

# Digital Literacy for Workforce Readiness: Bridging the Skills Gap in the 21st Century

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**Abstract:** Digital literacy is widely considered a prerequisite for 21st century workforce readiness due to the Fourth Industrial Revolution. Nevertheless, a significant digital skills gap remains between employer expectations and the digital skills of the workforce, which decreases the economy of the future and undermines social equity. This literature review systematically examines the dimensions of this gap, and synthesizes the literature to define modern-day digital literacies, including cognitive, technical, and ethical skills, such as data analytics, digital teamwork, and problem-solving. This review examines the evidence of significantly high employer demand for these and other important soft skills and discusses the implications of this digital talent shortage on the viability of the business. The main findings of this review illustrate how the skills gap is fuelled by a multi-instrumented digital divide, unresponsive educational systems, and personal barriers. The analysis of interventions demonstrated that the succession of training was not the answer. Instead, the deep integration of digital skill strands across the curriculum, comprehensive private corporate adult learning, and strong private-public partnerships offer solutions to the digital skills gap. Closing the digital skills gap from a systemic perspective requires a coordinated multi-stakeholder approach to build an increasingly adaptable and equitable 21st century workforce for the future. Concrete actions are provided to start a dialogue between educators, employers, and governing bodies about how the 21st century workforce could be better prepared for the future of work.

**Keywords:** Digital Literacy, Workforce Readiness, 21st-Century Skills, Digital Skills Gap, Fourth Industrial Revolution, Lifelong Learning, Public-Private Partnerships, Artificial Intelligence

## 1 Introduction

The Fourth Industrial Revolution (4IR) is creating a significant shift in the global economy and is defined by the convergence of technologies that blur the lines of the physical, digital, and biological worlds due to artificial intelligence (AI), the Internet of Things (IoT), robotics, and data analytics (Li, Hou, & Wu, 2017; Nautwima et al., 2022; Schwab 2017). Whereas earlier industrial revolutions brought about change, 4IR is distinguished by the speed, range, and systems-level impact of simultaneous technological disruptions (Lasi et al., 2014; Li et al., 2017). This paradigm shift has irrevocably transformed industries and business models, as well as the nature of work. For this reason, the competencies and skillsets that made up the workforce in the 20th century are rapidly becoming irrelevant. The modern economy will not reward routine manual or cognitive work, as it can be done through automation (Autor 2015; Goos, Manning, & Salomons, 2014). Rather, the value has shifted toward a group of higher-order cognitive, social, and technological skills, referred to as "21st century skills" (van Laar et al 2020). At the forefront of these skills is digital literacy, which has transitioned from a specialized need for IT professionals to an essential, fluid skill needed for meaningful participation and success in almost all areas of the global workforce (Johnson, 2024; Ng, 2012; Smith & Jones, 2024; van Laar et al., 2017). Therefore, workforce readiness in the 21st century

includes readiness to identify when to use digital tools and the ability to use them efficiently, critically, and ethically to access, manage, evaluate, create, and communicate information (Eshet, 2012).

Despite the obvious need for this set of competencies, an extended and growing skills gap still exists between the digital skills employers need to innovate and be competitive and the skills of the available labor force. This is referred to as the 'digital skills gap.' The skills gap is not just a lack of high-level programmers/developers or data scientists; it is a generalized shortage of the more broadly defined digital skills necessary for operational efficiency at work and for creativity, problem solving, and collaboration using technology in a digitized environment (Anjali et al., 2022; Bejaković & Mrnjavac, 2020; Brown & Davis, 2023). The impact of this widespread skills gap is both economic and social. Economically, it represents a major roadblock to productivity and growth (Johnson, 2024). Organizations find it difficult to fill crucial positions that prevent them from using new technologies, streamlining processes, or remaining competitive internationally, with evidence linking higher returns to higher skills using ICT (Falck, Heimisch, & Wiederhold, 2021).

For countries, a significant skill gap can lead to a stagnant economy (Hanushek et al., 2007). Socially, the skill gap contributes to social inequity. It creates a two-tiered labor market, whereby a portion of the population with scarce digital skills receives high wages and job security, while another portion of the workforce remains stuck in insecure low-wage positions or faces the threat of losing their jobs owing to technology (Acemoglu & Restrepo, 2019; Autor, 2015; Scheerder, van Deursen, & van Dijk, 2017). This digital divide has implications for social mobility and cohesion, resulting in a growing class of digitally disenfranchised citizens who are unable to participate in a more digitally driven society and economy. The digital skill gap represents a complex systemic challenge that cannot be resolved through isolated interventions. Bridging this gap requires a cohesive, multi-stakeholder strategy involving educational reform, targeted corporate training, and strategic public-private partnerships to prepare the workforce for the 21st century economy.

This literature review systematically explored the key facets of the digital skills gap and its responses. After specifying a clear methodology for source selection and analysis, this review first synthesizes the literature to develop an informed and updated definition of digital literacy and its key competencies for workforce readiness. The review then examines the particular digital skills required by employers in various industries using large industry and economic reports. This review examines the key systemic, institutional, and individual barriers to acquiring these critical skills. Subsequently, the review critically analyzes the overarching principles and types of interventions employed by education systems, businesses, and governments to address the gap in digital skills. Finally, the literature review identifies research opportunities beyond the existing literature and makes recommendations in the conclusion, summarizing the review's findings for key stakeholders.

## **2. Methodology**

This literature review employed systematic methods to identify, select, and synthesize the research literature to develop a thorough and balanced review. Our methodologies are based on a set of items for systematic reviews (PRISMA statement; Preferred Reporting Items for Systematic Reviews and Meta-Analyses) that aim to improve transparency and replicability (Page et al., 2021).

### **2.1. Search Strategy**

A thorough search was conducted using two primary academic databases: Scopus and Google Scholar. Scopus was chosen because of the substantial scope of peer-reviewed high-quality literature across a wide range of disciplines and its ability to conduct searches with powerful

search capabilities. Google Scholar was used as an additional source to engage a wider net (i.e., academic materials, conference proceedings, and institutional reports) that may not be captured in Scopus. The search was based on key constructs developed using Boolean operators (i.e., AND, OR, NOT) to limit the search results. These constructs serve as syntactic backbones for complex searches. The ability to combine keywords in a specific manner allows users to restrict search results (Jha, Sondhi, & Vasudevan, (2022). An example of a primary search string is as follows: ("digital literacy" OR "digital competence") AND ("workforce readiness" OR "skills gap" OR "21st century skills") AND (education OR employment OR training OR upskilling OR reskilling). Variant terminology applied in the search allowed the net to be as wide as possible, as well as forward and backward citation searching used on primary articles to connect to additional study literature.

## **2.2. Inclusion and Exclusion Criteria**

To ensure the quality and currency of the literature reviewed, rigorous criteria were instituted. The inclusion criteria focused on sources that met the following criteria: (1) peer-reviewed journal articles, (2) articles published from 2010 to the present to remain contemporaneous with current issues related to the digital economy, (3) articles published in English, and (4) articles engaged in the intersection of digital skills education and workforce needs. Significant reports produced by trustworthy global organizations (e.g., the World Economic Forum and OECD) were included for industry and policy contexts. The exclusion criteria were as follows: (1) opinion pieces, editorials, or non-academic articles; (2) published before 2010; (3) only addressed digital literacy in non-workforce avenues (e.g., K-8 educational use, with no relatedness to future work); or (4) technical reports and papers that did not discuss skills, training, or policy.

## **2.3 Synthesis and Analysis Approach**

Thematic analysis was used to integrate the findings from the selected literature (Braun & Clarke, 2012). The thematic analysis involved several stages. First, the selected articles were read in full to develop familiarity with the collected data. The second stage involved generating initial codes by highlighting the concepts, findings, and claims relevant to the research questions. These codes were collected and grouped into possible themes (e.g., "definitions of digital literacy," "employer needs," "educational barriers," "policy initiatives" policy initiatives). In the third stage, these themes were reviewed, revised, and incorporated into the main sections and subsections of the literature. This process enables a cohesive narrative synthesis of literature that identifies both well-accepted areas of agreement and primary areas of controversy, contradictions, and voids (Snyder, 2019).

# **3. Defining Digital Literacy in the Context of Workforce Readiness**

## **3.1. Evolution of the Concept**

Since its first recognition, the concept of "digital literacy" has changed significantly. Originally, digital literacy was synonymous with "ICT literacy," or computer skills – the procedural knowledge to use both hardware and software (Lankshear & Knobel, 2008). When many digital technologies became more ubiquitous and interactive, descriptions became insufficient. Landmark publications by authors like Paul Gilster (1997) extended the definition to be much broader, defining digital literacy as "the ability to understand and use information in multiple formats from wide range of sources when it presented via computers." This was a shift from technical to cognitive skills. Current definitions view digital literacy as a complex construct representing a variety of competencies required for both professional development and continuous learning (Spurava, & Kotilainen, 2023). Digital literacy is now seen largely as a collection of skills - cognitive, social, and technical - that allow people to perform in high-density

digital environments (Eshet, 2012; Tinmaz et al., 2022). The current perspective sees digital literacy as an important avenue for professional development and a precondition for employability and innovative work behavior (Caroline, et al., (2025); Johnson, 2024).

### **3.2. Core Competency Frameworks**

To operationalize the broad concept of digital literacy into a conceptualization appropriate for educational and policy implementation, several organizations have created competency frameworks (Falloon, 2020). Competency frameworks help organize curricula, training initiatives, and competencies systematically and uniformly (Asa et al., 2022). The European Union's Digital Competence Framework for Citizens (DigComp 2.1) is one of the most prolific frameworks in this area, delineating five associated competence areas: information and data literacy, communication and collaboration, digital content creation, Safety, and Problem-solving (Carretero, Vuorikari, & Punie, 2017). The ISTE Teaching and Student Standards (International Society for Technology in Education) are similar; under the ISTE standards, students adopt the roles of Empowered Learners, Digital Citizens, Knowledge Constructors, and others. A review of these and other frameworks provides a reasonable corroboration of the fundamental dimensions of digital literacy that citizens need to be productive in the current workforce of the present time. These domains are illustrated in Figure 1, and can be synthesized as follows:

#### **3.2.1. Information and Data Literacy**

This foundational competency is more than just finding information; it also involves critical appraisal and synthesis. In times of information overload and misinformation, employees must identify credible source information and not-cited-dose information, note their bias, and the context of the manner in which the data are presented (Covello, 2006; Dey, 2022; Metzger, 2007). In the workplace, this makes it possible to conduct good market research, analyse competing data, and use those data ethically to guide strategic decisions. It also entails a certain level of "data-driven thinking," where employees can comprehend the meaning metrics of measures and use those data to respond to business inquiries (Mandinach & Gummer, 2016). This is important because workers are required to manage complex data effectively (Hatlevik & Christophersen, 2023).

#### **3.2.2 Communication and Collaboration**

Currently, the workplace is becoming increasingly collaborative, with digital technologies serving as the foundation for team communication. This competency area goes beyond knowing how to use certain technologies (e.g., Slack, Microsoft Teams, and Asana) to developing increasingly sophisticated abilities in digital communication. This incorporates knowing how to best communicate in different digital channels (e.g., formal email versus informal chat), maintaining a professional digital presence on sites like LinkedIn, and engaging successfully in video meetings (Heine, Krepf & König, 2023; Lee & Meng, 2021). This includes collaborating on documents, accessing shared files, and being a productive member of distributed or remote teams, which have become essential in post-pandemic work settings (García-Peñalvo, 2021; Wang et al., 2021).

#### **3.2.3. Digital Content Creation**

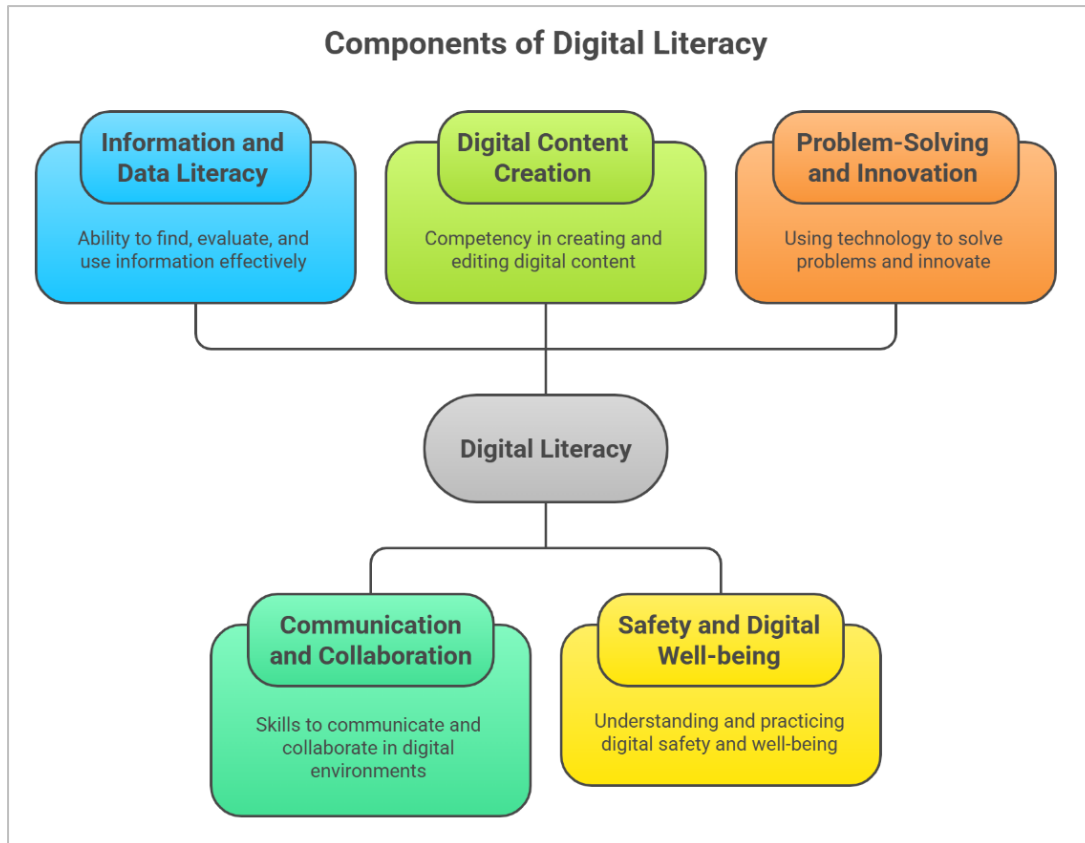
Even if not every employee is a graphic designer, the ability to create and edit clear, professional, and fit-for-purpose digital content is an almost universal requirement (Redecker, 2017). This can take many forms, from designing an effective presentation slide deck and creating attractive reports to producing short instructional videos or writing clear and concise copies for a corporate blog or social media channel (Scott, 2015). This competency also requires basic knowledge of intellectual property, requiring employees to properly attribute sources, that is, follow copyright law and use Creative Commons licenses when borrowing existing content into a new product (Revuelta-Domínguez et al., 2022).

#### **3.2.4. Safety and Digital Well-being**

As workplaces undergo increased digitalization, the risk of data breaches and cyberattacks increases dramatically (Kshetri, 2021). This competency domain is vital for organizational security and centers on employees' knowledge and compliance with best cybersecurity practices. This includes developing strong passwords, recognizing phishing attempts, using secure networks, and appropriately storing and utilizing private company and client data (Lee, & Chua, 2024). Evidence shows that effective cybersecurity awareness training is one of the most powerful organizational strategies for reducing these risks (Zhang-Kennedy, & Chiasson, 2021). This domain not only has consequences for security but also has implications for digital well-being and the capacity to manage one's digital life in a healthy and sustainable manner. This includes skills related to managing technostress, which can lead to lower job satisfaction and greater commitment to the organization (Ragu-Nathan et al., 2008; Tarafdar et al., 2007). Aspects of this competency domain include being able to maintain a healthy work-life balance in an "always on" culture and having a basic understanding of workstation ergonomic principles. Research indicates that personal resources, such as self-efficacy, are important for alleviating the negative impact of technostress on well-being (Mondo et al., 2023).

#### **3.2.5. Problem-Solving and Innovation**

Problem-solving and innovation can be considered the highest-order areas of digital competence, as they involve using technology not just to execute tasks but to solve a novel problem and create new value. It encapsulates the individual's capacity to select the most appropriate digital tool for addressing a given problem, deal with any technical problems, and learn to adapt quickly to new software and systems (Ibrahim, & Aldawsari, 2023). Related to this competence is a "growth mindset" and dedication to lifelong learning, since technology is constantly changing (Dweck, 2006). In the workplace, employees with good digital problem-solving skills have the capacity to improve efficiency in work processes, recognize the potential for automation, and help with digital entrepreneurship and innovation; thus, they are a valuable asset to any organization (Annunziata, 2020; Nambisan, 2017; Shanker, 2017).



**Figure 1:** Components of Digital Literacy  
**Source:** Authors' work (2025)

## 4. Employer Perspectives and Industry Demands

### 4.1 Identifying the Most In-Demand Digital Skills

Several industry reports and academic studies have identified an increasing demand for a combination of basic and advanced digital skills (Bejaković & Mrnjavac, 2020; van Laar et al., 2017). In large-scale studies, the World Economic Forum's "Future of Jobs Report" consistently identifies data analysis, AI and machine learning, and digital marketing as the most desired skills by employers (World Economic Forum, 2023). Beyond these advanced skills, there is a general demand for skills in collaboration tools, cloud computing environments, and data visualization tools. This demand for digital skills is industry-specific in healthcare, where skills in Electronic Health Records (EHR) and telemedicine are prioritized, while advanced manufacturing seeks skills in IoT and robotics (Brynjolfsson & McAfee, 2014). Variations in the required content areas for digital skills make it a challenge to justify a universal approach to digital literacy training programs as a digital literacy curriculum, which raises the need for instrument validity in measuring these specific loads (van Laar et al., 2020).

### 4.2 The Intersection of Digital and "Soft" Skills

Employers are increasingly recognizing that being technically skilled is not sufficient to be successful in today's workplace (Cinque, 2016; Lombardi, 2019). The best employees have the ability to integrate their digital abilities with a solid foundation of 'soft' or 'transversal' skills. The interdependent nature of these skill sets is apparent in this research. For example, it is impossible to digitally collaborate effectively without good communication, empathy, and teamwork (soft skills) (Obermayer et al, 2023). In a technology-mediated situation, emotional intelligence is essential for interpreting digital signals and sustaining group dynamics (Ritter & D'Auria, 2023). Similarly, digital problem-solving requires technical abilities, creativity, critical thinking, and a degree of agility to generate and implement a novel solution (Arya & Nardon,

2014). Employers actively seek candidates with hybrid skills. Surveys of employers' members (hiring managers) consistently show a preference for soft skills, such as critical thinking, communication, and agility, over technical abilities (Casner-Lotto & Barrington, 2006; Cinque, 2016). This is simply because specific software or platforms will become obsolete; however, lists as base transversal skills allow employees to navigate software/platforms to learn and adapt, which makes the employee resilient and future-ready for the organization.

### **4.3 Consequences of the Skills Gap for Businesses**

The digital skills gap is not just an economic issue but also has real-world negative implications for businesses of any size and in any industry (Falck, Heimisch, & Wiederhold, 2021; OECD, 2019). Recruitment had the most immediate negative impact. Evidence suggests that businesses struggle to find and acquire talent with appropriate digital skills. As a result, they incur considerable time and financial costs, with many critical positions remaining vacant for extended periods. This talent gap has a direct effect on hindering innovation, as businesses do not have the capacity to generate new digital products, services, or business models (Goos, Konings, & Rademakers, 2016). Additionally, the existing labor force's lack of digital competence holds back the adoption and use of new technologies, and in many cases, technology investments do not yield the returns expected, since firms do not become more productive - the so-called modern "productivity paradox" (Attewell, 1994; Bresnahan, Brynjolfsson, & Hitt, 2002; Nautwima et al., 2025). Skill shortages ultimately erode a firm's competitive position. Companies that are slow to digitize because of skill shortages will begin losing revenue to digitally mature competitors, which ultimately affects a company's bottom line and sustainability in the marketplace (Vial, 2019).

## **5. Challenges and Barriers to Acquiring Digital Literacy**

### **5.1 The Persistent Digital Divide**

From a research perspective, the "digital divide" is a cornerstone concept for understanding inequitable access to technology and skills. This digital divide is not a divide but a tier of divides (Hargittai, 2002; van Dijk, 2020;). The first divide, the access divide, comprises of friends and barriers to physical access to technology. Even with the presence of a wide array of digital devices, access barriers are still present based on the ability or affordability of stable Internet services and devices, especially in rural communities and low-income households (Robinson et al., 2015). The next tier, the skills divide, is arguably important when considering workforce readiness. The skills divide captures the divide between individuals' abilities to effectively and thoughtfully utilize the technology they access (Hargittai, 2002). Socioeconomic status plays a major role in this divide; higher-income individuals with higher levels of parental education typically have more engagement with developing the skills to use this different type of technology (Scheerder, van Deursen, & van Dijk, 2017). The final tier of the divide is personal demographics, which create barriers based on the generational divide. For example, younger or "digital natives" probably exhibit very high student literacy with social media but lack the critical information literacy skill sets that they need to utilize in the workforce (Kirschner & De Bruyckere, 2017). Older experienced workers have extensive field experience but often struggle with survival in digital workflows because they are often new compared to their younger peers who grew up with digital workflows (Köttel, Cohn-Schwartz, & Ayalon, 2021).

### **5.2 Shortcomings in Formal Education Systems**

K-12 and higher education systems are often slow to adapt to rapid changes in digital requirements in the workplace (Christensen, Johnson, & Horn, 2010; Voogt & Roblin, 2012). Content area curricula tend to remain siloed, and digital skills are treated as a separate "computer class" instead of being integrated into every content area, which is important for developing contextualized understanding (Voogt et al., 2013). Graduates are produced, and the

barrier is that they may have theoretical knowledge but do not have the applied, practical digital skills sought by employers. A significant influence in this area is the lack of system-wide professional development for educators. Teachers report a lack of research on how to teach digital competencies and professional development, as well as resources and support systems that are not up to date (Tondeur et al., 2012). The education system cannot prepare the next generation of the workforce without equipping educators with necessary skills and confidence.

### **5.3 Individual and Psychological Barriers**

Despite offering training opportunities, psychological and other barriers can inhibit skill acquisition. For instance, technophobia or computer anxiety, although not as pronounced today, can still be obstacles to training (Brosnan, 2002). The most common problem was low self-efficacy. When a person does not believe in their ability to learn a new digital skill, they are likely to be doing what Compeau and Higgins (1995) conceptualized as a self-fulfilling prophecy of failure. Another motivating aspect is that adult learners, particularly those in the incumbent workforce, encounter challenges of time and financial limitations in pursuing training. When a person has a work-life training balance, it can be overwhelming when work requires so much time, family obligations, and planning time to pursue training. This potential overload is likely to lead to low completion rates or attrition levels, even for well-intended and designed programs (Gruenewald, H., & Mueller, M. (2025)). Therefore, exploring these psychological and logistical barriers is critical from a design perspective and should be given equal airtime as thinking about the design of technical content training.

## **6. Strategies and Interventions for Bridging the Gap**

### **6.1. The Role of Educational Institutions**

Educational settings are pivotal in establishing the primary pipeline of a digitally literate workforce. The most effective approaches extend beyond mere computer labs and fully engage with a cohesive, across-the-board approach to computing literacy across the curriculum (Saleh, 2019). This approach ensures that students learn to employ digital skills in applied, discipline-specific settings; for example, students using data analysis software for a science class or a collaborative digital platform for a history project. The emergence of interdisciplinary experiences, such as computational social science or digital humanities, highlights this trend, whereby technical and applied domain skills converge with disciplinary knowledge (Georgopoulou et al., 2025). Finally, there is a strong consensus in the literature regarding the high impact of work-integrated learning. Models of internships, cooperative programs, and apprenticeships are sustained and impactful because they provide students with valuable practical experience to extend their theoretical and academic knowledge to apply to business challenges and provide opportunities to learn skills in response to employer needs (Jackson, 2015).

### **6.2. Vocational and Alternative Training Models**

Awareness that the traditional four-year degree is not the only pathway to a meaningful career has led to the development of a diverse ecosystem of alternative training models in the United States. For example, vocational training programs and coding bootcamps emphasize intensive, short-term, and targeted training to master specific and relevant technical proficiencies, such as data analytics or web development. Hence, research suggests that these options can benefit employment outcomes, particularly for career changers (Gerdeman, 2022). At the same time, the vast number of massive open online courses (MOOCs) offered through platforms such as Coursera and edX, which provide open access to high-quality educational content offered by leading universities and organizations (Kaplan & Haenlein, 2016), provides another alternative and pathway for engagement in the learning process. Micro-credentials and digital badges have emerged to authenticate and demonstrate the skill practices learned from these alternative strategies. These verified credentials provide employers with the opportunity to identify and demonstrate competencies in a flexible and specific manner. Consequently, a more fluid,

individualized, and structured system for providing recognition of skills outside the formal degree process has emerged in recent years (Ifenthaler, Bellin, & Mah, 2016).

### **6.3. Corporate and Lifelong Learning Initiatives**

The rapid pace of technological change demands lifelong learning, and companies are increasingly taking the initiative in employees' ongoing development. Upskilling and reskilling practices are regarded as strategic imperatives for companies that want to retain talent and navigate digital transformation. These range from subscriptions to online library-learning materials to creating custom in-house training academies (Li, 2022). The most critical aspect of success in such programs is fostering a "learning culture" (Senge, 2006). This relies not just on courses but also on leader board support, committed learning time, and management practices, making it a priority to institutionalize learning by rewarding experimentation, sharing, and knowledge (Senge, 2006). When employees feel well supported and able to engage in continuous skill development, the entire organization shifts, becoming agile, innovative, and more adaptable to change.

### **6.4. The Importance of Public-Private Partnerships (PPPs)**

The sprawling scale and complexity of the digital skills gap means that no sector can address it alone, making public-private partnerships (PPPs) an imperative approach. PPPs leverage the unique benefits of each stakeholder: education providers must lend pedagogical knowledge; industries should provide insight and opportunities for authentic experiential education; and governments should provide financial support, policy structure, and scale (Languille, 2017). Preferred examples, such as dual vocational education training in Germany and Pathways in Technology Early College High School (P-TECH) in the United States, highlight the value of deep collaboration. In dual vocational education, this pathway was characterized as co-designing the curriculum with educators and industries for relevance, weaving learning between the classroom and the workplace (Boudard, 2021; Schwartz, 2017). PPPs are vital for ensuring sustainable and large-scale talent pipelines that directly address the changing demands of the digital economy.

### **6.5 Implications and Recommendations**

This study provides several implications and recommendations for various stakeholders, as elaborated below. As for educators, all stakeholders in educational systems and organizations need to be proactive in including digital literacy and citizenship in the curriculum and then using project-based experiential learning. Schools need to do this through robust investment in professional learning so that educators can feel confident and competent in teaching these skills. Creating connections with industry is essential for keeping the curriculum up-to-date and providing additional curriculum to build on job market needs.

For employers, businesses need to emphasize that their workforce training is a capital investment rather than an ongoing expense. Setting up a continuous education/learning environment for workforce training that is aligned with continuous improvement hours of work and dedicated resources to reskilling individuals. Employers need to work with education to co-develop training and apprenticeships to build a sustainable talent development pipeline.

Lastly, for policymakers, it is critical that government digital skills strategy development is championed by the government. This would mean developing access to digital skills through funding digital infrastructure and bridging the gap, promoting public-private partnerships through monetary support and/or incentives or grants, or building a regulatory framework that would enable innovative credentialling and flexibility to earn badges and credentials outside of their degree.

## **7. Gaps in the Literature and Future Directions**

The integration of Artificial Intelligence (AI) and automation is rapidly becoming commonplace in workplaces, indicating a need to rethink the definition of digital literacy. The body of literature is solidified on foundational skills, but there is scant research on the ability to work effectively with intelligent systems. Further research needs to shift from digital skills as a tool use to digital literacy as teamwork with AI. There are abilities that are endemic to working with intelligent machines, such as prompt engineering, AI ethics, and skills to understand and critique AI-generated responses (Brynjolfsson & McAfee, 2017). How training programs can frame teaching workers not merely to use AI machines but also to enhance their own capabilities by using those machines remains an important and under-researched area.

The literature emphasizes the technical and cognitive aspects of digital literacy, while ethical dimensions are under-researched. Further research is required to examine effective pedagogies for teaching digital citizenship, data privacy, and societal technology issues. As workplaces become data-driven, all employees must be able to use data appropriately and be aware of the potential for algorithmic bias that perpetuates and amplifies inequality in society (O'Neil, 2016; Zuboff, 2019). Further research is needed to discern how to best weave complex ethical issues into a workforce training program to benefit the generation of responsible professionals.

There is a significant gap between assessing digital skills and meeting their demands. Many assessments in place today still rely on self-reports over multiple-choice assessments, which do not indicate how a person will utilize and apply it in real-world situations. The literature calls for more research to develop and validate assessments based on authentic, performance-based measures (e.g., project tasks, portfolio assessments, and simulations) that can cognitively reflect digital competence. (Shute, 2008; Audrin, Audrin, & Salamin, 2024). In addition, the advent of more micro-credentials will drive the need for research to determine their impact and how employers perceive and value non-traditional credentialing solutions.

The digital skills gap is an area of research that puts everyone, such as students, employers, employees, neighbors, and fellow citizens, on the same page and should take on a renewed sense of urgency. There are several areas for continued more in-depth research: the need for industry-specific research that departs from the generalized understanding of both the tech and business sectors to better understand the required sector-specific digital literacy skills for the agriculture industry (agri-tech), creative arts, and skilled trades; most research on the digital divide involves using general comparisons based on demographic categories; a more granular approach to studying possible solutions to the specific characteristics and needs of underrepresented or marginalized groups, including work with disabilities or neurodiversity, vocational experiences in non-digital industries, and workforce dislocation and solutions; and there is little in terms of longitudinal studies that are charting the careers and employment of students and skills learners involved in varying digital upskilling (e.g., bootcamps vs. community college certificates) to see what skilling interventions make a difference. This is critical information to provide evidence of which skilling interventions are effective and cost- and time-efficient in work, school, and life.

The Materials and Methods should be described with sufficient details to allow others to replicate and build on the published results. Please note that the publication of your manuscript implicates that you must make all materials, data, computer code, and protocols associated with the publication available to readers. Please disclose at the submission stage any restrictions on the availability of materials or information. New methods and protocols should be described in detail while well-established methods can be briefly described and appropriately cited.

## 8. Conclusion

In conclusion, this review confirms that digital literacy has transformed from a basic technical skill to a complex, multifaceted competency critical for workforce readiness in the 21st century. The review also indicates that there remains a chronic and significant “digital skills gap” that is driven by an incessant pace of technological change and is increased by systematic barriers such as a continuing digital divide, fossilized educational systems, and psychological barriers for individuals. The literature suggests that while there is no one fix, smart practices include integration, collaboration, and commitment to lifelong learning, such as embedding digital skills in the formal curriculum, flexible alternative training programs, and organizational investment in ongoing employee training and development. The literature supports the argument that the digital skills gap cannot be addressed through discrete or siloed interventions. A meaningful approach calls for a system-wide, multi-stakeholder response to seek alignment among educational institutions, private industry, and government policymakers to develop an adaptive and resilient talent development system. Closing the digital skill gap is one of the most significant challenges facing us. It is not only an economic issue but also a social equity issue. Ensuring that every citizen has the opportunity to develop the digital skills required to succeed in a fast-changing world is paramount for creating a more equitable, competitive, and resilient society in the 21st century and beyond.

## References

- Acemoglu, D., & Restrepo, P. (2019). Automation and new tasks: How technology displaces and reinstates labor. *Journal of Economic Perspectives*, 33(2), 3–30. <https://doi.org/10.1257/jep.33.2.3>
- Anjali, S., Sumi, J., Dinesh K. S., Abheesh S., (2022). Future of work: a systematic literature review and evolution of themes. *Foresight 14 February 2022*; 24 (1): 99–125. <https://doi.org/10.1108/FS-09-2020-0093>
- Annunziata, M. (2020, February 5). The skills of the future: Problem solving. *Forbes*. <https://www.forbes.com/sites/marcoannunziata/2020/02/05/the-skills-of-the-future-problem-solving/>
- Arya, A., & Nardon, L. (2014). Google It: Critical Thinking and Problem Solving in the Internet Age. In *EDULEARN14 Proceedings* (pp. 4166–4173). IATED.
- Asa, A. R., Campbell, H., & Nautwima, J. P. (2022). A critical review of organizing knowledge management for innovation. *International Journal of Management Science and Business Administration*, 8(2), 7–15. doi: <https://doi.org/10.18775/ijmsba.1849-5664-5419.2014.82.1001>
- Attewell, P. (1994). Information technology and the productivity paradox. In D. J. Hirsch (Ed.), *Organizational linkages: Understanding the productivity paradox* (pp. 13–42). National Academies Press.
- Audrin, B., Audrin, C., & Salamin, X. (2024). Digital skills at work—Conceptual development and empirical validation of a measurement scale. *Technological Forecasting and Social Change*, 202, 123279. <https://doi.org/10.1016/j.techfore.2024.123279>
- Autor, D. H. (2015). Why are there still so many jobs? The history and future of workplace automation. *Journal of Economic Perspectives*, 29(3), 3–30. <https://doi.org/10.1257/jep.29.3.3>
- Bejaković, P., & Mrnjavac, Ž. (2020). The importance of digital literacy on the labour market. *Employee Relations: The International Journal*, 42(4), 921–932. <https://doi.org/10.1108/ER-07-2019-0274>
- Boudard, J. C. (2021). Dual vocational training: A successful model for youth employment. *International Monetary Fund*.
- Braun, V., & Clarke, V. (2012). Thematic analysis. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in*

- psychology, Vol. 2. Research designs: Quantitative, qualitative, neuropsychological, and biological (pp. 57–71). *American Psychological Association*.
- Bresnahan, T. F., Brynjolfsson, E., & Hitt, L. M. (2002). Information technology, workplace organization, and the demand for skilled labor: Firm-level evidence. *The Quarterly Journal of Economics*, 117(1), 339-376. <https://doi.org/10.1162/003355302753399526>
  - Brosnan, M. J. (2002). Technophobia: The psychological impact of information technology. *Computers in Human Behavior*, 73, 1-13. <https://doi.org/10.4324/9780203436707>
  - Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. W. W. Norton & Company.
  - Brynjolfsson, E., & McAfee, A. (2017). *Machine, platform, crowd: Harnessing our digital future*. W. W. Norton & Company.
  - Caroline, A., Coun, M. J., Gunawan, A., & Stoffers, J. (2025). A systematic literature review on digital literacy, employability, and innovative work behavior: emphasizing the contextual approaches in HRM research. *Frontiers in Psychology*, 15, 1448555. <https://doi.org/10.3389/fpsyg.2024.1448555>
  - Carretero, S., Vuorikari, R., & Punie, Y. (2017). DigComp 2.1: The digital competence framework for citizens with eight proficiency levels and examples of use. Publications Office of the European Union. <https://doi.org/10.2760/38842>
  - Casner-Lotto, J., & Barrington, L. (2006). Are they really ready to work? Employers' perspectives on the basic knowledge and applied skills of new entrants to the 21st century US workforce. The Conference Board. <https://www.frontiersin.org/journals/education/articles/10.3389/feduc.2025.1562391/full>
  - Christensen, C. M., Johnson, C. W., & Horn, M. B. (2010). *Disrupting class: How disruptive innovation will change the way the world learns* (2nd ed.). McGraw-Hill.
  - Cinque, M. (2016). "Lost in translation". *Soft skills development in European countries*. *Tuning Journal for Higher Education*, 3(2), 389-427. [https://www.google.com/search?q=https://doi.org/10.18543/tjhe-3\(2\)-2016pp389-427](https://www.google.com/search?q=https://doi.org/10.18543/tjhe-3(2)-2016pp389-427)
  - Compeau, D. R., & Higgins, C. A. (1995). Computer self-efficacy: Development of a measure and initial test. *MIS Quarterly*, 19(2), 189–211. <https://doi.org/10.2307/249688>
  - Covello, V. T. (2006). Risk communication and message mapping: A new tool for communicating effectively in public health emergencies and disasters. *Journal of Emergency Management*, 4(3), 25-40. <https://doi.org/10.5055/jem.2006.0030>
  - Dey, J. (2022) 'The Digital Divide in Access to Information and Communication Technologies: A Global Perspective', *African Diaspora Journal of Mathematics*, 25(6), pp. 259–265. Available at: <https://research.ebsco.com/linkprocessor/plink?id=dd5d779d-9263-390d-9c47-6cc871e4b314>
  - Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random House.
  - Eshet, Y. (2012). Thinking in the digital era: A revised model for digital literacy. *Issues in Informing Science and Information Technology*, 9, 267-276. <https://doi.org/10.28945/1621>
  - Falck, O., Heimisch-Roecker, A., & Wiederhold, S. (2021). Returns to ICT skills. *Research policy*, 50(7), 104064. <https://doi.org/10.2139/ssrn.2744714>
  - Falloon, G. (2020). From digital literacy to digital competence: the teacher digital competency (TDC) framework. *Educational technology research and development*, 68(5), 2449-2472. <https://doi.org/10.1007/s11423-020-09767-4>
  - García-Peñalvo, F. J. (2021). Avoiding the dark side of digital transformation in teaching. An institutional reference framework for eLearning in higher education. *Sustainability*, 13(4), 2023. <https://doi.org/10.3390/su13042023>

- Georgopoulou, M. S., Troussas, C., Triperina, E., Sgouropoulou, C. (2025). Approaches to Digital Humanities Pedagogy: a systematic literature review within educational practice, *Digital Scholarship in the Humanities*, Volume 40, Issue 1, April 2025, Pages 121–137, <https://doi.org/10.1093/llc/fgae054>
- Gerdeman, D. (2022). Do coding bootcamps work?. Harvard Business School. <https://www.google.com/search?q=https://hbswk.hbs.edu/item/do-coding-bootcamps-work-new-research-shows-graduates-land-tech-jobs-and-increase-their-salaries>
- Gilster, P. (1999). *Digital literacy*. Wiley.
- Goos, M., Konings, J., & Rademakers, L. (2016). *The future of work in the digital age*. Centre for European Policy Studies.
- Goos, M., Manning, A., & Salomons, A. (2014). Explaining job polarization: Routine-biased technological change and offshoring. *American Economic Review*, 104(8), 2509–26. <https://doi.org/10.1257/aer.104.8.2509>
- Gruenewald, H., & Mueller, M. (2025). Challenges and Opportunities in Reskilling and Upskilling. *Reskilling and Upskilling in a Globalized Economy: Essential Strategies for Workforce Transformation*, 167-201.
- Hanushek, E. A., & Wößmann, L. (2007). The role of education quality in economic growth. <https://doi.org/10.5210/fm.v7i4.942>
- Hatlevik, O. E., & Christophersen, K. A. (2013). Digital competence at the beginning of upper secondary school: Identifying factors explaining digital inclusion. *Computers & education*, 63, 240-247. <https://doi.org/10.1016/j.compedu.2012.11.015>
- Heine, S., Krepf, M. & König, J., (2023). Digital resources as an aspect of teacher professional digital competence: One term, different definitions – a systematic review. *Educ Inf Technol* 28, 3711–3738 (2023). <https://doi.org/10.1007/s10639-022-11321-z>
- Ibrahim, R. K., & Aldawsari, A. N. (2023). Relationship between digital capabilities and academic performance: the mediating effect of self-efficacy. *BMC nursing*, 22(1), 434. <https://doi.org/10.1186/s12912-023-01593-2>
- Ifenthaler, D., Bellin, D., & Mah, D. K. (2016). *Digital badges in education: Trends, issues, and cases*. Springer.
- Jackson, D. (2015). Employability skill development in work-integrated learning: A mixed-methods analysis of student and employer perceptions. *Asia-Pacific Journal of Cooperative Education*, 16(3), 169-183.
- Jha, R., Sondhi, V., & Vasudevan, B. (2022). Literature search: Simple rules for confronting the unknown. *medical journal armed forces india*, 78, S14-S23.
- Johnson, R. (2024). Digital literacy and its importance in the modern workforce. *Journal of Workforce Development*, 45(2), 112-128.
- Kaplan, A. M., & Haenlein, M. (2016). Higher education and the digital revolution: About MOOCs, SPOCs, social media, and the Cookie Monster. *Business Horizons*, 59(4), 441-450. <https://doi.org/10.1016/j.bushor.2016.03.008>
- Kirschner, P. A., & De Bruyckere, P. (2017). The myths of the digital native and the multitasker. *Teaching and Teacher Education*, 67, 135-142. <https://doi.org/10.1016/j.tate.2017.06.001>
- Köttl, H., Cohn-Schwartz, E., & Ayalon, L. (2021). Self-Perceptions of Aging and Everyday ICT Engagement: A Test of Reciprocal Associations, *The Journals of Gerontology: Series B*, Volume 76, Issue 9, November 2021, Pages 1913–1922, <https://doi.org/10.1093/geronb/gbaa168>
- Kshetri, N. (2021). Economics of Artificial Intelligence in Cybersecurity. *IT Professional*, 23(5), 73–77. <https://doi.org/10.1109/MITP.2021.3100177>
- Labudova, V. & Fodranova, I. (2024). The Impact of Socio-Economic Factors on Digital Skills in the Population of the EU 27 Countries. *Virtual Economics*, 7(3), 81–101. [https://doi.org/10.34021/ve.2024.07.03\(5\)](https://doi.org/10.34021/ve.2024.07.03(5))
- Languille, S. (2017). Public Private partnerships in education and health in the global South: a literature review. *Journal of International and Comparative Social Policy*, 33(2), 142-165. <https://doi.org/10.1080/21699763.2017.1307779>

- Lankshear, C., & Knobel, M. (2008). Digital literacies: Concepts, policies and practices. Peter Lang.
- Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). *Industry 4.0. Business & Information Systems Engineering*, 6(4), 239–242. <https://doi.org/10.1007/s12599-014-0334-4>
- Lee, C. S., & Chua, Y. T. (2024). The role of cybersecurity knowledge and awareness in cybersecurity intention and behavior in the United States. *Crime & Delinquency*, 70(9), 2250-2277. <https://doi.org/10.1177/00111287231180093>
- Lee, J. J., & Meng, J. (2021). Digital competencies in communication management: a conceptual framework of Readiness for Industry 4.0 for communication professionals in the workplace. *Journal of Communication Management*, 25(4), 417-436. <https://doi.org/10.1108/JCOM-10-2020-0116>
- Li, G., Hou, Y., & Wu, A. (2017). Fourth Industrial Revolution: technological drivers, impacts and coping methods. *Chinese Geographical Science*, 27(4), 626–637. <https://doi.org/10.1007/s11769-017-0890-x>
- Li, L. (2022). Reskilling and Upskilling the Future-ready Workforce for Industry 4.0 and Beyond. *Inf Syst Front*. 2022 Jul 13:1-16. <https://doi.org/10.1007/s10796-022-10308-y>
- Lombardi, M. (2019). The future of work: The role of “soft skills” in the digital age. *Journal of Educational Technology & Society*, 22(1), 1-12.
- Mandinach, E. B., & Gummer, E. S. (2016). What does it mean for teachers to be data literate: Laying out the skills, knowledge, and dispositions? *Teaching and teacher education*, 60, 366-376. <https://doi.org/10.1016/j.tate.2016.07.011>
- Metzger, M. J. (2007). Making sense of credibility on the Web: Models for evaluating online information and recommendations for future research. *Journal of the American society for information science and technology*, 58(13), 2078-2091. <https://doi.org/10.1002/asi.20672>
- Mondo, M., Pileri, J., Barbieri, B., Bellini, D., & De Simone, S. (2023). The role of technostress and psychological detachment in the relationship between workload and well-being in a sample of Italian smart workers: a moderated mediated model. *Social Sciences*, 12(10), 530. <https://doi.org/10.3390/socsci12100530>
- Nambisan, S. (2017). Digital entrepreneurship: Toward a digital technology perspective of entrepreneurship. *Entrepreneurship theory and practice*, 41(6), 1029-1055. <https://doi.org/10.1111/etap.12254>
- Nautwima, J.P., Asa, A.R. & Nendongo, V.P. (2022). Integrating gamification into middle school mathematics curriculum: Game-based learning approach in Namibia. *International Journal of Operations Management*, 2(4), 719. doi: <https://doi.org/10.18775/ijom.2757-0509.2020.24.4001>
- Nautwima, J. P., Obrenovic, B., Asa, A. R., Johannes, H. N., & Abueva, N. (2025). Determinants of technology adoption in small and medium-sized enterprises. *Sustainable Futures*, 10(100919). <https://doi.org/10.1016/j.sfr.2025.100919>
- Ng, W. (2012). Can we teach digital natives digital literacy? *Computers & Education*, 59(3), 1065–1078. <https://doi.org/10.1016/j.compedu.2012.04.016>
- O’Neil, C. (2016). *Weapons of math destruction: How big data increases inequality and threatens democracy*. Crown.
- Obermayer, N., Csizmadia, T., Banász, Z., & Purnhauser, P. (2023, September). The importance of digital and soft skills in the digital age. In *European Conference on Knowledge Management (Vol. 24, No. 2)*. <https://www.proquest.com/conference-papers-proceedings/importance-digital-soft-skills-age/docview/2871351253/se-2>
- OECD. (2019). *OECD skills outlook 2019: Thriving in a digital world*. OECD Publishing. <https://doi.org/10.1787/df80bc12-en>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S.,

- ... Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, n71. <https://doi.org/10.1136/bmj.n71>
- Pangrazio, L. (2016). Reconceptualising critical digital literacy. *Discourse: Studies in the Cultural Politics of Education*, 37(2), 163-174. <https://doi.org/10.1080/01596306.2014.942836>
  - Pluto Insights. (2024). Developing effective search strategies for literature reviews. Pluto.im. Retrieved from <https://insights.pluto.im/developing-effective-search-strategies-for-literature-reviews/>
  - Ragu-Nathan, T. S., Tarafdar, M., Ragu-Nathan, B. S., & Tu, Q. (2008). The consequences of technostress for end-users in organizations: Conceptual development and empirical validation. *Information Systems Research*, 19(4), 417-433. <https://doi.org/10.1287/isre.1070.0165>
  - Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu. Publications Office of the European Union. <https://doi.org/10.2760/159770>
  - Revuelta-Domínguez, F. I., et al. (2022). Digital Teaching Competence: A Systematic Review. *Sustainability*, 14(11), 6428. <https://doi.org/10.3390/su14116428>
  - Ritter, G., & D'Auria, A. (2023). The human-tech interface: Why emotional intelligence is the new digital superpower. *Harvard Business Review*, 101(4), 88-97.
  - Robinson, L., Cotten, S. R., Ono, H., Quan-Haase, A., Mesch, G., Chen, W., ... & Stern, M. J. (2015). Digital inequalities and why they matter. *Information, Communication & Society*, 18(5), 569-586. <https://doi.org/10.1080/1369118X.2015.1012532>
  - Saleh, I. M. (2019). The integration of digital literacy in the curriculum: A case study. *Journal of Educational Technology & Society*, 22(1), 13-25.
  - Scheerder, A., van Deursen, A., & van Dijk, J. (2017). Determinants of Internet skills, uses and outcomes. A systematic review of the second- and third-level digital divide. *Telematics and Informatics*, 34(8), 1607-1624. <https://doi.org/10.1016/j.tele.2017.07.007>
  - Schwab, K. (2017). *The Fourth Industrial Revolution*. Crown Business.
  - Schwartz, R. B. (2017). *Pathways to prosperity: Meeting the challenge of preparing young Americans for the 21st century*. Harvard Education Press.
  - Scott, C. L. (2015). The futures of learning 3: What kind of pedagogies for the 21st century? UNESCO Education Research and Foresight, ERF Working Papers Series, No. 15. <https://unesdoc.unesco.org/ark:/48223/pf0000243126>
  - Senge, P. M. (2006). *The fifth discipline: The art and practice of the learning organization*. Doubleday/Currency.
  - Shanker, R. (2017). The future of jobs: The importance of problem-solving skills. *Journal of Management Research*, 17(2), 65-71.
  - Shute, V. J. (2008). Focus on formative feedback. *Review of educational research*, 78(1), 153-189. <https://doi.org/10.3102/0034654307313795>
  - Smith, J., & Jones, M. (2024). Digital literacy in the 21st century: Preparing students for the future workforce. *Journal of Higher Education and Skills*, 12(1), 45-60.
  - Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research*, 104, 333-339. <https://doi.org/10.1016/j.jbusres.2019.07.039>
  - Sonnentag, S. (2015). Dynamics of well-being. *Annual Review of Organizational Psychology and Organizational Behavior*, 2(1), 261-293. <https://doi.org/10.1146/annurev-orgpsych-032414-111347>
  - Spurava, G., & Kotilainen, S. (2023). Digital literacy as a pathway to professional development in the algorithm-driven world. *Nordic Journal of Digital Literacy*, 18(1), 48-59. <https://doi.org/10.18261/njdl.18.1.5>
  - Tarafdar, M., Tu, Q., Ragu-Nathan, B. S., & Ragu-Nathan, T. S. (2007). The impact of technostress on role stress and productivity. *Journal of Management Information Systems*, 24(1), 301-328. <https://doi.org/10.2753/MIS0742-1222240109>

- Tinmaz, H., Lee, Y. T., Fanea-Ivanovici, M., & Baber, H. (2022). A systematic review on digital literacy. *Smart Learning Environments*, 9(1), 21.  
<https://doi.org/10.1186/s40561-022-00204-y>
- van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review. *SAGE Open*, 10(1).  
<https://doi.org/10.1177/2158244019900176>
- Zhang-Kennedy, L., & Chiasson, S. (2021). A systematic review of multimedia tools for cybersecurity awareness and education. *ACM Computing Surveys (CSUR)*, 54(1), 1-39.  
<https://doi.org/10.1145/3427920>