Systematic Literature Review: Digital Competency Framework for Upper Secondary Students in Malaysia

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ABSTRACT

The transition from conventional to technology-driven education necessitates that students acquire essential digital competencies to navigate the complexities of globalization. This study aims to identify the key digital competencies aligned with the Fourth Industrial Revolution through a Systematic Literature Review (SLR) of research published between 2000 and 2022. Utilizing the PICOC framework (Population, Intervention, Comparison, Outcomes, and Context), this study systematically evaluates digital competency models for upper secondary students. A qualitative analysis of 14 selected studies reveals both convergences and divergences across the identified models. The findings indicate that digital competencies for upper secondary students encompass seven key domains: digital technology competence, problem-solving competence, interpersonal competence, information and data literacy, digital content creation, digital security, and digital citizenship. Drawing on these insights, this study formulates the Digital Competency Framework for Upper Secondary Students in Malaysia, which provides a structured approach to enhancing students' digital literacy and preparedness for a technology-driven society. This study contributes to the growing body of literature on digital competency in education by offering empirical insights that inform educational policies and instructional strategies. The proposed framework serves as a reference for educators, policymakers, and stakeholders seeking to equip students with the necessary skills to thrive in an increasingly digitalized and globalized landscape.

Keywords: digital competency, Fourth Industrial Revolution, systematic literature review, upper secondary students, digital literacy, education policy

INTRODUCTION

The Fourth Industrial Revolution (IR4.0) refers to the current technological era characterized by integration of physical, digital, and biological systems. IR4.0 involves using advanced technologies, such as artificial intelligence, robotics, the Internet of Things, and big data, to transform how we live and work [1]. It was described as a time of unprecedented change and innovation, with profound implications for education and training [2], [3] (World Economic Forum, 2020; Mohd et al., 2023). The development of IR4.0 sparked global competition [4]. The development of technology also modernises and transforms lives culturally, economically, and socially [1], [5]. In today's workplace, digital skills are becoming increasingly important, with many jobs requiring digital literacy and technological proficiency. Furthermore, IR4.0 heralds an epoch of unparalleled transformation and innovation, with far-reaching implications for education and training. Students must have the necessary skills and knowledge to succeed in a digitally driven society [6].

In the digital age, the development of digital competence has become increasingly important [7]. Digital competency refers to the set of abilities, understandings, and dispositions required to effectively use digital technologies to accomplish objectives and resolve issues. Several frameworks and models have been formulated to guide the enhancement of digital proficiency in various settings. The Digital Competence Framework for Citizens (DigComp), formulated by the European Commission, is an illustrative instance. This

framework outlines five discrete areas of digital expertise: information and data literacy, communication and cooperation, digital content generation, security, and critical thinking [7]. Furthermore, digital competency frameworks are developed with a focus on students in schools. The ISTE Standards for Students Framework, developed by the International Society for Technology in Education (ISTE), is an example. This framework aims to foster the acquisition of proficiencies pertaining to digital citizenship, computational thinking, creative expression, and collaboration among students. Meanwhile, the Australian Curriculum, Assessment, and Reporting Authority (ACARA) (2018), has seamlessly incorporated digital technologies into the Australian Curriculum, primarily emphasizing two pivotal domains: Digital Systems and Design and Technologies. These two domains are designed to nurture students' comprehension of the functioning of digital technologies and how they can be harnessed to craft innovative digital solutions.

The Ministry of Education (MOE), in collaboration with the Malaysia Digital Economy Corporation (MDEC), has developed the Digital Competency Standards (DCS) as a tool to measure and assess the level of digital competence among students [8]. DCS, utilizing a gamification approach, was developed in 2015 based on international models of digital competency standards and tailored to the curriculum implementation at that time. It assesses three main domains: cognitive (problem-solving), technological (understanding of technology concepts and operations), and global citizenship (safe, ethical, and effective use of technology). The combination of explicit and implicit digital education, as well as DCS, has assisted in the effort to build students' digital competence, effectively use technology, and generate various new ideas that significantly impact the quality of education, enhancing students' performance and experience [9].

The ambiguity in the definitions and framework of digital competency, digital literacy, and related concepts has been a long-standing issue in education. The absence of consensus regarding these definitions may result in incongruous methodologies and challenges in achieving a cohesive comprehension of digital competence [10]. Different frameworks have been using different terminologies, and no widely accepted definition of digital competency exists [11]. An examination of existing scholarly works on digital literacy in secondary education revealed significant disparities in the interpretations and explanations of digital competency [12]. The same goes for the Malaysian context. It is important to note that a specific digital competency framework still lacks one that could serve as a reliable indicator. This gap exists because the current digital competency framework was primarily designed based on international standards [8]. This situation leads to a notable issue: the absence of a consensus on the definitions and associated concepts within the digital competency framework. This presents a significant challenge in Malaysia's education sector. To address this, adopting a standardized approach to delineating the digital competency framework within the Malaysian context becomes crucial. Such a standardized approach would bring about greater clarity and consistency in teaching and learning methods and facilitate a more precise assessment of students' digital proficiency.

METHOD

In this study, the document analysis method was used among the qualitative research methods. Content analyses of academic studies on the concept of self-disclosure were carried out. This study aims to determine the essential digital skills that students need to possess in the context of the fourth industrial revolution. This research seeks to tackle the following inquiries:

What are the components of upper secondary school students' digital competence that align with IR4.0's requirements?

To examine previous investigations on students' digital competencies, the scholars employed the Systematic Literature Review (SLR) approach. SLR is a technique used to scrutinize published works relevant to research inquiries [13]. The primary aim of the SLR is to recognize, assess, and derive conclusions regarding highly commendable research that addresses problematic concerns. In addition to mitigating bias, this approach empowers researchers to construct analyses, adopt a systematic research process, and furnish structured procedures or case study protocols that can appraise the quality of the research. This investigation utilized four

phases of the systematic literature review approach, specifically identification, screening, qualification, and admission [13]. In addition to looking at the most recent developments in the areas studied, the researcher also limited the search to articles published between 2000 and 2022 that looked at digital competency models for students and other issues related to this topic.

The commencement of the identification process involves preliminary determination of the study parameters that will be conducted. In the present investigation, the PICOC approach is employed to ascertain the systematic literature review (SLR) parameters pertaining to the students' digital competency model. The PICOC approach, denoted by Population, Intervention, Comparison, Outcome, and Context, can be used to establish these parameters [14]. This technique aids in identifying specific matters that necessitate attention and target the population of interest. The PICOC criteria for this study are outlined as follows:

- Population: School students
- Intervention: The Digital Competency Framework was applied to school students.
- Comparison: Comparison of components of the digital competency framework for school students
- Outcome: Proposed components of the student's digital competence and a description of the relevant
- Context: Secondary School

By utilizing the structured PICOC method, relevant keywords and synonyms are identified to expand the desired criteria. To acquire a more extensive range of articles, English keywords are employed. Table 1 lists the keywords used for each PICOC component, as well as alternate terms.

TABLE I List of identified keywords

Key Terms	Alternative/Synonym Terms
Industrial Revolution 4.0	(1) Digital Era; (2) 21st century
Digital competency	(1) Computer skills; (2) Digital literacy;
	(3) Digital skills; (4) Computer literacy;
	(5) ICT skills; and (6) Information literacy
School	(1) Primary School; (2) Secondary School
Framework	(1) Model; (2) Strategy

After identifying the keywords, they are combined using Boolean operators such as "OR" and "AND" to build the search statement. The final search statement using these operators is presented in Table 2. Page Layout

An easy way to comply with the conference paper formatting requirements is to use this document as a template and simply type your text into it.

TABLE II Search Statement

Full Terms
(Industrial Revolution 4.0 OR Digital Era OR 21st century)
AND
(Digital Competency OR Computer skills OR Digital literacy OR Digital skills OR Computer literacy OR Cultural digital OR Digital culture OR ICT skills OR Information literacy)
AND
(School OR Primary School OR Secondary School)
AND
(Framework OR Model OR Strategy)

This study uses the final search statement on Google Scholar to retrieve relevant articles. Google Scholar is utilized due to several advantages, such as its ability to return vast results on this topic. A total of 271 articles

have been accumulated from various online databases, including ACM Digital Library, IEEE Xplore, ISI Web of Science, Emerald Insight, Science Direct, Springer, Taylor, and Francis Online. Upon acquiring these articles, a screening procedure is carried out to determine the suitability of the articles for the research. The criteria for inclusion and exclusion can be found in Table 3.

TABLE III Criteria For Inclusion And Exclusion

Screening Procedure	Screening Criteria
Exclusion	Overlap (DP)
	Language Compatibility (LC)
	No full text (NF)
	Unrelated (NR)
	Casual use (CA)
Inclusion	Half-linked (PR)
	Closely related (CR)

After the screening criteria, nine articles were removed as they were found to overlap (DP), bringing the total result to 262 articles. The initial screening process also excludes two articles written in languages other than English and Malay Language (LC), seven articles with no full text (NF), and a total of 140 unrelated articles (NR). Following this process, 111 articles remained for the next screening process. Then, the process of determining eligibility is implemented against the remaining 111 articles so that articles that are genuinely relevant to the digital competence of pupils can be identified. Therefore, reading the title and abstract has been implemented to narrow the number of articles further. As a result, 99 articles using the terms digital competency and IR4.0 but not specifying school students (CA) were removed from the list. As a result, a total of 14 articles met the selection criteria for this study and were available for the subsequent process. The detailed process of screening the article is shown in Fig. 1.
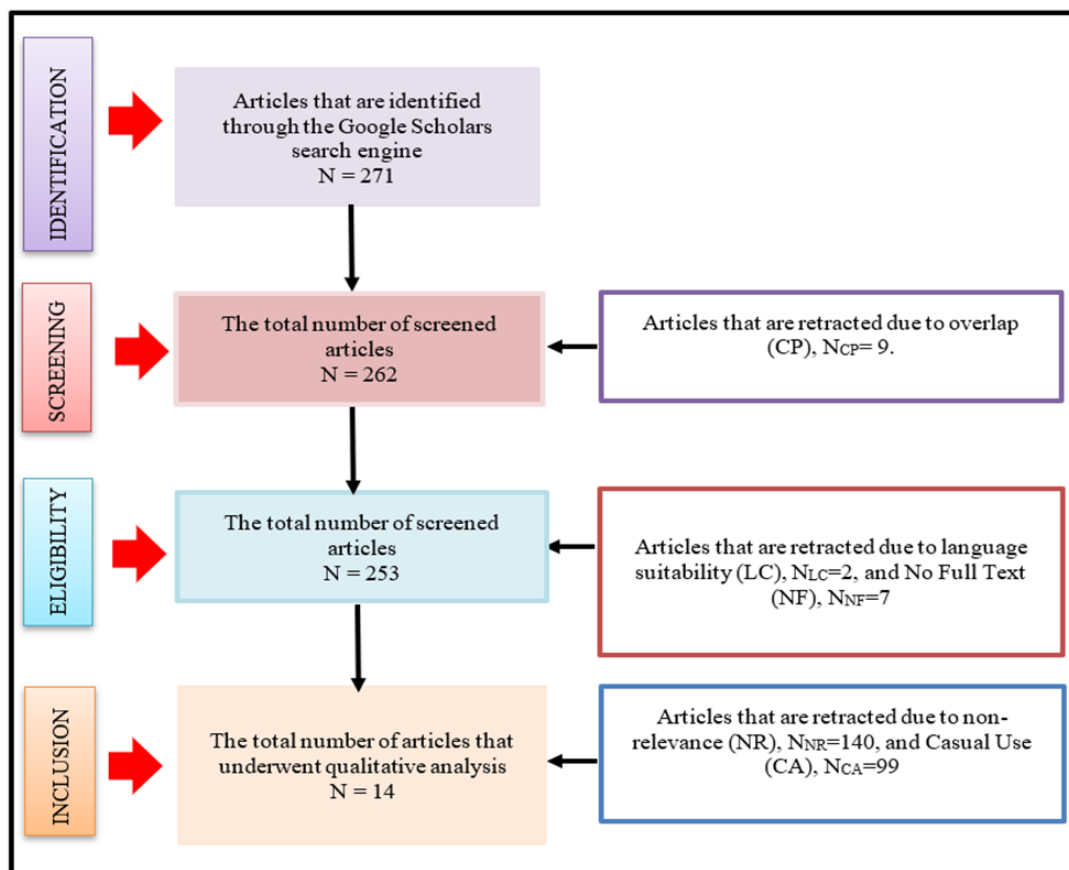

Fig. 1 PRISMA flow diagram for SLR, modified from [13]

FINDINGS AND DISCUSSION

Findings

The extensive examination of students' digital competency within educational institutions has been thoroughly explored in prior scholarly investigations, particularly in the context of the fourth industrial revolution. To comprehend the level of digital aptitude school children, possess, the analysis narrowed its focus to the fundamental components. This study discovered a total of 14 models of digital competency (refer to Table 4). Subsequently, a comparative matrix of digital competencies for school students was utilized to scrutinize the similarities and disparities between these constructs. The primary constituents were employed to encode and categorize the composition of each document.

TABLE IV Themes Analysis

Model	Author	Digital Technology Competence	Problem Solving Competence	Interpersonal Competence	Information & Data Literate Competence	Digital Content Creation Competence	Digital Safety Competence	Digital Citizenship Competence
1	World Economic Forum (2020)	√	√	√				√
2	Fraillon et al. (2019)	√	√	√	√			
3	The Tech Partnership (2018)	√	√	√	√		√	
4	Carretero et al. (2019)		√	√	√	√	√	
5	Hadziristic et al. (2020)	√	√					
6	Steeves et al. (2014)	√	√			√		
7	van Laar et al. (2020)		√	√	√			
8	Gallardo, R., & Wiltse, M. (2018)	√		√	√			
9	Bode, E., & Gold, R. (2018)	√			√	√		
10	Yang et al. (2021)	√	√	√				
11	Le et al. (2019)		√	√	√		√	
12	ISTE (2016)	√	√	√				√
13	ACARA (2018)	√	√	√	√	√		
14	Bravo et al. (2021)	√	√	√	√			√

According to the analysis, a comprehensive set of seven competencies was discerned: digital technology competence, problem-solving competence, interpersonal competence, information and data literacy

competence, digital content creation competence, digital safety competence, and digital citizenship competence (refer Fig.2). A digital competency framework for upper secondary students in Malaysia was developed based on thematic analysis findings.
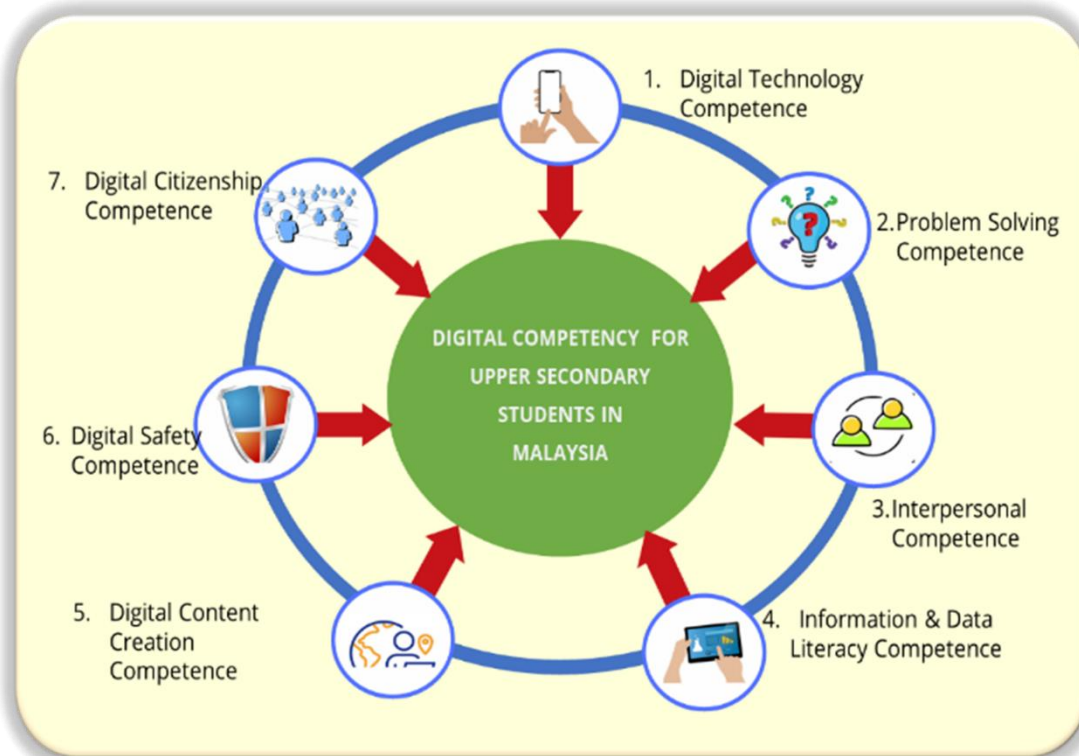

Fig. 2 Digital competency framework for upper secondary students in Malaysia

Discussion

Digital technology competence is knowledge, skills, attitudes, abilities, and strategies that enable individuals to effectively use digital technologies [15]. It has become an integral part of professional skill sets in both academic and industrial settings [16]. It encompasses a broad spectrum of skills and knowledge, ranging from professional skill sets, reflecting its multifaceted nature and significance in various domains. Engaging in the digital sphere, conducting thorough assessments of digital material, protecting one's privacy and security online, and participating in online endeavours with ethical and responsible conduct are merely a handful of the competencies, capabilities, and mindsets that are encompassed in this domain [17], [18], [19]. Digital technology proficiency is a noteworthy component of the skill set required in the 21st century, and it is vital for achieving personal success in the era of digital advancements [11]. Therefore, digital technology competence is essential for effectively using digital technologies in both academic and professional settings. As the digital landscape continues to evolve, possessing these competencies is vital for achieving success and staying competitive in the modern world.

The importance of problem-solving competence, as highlighted in DigComp 2.2, cannot be overstated. DigComp 2.2 delineates problem-solving competence as the capacity to "discern, formulate, and resolve predicaments utilizing digital tools and resources, in addition to generating, assessing, and implementing resolutions" [7]. Furthermore, [12] described problem-solving competence as the ability to recognize, scrutinize, and remedy intricate predicaments using digital tools and resources. This skill is indispensable in the 21st century, where the digital landscape is rapidly evolving [11]. Problem-solving competence is crucial in navigating cyber privacy and publicity predicaments, as it empowers individuals to make well-informed decisions about their digital footprint [17], [20]. Today's digital age, this competency has become even more critical, underscoring the pivotal role of problem-solving skills in achieving digital proficiency. Consequently,

fostering problem-solving competence is essential for preparing individuals to meet the challenges and opportunities of the digital era.

Interpersonal competence refers to an individual's ability to communicate and collaborate effectively, which are crucial skills for success in the digital age. Communication and collaboration are among the eight essential competencies for thriving in a digital society [12]. Online interpersonal communication mediates the impact of digital skills on digital participation, highlighting the importance of interpersonal skills in digital competence [21]. In educational contexts, the link between students' interpersonal skills and their academic achievement emphasizes the integral role of these skills in overall competence [22]. Individuals with strong communication skills can clearly and concisely convey their thoughts and ideas, while those with collaboration skills can effectively work with others to achieve common goals. Therefore, developing strong communication and teamwork skills is crucial for succeeding in today's digital world, helping people effectively interact online and working together towards common goals.

The concept of information and data literate competence refers to an individual's ability to competently and responsibly engage in locating, evaluating, analysing, and utilizing information across various contexts [23]. This competence is integral to digital competence and plays a crucial role in navigating the vast amount of information available online. Several studies have highlighted the significance of information and data literacy competence in the context of digital competence. For example, the DigComp 2.2 and ISTE Standards for Students framework identify digital competence, including information and data literacy [7]. Reference [24] stressed the importance of information processing and communication skills as crucial factors, indicating the significance of information and data literacy in utilizing digital technologies effectively. This shows that information and data literacy competence are integral components of digital competence, enabling individuals to effectively access, evaluate, and utilize information and data in digital environments. These literacies play a crucial role in navigating the digital landscape and are essential for enhancing overall digital competence.

The digital content creation competence refers to the ability to generate, conceive, produce, and disseminate diverse digital media configurations, including videos, images, audio, and textual content, using a variety of tools and platforms [7]. It is a critical component of digital competence, enabling individuals to effectively produce and manage digital content. The ability to generate and disseminate digital content is gradually emerging as an indispensable skill across various sectors, including the creative industries. A study on professionals working within the creative industries showed that the levels of 21st-century digital skills, including digital content creation, varied among professionals [25]. Reference [26] suggested the development of new approaches to enhance digital competence in educational contexts, emphasizing the need for improved digital content creation skills. Meanwhile, [26], [27] discussed the notion of digital competence and its components, highlighting the importance of digital content creation as a key aspect of digital competence. In essence, developing proficiency in digital content creation is essential for both professional success and educational advancement in today's digital landscape. By mastering these skills, individuals not only enhance their ability to create impactful digital media but also contribute significantly to digital innovation and engagement across various sectors. Therefore, fostering competence in digital content creation remains crucial for meeting the demands of an increasingly digital-driven world.

Digital safety competence is essential for active engagement in the digital era, given the rising risks such as cyberbullying, identity theft, and phishing scams [12], [18]. It requires individuals to understand these digital hazards and be proficient in utilizing available tools and strategies to mitigate risks. Extensive literature emphasizes the critical role of digital safety competence across diverse domains, particularly in education. Research underscores the impact of digital citizenship programs on enhancing children's online safety and fostering responsible digital behaviors [28], [29], [30]. Digital safety competence is integral to frameworks like DigComp 2.2 and ISTE (2016), which emphasize digital literacy and proficiency. In conclusion, teaching people how to stay safe online is crucial in today's digital age, especially with risks like cyberbullying and identity theft. Educational initiatives, including comprehensive digital citizenship programs in schools, play a pivotal role in imparting essential knowledge and practical strategies for online safety and responsible digital

conduct. This proactive approach not only enhances individual safety but also contributes to a more secure digital environment overall.

Digital citizenship competence encompasses understanding the moral, societal, and cultural implications of digital technologies [18], [31]. It equips individuals with the knowledge, skills, and ethical awareness necessary to responsibly engage in the digital world. As digital technologies increasingly permeate everyday life, proficiency in digital citizenship becomes essential. Research by [12], [32], [33], [34] underscores the urgent need to prepare individuals for responsible digital engagement. This highlights the importance of investing in digital literacy education to foster widespread digital citizenship competence. These findings are crucial for shaping educational practices and policies that integrate digital citizenship into curricula, empowering students with critical thinking and ethical decision-making skills. Furthermore, by cultivating digital citizenship competence, stakeholders can nurture a digitally responsible population capable of navigating the complexities of the digital age with integrity and awareness.

CONCLUSION

In conclusion, this research endeavoured to delineate the digital competencies essential for effective engagement in contemporary digital environments, encompassing digital technology competence, problem-solving competence, interpersonal competence, information and data literacy competence, digital content creation competence, digital security competence, and digital citizenship competence. Building upon the identification of these integral components, the study culminates in the development of a bespoke Digital Competency Framework tailored specifically for upper secondary students in Malaysia. This framework serves as a valuable instrument for augmenting students' preparedness to navigate the dynamic educational landscape characterized by digital integration. Nonetheless, it is imperative to acknowledge the need for further comprehensive investigations to validate these components within the context of prevailing practices pertaining to the utilization of digital technology.

In the context of Malaysia's education system, stakeholders must critically assess current practices regarding the integration of digital technology. Reference [35] highlight the prevalent shift towards online platforms for classroom activities, stressing the importance of effectively utilizing technology to meet educational objectives. Reference [36] and [37] emphasized the pivotal role of educators, particularly teachers, in leveraging technology creatively to deliver curriculum content and foster students' digital competencies. To advance our understanding of digital competencies further, detailed studies are needed to identify sub-components and validate existing frameworks. Exploratory factor analysis (EFA) can be instrumental in delineating the factors influencing students' digital competencies, while confirmatory factor analysis (CFA), as suggested by [38] can validate and ensure the reliability of these components. By employing rigorous research methodologies and effective pedagogical strategies, stakeholders can enhance educational practices and empower upper secondary students to thrive in an increasingly digital-centric world.

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