

Literature Study: Teachers' Digital Competence for 21st-Century Learning

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Abstract. 21st-century learning is an educational approach that incorporates technology to enhance students' knowledge and skills, equipping them with competencies that correspond to current developments. Consequently, teachers need to possess specific competencies to implement this approach, one of which is digital competency. The objective of this study is to investigate the digital abilities necessary for educators in 21st-century education. This study utilised a qualitative descriptive methodology, complemented by a literature review technique. The results show that teachers' digital skills include information literacy, communication, creating educational content, working together, being flexible, and using technology effectively in learning.

Keywords: 21st-century learning, technology, teacher competency, digital competency.

1 Introduction

The 21st century is characterized by data transparency and is often referred to as the era of globalization [1]. During this period, human life has undergone significant changes that differ greatly from previous centuries [2]. Rapid advancements in data technology and widespread automation are prominent features of this era, leading to the replacement of many traditional jobs by machines and robots [3]. Consequently, various old occupations have disappeared and been supplanted by new forms of work. In response, Technical Vocational Education and Training (TVET) must adapt to address the unpredictable challenges of the future. The 21st century is also marked by accelerated digital transformation and technological progress, which profoundly influence many areas of life, including education [4].

The evolution of education in the 21st century is characterized by the integration of technology and the development of essential skills that equip students for a rapidly evolving world. Central to this transformation is the concept of 21st-century skills, which encompass creativity, critical thinking, communication, and collaboration, commonly referred to as the 4Cs [5]. These skills are increasingly recognized as essential for students to thrive in today's society, where technological advances and global connectivity drive educational needs. Studies indicate that integrating technology into education significantly enhances the learning process. Tools such as

educational software, mobile applications, and online platforms, support independent learning and increase educational effectiveness [5]. Successful implementation of these tools requires a curriculum that aligns with 21st-century standards, emphasizing digital literacy and technological competence. Such a curriculum should be designed to encourage student-centered learning, enabling learners to acquire skills relevant to future careers [5]. Additionally, parental involvement plays a vital role in technology-based education. Engaging parents in the learning process can boost student motivation and achievement, as they are able to monitor progress and provide essential support [5]. Schools are encouraged to strengthen partnerships with parents through regular communication and information sessions regarding the technology used in classrooms.

The discourse on 21st-century education highlights the importance of equipping learners with a variety of skills that align with the evolving demands of the global workforce. As industries undergo transformations driven by technological advancements, particularly in the context of the Fourth Industrial Revolution, TVET institutions are challenged to adapt their curricula to meet these new conditions. This adjustment involves not only the integration of technical skills relevant to specific trades but also the cultivation of soft skills that enhance employability and adaptability [6]. Balancing the development of both types of skills is essential, as it prepares students to effectively manage the complexities of the modern workplace. Furthermore, the concept of digital literacy has become a key element of 21st-century education. As learners are increasingly expected to engage with digital devices and platforms, developing competencies in digital ethics, culture, and safety becomes paramount [6]. By focusing on 21st-century skills and digital literacy, educational institutions can more effectively equip students to meet the challenges and opportunities of the modern world, thereby contributing to a workforce that is both skilled and adaptable [6]. Ensuring that educational practices align with industry needs is key to fostering a generation capable of thriving in a technologically advanced and interconnected society.

Education systems can provide the critical support and resources needed to help school staff develop their digital competencies [7]. Although school support for technology integration is relevant, it does not necessarily guarantee effective use of technology in the classroom. A study identified several teachers who perceived high levels of institutional support for online teaching and learning but still report low self-efficacy in using technological tools [8]. Thus, despite adequate school support, teachers' own perceptions of their competencies remain a barrier to the effective adoption of technology. Teacher training is another important factor of successful technology integration in education. Educators must be equipped with the skills to effectively utilize digital resources and adapt their teaching methods to incorporate these tools [5]. Professional development programs should prioritize enhancing teachers' technological literacy and pedagogical strategies to ensure they can guide students in navigating the complexities of technology-driven learning environments. Gradually, educational practices are transforming into digital learning systems.

Digital learning systems offer several benefits, including ease of access to learning materials, flexibility in quizzes and assignments, and the ability to deliver content in audio or video formats [9]. The application of digital learning is not limited to online learning but can also be applied to offline learning [10]. Teachers who effectively utilize digital technology positively influence learning process effectiveness and learning outcomes [11]. Incorporating digital tools enables teachers to create more engaging and interactive learning environments, thereby increasing students' motivation and participation in the learning process. Moreover, digital technology also provides opportunities for teachers to offer more diverse, relevant, and easily accessible learning

modules to students [12]. Teachers significantly influence the implementation of digital learning in the classroom. Effective implementation reflects the teacher’s proficiency in digital competence [13]. Digital competence is therefore essential for educators as it becomes a key factor in whether they can successfully integrate technology into teaching. According to Petterson et al. [14], digital competence involves the ability to use technology to solve problems, complete tasks, and communicate effectively.

A more thorough and systematic investigation is required to assess teacher digital competence in 21st-century learning. This study seeks to delineate the precise digital abilities necessary for educators in 21st-century learning. We anticipate that the results will shed light on the digital capabilities instructors need to effectively engage in 21st-century learning. The findings of this study can serve as a foundation for the development of more effective teacher training programmes aimed at enhancing digital competencies.

2 Method

This study employs a qualitative descriptive research method utilizing a literature review methodology. Literature review is a research methodology that entails the theoretical analysis of diverse sources pertinent to the subject matter under investigation. The utilized data sources comprise literature, including books and periodicals pertinent to the subject, along with information from electronic sources. The steps in conducting literature-based research are: 1) determining the focus of the research topic, 2) reviewing various types of literature relevant to the topic, 3) selecting relevant learning materials from different references, 4) analyzing and organizing the review data and using it as a guideline for writing and language usage, and 5) utilizing the data obtained from the literature as material for discussion and reference. The data sources are limited to studies published within the last ten years.

3 Results and Discussion

The information derived from multiple sources regarding teachers' digital competencies is shown in the subsequent table:

Table 1. Literature List

No	Title	Author/Year
1	“European framework for the digital competence of educators: DigCompEdu”	Christine Redecker/2017
2	“UNESCO ICT Competency Framework for Teachers”	UNESCO/2018
3	“Formation Of Teachers’ Digital Competence: Domestic Challenges and Foreign Experience”	Tetyana Blyznyuk/2018
4	“Competency Profile of the Digital and Online Teacher in Future Education”	Mohamed Ally/2019
5	“Addressing 21st-century digital skills in schools – Development and validation of an instrument	Charlott Rubach, Rebecca Lazarides/2021

	to measure teachers' basic ICT competence beliefs”	
6	“Components and Indicators of Digital Teacher Competency in Schools under the Provincial Administration Organization”	Pakdee Siripan, Surachet Noirid/2022
7	“Teachers’ professional digital competence: an overview of conceptualisations in the literature”	Ewa Skantz-Åberg, Annika Lantz-Andersson, Mona Lundin and Pia Williams/2022

According to Redecker in The European Digital Competence Framework for Citizens (DigComp), all citizens are expected to actively participate in digital society. Therefore, they need to possess digital skills. Teachers play a vital role in this regard, as they serve as role models for the next generation. As role models, they must be able to effectively demonstrate their digital competencies to students and convey the creative and critical use of digital technology. DigComp has emerged as a broadly recognised framework for evaluating and certifying Digital Competence, serving as a foundation for teacher training and professional development throughout Europe. The DigCompEdu framework comprises six dimensions: professional involvement, digital resources, teaching and learning, assessment, empowering learners, and supporting learners' digital competence, encompassing a total of 22 competencies [15]. Additional information regarding digital competence as per DigCompEdu is provided in Table 2 below.

Table 2. Teachers’ Digital Competence According to DigCompEdu

No	Dimensions	Competencies
1	Professional involvement	Organizational communication Collaborative professionalism Contemplative methodology Digital CPD
2	Digital resources	Choosing Generating and altering Administering, safeguarding, disseminating
3	Teaching and learning	Instructional Guidance Cooperative education Autonomous learning Strategic assessment
4	Assessment	Evaluating evidence Feedback and Planning Accessibility and Inclusion
5	Empowering learners	Differentiation and personalization Proactively involving learners Media and information literacy
6	Supporting learners	Conveyance of information Content creation Accountable utilization Resolution of issues Instructional Guidance

The UNESCO ICT proficiency Framework for Teachers delineates 18 digital competencies, organized into six dimensions of teacher professional practice and structured across three tiers of digital proficiency for educators. [16]. The details of these competencies are presented in Table 3 below.

Table 3. Teachers' Digital Competence According to UNESCO

No	Aspects	Knowledge acquisition	Knowledge deepening	Knowledge creation
1	Comprehending Information and Communication Technology in education	Policy understanding	Policy application	Policy innovation
2	Curriculum and evaluation	Basic knowledge	Knowledge application	Knowledge society skills
3	Educational theory and practice	ICT-enhanced teaching	Complex problem-solving	Self-management
4	Utilization of digital competencies in organizational and administrative contexts	Application	Infusion	Transformation
5	Educator professional development	Standard classroom	Collaborative groups	Learning organization
6	Comprehending Information and Communication Technology in education	Digital literacy	Networking	Teacher as innovator

Blyznyuk defines teacher digital competence as a teacher's ability to effectively apply information and pedagogically grounded communication technology and its ramifications for learning. Blyznyuk categorizes digital competence into various components: information management, communication, educational material development, security, and problem-solving in education. [17]. The criteria for assessing teacher digital competence based on Blyznyuk's framework are presented in Table 4 below.

Table 4. Teachers' Digital Competence According to Blyznyuk

No	Competencies	Criteria
1	Information management	Educators possess data literacy skills (the ability to find, select, sort, evaluate, and manage information relevant to the learning process)
2	Communication	Skills to interact, participate, share, and collaborate through digital technology.
3	Educational material development	Educators' ability to create digital learning content (learning applications, interactive presentations, learning animations, etc.)
4	Security	Educators possess the ability to ensure that learners remain safe from technological products during the learning process
5	Problem solving in education	Problem solving and overcoming technical problems, the ability to identify technical

responses and requirements needed in learning, the ability to identify the weaknesses of digital technology in learning, and the ability to actively and creatively use technology products in learning process

A study conducted by Mohamed Ally in 2019 identified nine main dimensions that represent the key areas of responsibility for future digital teachers and 105 competencies included within these dimensions [18]. The details of these competencies are provided in Table 5 below.

Table 5. Teachers' Digital Competence According to Muhamed Ally

No	Dimensions	Competencies
1	General	<p>Exhibit proficiency in operating inside a virtual world.</p> <p>Facilitate learner support irrespective of geographical location and temporal constraints.</p> <p>Operate from any location and at any hour.</p> <p>Instruct students in essential life skills.</p> <p>Stay abreast with emerging educational technology for implementation in pedagogy.</p> <p>Maintain currency in the subject matter to enhance learning.</p> <p>Motivate pupils to exemplify exemplary citizenship.</p> <p>Fundamental understanding of artificial intelligence</p> <p>Cutting-edge knowledge in the topic area</p> <p>Engage in virtual collaboration with fellow educators to exchange insights regarding students' advancement.</p> <p>Disseminate good pedagogical strategies among fellow educators.</p> <p>Equip learners to coexist harmoniously with the environment.</p>
2	Make use of digital technology	<p>Possess digital literacy</p> <p>Incorporate technology into the curriculum effortlessly.</p> <p>Exhibit comfort while utilizing technology.</p> <p>Employ learning analytics to track the progress of individual learners.</p> <p>Diagnose fundamental technological issues</p> <p>Adjust to evolving technologies</p> <p>Utilize multimedia technologies to present educational content in many formats.</p> <p>Capacity for autonomous acquisition of new technological and software proficiencies</p> <p>Utilize technology to deliver effective assistance to learners.</p> <p>Investigate nascent technologies for education.</p> <p>Utilize technological characteristics to enhance the educational experience (geolocation, information capture, etc.).</p>

		Tailor the technology to the requirements of the learner
3	Create an online educational resource	<p>Possess understanding of the material</p> <p>Choose the suitable digital technology that aligns with the content and the desired learning outcome. Develop superior digital educational resources. Create educational resources tailored to individual learner need.</p> <p>Create educational resources considering the learner's limited knowledge of language, culture, and context.</p> <p>Determine high-quality and credible educational resources for learners to utilize.</p> <p>Employ diverse tactics for various learning contexts. Employ problem-based learning to cultivate learners' advanced knowledge and abilities.</p> <p>Disseminate educational resources among fellow educators</p>
4	Revise digital educational materials	<p>Identify suitable digital educational tools to optimize learning outcomes.</p> <p>Utilize suitable open educational resources for curricular integration. Adjust the learning materials to correspond with the desired learning outcomes. Adapt open educational resources to accommodate the requirements of individual learners.</p> <p>Evaluate the caliber of open educational resources</p> <p>Identify suitable digital educational tools to optimize learning outcomes.</p>
5	Conveyance of information	<p>Engage with the student at their level of understanding.</p> <p>Convey information in the learner's language</p> <p>Engage with the student at their level of understanding.</p>
6	Enhance education	<p>Customize the education for each individual student. Address learners' inquiries promptly and adapt techniques dynamically to accommodate their needs. Honor many learning styles and adjust to the learner's needs.</p> <p>Foster creativity Promote innovation</p> <p>Exhibit attentive listening skills</p> <p>Deliver suitable feedback</p> <p>Exhibit fervor over the educational resources.</p> <p>Modeling in the digital era</p> <p>Inspire students to engage in learning. Foster social interaction among learners.</p> <p>Capability to develop effective questions during interactions with learners</p> <p>Exemplify appropriate virtual conduct</p> <p>Exude approachability</p> <p>Advocate for and exemplify digital citizenship and responsibility.</p> <p>Promote genuine learning</p>

		<p>Motivate students</p> <p>Establish a conducive educational environment</p> <p>Deliver personalized feedback to address the specific needs of each student.</p> <p>Analyze the learner dashboard to assess the performance of each student.</p> <p>Analyze the inquiry posed by the learner.</p> <p>Address the learner's issue</p> <p>Offer assistance to mobile learners and serve as a coach for them.</p> <p>Serve as a mentor for students</p> <p>Assist learners using digital technology</p> <p>Possess expertise in the subject matter to assist learners at various stages of the educational journey.</p> <p>Motivate students to engage in unconventional thinking.</p> <p>Customize the education for each individual student.</p> <p>Address learners' inquiries promptly and adapt techniques dynamically to accommodate their needs.</p> <p>Honor many learning styles and adjust to the learner's needs.</p> <p>Foster creativity Promote innovation</p>
7	Educational methodologies	<p>Employ suitable instructional methods to align with the technology.</p> <p>Employ suitable learning theories to create techniques that optimize learning.</p> <p>Provide alternatives and many methods for conveying ideas via resources and assistance options.</p> <p>Design individualized learning activities for each participant</p> <p>Propose corrective measures to assist learners need further support.</p> <p>Employ diverse learning methodologies to cultivate advanced knowledge and skills.</p> <p>Involve learners throughout the educational process.</p> <p>Propose supplementary educational activities for pupils need assistance.</p> <p>Employ problem-based learning to foster advanced cognitive development.</p>
8	Evaluate comprehension	<p>Promote autonomous learning among students.</p> <p>Choose assessment strategies that align with the learning outcomes.</p> <p>Employ evaluative tools to gauge learners' performance.</p> <p>Employ virtual evaluation techniques to assess performance.</p>
9	Personal traits	<p>Offer evaluations to students</p> <p>Exhibit social responsibility in resource utilization and adopt ecologically sustainable practices.</p> <p>Exemplify commendable behavior for students.</p> <p>Collaborate in virtual teams to disseminate information among educators.</p>

Embrace innovation in the educational framework
 Exhibit passion in a virtual context
 Embrace perpetual learning
 Maintain the confidentiality of learners' information and address privacy concerns.
 Embrace digital thinking. Maintain an open mindset.
 Exhibit sensitivity to the different characteristics of learners.
 Employ effective social skills when collaborating digitally.
 Exhibit flexibility and adaptability in the contemporary digital era.
 Exhibit empathy by preserving humanity in virtual interactions.
 Exemplify appropriate virtual conduct
 Choose assessment strategies that align with the learning outcomes.
 Employ evaluative tools to gauge learners' performance.
 Employ virtual evaluation techniques to assess performance.
 Offer evaluations to students

Information and data literacy (INFO), communication and collaboration (COMM), digital content creation (CREAT), safety and security (SAFE), problem solving (PROBL), and analyzing and reflecting (ANALY) are the six characteristics of teachers' fundamental ICT competency beliefs, according to another study by Rubach and Lazarides [19]. The details of digital competencies according to Rubach and Lazarides is presented in Table 6 below.

Table 6. Teachers' Digital Competence According to Charlott Rubach & Rebecca Lazarides

No	Competencies	Criteria
1	INFO	In digital contexts, recognize and utilize relevant sources. Employ search techniques in online settings. Safely store digital data and information. Obtain the data
2	COMM	Use a variety of digital media to communicate. Share experiences with digital media in interactions with others
3	CREAT	Utilize well-known apps and programs as needed. Create digital goods in a variety of formats. Modify and combine digital content in various types
4	SAFE	Display digital stuff in various formats The risks and hazards in digital environments and take them into consideration. Take the necessary precautions to protect privacy in digital contexts. Update my security settings on a regular basis.

5	PROBL	<p>Make environmentally responsible and healthful use of digital technologies.</p> <p>Make use of digital resources and platforms.</p> <p>Modify digital tools for individual usage.</p> <p>Utilize the right resources and digital learning possibilities on your own.</p> <p>Arrange digital educational materials on your own</p> <p>Create fixes for technical issues.</p> <p>the operation and fundamentals of digital systems.</p>
6	ANALY	<p>Determine the tools' algorithmic structures.</p> <p>Examine how media affects digital settings.</p> <p>Analyze themes' dominance and interest-driven spread in digital environment.</p> <p>Consider the advantages and disadvantages of using media.</p> <p>Examine the advantages of conducting business and providing services in digital settings.</p> <p>Examine the dangers associated with conducting business and providing services online.</p>

Furthermore, according to research conducted by Pakdee Siripan and Surachet Noirid, “in modern teaching management, teachers must possess digital competencies, as digital platforms are increasingly utilized in various aspects of teaching and learning”. According to the study's findings, digital literacy and cognition, the use of digital tools and media, problem-solving using digital tools, and digital adaptation and transformation are the four primary components of teacher digital competence [20]. The indicators for each competency are presented in Table 7 below.

Table 7. Teachers' Digital Competence According to Pakdee Siripan and Surachet Noirid

No	Competencies	Criteria
1	Cognitive processes in digital contexts	<p>Mind-Set Determine the data needs Use digital technologies to find information.</p> <p>Recognize, arrange, handle, evaluate</p> <p>Critically analyze and assess the validity of data</p> <p>Knowledge and obligations</p> <p>Being well-versed in digital communication</p> <p>Possessing knowledge about digital security</p> <p>Knowing how to behave in a digital age</p> <p>Comprehending online sales</p> <p>Knowledge of digital law</p>
2	Utilizing digital instruments and media	<p>Digital technology can be utilized innovatively to enhance knowledge and foster innovation.</p> <p>Can utilize applications online.</p> <p>Safeguard and comprehending threats.</p> <p>Safeguard privacy.</p> <p>Digital technology can be utilized innovatively to enhance knowledge and foster innovation.</p>
3	Utilizing digital tools for problem-solving	<p>Technical issues can be diagnosed and resolved with digital technology</p>

	<p>Digital instruments can be employed to facilitate problem analysis.</p> <p>Identify the requisite information necessary to resolve the issue.</p> <p>Digital tools can facilitate the assessment of solutions. Identify apps that can effectively address challenges. Capable of identifying, assessing, selecting, and utilizing digital technology to address a specific task or problem. Identify possibilities for self-enhancement to remain abreast of digital advancements.</p>
4	<p>Adaptation and digitization</p> <p>Comprehend and adhere to the regulations pertaining to the utilization of digital technology.</p> <p>Establish a code of behavior for the utilization of digital technologies in creative collaboration.</p> <p>Strategize, assess, and contemplate the secure utilization of digital technology while respecting the rights of others. Demonstrate initiative and engage in innovation. Acquire the ability to generate content regarding societal and digital technological culture.</p> <p>Enhance societal welfare by utilizing public and commercial digital services.</p> <p>Manage your own and others' privacy data on digital platforms and media.</p> <p>Possess knowledge of copyright, licenses, information, and digital content.</p> <p>Pursue opportunities to invigorate oneself. For engaged citizenry via suitable digital technologies</p> <p>Disseminate information and knowledge to others with suitable digital technology tools and mediums.</p> <p>Comprehend and adhere to the regulations pertaining to the utilization of digital technology.</p>

Moreover, a study conducted by Aberg, Andersson, Lundin, and Williams on teachers' professional digital competence distinguishes seven recurring aspects [21]. The indicators for each of these competencies are presented in Table 8 below.

Table 8. Teacher Digital Competence According to Aberg, Andersson, Lundin, and Williams

No	Competencies	Indicators
1	Technological proficiency	<ul style="list-style-type: none"> Use of hardware Use of software Use of digital learning platforms Use of digital teaching aids Management of digital resources
2	Subject matter expertise	<ul style="list-style-type: none"> Ability to select learning content Ability to use learning content Ability to evaluate learning content Ability to create learning content
3	Attitudes to technology use	<ul style="list-style-type: none"> Confidence in using technology Motivation to use technology Emotional stability when using technology Optimistic attitude toward technology use

4	Pedagogical competence	Ability to plan and organize learning in a digital classroom Keeping up with the latest developments Innovating in teaching based on new technologies Evaluating student data produced via many digital platforms
5	Cultural consciousness	Ethics and internet etiquette Ability to recognize and avoid misleading information (hoaxes) Understanding of digital diversity and the digital divide in society
6	Analytical perspective	Evaluating the credibility of digital information sources, including websites, social media, and online publications Using critical thinking to plan and implement effective and relevant learning according to students' needs Analyzing learning problems and finding innovative solutions using digital technology Being critical in selecting the right digital technology for teaching
7	Professional involvement	Capability to cooperate and engage effectively with colleagues, students, caregivers, and other stakeholders via digital platforms. Ability to build a strong professional network Ability to develop professionalism

4 Conclusion

21st-century learning places strong emphasis on integrating information and communication technology with student-centered pedagogical approaches that suit both the subject matter and the learners. Consequently, teachers today must possess not only content knowledge and pedagogical expertise as well as the capacity to proficiently utilize technologies. Knowledge of technology is crucial for teachers, serving as a key factor in determining whether they can successfully incorporate technology into classroom instruction. Digital competence is described as the capability to utilize technology for problem-solving, complete tasks, and communicate effectively. Based on the literature review, Teachers' digital competence can be classified into the following domains: Information Literacy, Communication, Educational Content Creation, Collaboration and Adaptability, and the Effective Utilization of Technology in Learning.

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