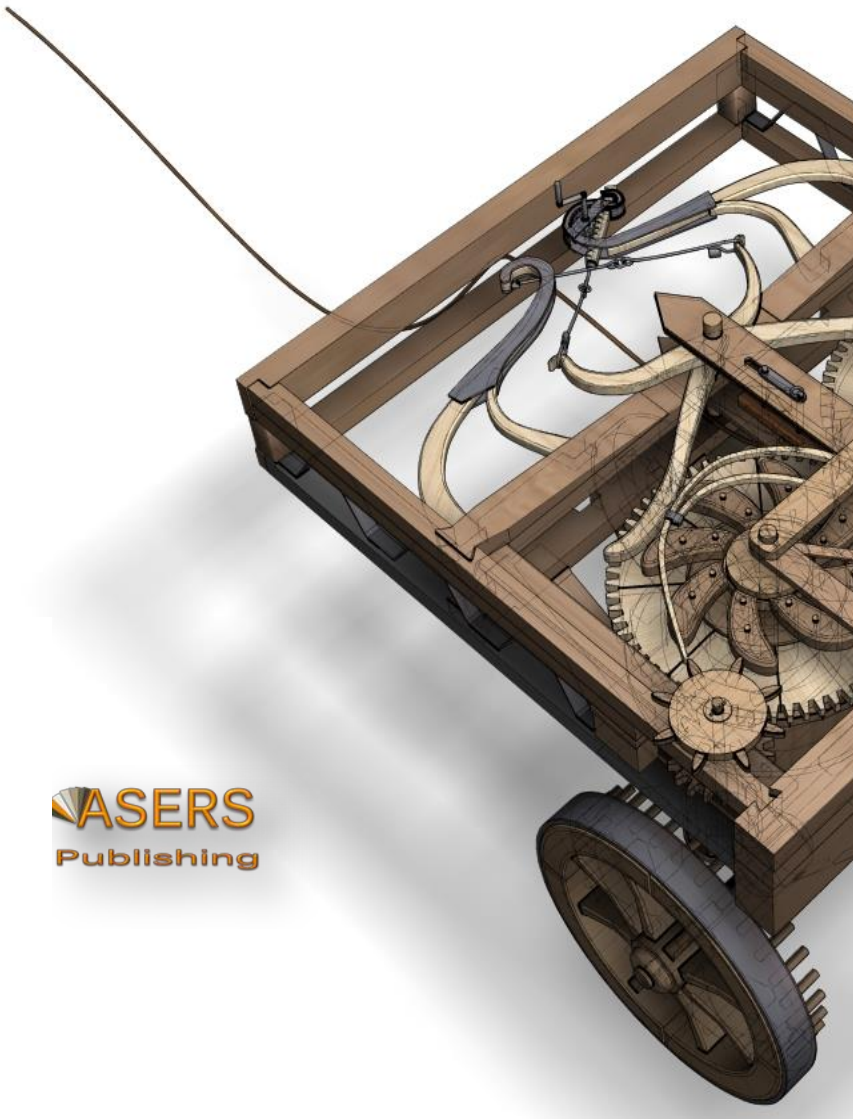
Theoretical and Practical Research in Economic Fields



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A Review and Comparative Analysis of Digital Literacy Frameworks – Where Are We Heading and Why?

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Abstract: *Digital literacy has become as important as other types of literacies that schools and universities teach. In this context, defining it and understanding its components are critical in order to be able to design meaningful policies meant to improve the digital literacy level of the population and to create adequate and well-articulated educational tools and curricula. The purpose of this paper is to identify, briefly describe and compare the existing digital literacy frameworks issued by academia, as well as by governmental and international organizations. Based on this comparative analysis, the paper concludes as to the strengths of the most recent and comprehensive digital literacy framework and discusses the need of progression from earlier frameworks to the most recent ones.*

Keywords: digital literacy; framework; education; categories; items; comparative analysis.

JEL Classification: I25; O39; A12.

Introduction

The academia and various other organizations have made numerous efforts to capture the entire extent of digital literacy in the digital frameworks they have proposed. Digital literacy is difficult to define, and this has been acknowledged by the researchers analyzing it - "[t]he term is so broad that some experts even stay away from it, preferring to speak more specifically about particular skills at the intersection of technology and literacy" (Loewus 2016, 2). Despite this difficulty of defining it, the European Commission has defined digital literacy as "the skills required to achieve digital competence, the confident and critical use of information and communication technology for work, leisure and communication". OECD (Organisation for Economic Co-operation and Development) (2016) stresses the importance of digital literacy for skills and expertise in the labor market. These are just some of the most frequently used definitions of digital literacy among the plethora of existing ones. Definitions are the backbone of designing and building digital literacy frameworks, as is the case of the European Commission or OECD case. While the importance of digital literacy has been increased as we get into the era of digital transformation, there has been a lack of effort in reviewing, comparing, and analysing various frameworks. In this article, we aim to identify and review, on one hand, and compare, on the other hand, the existing frameworks from the standpoint of their categories and items, and to comment on the most recent and comprehensive one, while stressing the need of progression from the earlier frameworks to the more recent ones.

1. Literature Review

There has been a continuous effort in defining digital literacy. Lanham (1995) claims that 'literacy' has extended its semantic reach from meaning 'the ability to read and write' to now meaning 'the ability to understand information' however presented.' He recognizes the changes of mode in delivering information from the conventional printed media to the digital multimedia and emphasizes the skill of deciphering complex images and sounds as well as the syntactical subtleties of words (Lanham 1995). Then, Gilster (1997) further emphasizes the inherent differences of conventional printed media from the new ones presented by computers that are connected via the Internet. He defines digital literacy as 'the ability to understand and use information in multiple formats from a wide variety of sources when it is presented via computers and, particularly, through the medium of the Internet' (Gilster 1997).

In the 1990s, due to the commercialization of the Internet, the amount of information increased super linearly, and the importance of handling information and media became crucial, resulting in the era of multimedia. In order to respond to the increased demand for better understanding of "digital literacy" and to provide digital workers with clear guidelines, it was necessary to refine the framework for the concept (Aviram 2004). Eshet-Alkalai (2004) proposed a new conceptual framework of digital literacy, which is consisted of five types of literacy skills: 1) photo-visual literacy, 2) reproduction literacy, 3) information literacy, 4) branching literacy, and 5) socio-emotional literacy.

In the 2000s, the concept of digital literacy extended to the ability to use digital technology including information processing and software handling. There was an additional effort in developing a more comprehensive framework because there was a belief that it was not sufficient only to include skills and competencies required for Internet literacy, ICT (information and communication technology) literacy, information literacy and media literacy (Shopova 2014). Ferrari (2012) suggests that the definition of digital literacy needs to include the different areas of learning, such as knowledge, attitudes and skills required to identify, locate, access, retrieve, store, and organize the information. Rather than focusing on technical skills, the framework highlights the importance of solving problems and building new knowledge. Then, Janseen *et al.* (2013) expanded the definition by identifying twelve digital competence areas such as 1) General knowledge and functional skills, 2) Use in everyday life, 3) Specialized and advanced competence for work and creative expression, 4) Technology mediated communication and collaboration, 5) Information processing and management, 6) Privacy and security, 7) Legal and ethical aspects, 8) Balanced attitude towards technology, 9) Understanding and awareness of role of ICT in society, 10) Learning about and with digital technologies, 11) Informed decisions on appropriate digital technologies, and 12) Seamless use demonstrating self-efficacy. Therefore, the concept of digital literacy evolved to digital competency that is comprised of knowledge, skills, and attitudes that are linked to various purposes, domains, and levels (Janseen *et al*. 2013).

As the information society is on its way in the 2010s, the concept of digital literacy further extended by including general knowledge in work and life, attitudes, ethics and even the citizenship of a member of digital society.

Digital skills have been acknowledged to be at the core of digital transformation capabilities and to contribute to the achievement of Sustainable Development Goals (SDG). According to Bravo *et al.* (2021), empowerment and technological mastery can be obtained by multidimensional digital literacy. The researchers state that such goals exceed the mere operational use of technology, and they regard 'broad, meaningful and innovative use of technology for the construction of an equitable society, decent employment, social participation' (Bravo *et al.* 2021, p. 76). The necessity to set up an inventory of digital skills and/or an index to measure digital literacy has arisen in the process of bridging digital divide in terms of skills acquisition. Also, a largely accepted digital literacy framework would ensure comparability of digital skills across countries and regions. It would also equip policymakers with an instrument that can help identify and then improve underdeveloped digital literacy areas (Chetty *et al.* 2017). At the same time, the existence of a framework and of an index would allow measuring the digital literacy performance of a country at a certain time moment and tracking progress over time (Kusumastuti and Nuryani 2019). Besides the macro approach rationale for developing a digital skills framework, other scholars have justified it in a university context – the need to create such a framework stem from the need to equip students with relevant digital skills for the workplace of the future (Johnston 2020). For narrower purposes, researchers have attempted to compile various other frameworks, as is the case of the digital media framework proposed by Reyna *et al.* (2018). The authors considered it useful to identify the set of digital media skills that students need in order to be able to produce digital artefacts during their higher education studies. Such a framework includes conceptual, functional and audio-visual skills.

For younger age learners, researchers have explained the importance of a digital skills literacy framework that is englobed in the broader emergent literacy skills, alongside proficiency in reading and writing (Neumann *et al.* 2017). The authors align digital skills with other life skills to highlight their importance in the current era. Peng and Yu (2022), from their work of reviewing digital literacy literature, pointed out the importance of gauging students' digital literacy and introduced three potential frameworks that have different focuses in measuring students' digital literacy. One of the recent works of reviewing 33 papers published in peer-reviewed journals (Nguyen and Habok 2023) noted that various frameworks access various aspect of digital literacy and the lack of effort in providing a comprehensive framework that fit all context exist.

It is not just universities and schools that are concerned about organising digital literacy components into frameworks (Handley 2018). Such endeavours belong to academia, as well. Feerrar (2019) worked on a digital literacy framework using consultations and focus groups. The output opens the way towards broad digital literacy initiatives.

Digital literacy frameworks mainly refer to skills and capabilities of the entire population. However, specific research has been conducted in the area of digital literacy for vulnerable populations, who are endowed with less supporting infrastructure. Thus, Nedungadi *et al.* (2018) proposes an Inclusive Digital Literacy Framework to concomitantly address digital and life skills via mobile technologies and to achieve digital inclusion. Also, the COVID-19 pandemic has revealed threats such as digital poverty, digital literacy and digital exclusion for the people with intellectual disabilities in a context in which survival of jobs and businesses depended on how quick adaptation to the online environment took place (Chadwick *et al.* 2022). From the recent study of the impact of digital literacy on people's daily lives, Tinmaz *et al.* (2023) discussed that digital literacy acquisition process has started with family in early ages and extended to lifelong learning approach implying the expanding scope of digital literacy.

Recently, the obvious intrusion of artificial intelligence (AI) in numerous fields has led to considering including AI in literacy education. Thus, Yang (2022) states that AI literacy is 'an organic part of digital literacy for all citizens in an increasingly intelligent society'. Nevertheless, there are voices that call for attention towards the ethical implications and challenges of AI use in the process of achieving quality education, which is one of the UNESCO 2030 Agenda SDGs (SDG4) (Flores-Vivar and Garcia-Penalvo, 2023).

2. Method

The research methodology used in this paper is a quantitative one. First of all, we did a review of all digital literacy components. To this purpose, we searched both the World Wide Web and the most representative databases of academic papers (Web of Science, Scopus). From each existing digital literacy framework, the authors extracted and listed the digital literacy components. Second of all, using the inventory of components collected in the first phase, a synoptic comparison of all digital literacy frameworks was performed. That is, the authors checked whether each item or category was present or not in each of the digital literacy frameworks under scrutiny. This comparative and synoptic analysis of the components was performed by three independent researchers in order to seek which items are common across the respective frameworks and which items are different or unique. It was necessary to have multiple people look at this checking of items due to the fact that items are called differently, but they may refer to one and the same thing (or not). A triple checking was needed to ensure error minimization. Therefore, the unit of analysis is the framework, and the criteria for comparison was the inventory of components (categories and items) identified. As a result of this endeavour, the authors identify the most comprehensive digital literacy framework, i.e. the Digital Literacy Framework of the CDL (Centre for Digital Literacy) and in what its scope is larger than that of other discussed frameworks. The items that make this model unique were found when performing the comparative analysis. At the end, we discuss the main implications based on the analysis conducted.

3. Research Results

3.1. The Identified Digital Literacy Frameworks

3.1.1. UNESCO on the Digital Literacy

In its efforts to achieve the 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", UNESCO (United Nations Educational, Scientific and Cultural Organization) has designed the Digital Literacy Global Framework (DLGF) drawing on the European Commission's Digital Competence Framework for Citizens (DigComp 2.0).

According to UNESCO, digital literacy is a set of basic skills required for working with digital media, information processing and retrieval. It enables participation in social networks for the creation and sharing of knowledge. It also consists in a wide range of professional computer skills, includes awareness of the cognitive and ethical concerns, while applying skills to evaluate, synthesize and produce new information and critique, it brings about change or care about how to apply technologies in a new, innovative and responsible manner. Digital literacy also presumes to be able to discern what is appropriate and how to derive meaning whilst using digital technologies. Last but not least, it involves abilities such as copying files, managing a spreadsheet and writing a computer programme (UNESCO, 2011; UNESCO, 2016). In A Global Framework to Measure Digital Literacy (UNESCO, n.d.), the framework comprises competence seven competence areas (fundamentals of hardware and software, information and data literacy, communication and collaboration, digital content creation, safety, problem solving, and career-related competences) with their subsumed competences.

3.1.2. The G20 Vision of Digital Literacy

The G20 group initially focused on the digital divide and on how to address it across the countries through infrastructure development, digital trade and financial inclusion. However, the focus then shifted towards addressing this gap from the perspective of digital literacy. At the same time, it was signalled that improvement in infrastructure without a general upskilling cannot help bridging the gap. One obstacle was that of defining and measuring digital literacy. G20 investigated the rich literature to find the most appropriate digital literacy framework. G20 (G20 Insights) adopted a simplified version of the UNESCO proposal for the digital literacy framework, which uses five dimensions (information-digital content; computer-hardware and software; media-text, sound, image, video, social; communication-non-linear interaction; technology-tools for life situations) and three corresponding perspectives (cognitive, technical, ethical) for each of them.

3.1.3. The European Digital Competence Framework as an Integral Part of the European Digital Agenda

The European Union intends to provide secure digital spaces and services, a level playing field in digital markets and digital sovereignty. The three objectives of the European Digital Agenda are: 1) to provide better access for consumers and businesses to digital goods and services across Europe; 2) to create the right conditions for digital networks and services to flourish; and 3) to maximize the growth potential of the digital economy (European Parliament). In order to achieve these goals, the population needs to be equipped with a set of skills for facing the challenges and benefiting from the opportunities of the 21st century. As of now, the European Union is already using the second edition of the European Digital Framework, which is designed and updated in line with the European Digital Agenda (European Commission, n.d.a; n.d.b). DigComp 2.1, issued in 2017) comes up with proficiency levels and examples of use, unlike the previous one (DigComp 2.0 of 2016), which only comprised competence areas and competences.

3.1.4. Digital Literacy in the ASEAN Countries

Kusumastuti and Nuryani (2019) proposed a digital literacy framework within an academic paper by using various components, which are called levels. These levels are further broken down into items and description of their measurement. The resulting digital literacy framework was designed in the context of explaining digital literacy levels in ASEAN (Association of Southeast Asian Nations) countries. The framework brings together five digital literacy level indicators and corresponding item questions and measurement descriptions.

3.1.5. Proposal for a Digital Literacy Index

Rosa (2013) from Getulio Vargas Foundation designed a digital literacy index using seven main pillars: recognition, use, photo-visual, reproduction, branching, information, social interaction. The author intends to shift the focus from the concern about access to information and communication technologies to concern about skills that enable people to use such technologies.

3.1.6. An Index for Measuring Digital and Media Literacy Developed by James L. Knight School of Communication

An index to measure digital and media literacy was designed by James L. Knight School of Communication (2018) in North Carolina. This index is the result of the partnership between Queens University of Charlotte and the city to improve digital and media literacy. The index comprises five types of activities (access and share; analyse; create; reflect; take action), and in order to measure the level of literature, each of these types of activities uses two statements.

3.1.7. COQS Index

SIBIS (Statistical Indicators Benchmarking the Information Society) develops various indicators to reflect the e-Europe initiative priorities and targets, and COQS index is one of them. It is meant to measure a digital literacy score, using the skills below (SIBIS, 2003):

- Communicating with others (by e-mail and other online methods),
- Obtaining (or downloading) and installing software on a computer,
- Questioning the source of information on the Internet and
- Searching for the required information using search engines.

The SIBIS project dates back from the early 2000s and, although improved by the DigComp framework, it remains as a benchmark in measuring digital literacy.

3.1.8. The Global Standard for Digital Literacy, Skills and Readiness of the Coalition for Digital Intelligence

The Coalition for Digital Intelligence is a platform formed through the participation of the World Economic Forum, OECD, IEEE Standards Association and DQ Institute. This coalition proposed a global standard for digital literacy, skills and readiness in 2019 to measure digital intelligence, DQ. It comprises 8 large categories (digital identity, digital use, digital safety, digital security, digital emotional intelligence, digital communication, digital literacy, digital rights), each containing 3 items, being "a comprehensive set of technical, cognitive, metacognitive, and socio-emotional competencies that enable individuals to face the challenges and harness the opportunities of digital life" (DQ Institute, 2019).

3.1.9. Digital Literacy Framework of Edith Cowan University, Australia

Academia, too, has been involved substantially in designing digital literacy frameworks. One such framework is created by Edith Cowan University in Australia (n.d.). It proposes a simple and supple five-category framework, as follows: digital technologies, digital learning (professional and lifelong), digital creation and communication, digital citizenship and identity, information, academic, media and data literacy). Having a digital literacy framework is necessary in order to better equip students with digital literacy skills both for university purposes and for their future career. According to the university, the framework is a tool to be used in policies and strategies concerning curriculum design.

3.1.10. Jisc Digital Capability Framework

Jisc is a UK-based organisation committed to provide digital solutions for national education and research. In this context, it designed a digital capability framework to present the skills required in academia, administration and in different professional roles. This framework considers digital identity and wellbeing to be the largest purpose, with the ICT proficiency being at the core and crossroads of: information, data and media literacies; digital creation, problem solving and innovation; digital learning and development; digital communication, collaboration and participation (Jisc, n.d.).

3.1.11. The Digital Literacy Framework of the National Council for Special Education in Ireland

The National Council for Special Education in Ireland is a body that is in charge with improving the delivery of education services to persons and children with special educational needs stemming from various disabilities. Education should be inclusive, and so should digital education. To this purpose, the National Council for Special Education in Ireland (n.d.) has proposed a Digital Literacy Framework based on six competencies (communicate, create, collaborate, integrate, manage, access) and three main objectives (communication and participation, making of meaning, functional digital skills).

3.1.12. Digital Literacy Model of Media Smarts, Canada

Media Smarts is a Canadian not-for-profit charitable organization for Digital and Media Literacy. It has developed numerous digital and media literacy programs and resources. At the core of its preoccupations is the formation of critical thinking skills in children in order for them to cope with the media. It designed a multi-layer model of digital literacy, which comprises skills and competencies and objectives in a hierarchical fashion (Media Smarts, n.d.).

3.1.13. The BC Digital Literacy Framework, Canada

The Digital Literacy Framework designed by the British Columbia University (n.d.) has six main areas, each of them explaining the main subsumed activities or actions: research and information literacy; critical thinking,

problem solving and decision making; creativity and innovation; digital citizenship; communication and collaboration; technology operations and concepts. This framework is part of the university's revised curriculum, and is meant to be used by the teaching staff in class. By mastering the skills and knowledge herein, students can cope in the current technological world. The index has been adapted by the Ministry of Education after certain revisions.

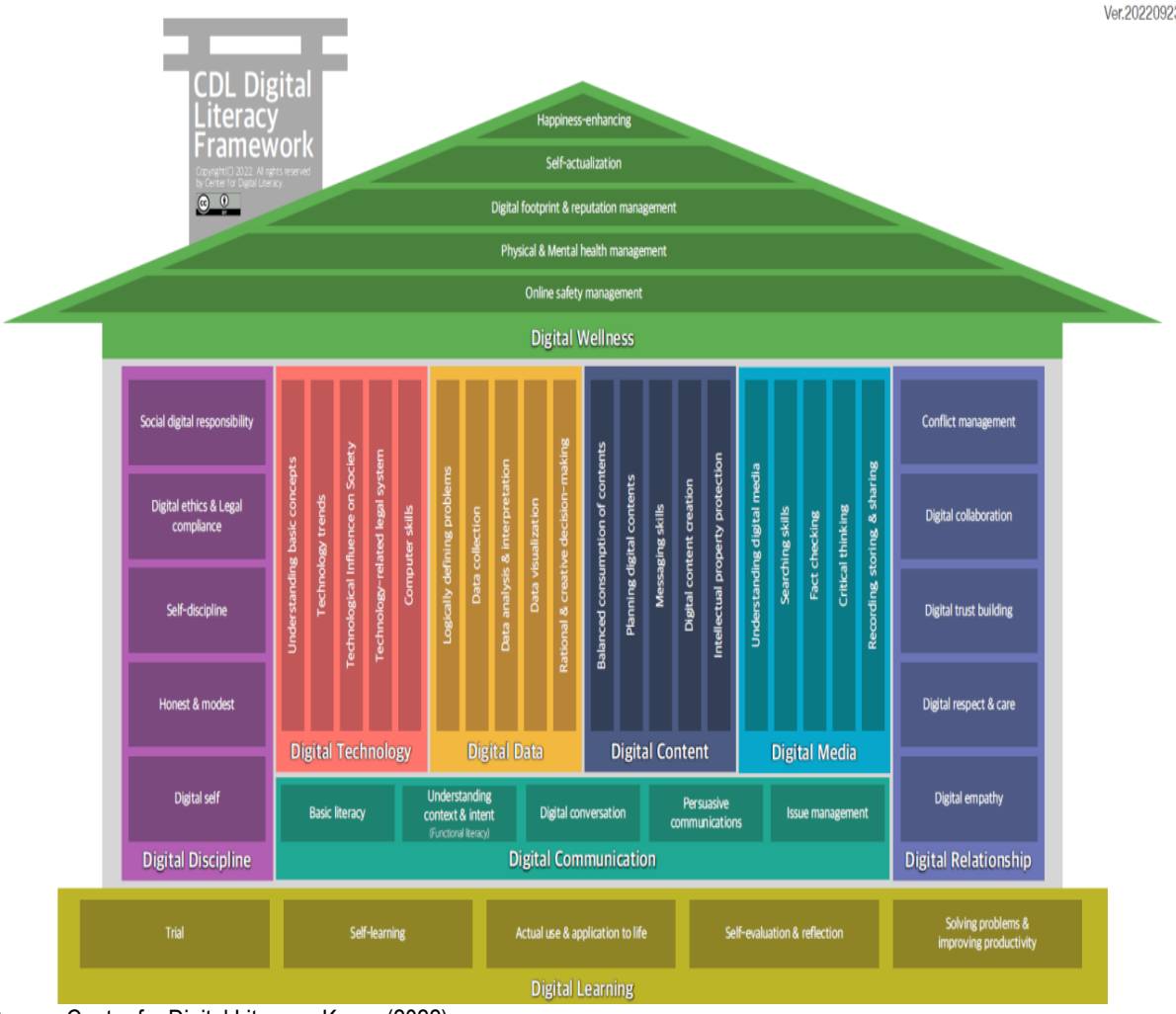
3.1.14. CAUL Digital Dexterity Framework of Macquarie University, Australia

The Council of Australian University Librarians (CAUL) draws from the Jisc model from the UK and proposes a Digital Dexterity Framework, which comprises six major areas: digital identity and wellbeing; collaboration, communication and participation; digital creation, problem solving and innovation; ICT proficiency and productivity; digital learning and development; information literacy, media literacy and data literacy (Macquarie University, n.d.).

3.1.15. The CDL Digital Literacy Framework of the Centre for Digital Literacy (CDL), South Korea

The Centre for Digital Literacy is a non-profit organization based in Korea that conducts research, develops educational content, and operates educational programs. CDL Digital Literacy Framework consists of 9 competency categories, each containing 5 indexes, and has kept evolving since 2017. Based on this framework, CDL is developing digital literacy education content, conducting education programs, and providing DIQ (Digital Intelligence Quotient) system that measures one's digital literacy on the web. Instead of defining digital literacy as the ability to learn and use digital technologies and tools, the CDL framework comprehensively includes all the virtues and abilities necessary to live in a digital society. The framework is shown in Figure 1.

Figure 1. Digital Literacy Framework



Source: Centre for Digital Literacy, Korea (2022)

3.2. An Inventory of Digital Literacy Components – Items and Categories Extracted from the Digital Literacy Frameworks under Investigation

Table 1 presents a synthesis of the fifteen digital literacy frameworks in order to understand how they were built and what categories have been used in their classifications.

Table 1. Synthesis of the analysed frameworks

1. UNESCO Digital Literacy Framework	
To increase the Percentage of youth/adults who have achieved at least a minimum level of proficiency in digital literacy skills	
7 Digital Literacy Skills	1. Fundamentals of Hardware and Software 2. Information and Data Literacy 3. Communication and Collaboration 4. Digital Content Creation 5. Safety 6. Problem-solving 7. Career-related Competence
2. The G20 Vision of Digital Literacy	
Initially focused on the digital divide and on how to address it across the countries via the infrastructure development, digital trade, and financial inclusion. But, the focus then shifted to address the gap from the perspective of digital literacy.	
5 Dimensions	1. Information (Digital Content) 2. Computer (Hardware and Software) 3. Media (Text, Sound, Image, Video, Social) 4. Communication (Non-linear Interaction) 5. Technology (Tools for life Situations)
3 Perspectives	Cognitive Technical Ethical
3. The European Digital Competence Framework	
To provide secure digital spaces and services, a level playing field in digital markets and digital sovereignty. The three objectives: 1) to provide better access for consumers and business to digital goods and services across Europe, 2) to create the right conditions for digital networks and services to flourish, 3) to maximize the growth potential of the digital economy.	
5 Competence Areas	1. Information and Data Literacy 2. Communication and Collaboration 3. Digital Contents Creation 4. Safety 5. Problem Solving
4. Digital Literacy in the ASEAN Countries	
Kusumastuti and Nuryani (2019) proposed the framework which is consisted of 5 levels and those levels are further broken down into items and description of their measurement.	
5 Level Indicators	1. Information Literacy 2. Computer Literacy (Software and Hardware) 3. Media Literacy (text, sound, image, video)

	4. Communication Literacy (interaction) 5. Technology Literacy (tools for life) 1. Item Question 2. Measurement Description
5. Proposal for a Digital Literacy Index (Rosa, 2013) Getulio Vargas Foundation	
Rosa (2013) designed a digital literacy index using seven main pillars. Intends to shift the focus from the concern about access to information and communication technologies to concern about skills that enable people to use such technologies.	
7 Pillars	1. Recognition (RT1-RT12) 2. Use (UT1-UT17) 3. Photo Visual (FI1-FI3) 4. Reproduction (RI1-RI2) 5. Branching (MI1-MI3) 6. Information (II1-II4) 7. Social Interaction (SI1-SI3)
2 Dimensions	1 Descriptor 2. Detailing
6. An Index for Measuring Digital and Media Literacy by James L. Knight School of Communication	
The index comprises five types of activities with two statements for each to measure the level of literacy	
5 Type of Activities	1. Access and Share 2. Analyse 3. Create 4. Reflect 5. Take Action
7. COQS Index	
Developed by Statistical Indicators Benchmarking the Information Society (SIBIS). It is meant to measure a digital literacy score, using the skills.	
4 Skills	1. Communicating with others 2. Obtaining and Installing Software on a Computer 3. Questioning the Source of Information on the Internet 4. Searching for the Required Information using Search Engines
8. The Global Standard for Digital Literacy, Skills, and Readiness of the Condition for Digital Intelligence	
This coalition proposes a global standard for digital literacy, skills and readiness in 2019 to measure digital intelligence, DQ. It comprises 8 categories, each containing 3 items, being "a comprehensive set of technical, cognitive, metacognitive, and socio-emotional competencies".	
8 Categories	1. Digital Identity 2. Digital Right 3. Digital Literacy 4. Digital Communication 5. Digital Emotional Intelligence 6. Digital Security 7. Digital Security 8. Digital Safety 9. Digital Use
3 Items for each	
9. Digital Literacy Framework of Edith Cowan University, Australia	

It proposes a simple and supple five-category framework. Having a digital literacy framework is necessary in order to better equip students with digital literacy skills both for university purposes and for their future career.	
5 Categories	1. Digital Technologies 2. Information, Academic Media, and Data Literacy 3. Digital Citizenship and Identity 4. Digital Creation and Communication 5. Digital Learning (Professional and Lifelong)
10. JISC Digital Capability Framework	
It designed a digital capability framework to present the skills required in academia, administration and in different professional roles.	
6 Skills	1. ICT Proficiency 2. Digital Creation, Problem Solving and Innovation 3. Digital Communication, Collaboration and Participation 4. Digital Learning and Development 5. Information, Data and Media Literacies 6. Digital Identity and Wellbeing
11. The Digital literacy Framework of the National Council for Special Education in Ireland	
The National Council for Special Education in Ireland has proposed a Digital Literacy Framework based on six competencies and three main objectives.	
6 Competencies	1. Communicate 2. Create 3. Collaborate 4. Integrate 5. Manage 6. Access
3 Objectives	1. Communication and Participation 2. Making of Meaning 3. Functional Digital Skills
12. Digital Literacy Model for Media Smarts, Canada	
Media Smarts is a Canadian not-for-profit organization for Digital and Media Literacy. It designed a multi-layer model of digital literacy, which comprises skills and competencies and objectives in a hierarchical fashion.	
3 Skills	1. ICT Innovation (In ITC/With ICT) 2. Constructive Social Action 3. Critical/Creative Thinking
4 Objective	1. Create 2. Understand 3. Use 4. Access
Multiple Competences	
13. The BC Digital Literacy Framework, Canada	
The British Columbia University developed a Digital Literacy Framework that has six main areas, each of them explaining the main subsumed activities or actions.	
6 Main Areas	1. Research and Information Literacy

	2. Critical Thinking, Problem Solving, and Decision Making 3. Creativity and Innovation 4. Digital Citizenship 5. Communication and Collaboration 6. Technology Operations and Concepts
14. CAUL Digital Dexterity Framework of Macquarie University, Australia	
The Council of Australian University Librarians (CAUL) proposes a Digital Dexterity Framework, which comprises six major areas.	
6 Major Areas	1. Information Literacy, Media Literacy and Data Literacy 2. Digital Learning and Development 3. ICT Proficiency and Productivity 4. Digital Creation, Problem Solving, and Innovation 5, Collaboration, Communication, and Participation 6. Digital Identity and Wellbeing
15. The CDL Digital Literacy Framework of Centre for Digital Literacy, South Korea	
The CDL Digital Literacy Framework consists of 9 competency categories, each containing 5 indexes. This framework is a comprehensive set of knowledge, skills and attitudes aspects, and the CDL provides educational programs developed by this framework and enables the measurement of digital literacy through the DIQ (Digital Intelligence Quotient) assessment system.	
9 Competencies 5 Index for each	1. Digital Technology Literacy 2. Digital Data Literacy 3. Digital Content Literacy 4. Digital Media Literacy 5. Digital Communication Literacy 6. Digital Relationship Literacy 7. Digital Discipline Literacy 8. Digital Learning Literacy 9. Digital Wellness Literacy

Source: Authors' compilation based on the frameworks cited herein

Digital literacy has been detailed under the umbrella of various heterogeneous frameworks. These frameworks are titled using terms such as digital literacy, digital competence, digital capability, digital dexterity or even media literacy. The most frequent term used in the framework denomination is digital literacy. Within the framework, other types of literacies are found, such as information literacy, data literacy, computer literacy, communication literacy and technology literacy. Given the prevalence of digital literacy in the investigated frameworks, we conclude that the more general term that we can recommend for use is digital literacy, and the other types of literacies can be placed as its components.

The components of the analysed frameworks are also diverse. For instance, their detailing can be found on several layers, comprising: skills, dimensions and perspectives, competence areas, level indicators, pillars and dimensions, types of activities, categories, categories and items, competences and objectives. For a better illustration of the components of indexes, we recommend presentation on at least two layers, based on the best practice examples discussed above.

3.3. A Synoptic Comparative Analysis of Existing Digital Literacy Frameworks

Based on the inventory of digital literacy components identified above, we will compare in a synoptic manner all indexes – in the first column the digital literacy components are listed, and on the other columns all the fifteen frameworks in a chronological order. That is, we will check for each component and then count how many there are in each framework to identify the more comprehensive one.

Table 2. Synoptic comparative analysis of the analysed frameworks

Classification	COQS Index (2003)	Rosa from Getulio Vargas Foundation (2013)	The BC Digital Literacy Framework (2013)	The National Council (2014)	Media Smarts (2014?)	UNESCO Digital Literacy (2016)	G20 Vision of Digital Literacy (2016)	DigComp (2017)	Edith Cowan University (2017?)	Jisc (2017)	James L. Knight School of Communication (2018)	Digital Literacy in the ASEAN (2019)	The Coalition for Digital Intelligence (2019)	CAUL Digital Dexterity Framework (2019)	The CDL Digital Literacy Framework (2022)
Information searching	O	O	O	O	O	O	O	O	O	O		O	O	O	O
Computer skills	O	O	O	O	O	O	O		O	O	O	O		O	O
Content creation		O	O	O	+	O	O	O	O	O	O	+	O	O	O
Filtering and managing data	O	O	O	O		O	O	O	O	O		+	O		O
Information sharing		O	O	-	+	O		O	O	O	O		O	O	O
Communication	O	+	O	O		O	O	O	O	O		+	O	O	O
Data analysis		O		O		O		O	O	O			O	O	O
Media		O	+	-			O		O	O		O	O	O	O
Digital identity		+	-		O	O		O	O	O			O	O	O
Programming		O				O	O	O	O	O				O	O
Collaboration			O	O	+	O		O		O			O	O	O
Social participation			O	O	O					O	O		O	O	O
e-Safety			-		O	O		O				O	O		O
Citizenship			O		O	O		O	O				O		O
Problem-solving			O		O	O		O		O		+		O	O
Intellectual property protection			-			O		O					O	-	O
Privacy			-			O		O				O	O		O
Critical thinking		+	O		O		O					+		-	O
Digital learning			O			+			O	O				O	O
Digital well-being						O		O		O				O	O

Classification	COQS Index (2003)	Rosa from Getulio Vargas Foundation (2013)	The BC Digital Literacy Framework (2013)	The National Council (2014)	Media Smarts (20147)	UNESCO Digital Literacy (2016)	G20 Vision of Digital Literacy (2016)	DigComp (2017)	Edith Cowan University (20177)	Jisc (2017)	James L. Knight School of Communication (2018)	Digital Literacy in the ASEAN (2019)	The Coalition for Digital Intelligence (2019)	CAUL Digital Dexterity Framework (2019)	The CDL Digital Literacy Framework (2022)
Computational thinking						O		O					O		O
Decision-making			O		O									-	O
Netiquette			O			O		O							O
Social interaction		O			O	+		+			O				O
Innovation			O		O		+			O		+		O	
Self-reflection					O						O			-	O
Career-related competence						O			O				O		O
Digital health						O		O				+	+	-	O
Digital footprint management			O						-				O		O
Relationship management			O										O		O
Creativity			O		O	+								O	
Reputation management			-											-	O
Literacy					O					+		+			O
Understanding impacts of tech			O												O
Actual use			O												O
Fact checking											O	+			O
Empathy													O		O
Risk management													O		O
Productivity														O	O
Social Responsibilities					O	+		+							O
Trust building															O
Conflict management															O

Classification	COQS Index (2003)	Rosa from Getulio Vargas Foundation (2013)	The BC Digital Literacy Framework (2013)	The National Council (2014)	Media Smarts (2014?)	UNESCO Digital Literacy (2016)	G20 Vision of Digital Literacy (2016)	DigComp (2017)	Edith Cowan University (2017?)	Jisc (2017)	James L. Knight School of Communication (2018)	Digital Literacy in the ASEAN (2019)	The Coalition for Digital Intelligence (2019)	CAUL Digital Dexterity Framework (2019)	The CDL Digital Literacy Framework (2022)
Happiness															O
	4	10 (12)	25 (21)	10 (8)	15 (18)	20 (24)	8 (9)	18 (20)	14 (13)	16 (17)	7	5 (14)	20 (21)	23 (17)	41
Consensus	4	12	21	10	18	24	9	20	13	17	7	14	21	17	41

Source: Authors' compilation based on the frameworks cited herein

4. Discussions

In order to compare the fifteen identified digital literacy frameworks, the authors developed Table 2. First, the authors listed digital literacy frameworks in a chronological order in the first row and the items identified from the most comprehensive framework from the first round of review process on the first column. Whenever a new item was identified, the researchers added it to the list. Second, two researchers independently reviewed all the frameworks and put a mark in each cell by using three different kinds of symbols such as circle, plus, and minus. Each researcher put a circle mark in the cell whenever the item was identified from each of framework. Finally, an additional researcher compared the results from two researchers and put a '+' mark when a researcher identified additional items and '-' mark when one of the researchers claimed that they could not find it. Then, the researcher counted the number of items that was identified from each researcher as can be seen from the 2nd last row and reviewed the framework to make the final decision. The number in the last row presents the confirmed one by all three researchers. The main reason of the big difference between the numbers from two reviewers was caused by the fact that they looked at different sources. For example, one only looked at the table or figure, but the other one reviewed the text contents that carry more detail description of the table or figure.

As shown in Table 2 above, from 2003 to 2022, we can notice that the scope of the frameworks expanded and included more and more items in most of the cases. From simply listing computer skills, managing data, communication or information searching, they became more and more sophisticated and went as far as to include citizenship, digital well-being, e-safety, empathy, trust building, conflict management, and so on. Computers and the web have first served as primitive tools to make our tasks easier; as of now, they have enriched the ways of doing things and provided new types of capabilities.

The authors have independently compared the above digital literacy frameworks and models and have reached the conclusion that, although differently phrased, most categories and items are to be found in the Digital Literacy Framework of CDL, with very few exceptions. Moreover, it is one of the most comprehensive, if not the richest framework proposed for digital literacy. Some of the items it suggests do not exist in other frameworks as such or similarly (e.g., self-realization, consistency, self-motivation, pros and cons of technology, technology-related legal system, digital content planning, understanding media, conflict resolution in cyberspace, digital humanism, trust building, self-learning, digital distraction management). We therefore posit that the Korean Digital Literacy Framework of CDL is one of the most recent and comprehensive of those identified.

Conclusions and Further Research

The dynamics of digital literacy framework design and scope is a clear indication that digital skills have come at the fore of educational concerns in recent years and of the weight gained by new digital technologies in practically all areas of activity. As a result, those economies that successfully adopt and utilize digital technology would grow super linearly because of the network effects while the other economies grow linearly at most if they do well. The

gap between those two groups will be bigger and bigger as time goes by. We could also estimate and foresee that, with the advent of artificial intelligence, these frameworks will further develop and become broader and inclusive of more domains and fields, which until recently knew little or no digital interference, such as sports or the art. It is highly important to understand the development of digital literacy frameworks for various reasons, such as a comprehensive and reality-anchored education, technological transfer, enhanced work capabilities, etc. The main implications of the study are presented below.

Implications

From a research point of view, this paper is useful in that, to the best of the authors' knowledge, it brings together all existing digital literacy frameworks both in a synthetic approach and in a comparative synoptic approach. This synoptic presentation reflects the swift pace at which the digital world has amplified and protruded in all aspects of life. From a policy perspective, accounting for all digital skills and competencies can be of use in terms of educational policy design. Therefore, the most comprehensive digital literacy framework that was identified needs to be checked by policymakers in the field of education as they can have the whole picture in front of their eyes when designing curricula and policy to upgrade digital literacy among various populations and countrywide. Also, digital literacy frameworks stemming from practitioners keep educational agents abreast with the newest technologies. From a practical perspective, knowledge of digital literacy scope and coverage can represent a basis for evaluation of such skills and identifying and using the most comprehensive framework will help diversify learning, education and assessment of digital skills. Moreover, the progression of digital skills from very simple to very complex ones reflect the need to ensure more types of digital capabilities to cope in today's very complex world, which is faced both with growing opportunities and with increasing risks.

Limitation and Future Direction

Due to the nature of the exploratory research, it is required to pay extra attention to the interpretation of the result. First, the initial search of the digital literacy frameworks was limited to the World Wide Web, Web of Science and SCOPUS. There might be more frameworks that can be found from other sources. Second, the review process of digital literacy frameworks was limited to the second level of each framework. Since some frameworks might contain more information at the lower level, it is required to obtain the official document of each framework that contains the detailed information for more comprehensive analysis. Finally, more structured analysis rather than manual review of frameworks is required. This is because each framework uses different terminologies and has different levels.

Future research can be based on the current synoptic presentation to provide useful insights to educational professionals in their attempt to enrich digital literacy curriculum in schools and universities with currently missing items. As mainstream literature shows it, it is high time artificial intelligence was included in such frameworks, too. However, this step needs to be carefully considered due to the risks it comes with. None of the investigated frameworks includes artificial intelligence, and an update is required in this sense.

Credit Authorship Contribution Statement

Yoo-Taek Lee: Conceptualization, Investigation, Methodology, Project administration, Formal analysis, Supervision, Validation, Writing – review and editing, Visualization.
Mina Fanea - Ivanovici: Conceptualization, Investigation, Methodology, Project administration, Formal analysis, Writing – original draft, Supervision, Validation, Writing – review and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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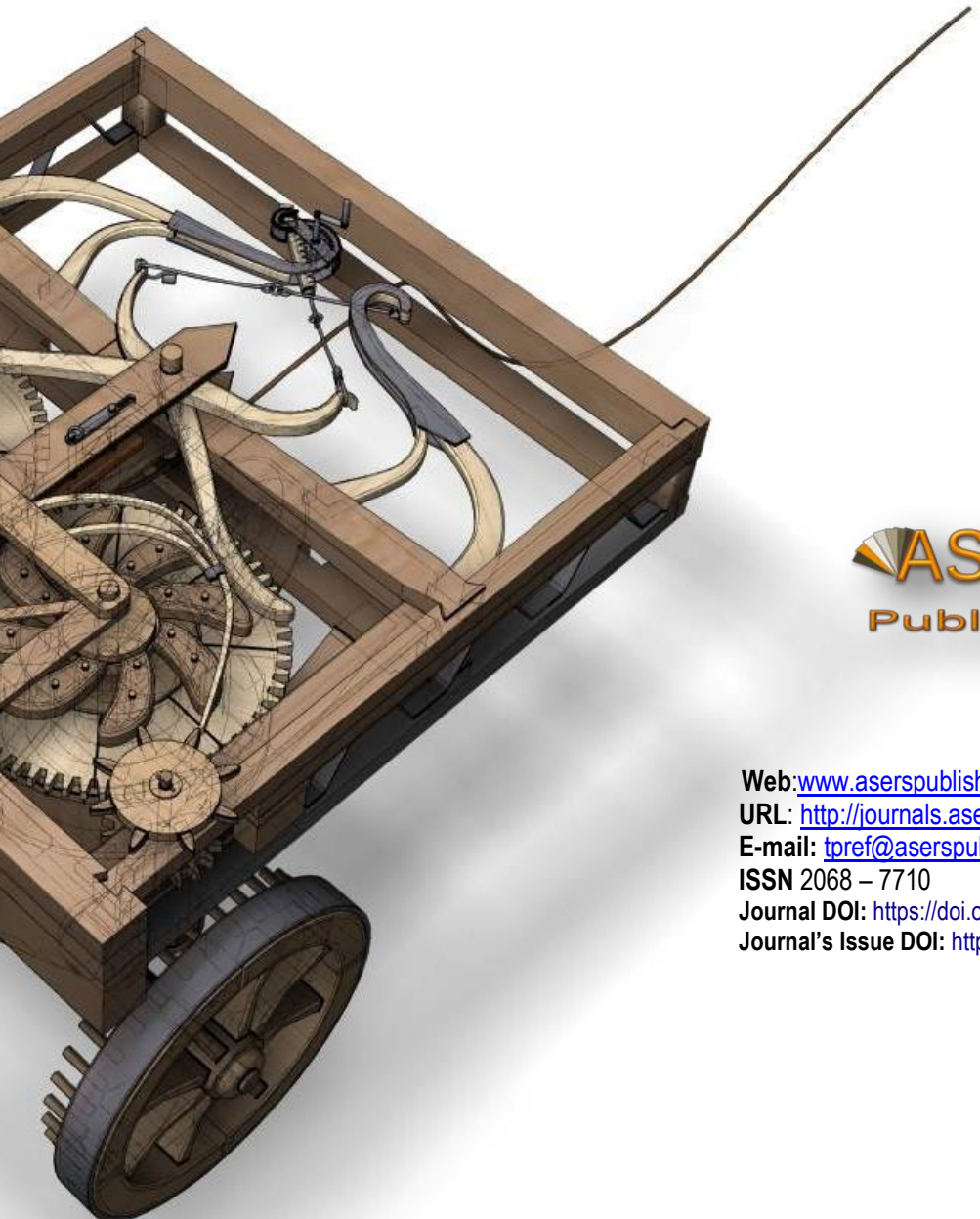

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