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RESEARCH ARTICLE

Digital Skills Measures for Digitalization- An Aggregative Analysis

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ARTICLE INFO	ABSTRACT
  *Corresponding Author: ismailr@ppu.edu	Digitalization is a rapidly expanding phenomenon in the digital age, where digital technologies dominate all life aspects; such as the automation of tasks, new products and services, new business models, new economic drivers, and so forth. Prior researches emphasized the fact that there is a gap between the existing and needed digital skills to respond to the challenges of the digitalized workplace in the future. Meanwhile, these researches suggest several frameworks for measuring digital skills. Therefore, the main objective of this study is to find a unified measurement tool for digital skills. To pursue the objective of this study, an aggregation analysis was conducted on the digital skills frameworks suggested in prior researches. The main findings show that digital skills can be divided into four main categories; each of which can be measured by a set of tasks - items. These categories include general digital skills, essential digital skills, work digital skills, and advanced/specialized digital skills. Where, applying this digital skills measurement tool can help both academics, and organizations in determining the digital skills gap, and formulate curriculums, and training courses to bridge the digital skills gap that may occur.

INTRODUCTION

The rise of digitalization is the main feature of the 21st century, where digital technologies dominate all life aspects. It's highlighted that digital technologies impact societies and economies, where the automation of tasks, new products and services, new business models, new economic drivers, and so forth (OECD, 2019). Furthermore, it is projected that in the coming years, businesses will invest more in developing technologies such as AI, AR/VR, and IoT. Where, Quixy (2023) shows that the global digitalization market is expected to grow from 469.8 billion in 2020 to $1,009.8 billion in 2025, which will raise the world economy by $100 trillion. He adds that 91% of organizations are involved in some aspects of the digital effort, while 87% of senior business leaders believe that digitalization is a priority.

MyHUb (2023) reported that participants of the Global Digital Skills Index think that digital skills will be critical within the next five years, where, digital skills are required for 90% of occupations. However, 25% of the participants believe that advanced digital skills are required to promote sustainable business activity. Meanwhile, 75% are not equipped to develop the necessary digital skills, and 76% are unequipped for the future. Moreover, it has been reported that 89% of global

organizations are expected to have a skills gap. Thus, the digital skills gap is predicted to disrupt business growth, potentially costing 14 of the G20 countries $1.5 trillion in aggregate GDP growth. On the other hand, it's reported that 90% of company strategies will consider information as a business asset, and analytics as a key capability. Where information systems decision-makers are at the forefront of success. Moreover, companies that engage a chief digital officer can achieve successful digital transformation.

OECD (2018) shows that in the era of knowledge explosion and the growing of complex problems; academic curriculums should evolve to cope with this explosion. In addition, assisting students to have a positive impact on society, influence the future, realize the intentions, and behavior of others, and predict the instant and long-term ramifications of their activities. As well as preparing them to apply their knowledge in new and changing situations.

Depending on these clarifications, the main objectives of the current study is to provide further insight into digitalization skills, find out a digital skills measurement tool, and align these skills for the work-domain benefits. To pursue these goals, an investigation will be conducted into prior researches in order to find out specialists' and none specialists' digital skills that enable the organizations' sustainability in the era of digitalization.

BACKGROUND AND LITERATURE REVIEW

Background

OECD (2018) reported that in the era of knowledge explosion and the growing of complex problems; academic curriculums should evolve to cope with this explosion. In addition to preparing students to have a positive impact on their societies, affect the future, understand the intentions, actions, feelings of others, and anticipate the immediate and long-term consequences of their activities. As well as preparing them to apply their knowledge in new and changing situations. OCED (2018) adds that preparing students for that requires providing them with a variety of skills; primarily, cognitive skills such as self-regulation, learning to learn, critical thinking, and creative thinking, besides social and emotional skills such as collaboration, empathy, and self-efficacy, as well as practical and physical skills such as using new information and communication technology devices.

In their learning framework, OECD (2018) suggests encapsulating the mobilization of information, skills, attitudes, and values through a process of reflection, anticipation, and action to create the linked competencies required to engage with the world. Where transformative competencies and other concepts are transformed into a set of particular components including critical thinking, creativity, collaboration, responsibility, and resilience.

OECD (2016) highlights that the advancements in information and communication technology (ICT) change the jobs' required skills. Therefore, digitization requires ICT skills in addition to complementary skills; such as literacy and numeracy skills, and socio-emotional skills to work collaboratively and flexibly. Thus, several types of skills are needed: technical and professional skills for ICT specialists, ICT generic skills for workers and citizens, and ICT complementary skills, such as leadership, communication, and teamwork skills. Thus, the future is increasingly digital with improved connectivity, disruptive digital business models, largely automated physical production, increasing virtual work, and global commerce. demand is digitized. All of these will change businesses and markets, the nature of work and skills needs, and how people participate in real or virtual communities and engage in personal relationships (OECD, 2023).

Digital skills concept

Lang and Triantoro (2022) reported from van Laar et al. (2020) that digital skills are dynamic and evolving skills necessary to use software or operate a digital device. ITU (2020) adds that digital skills encompass the knowledge and skills required for an individual to be able to use ICTs to accomplish

goals in his or her personal and professional life. In their review of the literature (Starkey, 2011; Assert et al., 2014; Balau & Utz, 2017; Barak, 2018; Jam et al., 2013). Mazurchenko et al. (2022) show that digital skills include digital information processing and communication, critical thinking, ability to work on shared documents online, and problem-solving skills needed to find solutions and transfer knowledge to new working conditions.

Meanwhile, AWS (2022) defines digital skills as the ability to effectively use digital devices, communication applications, and electronic information networks to perform work. Furthermore, Martin, et al. (2023) digitization refers to the process of converting existing non-digital practices into digital form, whereas digitalization is the use of digital technologies to provide innovative and improved services, products, processes, or practices.

Digital skills gaps

Mazurchenko et al. (2022) reported from (Oberländer et al., 2020; Lingga, 2020) that there is a gap between the existing and needed digital skills; which can be considered as a challenge of the digitalized workplace in the future. Where an insufficient level of the users' digital skills can cause the ineffective utilization of information systems processing the data. In addition, Siddiqui et al (2022) show that researchers (Fitriani and Ajayi, 2021; Sriyolja et al., 2021; Suprun et al., 2019; Tayeh et al., 2020) claim that in implementing digital technologies and related Industry 4.0 concepts, lack of skills, knowledge, expertise, and experience are the major barriers which in turn affect the individual's and firm's performance. Furthermore, O'Loughlin (2022) shows that the digital skills gap presents a barrier to achieving digital transformation; where, this barrier reduces the likelihood of achieving business transformation through the use of digital services. Whilst, in their review of the Broadband Commission for Sustainable Development (2017) Land and Triantoro (2022) show that governments, businesses, and educational institutions need to collaborate and make significant investments to address the digital skills crisis, which is a gap between necessary digital skills and available digital skills. Approximately 90% of jobs in developed economies require some level of digital skills, while one-third of the labor force has a limited ability to use digital skills productively.

Importance of digital skills

Borowiecki et al (2021) reported that OECD (2019) encourages the essentiality of digital skills use at work, and includes computer use skills and specialist ICT skills, such as those of programmers. In addition, Lang, and Triantoro (2022) show that the European Commission (2021) suggests that digital skills are required in all types of jobs, including those that are not directly associated with digitization, where digital skills are necessary to use software and enable people to use digital services, engage in online activities, consume information, and communicate online. Furthermore, Martin et al (2023) show that equipping professionals with skills enabling the exploitation of digital opportunities become increasingly important. Moreover, Consoli (2023) reported from (Castellacci, Consoli, and Santoalha, 2020; Rashid et al., 2023) that digital skills are required for researching, developing and designing, managing, producing, consulting, marketing, selling, integrating, installing and administrating, maintaining, supporting, and servicing ICT systems. Therefore, the digital skills endowment of the workforce is crucial to regional economic development. In addition, Lang and Triantoro (2022) show that digital skills are a prerequisite for the general public to be able to access government-related information, participate in online banking, obtain telehealth treatments, consume information, and communicate online.

Digital skills measurement

Desjardins et al (2013) show that Information-processing skills include reading documents, writing documents, Numeracy, ICT skills, and Problem-solving. ITU (2020) divides digital skills levels into three categories: basic, intermediate, and advanced. Where basic digital skills provide the foundation for using ICTs, intermediate skills enable people to use digital technology in meaningful and

beneficial ways, and advanced skills are required for ICT specialists. Bank (2021) formulated a framework with three levels of essential digital skills; mainly, the foundation skills, life essential digital skills, and work essential digital skills. All levels include communicating skills, handling information and content, transacting, problem-solving, and being safe and legal online. Meanwhile, AWS (2022) - Amazon Web Services- categorized digital skills into basic digital skills (e.g., email, word processing, social media posting), intermediate digital skills (e.g., drag-and-drop website design, troubleshooting applications, data analysis), and advanced digital skills (e.g., cloud architecture or maintenance, software or application development, artificial intelligence, and machine learning).

Mazurchenko et al (2022) show that skills connected to data processing are ranked among the most important digital skills needed in the financial sector. Advanced data skills (data management or advanced analytics) are required in 50% of the surveyed financial institutions. Also, 60% of the respondents see the importance of the general skills necessary for problem-solving in the digital environment. Fähndrich (2023) adds that management accountants need a basic understanding of data architecture, the organization's IT system landscape, data extraction, processing, and visualization.

Lang and Triantoro (2022) reported from the literature (Broadband Commission for Sustainable Development, 2017; Krcmar et al., 2017) that digital skills include basic functional digital skills necessary for social inclusion and participation in day-to-day life. In addition, specialized digital skills, such as mobile technologies, data analytics, cloud computing, and the Internet of Things. These specialized digital skills are a prerequisite for digital transformation and are necessary to create competitive business models and demonstrate profitability and sustainability.

Siddiqui et al (2022) represent the digital skills, categories, and relevant terminologies utilized in the literature (Kanval et al., 2024; Oesterreich & Teuteberg, 2016; Tayeh et al., 2020). Different categories include automation and robotics, coding and programming, communication, design, drafting and engineering, digital literacy, digitization and virtualization, modeling and simulation, and planning and estimation. Siddiq et al (2023) show that digital competence and skills keep evolving along with the changes and needs in society, including new competence areas such as artificial intelligence literacy, and algorithmic literacy. Bouchrika (2023) divided information systems professionals' skills into essential skills and general skills. Where, essential skills include computer science and programming, software development, and cybersecurity skills. General skills include problem-solving skills, interpersonal skills, and communication skills.

Europass (2023) reported the competence areas that will be tested, primarily information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. Where, information and data literacy include a set of skills needed to search, access, and navigate between different types of content, compare different sources of information and understand which ones are reliable, and the ability to store, manage, and organize folders and various types of files. Communication and collaboration include a set of skills needed to use digital technologies to interact, communicate, and collaborate with other people, being able to participate in society through the use of public and private digital services, and the ability to manage one's identity and reputation on the web. Digital content creation includes a set of skills needed to create and edit various types of digital content, including text and multimedia files, improve and integrate different kinds of information and content, and the ability to understand how copyright and licenses work and how to develop instructions for a computing system. Safety consists of skills needed to protect devices, content, personal data, and privacy, and understand the risks and threats of digital technologies and their environmental and social impacts. Problem-solving includes a set of skills to identify needs and technical problems, select appropriate technological responses to solve them, use digital tools to

innovate processes and products, and understand which digital competencies need to be improved and to keep up-to-date with the digital progress.

RESEARCH METHODOLOGY AND METHOD

Population and sample

The interest of the current study is to find out the digital skills' constructs and measures in prior researches. Therefore, the eligible prior studies are all studies with one or more of the predefined interests which include digital skills measures. As a result of searching a lot of databases, the used measures of the specialized bodies have been selected; mainly OECD, ITU, AWS, Bank, Europass, and other related studies.

Aggregation analysis method

A lot of digital skills' measures were developed. To review these measures, an aggregative review method will be used; Romi (2023) reported from Pare and Kitsiou (2017) that an aggregative review method is an approach for reviewing a large body of research evidence to aggregate, evaluate, and synthesize all empirical evidence that meets a specified criterion of interest.

RESULTS

The results of the aggregation review (Table 1) show the selected studies, and the extracted constructs of the digital skills measures.

Table 1: Digital skills' measures

Literature	Skills' Constructs	Items
Desjardins et al (2013)- OECD	Reading documents	Directions, instructions, letters, memos, e-mails, articles, books, manuals, bills, invoices, diagrams, maps.
	Writing documents	Letters, memos, e-mails, articles, reports, forms
	Numeracy	Use of fractions, decimals or percentages, use of calculators, preparing graphs or tables, algebra or formulas, use of advanced math or statistics
	ICT skills and Problem solving	Using e-mail, Internet, spreadsheets, word processors, programming languages; conducting transactions on line; participating in online discussions
	Problem solving	Facing complex problems
ITU (2020)	Basic skills	Provide the foundation for using ICTs
	Intermediate skills	Enable people to use digital technology in meaningful and beneficial ways
	Advanced skills	Required for ICT specialists.
Bank (2021)	Foundation skills	All levels include communicating skills, handling information and content, transacting, problem solving, and being safe and legal online.
	Life essential digital skills	
	Work essential digital skills	
AWS (2022) *Amazon Web Services*	Basic digital skills	Email, word processing, social media posting.
	Intermediate digital skills	Drag-and-drop website design, troubleshooting applications, data analysis.
	Advanced digital skills	Cloud architecture or maintenance, software or application development, artificial intelligence, and machine learning.

Mazurchenko et al (2022)	General digital skills	Basic understanding of data architecture, the organization's IT system landscape, data extraction, processing, and visualization.
	Digital problem-solving skills	General skills necessary for problem-solving in the digital environment.
	Advanced digital data skills	Advanced data skills (data management or advanced analytics)
Lang and Triantoro (2022)	Basic functional digital skills	Access to the Internet, understanding social and digital media, and accessing services online....
	Specialized digital skills	Mobile technologies, data analytics, cloud computing, and the Internet of Things ...
Siddiqui et al (2022)	Specialized digital skills	Automation and robotics, coding and programming, communication, design, drafting and engineering, digital literacy, digitization and virtualization, modelling and simulation, and planning and estimation.
Bouchrika (2023)	General skills	Problem-solving skills, interpersonal skills, and communication skills
	Essential skills	Computer science and programming, software development, and cybersecurity skills
Europass (2023)	Information and data literacy	- Search for, access and navigate between different types of digital content (files, websites, etc.). - Compare different sources of information and understand which ones are reliable. - The ability to store, manage, and organize folders and various types of files.
	Communication and collaboration	- Using digital technologies to interact, communicate and collaborate with other people. - Being able to participate in society through use of public and private digital services - The ability to manage one's identity and reputation on the web.
	Digital content creation	- Create and edit various types of digital content, including text and multimedia files - Improve and integrate different kinds of information and content together - Understand how copyright and licenses work.
	Safety	- Protect devices, content, personal data and privacy, - Understanding risks and threats of digital environments - Protect physical and psychological health - Aware of digital technologies for social well-being and inclusion - The awareness of the environmental impact of using digital technologies
	Problem solving	- Identify needs and technical problems and select appropriate technological responses to solve them - Using digital tools to innovate processes and products - Understanding which digital competences need to be improved and to keep up-to-date with the digital progress.

Table (2) shows the aggregation of digital skills depending on general criterion mainly; general digital skills, essential digital skills, work digital skills, and advanced/specialized digital skills. Where, general digital skills refer to digital skills which everyone can possess regardless of specialization

and work. Essential digital skills refer to the required for handling the day-to-day life tasks. Work digital skills refer to the required skills for handling the work tasks. Advanced/specialized digital skills refer to the digital skills required for computing/ information specialists.

Table (2): Aggregation analysis

Literature	General Digital Skills	Essential Digital Skills	Work Digital Skills	Advanced/ Specialized Digital Skills
Desjardins et al (2013)- OECD	√	√	√	
ITU (2020)	√	√	√	√
Bank (2021)	√	√	√	
AWS (2022)	√	√	√	√
Mazurchenko et al (2022)		√	√	√
Lang and Triantoro (2022)	√	√	√	√
Siddiqui et al (2022)				√
Bouchrika (2023)			√	√
Europass (2023)	√	√	√	√

CONCLUSION AND RECOMMENDATIONS

It's highlighted that the digital technologies impact societies and economies, where the automation of tasks, new products and services, new business models, new economic drivers, and so forth. Prior researches (Siddiqui et al., 2022; Mazurchenko et al.,2022; Oberländer et al., 2020; Lingga, 2020) emphasized the fact that there is a gap between the existing and needed digital skills to respond to the challenges of the digitalized workplace in the future.

In an attempt to find out the digital skills measurement tool, an aggregation analysis was conducted to prior researches. The main findings show that digital skills can be divided into four main categories (levels); each of which can be measured by set of tasks - items (Appendix 1). These categories (levels) include general digital skills, essential digital skills, work digital skills, and advanced/specialized digital skills.

It's recommended that testing the digital skills requires the participant to go through the measurement tool level by level (adapted from Bank, 2021) as follow:

▪ *Level 1* - the general digital skills: the participant has to pass level one (general digital skills) by providing a satisfying answer to all tasks (items).

▪ *Level 2* - the essential digital skills: the participant has to pass level 1, then provide a satisfying answer to at least one task (item) in each of the five essential skills areas.

▪ *Level 3* - the work digital skills: the participant has to pass level 2, then provide a satisfying answer to at least one task (item) in each of the five work skills areas.

- *Level 4* - the advanced/specialized digital skills: the participant has to pass level 2, then provide a satisfying answer to at least one task (item) in the advanced/specialized digital skills depending on the required specialization area.

Applying this digital skills measurement tool can help both academics, and organization in determining the digital skills gap, and formulate curriculums, and training courses to bridge the digital skills gap that may occur.

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APPENDIX 1: A PROPOSED MEASUREMENT TOOL

General digital skills

Refer to digital skills which everyone can possess regardless of specialization and work. The main items than can be used to measure this type of skills are:

1. Use the available controls on a device (e.g. mouse, keyboard, touchscreen etc.)
2. Open an Internet browser to find and use websites
3. Turn on a device and log in to any accounts/profiles I have
4. Update and change my password when prompted to do so
5. Find and open different applications/ programs on a device
6. Connect a device to a Wi-Fi network
7. Use the different menu settings on a device to make it easier to use (e.g. change the font size to make it easier to read)

Essential digital skills

The required digital skills for handling the day-to-day life tasks. The main items than can be used to measure this type of skills are:

Communicating

1. I can communicate with others digitally using email or other messaging applications (e.g. WhatsApp or Messenger)
2. I can share documents with others by attaching them to an email
3. I can set up an email account
4. I can communicate with others using video tools (e.g. FaceTime or Skype)
5. I can use word processing applications to create documents (e.g. a CV or a letter)
6. I can post content on social media platforms (e.g. Facebook, Instagram or Snapchat) for example messages, photographs, video etc.

Transacting

7. I can set up an account online that enables me to buy goods or services (e.g. Amazon account, eBay, John Lewis etc.)
8. I can use credit/debit cards or other forms of online payment to buy goods/services online (e.g. PayPal, WorldPay)
9. I can access and use public services online, including filling in forms (e.g. vehicle tax, voting registration, ordering repeat prescriptions, booking doctor appointments)
10. I can upload documents and photographs when this is required to complete an online transaction

11. I can manage my money and transactions online securely, via websites or Apps (e.g. bank account)

Problem solving
12. I can use the Internet to find information that helps me solve problems
13. I can use online tutorials, web chat, FAQs and forums to solve problems
14. I can use online tutorials, web chat, FAQs and forums to improve my skills in using the Internet and digital apps/products/services

Information and data processing
15. I can use search engines to find the information I'm looking for (e.g. search for news using a browser such as Chrome, Internet Explorer or Safari)
16. I can recognise what information or content may, or may not, be trustworthy on websites/apps
17. I can organise my information and content using files and folders (either on my device, across multiple devices, or on the Cloud)
18. I can use the Internet to stream or download entertainment content (e.g. films, music, games or books)
19. I can use bookmarks to save and retrieve websites and information
20. I can store information online and access content from a different device (e.g. using the Cloud)

Being safe and legal online
21. I can respond to requests for authentication (e.g. reactivate an account when I've forgotten my password)
22. I can recognise and avoid suspicious links in email, websites, social media messages and pop-ups and know that clicking on these links is a risk
23. I am careful with what I share online as I know that online activity produces a permanent record that can be accessed by others
24. I can keep the information I use to access my online accounts secure, by using different and secure passwords for websites and accounts
25. I make sure not to share or use other people's data or intellectual property without their consent
26. I can assess the risks and threats involved in carrying out activities online and act accordingly
27. I can identify secure websites by looking for the padlock and 'https' in the address bar
28. I can set privacy settings on my social media and other accounts
29. I can update my computer security systems when necessary to prevent viruses and other risks

Work digital skills

Refer to the required skills for handling the work tasks. The main items than can be used to measure this type of skills are:

Communicating
1. I can use digital collaboration tools to meet with, share and collaborate with people (e.g. Skype/Google docs/Dropbox etc.)
2. I can set up and manage an account on a professional online network/community, (e.g. LinkedIn, Total Jobs, Indeed)

Transacting
3. I can access salary and expenses information digitally, including password-protected payslips
4. I can manage digital records and financial accounts (e.g. expenses, budgets) through digital systems

Problem solving
5. I can use the Internet to find information that helps me solve problems
6. I can use different digital tools to improve my own productivity i.e. saving time or working more efficiently

7. I can use appropriate software, including a spreadsheet, to manipulate and analyse data

Information and data processing

8. I can access, synchronize and share information across different devices (e.g. manage a calendar or appointment system via phone or desktop)
9. Developing digital content
10. Integrating and re-elaborating digital content

Being safe and legal online

11. I make sure not to share or use other people's data or intellectual property without their consent
12. I can recognize and avoid suspicious links in email, websites, social media messages and pop-ups and know that clicking on these links is a risk
13. I can keep the information I use to access my online accounts secure, by using different and secure passwords for websites and accounts
14. I can respond to requests for authentication (e.g. reactivate an account when I've forgotten my password)
15. I can identify secure websites by looking for the padlock and 'https' in the address bar
16. I am careful with what I share online as I know that online activity produces a permanent record that can be accessed by others
17. I can assess the risks and threats involved in carrying out activities online and act accordingly (e.g. use security software)
18. I can update my computer security systems when necessary to prevent viruses and other risks
19. I can set privacy settings on my social media and other accounts

Advanced/specialized digital skills

Refer to the digital skills possessed by ICT specialists. The main items than can be used to measure this type of skills are:

1. Application Development
2. Web Development
3. Graphic and Visual Design
4. Database management and Programming
5. Data Analytics
6. Enterprise Resource Planning (ERP)
7. Network Configuration, General Networking
8. Cybersecurity
9. Operating Systems
10. Software Quality Assurance
11. Artificial intelligence
12. Augmented Reality/Virtual Reality (AR/VR)
13. Cloud-based tools (e.g., file-sharing services, messaging applications like Slack, cloud-based CRM tools)
14. Internet of Things (IoT)
15. Machine Learning (ML)
16. Blockchain
17. Big Data