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Global perspectives on Teacher ICT Competencies: diversity and commonalities in eight representative frameworks

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Abstract

This study comprehensively compares and analyzes eight representative global frameworks for teacher Information and Communication Technology (ICT) competencies, each reflecting regional educational priorities and philosophies. The research aims to transcend geographical boundaries by identifying consensus on key areas of teacher ICT competencies and exploring unique characteristics of each framework within specific educational contexts and challenges. The findings indicate that despite diversity, global teacher ICT competencies represent an integration of knowledge, skills, and values, particularly in digital society building, digital career development, digital communication and collaboration, digital assessment, digital teaching and learning, and development of students' digital competencies. The study further highlights varying emphasizes among frameworks in core areas and competencies, accompanied by varying levels of implementation support. Ultimately, the paper provides recommendations to assist educators, policymakers, and digital leaders in understanding global standards for teacher ICT competencies, developing effective and inclusive frameworks, and exploring best practices for advancing teacher ICT competencies.

KEYWORDS: Teacher ICT Competencies Framework; Comparative Analysis; Information and Communication Technology.

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1. Introduction

The digital age has ushered in a new era of educational reform, especially in the post-pandemic period, where Information and Communication Technology (ICT) has become an indispensable part of the global teaching and learning process. As ICT permeates classrooms worldwide, the competencies required for teachers to effectively integrate ICT into their teaching have garnered widespread attention. ICT does not only impact teachers' professional capabilities but also significantly expands their scope of activities. Teacher ICT competencies has become an essential component of modern teacher qualifications (Skakun, 2021).

An ICT competencies framework is a tool designed to develop or assess the ICT competencies of a specific target group based on a set of interrelated competencies (Ferrari et al., 2012). To support the measurement of teacher ICT competencies, predict training needs and development requirements, or explore their application in specific contexts, various teacher ICT competencies frameworks have been designed by national education departments, supranational organizations, and professional bodies worldwide (Nguyen & Habók, 2023).

The development and formation of ICT competencies for students and teachers across all educational stages is a priority in new education standards. However, considerable debate in the literature about the precise definition, nature, and scope of teacher ICT competencies, and how best to develop it in initial teacher education were published.

According to the Technology, Pedagogy And Content Knowledge (TPACK) model, teacher knowledge is categorized into Technical Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK), as well as their intersections (Mishra & Koehler, 2006). It outlines what is taught and how the teacher

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delivers that content, and should form the basis of any effective integration of technology to enhance the student learning experience. The Substitution, Augmentation, Modification, and Redefinition (SAMR) Model illustrates how technology can be integrated into tasks to transform learning, progressing from a lower level of enhancement to a higher level of transformation (Puentedura, 2003). Pragmatists represented by these two models emphasize the ability to effectively integrate technology, pedagogy, and content knowledge to enhance subject knowledge outcomes. Other discussions include broader interpretations, encompassing personal "digital dispositions" and behaviors such as personal privacy, cyberbullying, and the impacts of ICT on human health, society, and the environment, called "digital wellbeing" (Falloon, 2020).

Some scholars have revealed the relationship between the development of teacher ICT competencies and the transformative activities within the school's informational and educational environment (Yuldasheva, 2021). Mastery of resources, participation in lifelong education systems, engagement in innovative activities, transformation of teaching systems, and the creation of local educational environments all influence the level of teacher ICT competencies. Yuldasheva (2021) identifies three components of teacher ICT competencies: (1) functional ICT literacy sufficient to support teaching; (2) the effective and informed use of ICT to achieve professional, social, and personal goals; (3) understanding ICT as a new educational paradigm These competencies involve cultivating learners capability in creating knowledge and knowing how to use vast amounts of information to achieve intellectual and active outcomes, thus becoming contributors to the society.

Based on those findings, our study conducts a comprehensive comparative analysis of eight representative teacher ICT competencies frameworks from various parts of the world and discusses their commonalities and diversities. These frameworks provide a structured approach in defining and assessing the ICT competencies needed for teachers to effectively fulfill their duties, reflecting the priorities and educational philosophies of their regions of origin. On the one hand, this study aims to reach a consensus on the main areas of teacher ICT competencies that transcend geographical boundaries, identifying the core and peripheral areas of current teacher education. On the other hand, this study explores the unique characteristics of each framework in specific educational environments and challenges, uncovering the complex interactions between local needs and global trends.

The purpose of these comparative analyses and discussions is not to undermine or question the validity and relevance of existing frameworks. On the contrary, this study aims to embrace the diversity to stimulate debate about the needs for teacher ICT competencies in an increasingly diverse society in terms of culture, language, and technology. We hope that this study can contribute to the educators, policymakers, and digital leaders, fully harnessing the potential of ICT in education.

2. Materials and Methods

This study employs a case-oriented comparative method and thematic analysis as the overarching qualitative methodology. The case-oriented comparative method can supplement comparative

No.	Name	Organization/Author	Country/Area	Publication Year	Accessibility
1	ISTE standards for educators: a guide for teachers and other professionals (ISTE Standard)	The International Society for Technology in Education (ISTE)	USA	2017	https://cdn.iste.org/www-root/Downloads/Downloads/Download-4070.pdf
2	Digital Competence Framework for Educators (DigCompEdu)	European Commission (EU)	International	2017	https://publications.jrc.ec.europa.eu/repository/handle/JRC107466
3	UNESCO ICT competency framework for teachers (ICT CTF) Version 3	UNESCO	International	2018	https://unesdoc.unesco.org/ark:/48223/pf0000265721
4	Professional Development Framework for Digital Learning (PDF-FDL)	Department of Basic Education (DBE)	South African	2018	https://www.education.gov.za/Resources/Publications.aspx
5	Digital literacy of teachers (DLoT)	Ministry of Education of the People's Republic of China (MOE of PRC)	China	2022	http://www.moe.gov.cn/srcsite/A16/s3342/202302/W020230214594527529113.pdf
6	Building digital capabilities framework (BDCF)	Joint Information Systems Committee (JISC)	UK	2022	https://repository.jisc.ac.uk/8846/1/2022_Jisc_BDC_Individual_Framework.pdf
7	Educators' Digital Competence Framework (EDC Framework)	UNICEF Regional Office for Europe and Central Asia (ECARO)	the Western Balkans	2022	https://www.unicef.org/eca/media/24526/file/Educators'%20Digital%20Competence%20Framework.pdf
8	Digital Teaching Professional Framework (DTPF) Version 2	Education and Training Foundation (ETF)	UK	2023	https://www.et-foundation.co.uk/wp-content/uploads/2023/06/ETF-DTPF-Full.pdf

Table 1 - Information on eight representative frameworks.

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analysis that cannot be systematically monitored due to a lack of case numbers through logical reasoning (Porta & Keating, 2008). Thematic analysis focuses on identifying and refining themes, exploring the intrinsic connections within qualitative data, and Thomas (2006) proposed data summarization process provides effective guidance. These two methods complement each other, offering an in-depth perspective for understanding the connections between different frameworks.

2.1 Data Strategies

This study reviewed 35 national and international teacher ICT competencies frameworks and finally identified 8 representative frameworks for analysis. Table 1 describes their basic information and sources. The inclusion and exclusion criteria for the frameworks are as follows:

- Frameworks widely recognized and adopted in global education systems;
- Frameworks focusing on a comprehensive view of teacher ICT competencies;
- Frameworks published or continuously updated after 2017;
- Frameworks published in English or Chinese.

2.2 Topic Setting

This study utilizes the computer-assisted qualitative analysis software NVivo for coding, conducting a cross-sectional comparison of teacher ICT competencies frameworks through the following topics:

- Framework structure;
- Definition of ICT competencies;
- Objectives and scope;
- Theoretical foundations;
- Framework content;
- Support resources;
- Implementation.

3. Results

3.1 Framework Structure

To facilitate understanding and readability, this study first provides an overview of the structure of the eight representative frameworks, and their original images are presented in Appendix.

3.1.1 ISTE standards for educators: a guide for teachers and other professionals (ISTE Standard)

The ISTE Standards recognize the need for educators to leverage technology and tools to achieve optimal practice and promote student-centered learning. Educators effectively serve as both empowered professional and learning transformation catalysts, the ISTE Standards identify seven standards that educators should possess:

- Learner;
- Leader;
- Citizen;
- Collaborator;
- Designer;
- Facilitator;
- Analyst.

The learner standard emphasizes educators' responsibility to learn from and collaborate with others to improve teaching and learning. The leader standard encourages educators to seek leadership opportunities to support student empowerment and success. The citizen standard highlights educators' role in inspiring students to contribute positively and engage responsibly in the digital world. The collaborator standard focuses on educators working with colleagues and students to enhance practice, share resources, and solve problems. The designer standard requires educators to create authentic, learner-driven activities and environments. The facilitator standard expects educators to use technology to support students in meeting ISTE student standards. The analyst standard involves using data to inform instruction and help students achieve their learning goals.

The first three standards are categorized as "empowered professional," and the latter four as "learning catalyst." Each standard is initially interpreted through its statement and indicators, detailing how technology is utilized. There is a total of 24 standard statements and 66 indicators, with three examples of successful implementation provided for each. The ISTE Standards also include reflective questions and tips sections for each indicator, with 71 questions and 128 tips in total.

3.1.2 Digital Competence Framework for Educators (DigCompEdu)

DigCompEdu proposes six areas of teacher ICT competencies:

- Area 1 Professional engagement;
- Area 2 Digital resources;
- Area 3 Teaching and learning;
- Area 4 Assessment;
- Area 5 Empowering learners;
- Area 6 Facilitating learners' digital competence.

Area 1: Professional engagement focuses on educators engaging professionally with stakeholders for personal and organizational development in the broader professional context. Area 2: Digital resources cover the effective and responsible use, creation, and sharing of digital learning resources. Area 3: Teaching and learning involve managing and coordinating digital technologies in teaching. Area 4: Assessment uses digital strategies to enhance assessment. Area 5: Empowering learners emphasizes learner-centered teaching using digital technology. Area 6: Facilitating

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learners' digital competence details teaching capabilities to promote students' digital competence. These areas are not parallel to each other. Area 1 is seen as educators' professional competencies, areas 2-5 as educators' pedagogical competencies, and area 6 as learner's competencies.

DigCompEdu features a three-block, six-level Progression Model, linked to the Common European Framework of Reference for Languages (CEFR) and Bloom's taxonomy. In Newcomer (A1) and Explorer (A2), educators absorb new information and develop basic digital practices. Integrator (B1) and Expert (B2) involve applying, expanding, and reflecting on digital practices. Leader (C1) and Pioneer (C2) focus on disseminating knowledge, critiquing, and developing new practices.

The six areas of DigCompEdu cover 22 competencies, each with a descriptor, progression and proficiency statements, and examples of typical activities for each level, totaling 156 activities. Notably, the progression model is intended as a reflective tool, not a prescriptive framework or performance assessment.

3.1.3 UNESCO ICT competency framework for teachers (ICT CTF) Version 3

The ICT CFT forms a two-dimensional structure with 18 teacher competency elements. It's organized vertically into the following six aspects:

- Understanding ICT in Education Policy;
- Curriculum and Assessment;
- Pedagogy;
- Application of Digital Skills;
- Organization and Administration;
- Teacher Professional Learning.

The six aspects of ICT application can be horizontally categorized into three progressive levels, which align with how teachers typically adopt technology, becoming progressively more complex with less emphasis on the technology itself. The levels are:

- knowledge acquisition;
- knowledge deepening;
- knowledge creation.

The first Knowledge Acquisition aims for teachers help diverse students use ICT and become effective learners and productive members of society. Then Knowledge Deepening require teachers assist students in applying knowledge to solve complex, real-world problems. The last Knowledge Creation ask teachers to engage in innovation and lifelong learning, designing activities and plans that support these goals inside and outside the classroom. This stage is transformative, promoting the highest levels of Bloom's taxonomy.

Each level is divided into six areas, and teachers generally possess competencies in all three levels, with varying strengths in different areas. ICT CFT provides detailed explanations in tabular form for each of the 18 teacher competencies, including curricular goals, teacher competencies, objectives, and total 83 example activities.

3.1.4 Professional Development Framework for Digital Learning (PDF-FDL)

PDF-FDL views teacher ICT competencies as essential for beginner teachers. It builds on this foundation within two contexts: the Integrated Strategic Planning Framework for Teacher Education and Development in South Africa 2011-2025, and the seven collective roles of the educator. The former expands the application scope of teacher ICT competencies into three key areas of curriculum integration:

- Professional Growth and Knowledge;
- Curriculum Focus;
- Leadership.

Professional Growth and Knowledge requires teachers to explore digital tools for their own development, enhancing learner engagement and learning value. Curriculum Focus demands continual and appropriate use of digital tools to achieve curriculum goals. Leadership expects teachers to demonstrate a vision for digital learning and take responsibility for its implementation and development. These three areas encompass 13 digital learning competencies, each with indicators, applicability for educators in different contexts, and requirements for knowledge, skills, and attitudes, totaling 52 indicators and 44 requirements.

PDF-FDL extends the application of teacher ICT competencies to the seven collective roles of the educator, they are Specialist; Learning Mediator; Interpreter and Designer; Leader, Administrator, and Manager; Scholar, Researcher, and Lifelong Learner; Assessor; Community, Citizenship, and Pastoral Role. These roles highlight various aspects of educators' responsibilities, emphasizing how ICT competencies enhance their effectiveness across these functions.

3.1.5 Digital literacy of teachers (DLoT)

DLoT specifies five dimensions of teacher ICT competencies requirements:

- Digital awareness;
- Digital technology knowledge and skills;
- Digital application;
- Digital social responsibility;
- Professional Development.

Digital awareness involves teachers' digital activities. Digital technology knowledge and skills encompass the knowledge and skills teachers need for daily educational activities. Digital application refers to the use of digital resources for educational activities, including instructional design, teaching implementation, academic assessment, and collaborative education. Digital social responsibility includes ethical behavior in digital activities, such as protecting personal information, maintaining data security, and ensuring network security. Professional

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development involves using digital resources for personal and community growth. DLoT details these areas through 13 secondary dimensions, refined into 33 tertiary dimensions.

3.1.6 Building digital capabilities framework (BDCF)

The BDCF framework centers on digital proficiency and productivity. Digital proficiency involves using digital devices, networks, applications, software, and services, while digital productivity refers to utilizing digital skills to accomplish tasks. Expanding further outward from them, ICT competencies divide into the following five areas:

- Digital creation, problem-solving and innovation;
- Digital learning and development;
- Information, data and media literacies;
- Digital communication, collaboration and participation;
- Digital identity and wellbeing.

Digital creation, problem-solving, and innovation involve the ability to digitally produce, make decisions, solve problems, and innovate with digital technologies. Digital learning and development is about gaining personal learning benefits from digital resources and supporting others in digital environments. Information, data, and media literacies including finding, evaluating, organizing, and sharing information, processing data, and responding to digital media. Digital communication, collaboration, and participation encompass all means of communicating and collaborating in digital media and networks to achieve a specific goal. Digital identity and wellbeing require to develop and manage digital identities and reputations, and control ICT's impact on oneself.

To aid understanding, BDCF breaks each area into several elements, with reflective questions and practical examples. The five areas comprise 13 elements and 50 examples in total.

3.1.7 Educators' Digital Competence Framework (EDC Framework)

The EDC framework divides teacher ICT competencies into four progressively advancing areas:

- Knowledge development;
- Knowledge application;
- Knowledge sharing;
- Knowledge communication.

The Knowledge Development area covers educators' digital competencies related to digital teaching and learning, focusing on their connection to national policies, digital teaching methods, learning, and assessment approaches. The Knowledge Application area involves promote effective learning, responsible ICT use, and problem-solving, aiming to develop, disseminate, and create new knowledge. The Knowledge Sharing area explores the use of communities of practice (CoP) to enhance competencies for constructive dialogues, fostering a collaborative professional culture. The Knowledge Communication area focuses on using digital technologies to support organizational communication, improving communication with learners and stakeholders, and ensuring the safe and responsible use of digital resources.

These four areas are subdivided into 12 subareas with 21 competencies, each containing several objectives, totaling 93 objectives. This framework provides detailed answers to "what" and "how" questions, outlining the competencies needed for innovative and inclusive digital education and explaining how to support digital education in areas such as environment, communication, and learning.

3.1.8 Digital Teaching Professional Framework (DTPF) Version 2

DTPF interprets teacher ICT competencies across 7 areas:

- Planning your teaching;
- Approaches to teaching;
- Supporting learners to develop employment skills;
- Subject and industry specific teaching;
- Assessment;
- Accessibility and inclusion;
- Self development.

Planning your teaching encourages the use of digital technology to enhance teaching and learning. Approaches to teaching involves using resources to promote learner engagement in various instructional scenarios, including face-to-face, blended, online, and hybrid learning. Supporting learners to develop employment skills uses digital technology to improve learners' employment prospects. Subject and industry-specific teaching organizes professional development activities to enhance subject knowledge and industry awareness. Assessment uses digital technology to improve assessment and feedback. Accessibility and inclusion ensure all learners can fully utilize digital technology. Self-development encourages reflection on professional practice, continuous professional development, and promoting safe digital identities.

These seven areas contain 21 competencies, with specific activity descriptions (170 total) and exemplary descriptions for three proficiency levels: Exploring, Adopting, and Leading, based on DigCompEdu. Each competency also includes a key indicating how components map across five reference models, highlighting connections and relationships between DTPF and these frameworks.

3.2 Definition of ICT Competencies

The frameworks use inconsistent terms, with "digital literacy," "digital capability," "digital competence," and "ICT literacy" all being synonyms for "ICT

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competencies." The ISTE standards and DTPF do not explicitly define ICT competencies. DigCompEdu, BDCF, and PDF-FDL regard ICT competencies as fundamental life skills, including attitudes towards ICT. ICT CFT focuses on using ICT to perform tasks, while DLoT restricts this to teachers' educational work, emphasizing awareness, ability, and responsibility. Despite the contrary, both frameworks emphasize understanding, processing, and presenting information using ICT. The EDC Framework uses the ICT CFT definition, since they both originate from UNESCO.

3.3 Objectives and Scope

Except for DLoT and PDF-FDL, which are published as standards, other frameworks serve as references to enhance teacher ICT competencies, supporting adaptation to local contexts. DigCompEdu, ICT CTF, EDC Framework and PDF-FDL are aimed at equity and inclusion in education, while the first three of these also promote lifelong learning. DLoT, DTPF, DigCompEdu, ICT CTF, and PDF-FDL foster ICT use in education and innovation, and the last two highlight updates due to ICT advancements. ISTE Standards aim to help educators recognize their roles as catalysts for transforming learning and fostering student independence.

Most frameworks support various educational stages and provide guidance in policy-making, training, reflection, practice, and assessment. BDCF extends its scope to employees and students in any role. However, EDC Framework targets primary and secondary education policy-making, DLoT focuses on teacher training and evaluation, and DTPF is for further and TVET education. Only ICT CTF recommends including ICT training in teachers' professional development cycles, covering pre-service and in-service training, both formal and informal.

3.4 Theoretical Foundations

Despite the different structural frameworks of the ICT CTF and the DigCompEdu, both coincidentally referred Bloom's taxonomy to categorize stages/levels of teachers' ICT competencies. This helps educators reflect on their proficiency levels and identify specific development needs. Both frameworks also provide a solid foundation for the construction of other frameworks; the EDC Framework and the DLoT align to some extent with the DigCompEdu and the ICT CTF (China Education Newspaper, 2023).

The PDF-FDL, the ISTE Standards, and the BDCF do not include any description of theoretical foundations, while the DTPF draws broader references from the ETF's Professional Standards for Teachers and Trainers; the ETF's Professional Standards for Aspiring Leaders; the ETF's Professional Standards for Middle Leaders; the BDCF and the DigCompEdu.

In addition, SAMR model and TPACK model have also been widely applied (Mishra & Koehler, 2006; Puentedura, 2003). For instance, PDF-FDL provides a TPACK-based lesson analysis tool and SAMR-based progress assessment standards. DTPF also demonstrates how to use the SAMR model within its framework.

3.5 Framework Content

NVivo software was adopted to perform a thematic analysis of the content from those 8 ICT competencies frameworks, categorizing it into 9 competencies and 28 sub-competencies, as shown in Table 2. It has been shown that, based on differences in national contexts and educational backgrounds, the areas covered by these frameworks overlap to some extent, but they emphasize different roles played by teachers.

DLoT emphasizes teachers as citizens and designers, focusing on digital society building, digital assessment, and digital teaching and learning. This makes it more suitable for foundational education stages but overlooks teachers' roles as leaders, collaborators, and facilitators (Liu & Yi, 2023). Despite emphasizing ICT skills and knowledge, DLoT lacks specific ICT types and application examples, which may challenge in-service teachers in becoming learners.

The development of ICT CFT is evidence-based, incorporating feedback from global experts, educators, policymakers, school administrators, and teachers. Thus, it emphasizes teachers as designers and collaborators, focusing on interdisciplinary collaboration, negotiation, and stakeholder interaction. It coordinates pre-service and in-service teacher ICT competencies training, providing a framework for digital teaching transformation (Dai & Huangfu, 2021; Lan et al., 2021). However, as a universal framework, it only briefly mentions specific technological innovations without detailed analysis.

The BDCF's rich descriptions of digital awareness, ICT knowledge and skills, digital society building, and digital career development reflect teachers as both citizens and learners. DigCompEdu, DTPF, ISTE standards, PDF-FDL, and the EDC Framework emphasize teachers as facilitators, serving student needs and supporting development. DigCompEdu offers a comprehensive overview of teacher digital competencies for people to fully perceive, understand, and evaluate (Lai et al., 2023; Yan & Liu, 2022). In contrast, BDCF fail to reflect the facilitator role, while PDF-FDL also emphasizes teachers as collaborators.

This study conducted a statistical analysis of the frequency of descriptions for each competency, as shown in Figure 1. "Development of Students' Digital Competencies" is the most emphasized teacher competency, aligning with the current "student-centered" educational philosophy (Shehata et al., 2024). The description frequency of "Digital Inclusive Education" is only 5%, partly because some

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frameworks, like DLoF, do not include "equity and inclusion" or covering only certain sub-competencies. Moreover, "inclusive education" is often presented as a philosophical concept within frameworks, lacking detailed elaboration.

The proportions of competencies such as Digital Society Building, Digital Career Development, Digital Communication and Collaboration, Digital Assessment, and Digital Teaching and Learning are relatively similar, indicating their importance as supported by various frameworks.

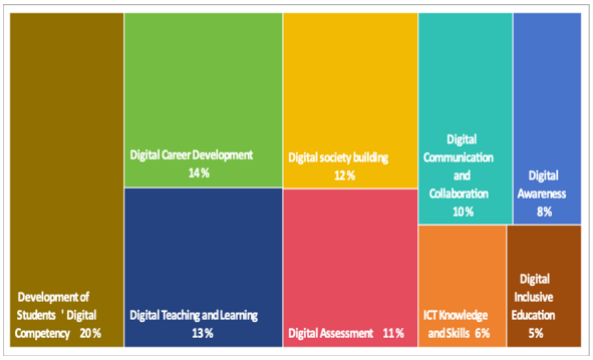

Figure 1 - The frequency of descriptions for each competency.

For the competencies of Digital Awareness and ICT Knowledge and Skills, different frameworks exhibit significant variation in interpretation. Digital Awareness can be viewed as an intermediate variable, suggesting that frameworks should assume teachers using them already possess adequate digital awareness. Alternatively, Digital Awareness can be seen as an aspect of teacher ICT competencies, which encompass a combination of knowledge, skills, and values.

The TPACK theory from Mishra & Koehler (2006) provides framework developers with the option to construct frameworks from different perspectives: either treating TK as standalone competencies (including the description of ICT Knowledge and Skills) or describing it through TCK, TPK, and TPCK (excluding the specific description of ICT Knowledge and Skills).

3.6 Support Resources

To support the explanation and understanding of frameworks, most manuals provide explanations of related terms or vocabulary. For example, the EDC Framework, ICT CTF, and PDF-FDL manuals include glossaries. The ICT CTF manual also discusses emerging technologies and international principles extensively. Manuals are tailored for readability and meet educators' diverse needs, with options like the "In Brief" and detailed "In Detail" versions in the EDC Framework and DTPF. DigCompEdu offers three versions: Nutshell, Explained, and Detail. Frameworks often include modules to aid implementation; for instance, ICT CTF showcases numerous case studies, and DTPF integrates the SAMR model. The ISTE standards detail alignment with other frameworks and standards, featuring adoption and implementation profiles, tips, and essential conditions modules. PDF-FDL includes self-assessment tools and progress, professional development activities, a TPACK model-based lesson analysis checklist, learning activities, and a digital learning progress rubric with the SAMR model context.

Frameworks are also supported by a wealth of digital resources. ICT CTF, BDCF, DigCompEdu, and ISTE Standards offer online courses and multilingual translations. DTPF, DigCompEdu, BDCF, ISTE Standards, and EDC Framework provide self-reflection tools, posters, research, reports, and other digital resources. Both ETF and ISTE offer professional certification services. JISC not only offers personalized frameworks for practitioners in different roles, but also organizational-level frameworks for digital leaders.

3.7 Implementation

The ICT CFT has had a global impact, influencing education policies, national teacher standards, ICT competencies assessments, curriculum design, and professional development across Latin America and the Caribbean, Asia and the Pacific, Europe, and North America (UNESCO, 2018). In the EU, more than 20 major studies on teacher ICT competencies have been conducted, resulting in over 120 publications aimed at helping member states tailor teacher training to national contexts (European Commission, n.d.). DigCompEdu has gained widespread recognition among scholars, framework developers, and educational departments globally, establishing itself as a fundamental framework for teacher ICT competencies worldwide.

Since 2018, supported by the South African Department of Basic Education, PDF-FDL initiatives have included roadshows, conferences, workshops, online courses, self-reflection portals, electronic portfolios, and Professional Learning Communities (PLCs) on online platforms (Department of Basic Education, n.d., 2018). The ISTE Standards are continuously researched and updated, adopted in all 50 U.S. states and numerous countries globally (International Society for Technology in Education, n.d.). In 2021, the ETF supported 3,226 teachers, trainers, and assessors, with 91% of ICT teachers recommending DTPF courses (Education and Training Foundation, n.d.). In 2022, ETF introduced a new learning management system, implementing BDCF-based training courses and strategies in UK schools (Joint Information Systems Committee, n.d.).

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Competency	Sub-Competency	Description	ISTE Standard	DigCompEdu	ICT CTF	PDF-FDL	DLoT	BD CF	EDC Framework	DTPF
Digital Awareness	Digital Cognition	Understanding the value of ICT in economic, social, and educational development.			√		√	√	√	√
		Understanding the opportunities and challenges brought by the development of ICT to education and teaching.			√	√	√	√		
	Digital Attitude	The willingness to actively learn and use ICT resources.					√			
		The initiative to engage in educational digital practices, exploration, and innovation.	√			√	√	√		
	Digital Willpower	The confidence and determination to overcome difficulties and challenges encountered in educational digitization.					√			
ICT Knowledge and Skills	ICT Knowledge	Understanding common concepts and basic principles of ICT.			√	√	√	√		
	ICT Skill	Acquiring, evaluating, organizing, using, and disseminating information on digital platforms.	√		√	√		√		√
		Mastering the principles and methods of using and selecting digital devices, software, and platforms for teaching.	√		√	√	√	√		
Digital society building	Law and Ethics	Compliance with Internet laws and regulations, regulating various online behaviors conscientiously.	√		√		√	√		
		Respecting intellectual property rights, maintaining a balance between the digital environment and personal health, safety, interpersonal relationships, as well as work and life (digital wellbeing).	√	√	√		√	√	√	√
		Adhering to online communication norms, engaging in civilized communication, and safeguarding the privacy of personal communication.	√		√		√	√		
	Digital Security Protection	Managing and protecting personal information, privacy data, and digital identity, and maintaining one's digital reputation.	√		√		√	√		√
		Prioritizing the security maintenance of student, parent, business, and research data.	√	√			√	√	√	√
		Identifying, preventing, and dealing with online risks such as rumors, cyberbullying, telecommunications fraud, and information theft.	√	√	√		√			√
Digital Career Development	Digital Learning	Keeping updated on developments in relevant industry fields.						√		√
		Using ICT resources for continuous learning according to personal development needs.	√	√	√	√		√	√	√
		Using ICT resources to analyze personal teaching practices, supporting reflection and improvement in teaching, scientific research, industry-academia-research collaboration, social services, etc.	√	√		√	√	√	√	√
	Digital Research and Innovation	Using ICT resources to support research activities such as teaching, scientific research, industry-academia-research collaboration, and social services, etc.				√				
		Using ICT resources to Continuously innovative teaching models, improve teaching activities, and transform student learning methods.	√	√		√	√	√	√	√
	Digital Leadership	Participating in, promoting, and assisting colleagues in digital education practices.	√	√	√				√	√
		Promoting further development of organizational practices, policies, and visions related to ICT usage actively.	√	√	√	√		√	√	√
Digital Communication and Collaboration	Peer Communication and Collaboration	Using ICT to support dialogue, collaboration, cooperative learning, and innovation among peers.	√	√	√	√	√	√	√	√
	Teacher-Student Communication and Collaboration	Using ICT to support dialogue, collaboration, cooperative learning, and innovation between students and teachers.	√	√	√	√	√	√	√	√
	School-Enterprise Communication and Collaboration	Using ICT to support dialogue, collaboration, cooperative learning, and innovation between teachers and stakeholders such as industry.		√	√			√	√	
	Home-School Communication and Collaboration	Using ICT to support dialogue and collaboration between teachers and parents.	√	√	√		√	√	√	

Table 2 - Thematic analysis of the content of the eight representative frameworks.

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(continued)

Competency	Sub-Competency	Description	ISTE Standard	DigCompEdu	ICT CTF	PDF-FDL	DLoT	BD CF	EDC Framework	DTPF
Digital Assessment	Strategy Selection and Optimization	Making rational choices and using ICT to enhance the diversity of assessment formats and methods.	√	√	√	√	√		√	√
		Designing and optimizing digital academic assessment strategies reasonably and flexibly.		√	√	√			√	√
	Tool Selection and Data Monitoring	Selecting and applying digital tools to monitor students' progress reasonably and collect multimodal academic assessment data.	√	√	√	√	√		√	√
	Data Analysis and Feedback	Selecting and applying appropriate models for data analysis and providing reasonable interpretations.	√	√		√	√	√		√
		Maximizing the use of digital tools for feedback and providing substantive feedback to stakeholders such as students and parents as soon as possible.	√	√						√
Digital Teaching and Learning	Digital Teaching and Learning Design	Collecting digital educational resources through multiple channels, and selecting, managing, and creating them based on teaching needs.	√	√	√		√	√	√	√
		Designing teaching activities that integrate ICT resources based on teaching objectives and student characteristics.	√	√	√	√	√	√	√	√
		Using ICT resources to overcome temporal and spatial constraints, integrating various learning environments such as online education, mobile learning, and blended learning.	√	√	√	√	√	√	√	√
	Digital Teaching and Learning Implementation	Using ICT resources to Organize teaching activities in an orderly manner, and to enhance student engagement and promoting proactive communication.	√	√	√	√	√			√
		Using ICT resources to identify students' learning differences and provide targeted guidance.	√	√			√		√	√
Digital Inclusive Education	Digital Moral and Psychological Education	Using ICT to conduct various forms of moral education and mental health education activities.					√			
	Inclusivity	Ensuring equitable access to appropriate ICT and resources, so that all students, including those with special needs, can access learning resources and activities.	√	√	√	√			√	√
	Personalization and Diversity	Using ICT to meet the diverse learning needs of students, enabling them to progress at different levels and speeds, and following their individual learning paths and goals.	√	√	√			√	√	√
Development of Students' Digital Competency	Digital Learning and Reflection	Cultivating students' ability to autonomously plan and support their learning using ICT.	√	√	√	√	√	√	√	√
		Cultivating students' ability to engage in self-reflection and self-assessment using ICT.	√	√	√				√	√
	Digital Skills and Creation	Developing students' fluency in using ICT.	√			√	√		√	
		Encouraging students to express themselves digitally, edit, and create digital content in various formats.	√	√					√	√
	Digital Communication and Collaboration	Cultivating students' ability to communicate, share, and collaborate with others using ICT.	√	√	√	√			√	√
	Digital Responsibility and Security	Enhancing students' literacy in organizing, storing, and retrieving data, information, and content in a digital environment (media literacy and information literacy).	√	√	√	√			√	√
		Instilling in students an awareness of using ICT responsibly to avoid risks and threats and to protect their physical and mental well-being (digital wellbeing).		√					√	√
		Instilling in students an awareness of copyright, privacy protection, and maintaining digital reputation.	√	√		√	√		√	√
	Digital Problem-Solving Thinking	Fostering students' critical thinking, computational thinking, problem-solving skills, and higher-order thinking using ICT.	√	√	√		√		√	√
	Digital Organization and Entrepreneurship	Encouraging students to use ICT to develop project plans, assign tasks to group members, set progress standards, and allocate responsibilities.			√					
		Developing students' financial digital skills to support future self-employment or freelance careers.								√

Table 2 - Thematic analysis of the content of the eight representative frameworks.

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The EDC Framework, under the LearnIn initiative, is being systematically implemented in several Western Balkan countries with comprehensive support from ECARO, including platforms, content, national tasks, internet access, and devices (UNICEF ECARO, 2021). In China, provincial education bureaus have launched teacher digital enhancement projects based on DLoT, such as the ongoing Teacher Digital Enhancement Project 2.0 in Guangdong Province (Guangdong Education Department, 2020).

4. Discussion and Conclusions

4.1 Commonalities

From a global perspective, teacher ICT competencies represent a fusion of knowledge, skills, and values, focusing on how teachers acquire, process, and convey information. The objectives of the eight representative frameworks for teacher ICT competencies are inherently aligned with Sustainable Development Goal 4 (SDG 4), which aims to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (United Nations, 2022).

These frameworks articulate their core areas through structured divisions, supported by detailed lists that expand on statements, indicators, and examples of activities. In today's digital era, it is crucial for educators to enhance the usage ICT to foster their own professional growth, foster a digital social environment, engage in digital communication and collaboration, drive digital teaching transformations, and importantly, nurture students' ICT competencies. These areas have transcended geographical boundaries, achieving global consensus.

To facilitate the effective implementation of these frameworks, developers have provided extensive resources, particularly digital ones. These efforts have proven impactful, benefiting teachers worldwide to varying extents through comprehensive support and resources.

4.2 Diversity

The diversity in educational environments globally necessitates nuanced approaches to developing teacher ICT competencies, leading to variations in requirements, terminology, definitions, goals, and scopes across the eight representative frameworks. Each framework places unique emphasis based on regional and educational needs. For instance, while some prioritize "equity and inclusion," others focus on fostering "educational innovation" as core objectives.

Secondly, frameworks delineate distinct core areas and competencies. The ISTE standards outline seven roles for teachers, emphasizing transformational learning. Frameworks like EDC, DigCompEdu, PDF-FDL, and ISTE underscore the role of "Facilitator," whereas ICT CTF focuses more on "Collaborator." Others like DTPF highlight dual roles such as "Facilitator" and "Collaborator"; DBCF focus on "Citizen" and "Learner," and DLoT emphasizes "Designer" and "Citizen".

Finally, practical implementation support varies among frameworks. DigCompEdu and ICT CTF facilitate self-assessment based on Bloom's taxonomy, whereas DTPF and PDF-FDL utilize the SAMR model to aid implementation. The availability and richness of digital resources accompanying these frameworks depend on factors like developer influence, funding levels, and expert involvement.

4.3 Conclusions and Recommendations

In conclusion, this study comprehensively analyzes eight representative frameworks from around the world, elucidating the commonalities and differences in the global landscape of teacher ICT competencies. This study aims to contribute to the ongoing dialogue about shaping the future of teacher education, helping educators, policymakers, and digital leaders understand global standards for teacher ICT competencies, develop effective and inclusive frameworks, and explore best practices for the development of teacher ICT competencies.

We recommend that future researchers delve deeply into the educational needs of different regions, ensuring that the teacher ICT competencies framework for is closely aligned with local policies and cultural contexts. On this basis, further develop a teacher ICT competencies framework that meets the needs of various educational stages. Additionally, we advocate for empirical research to assess the effectiveness of these frameworks in practical application, to ensure they can truly enhance the professionalism of teachers.

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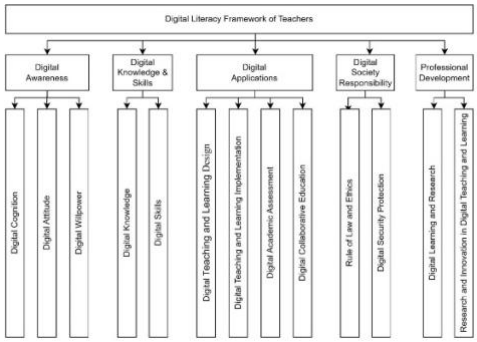
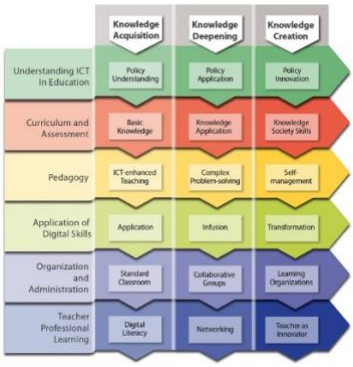
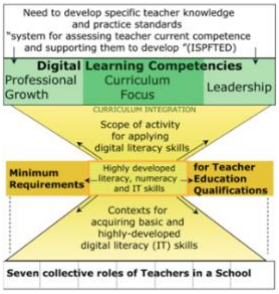
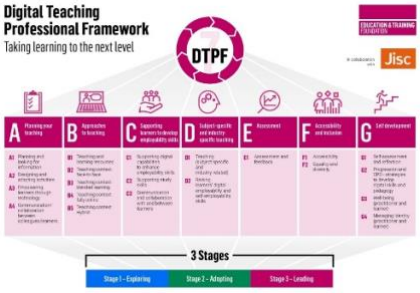
Appendix - Original Images of Eight Representative Frameworks

No.	Name	No.	Original Image
1	 ISTE standards for educators: a guide for teachers and other professionals (ISTE Standard, 2017)	5	 Digital literacy of teachers (DLoT, 2022)
2	 Digital Competence Framework for Educators (DigCompEdu, 2017)	6	 Building digital capabilities framework (BDCF, 2022)
3	 UNESCO ICT competency framework for teachers (ICT CTF, 2018) Version 3	7	 Educators' Digital Competence Framework (EDC Framework, 2022)
4	 Professional Development Framework for Digital Learning (PDF-FDL, 2018)	8	 Digital Teaching Professional Framework (DTPF, 2023) Version 2

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