy - Physical and health literacy
		D/T	Compound competencies: - Global competency - Media literacy - Literacy for sustainable development - Computational thinking, programming - Financial literacy - Entrepreneurship
	Digital literacy Data literacy	T	Transformative competencies: -Creating new value - Taking responsibility -Reconciling conflicts, tensions, and dilemmas
		D/T	Competences/Skills (values & attitudes): -Cognitive and metacognitive skills: critical thinking, creative thinking, learning to learn, self-regulation. - Social and emotional skills: empathy, self-efficacy, responsibility, and collaboration. - Practical and physical skills: using new information and communication technology devices.
		T	Anticipation - Action - Reflection (AAR)

Source: Self-made and translated based on frameworks: ATCS, enGauge, Naep, Nets, OECD, P21, Unesco, EU. * More than one name is expressed in the analyzed framework to refer to the skill

Table (4) shows the most and least recurrent competencies between the analyzed frameworks. Information, communication, collaboration, and technical (ICT) competencies are the ones that prevail in all. These are direct contributions from the most common areas of research that media studies, information sciences, communication, education, and computer sciences and engineering span.

In most *frameworks*, a strong vision of the social and multicultural can also be seen, hand in hand with the approach of participation through technologies and digital citizenship. Problem-solving and critical thinking are also recurring skills, although in various structures, that is, they are not always at the level of skills, but rather of abilities or even as transversal characteristics. Other skills add great value from creative, ethical, economic, futuristic, productive, scientific, social, or emotional perspectives.

Table 4. *Recurrence of digital skills identified in the 21st-century frameworks*

Mentioned in all frameworks	Mentioned in most (5-7) frameworks	Mentioned in a few (2-4) frameworks	Mentioned in only one framework
- Information - Communication - Collaboration - Technical (ICT)	- Cultural and Social - Problem solving - Critical thinking	- Media - Creativity - Data - Career-related - Security - Content creation - Responsibility - Basic - Economic and financial - Interpersonal	- Health - Productivity - Scientific - Anticipation, reflection, and action -Sustainable development - Creating new value - Self-direction - Risk-taking - Adaptation - Learning to learn

Source: Self-made and translated based on frameworks: ATCS, enGauge, Naep, Nets, OECD, P21, Unesco, EU.

To articulate the different competencies raised in the proposals, the competencies with exact coincidence (recurring) were identified first, secondly, the conceptually similar competencies with different names, and thirdly, the competencies that were part of broader categories. To integrate them, two modalities were established: 1) articulation by recurrence and 2) articulation by wide relationship.

Table 5 presents the integrated skills and the *frameworks* where they are located. In the first category of recurrent articulation, there are five skills present in all or most of the frameworks. For its part, regarding the second category of broad articulation, there are three competencies, which are established from integrative concepts that integrate various skills

Table 5. *Articulation of skills and location in frameworks*

Articulation category	Competencies	*Frameworks*
Recurrent	Information and data	All
	Communication and collaboration	All
	Technical	All
	Problem-solving	ATCS, enGauge, Unesco, EU, Naep, Nets
	Global citizenship and multicultural awareness	enGauge, EU, Unesco, Naep, Nets
Wide*	Interpersonal	OECD, enGauge, EU, Unesco
	Future thinking	enGauge, OECD, Nets
	Creative thinking	All
	Critical thinking	All

Source: Self-made and translated based on frameworks: ATCS, enGauge, Naep, Nets, OECD, P21, Unesco, EU. * The concepts appear transversely, not necessarily as specific skills, but as combined abilities.

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Digital literacy is more than a sum of technical skills that facilitate the use of tools, software, or hardware. Interdisciplinarily-nurtured digital literacy consolidates the techno-social perspective that promotes the broad, meaningful, and innovative use of ICT for the construction of an equitable society, decent employment, or social participation, all of which contribute to the construction of an information and knowledge society.

5. Discussion and conclusions

5.1. A proposed meta-framework for multidimensional digital literacy

Image (2) shows, by way of synthesis, the structure of a proposed meta-framework of digital literacy, which is made up of a total of nine skills and 53 abilities. In Annex (3) the definitions of the skills identified in the *frameworks* and related researches are detailed.

The meta-framework includes three direct skills: 1) information and data, 2) technical, and 3) communication and collaboration; and five transversal ones: 1) critical thinking, 2) creative thinking, 3) future thinking, 4) interpersonal, and 5) global citizenry and multicultural awareness. Direct skills (indicated with the letter D) refer to linear skills that are direct contributions from the fields of information literacy, media literacy, ICT literacy, and technological literacy, that is, all the literacies integrated into the concept of digital literacy. The transversal skills (identified with the letter T) are all those that fulfill a complementary role.

Direct and transversal skills interact with each other. As an example, to understand both typologies, when a user decides to use a tool (direct skill: technical), they evaluate the security of their data in the tool (transversal skill: critical thinking) and make effective management of their digital identity in the said tool (transversal skill: interpersonal). That is, they put into practice direct and transversal skills, which go beyond the technical approach, in each experience. All this leads us to consider a multidimensional approach to digital literacy to not "reduce digital skill to its most technological and instrumental dimension" (Gutiérrez & Tyner, 2012).

Following the dimensions of digital literacy identified by Martínez-Bravo, Sádaba, Serrano-Puche (2020), in the proposed meta-framework, competencies are reflected in six dimension categories, as large areas where competencies converge. The cognitive dimension integrates high-order competencies such as problem-solving, the development of logical reasoning, processes such as analysis, interpretation, creativity, production, etc. The operational dimension has an instrumental approach and involves, among others, skills for the use of tools or the solution of technical problems. The critical dimension encompasses attitudes and values, the critical use of information, and tools. The social dimension integrates the sense of belonging to a global community, participation in networks, and communication in the digital ecosystem. The emotional dimension is focused on managing emotions and building healthy relationships. Finally, the projective dimension encompasses the awareness of inhabiting complex and changing environments, the attitude of acquiring knowledge to make predictions, generate anticipated responses, and solve problems based on innovative technologies.

There is a direct and consistent connection between dimension, competence, and skill. The 53 skills are displayed in Annex (4) with the definitions located in the different *frameworks*.

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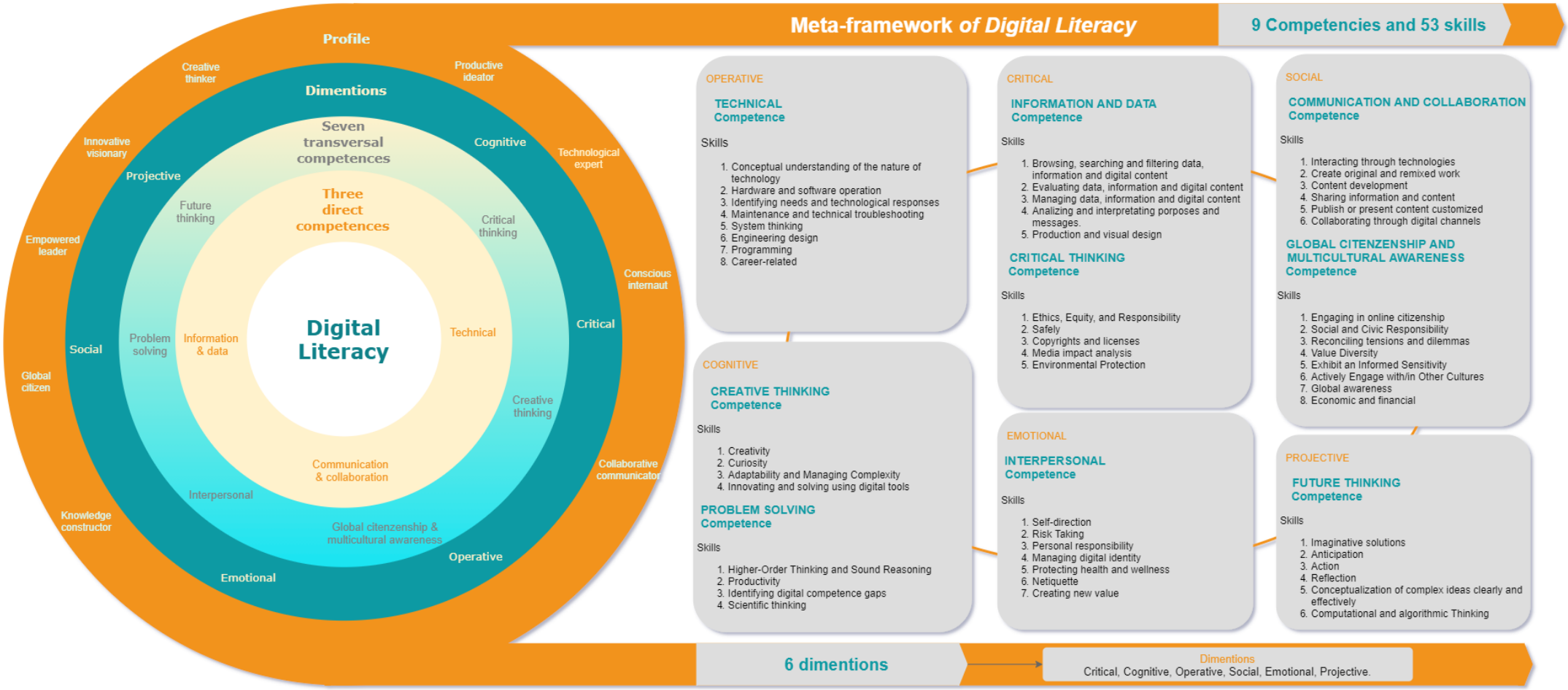

Image 2: *Proposed meta-framework of digital literacy*

Source: Self-made integrating the competence frameworks of the 21st-century: ATCS, enGauge, Naep, Nets, OECD, P21, Unesco, EU. * Annex 3 presents a detailed version with definitions of the proposed meta-framework, as well as its interrelation between profile, dimension, type of competence, competence, and skill.

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Although there is no agreement for the use of the term digital literacy (Gallardo- Echanique et al. 2015; Ilomäki et al., 2016; Siddiq; Gochyyev; Wilson, 2017; Chu et al., 2017), this meta-framework adopts this term since it has been pointed out as a concept that integrates various related literacies, both in the studied frameworks, especially the most current ones, and in other research pieces (Ferrari, 2012; Van-Laar et al., 2017; Unesco, 2018; Pérez-Escoda, García-Ruiz, and Aguaded, 2019; Martínez-Bravo, Sádaba, Serrano-Puche, 2020).

This proposed meta-framework includes eight visions, which in turn have different emphasis on multiple literacies, which allows reaching a detailed level of the scope of skills and abilities and, therefore, understanding the impact radius of each one and its implications, which favors the implementation of implementation ecosystems and evaluation systems.

The development of the digital skills identified in this proposal seeks to display a more critical and thoughtful profile that consolidates the learner as: a creative thinker, builder of knowledge, productive creator, technological expert, conscious internet user, collaborative communicator, innovative visionary, global citizen, and an empowered leader, through the responsible and meaningful use of technologies.

5.2. Contribution of digital literacy to the 2030 Agenda, human rights, and common well-being

The holistic and humanistic approach to digital competence is a shared vision in the reference frameworks of 21st-century skills, where the use of ICT is promoted in an effective, efficient, appropriate, critical, creative, autonomous, flexible, ethical, and thoughtful way.

By way of consensus between the different *frameworks*, multidimensional digital literacy can be synthesized in six key ideas:

1. Being literate in the 21st-century requires the ability to read, interpret, give meaning, and communicate in the digital ecosystem.
2. Digital skill is a core skill and fundamental foundation in the frameworks of 21st-century skills.
3. Digital literacy is a convergent concept of different approaches, covering many areas and literacies.
4. It is the set of knowledge, skills, attitudes, and values.
5. It involves the safe, critical, effective, efficient, appropriate, creative, autonomous, flexible, ethical, thoughtful use of ICT and digital media, tools, and platforms.
6. It favors participation in society, personal and professional development, and empowerment in daily life, contributing to the construction of an equitable society.

It should be noted that traditional literacy is the gateway to digital literacy, which is why the improvement of the current system and the coverage of initial, basic, and secondary education continues to be a fundamental challenge.

It is also important to point out that digital literacy and the significant use of ICT have a great connection with the Sustainable Development Goals, not only because it promotes social, technological, and scientific innovation, but also because it consolidates spaces that contribute to the progress of the goals (Porcelli, 2020) and the protection of human rights (Ferrari, 2012). Likewise, among the skills of digital competence, the sustainable use of technologies, ethical responsibilities with the planet and people, innovation, social, personal, and work empowerment are pointed out, which are related to the vision of the 2030 Agenda.

For its part, an issue to be considered in the proposals regarding the implementation of 21st-century skills, in particular digital competence, is to generate mechanisms and guides that guarantee their development beyond the formal learning environment and the children or adolescent audiences (Pessoa, 2015). Most of the initiatives consider the environment of the educational centers, which often leads to a government implementation that remains reduced in this context, generating a generational and social digital gap (Busquet-Duran, Medina-Cambrón, and Ballano-Macías, 2013).

Undoubtedly, one of the most important purposes of digital literacy is precisely to close the digital gap for participation on equal terms. Although in a digital age traditional literacy is not enough, both (traditional and digital) are essential to live, work, and participate in today's society.

Finally, it is convenient to reflect on the digital adjective of literacy. The concepts continue to evolve and compared to the traditional vision of reading and writing, the 21st-century demands a new way of reading and writing through tools and technologies in an internet ecosystem. Therefore, rather than thinking about the concept of digital literacy, we could talk about literacy in the digital age.

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8. Annexes

Annex 1. An exploratory review of documents of the 21st-century competence frameworks

N°	Document	Author/s	Framework	Year
1	Assessment and Teaching of 21st-century skills	Esther Care, Patrick Griffin, Mark Wilson. Editors	ATCS	2018
2	Assessment and Teaching of 21st-century skills: Collaborative Problem Solving.Empirical Progressions	ATCS	ATCS	2014
3	21st-century competencies: A practical guide to promote their Learning and assessment. Latin American chapter of the atc21s project	Omar Dengo Foundation. María Eugenia Bujanda Bujanda, Valeria Ruiz González, Andrea Molina Ovares, Sofía QEUsada Montano	ATCS	2014
4	Introductory module: An introduction to assessment and teaching of 21st-century skills	Patrick Griffin	ATCS	2013
5	Module 1: Using a developmental model to assess student learning. Developmental learning frameworks	Patrick Griffin, Kerry Woods, Roz Mountain, Claire Scoular	ATCS	2013
6	Module 2: defining and assessing 21st-century skills	Esther Care, Patrick Griffin, Kerry Woods, Roz Mountain	ATCS	2013
7	Module 3: Atc21s collaborative problem-solving assessments	Claire Scoular, Nafisa Awwal	ATCS	2013
8	Module 4: Use of a developmental framework for teaching	Kerry Woods, Roz Mountain, Patrick Griffin, Claire Scoular	ATCS	2013
9	Module 5: Teaching and learning 21st-century skills	Roz Mountain, Esther Care, Claire Scoular, Kerry Woods	ATCS	2013
10	Technology and Engineering Literacy Assessment and Item Specifications for the 2014 National Assessment of Educational Progress. Pre-Publication Edition	Developed by WestEd under contract to the National Assessment Governing Board	NAEP	2014
11	Technology and Engineering Literacy Framework for the 2018 National Assessment of Educational Progress	Developed for the National Assessment Governing Board	NAEP	2018
12	A History of NAEP Assessment Frameworks. Paper Commissioned for the 20th Anniversary of the National Assessment Governing Board 1988-2008	Carol Jago	NAEP	2009
13	National Assessment of Educational Progress (NAEP)	NAEP	NAEP	2012
14	Profile for Technology (ICT) Literate Students	International Society for Technology in Education (ISTE)	NETS	2007
15	ISTE Standards Coaches	International Society for Technology in Education (ISTE)	NETS	2011
16	ISTE Standards Students	International Society for Technology in Education (ISTE)	NETS	2007
17	ISTE Standards Teachers	International Society for Technology in Education (ISTE)	NETS	2008
18	2016 ISTE Standards for Students	International Society for Technology in Education (ISTE)	NETS	2016
19	A Constructivist Approach to the National Educational Technology Standards for Teachers.	International Society for Technology in Education (ISTE)	NETS	2012
20	ISTE Standards for students	International Society for Technology in Education (ISTE)	NETS	2016
21	Redefining learning in a technology-driven world. A report to support the adoption of the ISTE Standards for Students	International Society for Technology in Education (ISTE)	NETS	2016
22	ISTE Standards for educators	International Society for Technology in Education (ISTE)	NETS	2017
23	Future Ready LibrariansTM Framework and ISTE Standards for Educators	International Society for Technology in Education (ISTE)	NETS	2018
24	ISTE Standards for education leaders	International Society for Technology in Education (ISTE)	NETS	2018
25	ISTE Standards for educators	International Society for Technology in	NETS	2018

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		Education (ISTE)		
26	21st-century Skills Early Learning Framework (P21 ELF)	Lee A. Scott / P21	P21	2017
27	Framework for 21st-century Learning (Brief)	Partnership for 21st-century Learning, P21	P21	2016
28	Framework for 21st-Century Learning. A unified vision for learning to ensure student success in a world where change is constant and learning never stops.	Battelle for Kids	P21	2019
29	P21 Framework Definitions	Partnership for 21st-century Learning, P21	P21	2015
30	Framework for 21st-century learning. Definitions	Battelle for Kids	P21	2019
31	21st-century Learning for Early Childhood Framework	Battelle for Kids	P21	2019
32	21st-century Learning for Early Childhood Guide	Battelle for Kids	P21	2019
33	Digital Competence in Practice: An Analysis of Frameworks	Anusca Ferrari. European Commission Joint Research Centre. Institute for Prospective Technological Studies	European Union	2012
34	DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe	Anusca Ferrari Editors: Yves Punie and Barbara N. Brečko. European Commission Joint Research Centre. Institute for Prospective Technological Studies	European Union	2013
35	A common European Digital Competence Framework for Citizens	European Commission	European Union	2006
36	Digital Competence for Lifelong Learning. Policy Brief	Kirsti Ala-Mutka, Yves Punie and Christine Redecker. European Commission Joint Research Centre. Institute for Prospective Technological Studies	European Union	2008
37	Key Competencies for Lifelong Learning. European Reference Framework	European Commission	European Union	2007
38	DigComp 2.0: The Digital Competence Framework for Citizens	Riina Vuorikari, Yves Punie, Stephanie Carretero, Lieve Van den Brande	European Union	2016
39	DigComp 2.1: The Digital Competence Framework for Citizens with eight proficiency levels and examples of use.	Carretero, S.; Vuorikari, R. and Punie. European Union.	European Union	2017
40	European Framework for the Digital Competence of Educators: DigCompEdu	Redecker Christine. Punie Yves. European Union.	European Union	2017
41	Unesco Institute for Lifelong Learning, Report 2017	United Nations Educational, Scientific, and Cultural Organization. UNESCO	Unesco	2018
42	A Global measure of digital and ICT literacy skills	United Nations Educational, Scientific, and Cultural Organization. UNESCO	Unesco	2016
43	A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2	United Nations Educational, Scientific, and Cultural Organization. UNESCO	Unesco	2018
44	Global Media and Information Literacy Assessment Framework: Country Readiness and Competencies	United Nations Educational, Scientific, and Cultural Organization. UNESCO	Unesco	2013
45	Media and information literacy curriculum for teachers	United Nations Educational, Scientific, and Cultural Organization. UNESCO	Unesco	2011
46	ICT Competency Framework for Teachers	United Nations Educational, Scientific, and Cultural Organization. UNESCO	Unesco	2018
47	enGauge 21st-century Skills: Literacy in the Digital Age	North Central Regional Educational Laboratory and the Metiri Group	EnGauge	2003
48	Projects on competencies in the OECD context: Analysis of theoretical and conceptual foundations	L.H. Salganik, D.S. Rychen, U. Moser, and J. Konstant	OECD	1999
49	Defining and selecting key competencies	D.S. Rychen and L.H. Salganik (eds.)	OECD	2001
50	Key competencies for a successful life and a well-functioning society	D.S. Rychen and L.H. Salganik (eds.)	OECD	2003
51	The key competencies for personal, economic, and social well-being	Comp. DominiqEU Simona Rychen and Laura Hersh Salganik.	OECD	2006
52	E2030 Conceptual framework: key competencies for 2030 (DeSeCo 2.0)	Miho Taguma, DominiqEU Simona Rychen	OECD	2016
53	Future of education and skills 2030: reflections on Transformative competencies 2030	Miho Taguma, Lars Barteit	OECD	2017
54	Trends Analysis. Future Shocks and Shifts: Challenges for the Global Workforce and Skills Development. OECD EDUCATION 2030, first informal working group webinar/meeting	Miho Taguma, Katja Anger	OECD	2017

55	Education 2030 - Conceptual learning framework: Background papers. The Future of Education and Skills: Education 2030. 6th Informal Working Group (IWG) meeting	Miho Taguma, Lars Barteit, Meow Hwee LIM	OECD	2017
56	Future of Education and Skills 2030: Curriculum Analysis. Preparing humanity for change and artificial intelligence: Learning to learn as a safeguard against volatility, uncertainty, complexity, and ambiguity	Miho Taguma, Gabriel Florence	OECD	2018
57	The future of education and skills. Education 2030. Position paper.	OECD	OECD	2018
58	OECD Future of Education and Skills 2030. OECD Learning Compass 2030. A series of concept notes	OECD	OECD	2019
59	OECD Future of education and skill 2030. Conceptual learning framework. Core Foundations for 2030	OECD	OECD	2019
60	OECD Future of education and skill 2030. Conceptual learning framework. Learning Compass 2030	OECD	OECD	2019
61	OECD Future of education and skill 2030. Conceptual learning framework. Knowledge for 2030	OECD	OECD	2019
62	OECD Future of education and skill 2030. Conceptual learning framework. Transformative competencies FOR 2030.	OECD	OECD	2019
63	OECD Future of education and skill 2030. Conceptual learning framework. Skills 2030	OECD	OECD	2019
64	OECD Future of education and skill 2030. Conceptual learning framework. Attitudes and Values for 2030	OECD	OECD	2019
65	OECD Future of education and skill 2030. Conceptual learning framework. Student Agency	OECD	OECD	2019
66	OECD Future of education and skill 2030. Conceptual learning framework. Anticipation-Action-Reflection (AAR) Cycle	OECD	OECD	2019
67	Curriculum (re)design. A series of thematic reports from the OECD Education 2030 project overview brochure	OECD	OECD	2020
68	Technical Report for Curriculum Redesign series	OECD	OECD	2020
69	What Students Learn Matters. Towards a 21st-century Curriculum	OECD	OECD	2020
70	Curriculum Overload. A Way Forward	OECD	OECD	2020

Source: Self-made

Annex 2. Model form for collecting information on cases.

Name of analyzed reference frame

Comparative components	**Field description**
Institution	Organization(s) developing document
Title of the document	Main document title
Year of publication	Date it was publicly shared
Website	Initiative's URL
Number of documents analyzed of this framework	The revised document number (main and secondary) is specified
Scope	The scope of the initiative is specified: regional, national, international.
Target Group	People to whom the document is addressed
The methodology employed for the construction of this framework	Methodological procedures directed by the different initiatives to translate their proposals
Works related or integrated to this proposal	Other types of jobs related in the proposal
Proposal's objective	Transcription of objectives
Vision	Transcription of vision
Structure of the document	Enumeration of the general structure of the document
Components of the competencies proposal	Structure of the competencies proposal: dimensions, skills, areas, abilities, etc.
Literacy approach	Main focus or name of the literacy with which the proposal is developed
Definition of literacy (general category)	Transcript of definition
Specific competencies and/or areas identified	Transcript of competencies
Does the proposal have a competency implementation guide?	It is detailed yes or no
Recommended implementation type	It is detailed if the proposal mentions some type of implementation: transversal or direct
Does the proposal have a competency evaluation guide?	It is detailed yes or no

Source: self-made

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Annex 3. Meta-framework of digital literacy - Definition of competencies identified in the studied frameworks

Dimension	Role	Profile	Competencies	Description	Skills
Cognitive	T	Creative thinker	Creative thinking	**Unesco Framework:** "Creative use of digital technologies, use of digital tools and technologies to create knowledge and innovate processes and products" **NETS Framework:** "Produce creative artifacts and create meaningful learning experiences"	1.1. Creativity 1.2. Curiosity 1.3. Adaptability and complexity management 1.4. Innovation with digital tools
	T	Productive creator	Problem solving	**Unesco and EU Frameworks:** "Identify needs and problems, and solve conceptual problems and problematic situations in digital environments. Use digital tools to innovate processes and products. Keep up to date with digital evolution" **ATCS Framework:** "Problem-solving involves being able to negotiate complex environments and situations that dynamically change successfully by relying on behavior patterns to achieve the desired goal. More specifically, dynamic or complex problem solving has been defined as" the successful interaction with tasks' dynamic environments (that is, they change based on user intervention and/or time) and in which some, if not all, the regularities of the environment can only be revealed by exploration and successful integration of the information obtained in that process. Therefore, someone who is successful in solving problems can interact with the task's environment and adapt to the dynamic nature of these environments to collect information; integrate and structure information in a meaningful way, and effectively apply the knowledge gained to make predictions and solve the problem in question"	2.1. Higher-order thinking and sound reasoning 2.2. Productivity 2.3. Identification of digital competence gap 2.4. Scientific thinking
Operational	D	Technology expert	Technical	**enGauge Framework:** "Knowledge of what technology is, how it works, what it is for and how it can be used efficiently and effectively to achieve specific objectives" **NAEP Framework:** "Design and Systems cover the nature of technology, the engineering design process by which technologies are developed, and the basic principles for dealing with everyday technologies, including maintenance and troubleshooting. Understanding the design process is particularly valuable in technology assessment, and can also be applied in areas outside of technology, as design is a widely applicable skill. " **Unesco Framework:** "Device and software operation: involves identifying and using hardware tools and technologies. Identifying data, information, and digital content necessary to operate software tools and technologies."	3.1. Conceptual understanding of the nature of technology 3.2. Hardware and software operation 3.3. Identification of technological needs and responses 3.4. Maintenance and technical troubleshooting 3.5. Systemic thinking 3.6. Engineering design 3.7. Programming 3.8. Profession-related use of technology
Critical	D	Knowledge builder	Information and data	**Unesco and EU Frameworks:** "involves articulating the information needs, locating and retrieving data, information and digital content. Judging the relevance of the source and its content. Storing, managing and organizing data, information and digital content" **enGauge Framework:** "Ability to evaluate information through a variety of media, recognize when information is needed, locate, synthesize, and use information effectively, and perform these functions through technology, communication networks, and electronic resources, evaluating it critically and competently, and using it accurately and creatively " **Framework P21:** "Access and evaluation of information; use and administration of information"	4.1. Browse, search, and filtering of data, information, and digital content. 4.2. Evaluation of data, information, and digital content 4.3. Management of data, information, and digital content 4.4. Analyze and interpret proposals and messages 4.5. Production and visual design

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Dimension	Role	Profile	Competencies	Description	Skills
	T	Conscious Internet user	Critical thinking	**NAEP Framework:** Awareness of the effects that technology has on society and the natural world and the kinds of ethical issues that arise from those effects. **OECD Framework:** "Critical thinking can be used when one reflects on one's actions and the actions of others." **Cortoni, LoPresti, & Cervelli (2015)**. "Critical competence is the ability to analyze and reason autonomously about the logic, nature, and content of messages, as well as the interpretation of symbols, codes, and cultural conventions used by the media" **Ala-Mutka, Punie, and Redecker (2007)** The critical use of ICT include the approach of privacy and security, ethical and legal use, critical attitude in the use and creation of content.	5.1. Ethics, Fairness, and Responsibility 5.2. Security 5.3. Copyrights and licenses 5.4. Analysis of the media impact 5.5. Environmental protection
Social	D	Collaborative communicator	Communication and collaboration	**Unesco and EU frameworks:** "It implies interacting, communicating, and collaborating through digital technologies being aware of cultural and generational diversity. Participating in society through public and private digital services and participatory citizenry". **NAEP Framework:** "Building and exchanging ideas and solutions is an essential set of skills required to use information and communication technology (ICT) and the media to communicate ideas and collaborate with others."	6.1. Interact through technologies 6.2. Create original and re-elaborated work 6.3. Content development 6.4. Share information and content 6.5. Publish or present personalized content 6.6. Collaborating through digital channels
	T	Global citizen	Global citizenship and multicultural awareness	**enGauge Framework:** "Global awareness. The recognition and understanding of the interrelationships between international organizations, nation-states, public and private economic entities, socio-cultural groups, and individuals throughout the world." **enGauge framework:** "Multicultural literacy. Ability to understand and appreciate the similarities and differences in customs, values, and beliefs of one's own culture and the cultures of others." **NETS Framework**: "Global Contributor. Use digital tools to broaden your perspectives and enrich your learning by collaborating with others and working effectively in teams locally and globally." **ATCS Framework**: "Global citizenship can be broadly described as a sense of collective identity and belonging to a global community, with the implication that people are connected in multiple ways with each other and with their environments."	7.1. Participate in online citizenship 7.2. Social and civic responsibility 7.3. Reconcile tensions and dilemmas 7.4. Value of diversity 7.5. Exhibit an informed sensitivity 7.6. Actively participate in other cultures 7.7. Global awareness 7.8. Economic and financial
Emotional	T	Empowered leader	Interpersonal	**enGauge framework**: "Ability to read and manage the emotions, motivations, and behaviors of oneself and others during social interactions or in a social-interactive context". Shek, Yu, & Siu (2015) "Several approaches have been developed to measure interpersonal competence, focusing on different indices of 'successful social functioning' (…) Specifically, the functional approach to interpersonal relationships focuses on behavioral social outcomes. Having a high level of interpersonal competence requires different skills, including interaction and initiation of relationships, affirmation of personal rights and discontent with others, openness, emotional support, and management of interpersonal conflict "	8.1. Autonomy 8.2. Risk-taking 8.3. Personal responsibility 8.4. Digital identity management 8.5. Protection of health and well-being 8.6. Net-tag 8.7. Creation of new value
Projective	T	Innovative Visionary	Future thinking	**Atance & O'Neill (2005).** "Ability to project into the future to pre-experience an event" **OECD Framework:** "Ability not only to respond to current events but to anticipate future events. This requires the student to be proactive: foresee and be willing to act on what may be necessary for the future"	9.1. Imaginative solutions 9.2. Anticipation 9.3. Action 9.4. Reflection 9.5. Conceptualization of complex ideas 9.6. Computational and algorithmic thinking

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Annex 4. Meta-framework of digital literacy - Description of skills identified in the studied frameworks

Dimension	Competencies	Skills	Framework	Description of skills in *frameworks*
Cognitive	Creative thinking	1.1 Creativity	enGauge	The act of bringing something into existence that is genuinely new and original.
		1.2 Curiosity	enGauge	The desire to know or the spark of interest that leads to inquiry.
		1.3. Adaptability and complexity management	enGauge	The ability to modify one's thinking, attitude, or behavior to better adapt to current or future environments; and the ability to manage multiple objectives, tasks, and inputs, while understanding and adhering to time, resources, and systems constraints.
		1.4. Innovation with digital tools	EU	Innovate with technology, actively participate in collaborative digital and multimedia production, express oneself creatively through digital media and technologies, generate knowledge and solve conceptual problems with the support of digital tools.
	Problem-solving	2.1. Higher-order thinking and sound reasoning	enGauge	The cognitive processes of analysis, comparison, inference and interpretation, evaluation, and synthesis applied to a variety of academic domains and problem-solving contexts.
		2.2. Productivity	enGauge	Prioritization, planning, and results-oriented management. The ability to organize to efficiently achieve the objectives of a specific project or problem. The ability to use real-world tools to communicate, collaborate, solve problems, and perform tasks. The ability to produce intellectual, informational products or materials that serve authentic purposes and occur as a result of students using real-world tools to solve or communicate about real-world problems.
		2.3. Identification of digital competence gap	OECD	Understand where digital competence needs to be improved or updated. Being able to support others in the development of their digital skills. Look for opportunities for self-development and keep up to date with digital evolution.
		2.4. Scientific thinking	enGauge	Knowledge and understanding of scientific concepts and processes necessary for personal decision-making, participation in civic and cultural affairs, and economic productivity. Scientific literacy is important throughout the life of students as they participate in public policy issues related to technology; as they keep up-to-date with advances in areas such as biotechnology, medicine, and space exploration; and especially as they enter an increasingly science-based workforce
Operational	Technical	3.1. Conceptual understanding of the nature of technology	enGauge	Demonstrate a strong conceptual understanding of the nature of technological systems and view themselves as competent users of these systems.
		3.2. Hardware and software operation	Unesco	The physical operation of digital devices: Identify and use the functions and characteristics of hardware tools and technologies. Software operation on digital devices: Know and understand the data, information, and/or digital content that is needed to operate software tools and technologies.
		3.3. Identification of technological needs and responses	EU	Assess your own needs in terms of resources, tools, and skill development, to match needs with possible solutions, adapting tools to personal needs, to critically evaluate possible solutions and digital tools.
		3.4. Maintenance and technical troubleshooting	NAEP	Maintenance and troubleshooting are the set of methods used to prevent technological devices and systems from breaking down and to diagnose and repair them when they fail.
		3.5. Systemic thinking	NAEP	It is a way of thinking about devices and situations to better understand the interactions between components, the root causes of problems, and the consequences of various solutions.
		3.6. Engineering design	NAEP	A systematic approach to creating solutions to technological problems and finding ways to satisfy people' needs and wants
		3.7. Programming	Unesco	Plan and develop an understandable sequence of instructions for a computer system to solve a specific problem or perform a specific task.

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		3.8. Profession-related use of technology	Unesco	Operate specialized digital technologies for a particular field: Identify and use specialized digital tools and technologies for a particular field. Interpret and manipulate data, information, and digital content for a particular field: Understand, analyze, and evaluate specialized data, information, and digital content for a particular field within a digital environment.
Critical	Information and data	5.1. Browse, search, and filtering of data, information, and digital content (EU).	EU	Access and search information online, articulate information needs, find relevant information, select resources effectively, browse through online sources, create personal information strategies.
		5.2. Evaluation of data, information, and digital content	Unesco	Analyze, compare, and critically evaluate the credibility and reliability of data, information, and digital content sources. Analyze, interpret, and critically evaluate data, information, and digital content.
		5.3. Management of data, information, and digital content	Unesco	Organize, store and retrieve data, information, and content in digital environments. Organize and process them in a structured environment.
		5.4. Analyze and interpret proposals and messages	P21	Understand how and why media messages are constructed and for what purposes.
		5.5. Production and visual design	enGauge	Have practical knowledge of the visual elements produced or exhibited through electronic media: Understand the basic elements of visual design, technique, and media. Awareness of emotional, psychological, physiological, and cognitive influences on image perceptions. Understand representative, explanatory, abstract, and symbolic images. Apply knowledge of images in electronic media: they are informed viewers, critics, and consumers of visual information. They are expert designers, composers, and producers of visual information. They are effective visual communicators.
	Critical thinking	6.1. Ethics, Fairness, and Responsibility	NAEP	It refers to the profound effects that technologies have on people, how those effects can widen or reduce disparities, and the responsibility that people have for the social consequences of their technological decisions.
		6.2 Security	Unesco	Device protection: protect devices and digital content, understand risks and threats in digital environments. Know the security and protection measures and take due account of reliability and privacy. Protection of personal data and privacy: to protect personal data and privacy in digital environments. Understand how to use and share personal identification information while protecting yourself and others from harm. To understand that digital services use a "Privacy Policy" to inform how personal data is used.
		6.3. Copyrights and licenses	Unesco	Understand how copyrights and licenses apply to data, information, and digital content.
		6.4. Analysis of the media impact	P21	Examine how people interpret messages differently, how values and views are included or excluded, and how the media can influence beliefs and behaviors.
		6.5. Environmental protection	Unesco	Know the environmental impact of digital technologies and their use.
Social	Communication and collaboration	7.1. Interact through technologies	EU	Interact through a variety of digital devices and applications, understand how digital communication is distributed, displayed, and managed, understand appropriate ways to communicate through digital media, refer to different communication formats, adapt communication modes and strategies to the specific audience.
		7.2. Create original and re-elaborated work	NAEP	Creation of original works or responsibly reuse or mix digital resources into new creations.
		7.3. Content development	EU	Create content in different formats including multimedia, edit and improve the content that you have created or that others have created, express yourself creatively through digital media and technologies.
		7.4. Share information and content	EU	Share with others the location and content of the information found, be willing and able to share knowledge, content, and resources, act as an intermediary, be proactive in the dissemination of news, content, and resources, know citation practices and integrate new information in an existing body of knowledge.
		7.5. Publish or present personalized content	NAEP	Post or present content that personalizes the message and media for its target audiences.

		7.6. Collaborating through digital channels	EU	Use technologies and means for teamwork, collaborative processes, and co-construction and co-creation of resources, knowledge, and content.
	Global citizenship and multicultural awareness	8.1. Participate in the online citizenry	NETS EU	They recognize the rights, responsibilities, and opportunities to live, learn and work in an interconnected digital world, and they act and model in a safe, legal and ethical manner. Participate in society through online engagement, seek opportunities for self-development and empowerment in the use of technologies and digital environments, be aware of the potential of technologies for citizen participation.
		8.2. Social and civic responsibility	enGauge	The ability to manage technology and govern its use in a way that promotes the public well-being and protects society, the environment, and democratic ideals.
		8.3. Reconcile tensions and dilemmas	OECD	Ability to handle tensions, dilemmas, and trade-offs, for example, between fairness and freedom; autonomy and solidarity; efficiency and democratic processes; ecology and simplistic economic models; diversity and universality; and innovation and continuity. This requires the ability to balance seemingly contradictory or incompatible demands. Understanding the needs and interests of others is critical to ensuring your own well-being and that of families and communities over time. Therefore, it is essential to develop the ability to understand and work together with the needs, interests, and perspectives of others. The challenge is to reconcile multiple ideas or positions, often in conflict, and to recognize that there may be more than one solution or method of finding a solution.
		8.4. Value of diversity	enGauge	Awareness of how beliefs, values, and cultural sensitivities affect how they and others think and behave: They appreciate and accept similarities and differences in beliefs, appearances, and lifestyles; Understand how technology impacts culture.
		8.5. Exhibit an informed sensitivity	enGauge	Know the history of both dominant and non-dominant cultures. Take the perspectives of other cultural groups. Be sensitive to issues of prejudice, racism, prejudice, and stereotypes.
		8.6. Actively participate in other cultures	enGauge	Be bilingual/multilingual or be working towards becoming bilingual/multilingual. Communicate, interact, and work with people from other cultural groups, using technology when appropriate. Be familiar with the cultural norms of technological environments to successfully interact in such environments.
		8.7. Global awareness	enGauge	Know the connection of the nations of the world historically, politically, economically, technologically, socially, linguistically, and ecologically. Being able to recognize, analyze, and evaluate the main trends in global relationships and the interconnections of these trends with their local and national communities. Understand how national cultural differences impact the interpretation of events on a global level. Understand the impact of ideology and culture on national decisions about access and use of technology.
		8.8. Economic and financial	enGauge	Ability to identify economic problems, alternatives, costs, and benefits; analyze incentives at work in economic situations; examine the consequences of changes in economic conditions and public policies; collect and organize economic evidence; and weigh the costs against the benefits.
Emotional	Interpersonal	9.1. Autonomy	enGauge	Ability to set learning-related goals, plan the achievement of those goals, manage time and effort independently, and independently assess the quality of learning and any outputs that result from the learning experience.
		9.2. Risk-taking	enGauge	Willingness to make mistakes, defend unconventional or unpopular positions, or tackle extremely challenging problems with no obvious solutions, in ways that enhance personal growth, integrity, or achievement.
		9.3. Personal responsibility	enGauge	The depth and up-to-date knowledge about legal and ethical issues related to technology, combined with one's ability to apply this knowledge to achieve balance, integrity, and quality of life as a citizen, family and community member, learner, and employee.

		9.4. Digital identity management	EU	Create, adapt, and manage one or more digital identities, be able to protect one's own electronic reputation, process the data that is produced through various accounts and applications.
		9.5. Protection of health and well-being	Unesco	Protection of health and well-being: being able to avoid health risks and threats to physical and psychological well-being through the use of digital technologies. Being able to protect yourself and others from potential dangers in digital environments (e.g. cyberbullying). Know digital technologies for social welfare and social inclusion.
		9.6. Net-tag	EU	Have the knowledge and know-how of the behavioral rules in virtual/online interactions
		9.7. Creation of new value	OECD	It refers to the ability of a person to innovate and act in an entrepreneurial way, in a general sense, taking informed and responsible actions. To create a new value, students must have a sense of purpose, curiosity, and an open mind toward new ideas, perspectives, and experiences. Create new value requires critical thinking and creativity to find different approaches to solving problems and collaborating with others to find solutions to complex problems. When evaluating whether or not their solutions are working, students may need agility to try out new ideas and may need to be able to manage the risks associated with these new ideas. Students also need adaptability as their approaches change based on new and emerging insights and knowledge.
Projective	Future thinking	10.1. Imaginative solutions	NETS	Know and use a deliberate design process to generate ideas, test theories, create innovative artifacts, or solve authentic problems. Select and use digital tools to plan and manage a design process that considers design limitations and calculated risks. Develop, test, and refine prototypes as part of a cyclical design process. Show tolerance to ambiguity, perseverance, and capability to work with open problems.
		10.2. Anticipation	OECD	Ability to develop an awareness of how actions that are taken today may have consequences in the future. Anticipation requires more than asking questions; It involves projecting the consequences and potential impact of doing one thing over another or doing nothing at all. By anticipating, students use their ability to understand problems, manage stresses and dilemmas, and consider the short- and long-term consequences that result from their actions (or inaction). Students also consider how problem-solving or creating new value anticipates future needs. A critical element of anticipation is prospecting: the ability to "pre-experience the future by simulating it in [the] mind." Prospecting allows the student to consider and predict the different possible outcomes of their potential actions.
		10.3. Action	OECD	Action is a bridge between what students already know and what they want to do. Through anticipation, the student defines a goal and a purpose for action. Actions can be of research, they can be aimed at taking responsibility or creating new value, or they can be aimed at making changes. Actions can be individual or collective.
		10.4. Reflection	OECD	"The process of the creation of meaning that moves a student from one experience to the next with a deeper understanding of their relationships and connections to other experiences and ideas." Reflection is the common thread that enables the continuity of learning. It enables students to improve their thinking, which leads to better actions towards wellness over time. Through reflection, students acquire a sense of power over their future actions, and a sense of direction, which leads to the agency's development. Reflection is a systematic, rigorous, and disciplined way of thinking, with its roots in scientific research. Reflection involves the combined use of self-directed skills and creative thinking skills and encompasses motivation, ethics, and social and behavioral components, besides cognitive components.
		10.5. Conceptualization and complex ideas in a clear and effective way	NAEP	Clear and effective communication of complex ideas by creating or using a variety of digital objects such as visualizations, models, or simulations.
		10.6. Computational and algorithmic thinking	NETS	Formulate suitable definitions of problems for technology-assisted methods such as data analysis, abstract modeling, and algorithmic thinking to explore and find solutions. Data

				collection or identification of relevant data sets, digital tools to analyze and represent data in various ways to facilitate problem-solving and decision making. Divide problems into components, extract key information, and develop descriptive models to understand complex systems or facilitate problem-solving. Understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

Source: Self-made based on frameworks: ATCS, enGauge, Naep, Nets, OECD, P21, Unesco, EU.