

Assessment of ICT Competencies Among Primary School Teachers for Teaching and Learning in Ileje District, Songwe Region: A Literature review

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Abstract

This study examines the integration of information and communication technology (ICT) in primary education, focusing on teacher competencies, infrastructure, and pedagogical practices. It highlights global and national frameworks such as UNESCO's ICT Competency Framework for Teachers and the European DigCompEdu, which outline progressive stages from basic ICT skills to advanced pedagogical integration and innovation. The research identifies persistent challenges in sub-Saharan Africa, including limited access to electricity, inadequate hardware and software resources, and gaps in continuous professional development. Evidence from Tanzanian contexts, particularly Ileje District, reveals that while basic ICT operational skills are commonly acquired, application of ICT-pedagogical competencies remains limited due to infrastructural constraints, insufficient institutional support, and fragmented training approaches. Innovative teaching strategies like project-based and blended learning are discussed as effective methods for embedding technology into curriculum delivery, contingent on teacher preparedness and resource availability. Assessment frameworks based on international standards provide tools for measuring ICT competence and integration effectiveness, linking teacher skills to improved educational quality and student outcomes. The findings emphasize the importance of leadership, infrastructure, and sustained professional development in advancing ICT use in classrooms. Future directions include promoting collaborative professional networks, ensuring equitable access to technology, and embedding ICT skill development within authentic teaching scenarios to enhance instructional practices and learner engagement.

Keywords: ICT competencies, Primary School Teachers, Teaching and Learning, ICT Use

1 Introduction

The integration of information and communication technology (ICT) into teaching practices has been widely studied, with research showing both its potential to enhance learning and the persistent barriers that hinder effective use in classrooms. While ICT can improve student skills, motivation, and knowledge, its success depends heavily on factors such as access to resources, teacher competencies, leadership support, and the specific ways technology is applied in different subjects (Bingimlas, 2009). Teachers' ability to competently use modern technologies in their instructional practices is considered fundamental for effective ICT integration in education. Studies highlight that technological competence among teachers supports active learning and can be influenced by internet connectivity, access to communication networks, data literacy, training programs, and updated infrastructure. In contexts like sub-Saharan Africa, large disparities in ICT skills are observed due to inadequate digital content use, minimal training opportunities, poor electricity supply, limited device availability, outdated curricula, restricted financing for continuous professional development (CPD), and reluctance among some educators to adopt technology (Kalinga & Ndibalema, 2023). Specific initiatives have sought to address these gaps. For example, Tanzania has adopted ICT competence standards for teachers based on UNESCO's ICT Competency Framework for Teachers (ICT-CFT), incorporating levels such as Knowledge Acquisition, Knowledge Deepening, and Knowledge Creation. These levels range from basic technological proficiency, using tools to supplement classroom practice, to more advanced capabilities where teachers identify learning needs requiring ICT interventions and apply appropriate technologies collaboratively. The competencies span six domains of professional practice: understanding ICT in education policies; curriculum and assessment; pedagogy; application of digital skills; organisation and administration; and professional learning. Despite these frameworks, evaluations of ICT training projects between 2005 and 2014 have revealed persistent limitations in the application of developed competencies by tutors in teachers' colleges. Several large-scale initiatives, the ICT Project for Teachers' Colleges (2005–2008), Teacher Development and Management Strategy (TDMS) (2008–2013), and Teacher Education Support Project (TESP) (2017–2021), offered training in both basic ICT skills and ICT-in-education competencies across all public teachers' colleges. Basic skills included word processing, spreadsheets, presentations, databases, internet browsing, email communication, and social media use. However, actual adoption of these competencies within teaching varied substantially (Lubuva et al., 2022). Research also points out that technology integration into teaching is often

incomplete. Many educators may know how to operate computers but not apply them directly in classroom interactions with pupils. Attitudes toward ICT vary widely, some teachers view it as central to instructional improvement while others express anxiety or remain unconvinced about its benefits. Factors influencing adoption are multifaceted: they encompass individual determinants such as attitudes toward ICT utility in learning contexts; expectations of effectiveness; satisfaction with outcomes; technical mastery; collaborative capacity; and awareness of relevant pedagogical models. They also involve contextual determinants such as equipment availability; infrastructure; human resources for technical support; curriculum integration; leadership; policy backing; networking facilities; incentives for project development; systems for ongoing CPD; quality of pedagogical content; observatories for innovation; and alignment with national or regional curricular visions (Peralta & Costa, 2007). In sub-Saharan regions specifically, UNESCO-UIS data indicate that only 64% of primary school teachers and 50% of secondary school teachers have received minimum training on ICT use. Digital inequalities are shaped by demographic variables including age, educational level, employment situation, and access to necessary tools, teachers with positive perceptions toward technology tend to demonstrate higher competence levels compared to those holding negative attitudes. Rural schools often experience additional constraints through limited network connectivity and insufficient equipment (Kalinga & Ndibalema, 2023). Past research programs further illustrate how long-term teacher engagement with technology-rich environments can transform instructional practices. For example, projects such as PALM encouraged action research approaches where teachers experimented with classroom computer use alongside pupils. This model proved effective by strengthening technical skills through situated cognition, learning occurred during real classroom activities rather than isolated training sessions. Similarly, the Apple Classrooms of Tomorrow (ACOT) initiative provided substantial hardware resources coupled with ongoing training support over several years. Teachers progressed through identifiable phases from initial technical challenges toward full pedagogical integration over time (Mumtaz, 2000). Overall evidence suggests that while there exists extensive recognition of the potential benefits of ICT for enhancing both teaching quality and student achievement (Bingimlas, 2009), persistent infrastructural barriers and gaps in teacher competencies continue to limit its impact in many regions. Addressing these issues requires not only material provision but also sustained professional development aligned with pedagogical needs (Kalinga & Ndibalema, 2023; Lubuva et al., 2022), a reality especially relevant for districts such as Ileje within Songwe Region where this study is situated.

2 Background and Context of ICT in Education

2.1 Global trends in ICT integration in primary education

Global initiatives in ICT integration have largely emphasized aligning digital education policies with teacher competence frameworks to prepare students for a digitally oriented society. For example, the European Digital Competence Framework (DigComp) has been adopted and refined by various national authorities to describe the competences every citizen should acquire for life in a digital society, including information and data literacy, communication and collaboration, digital content creation, safety, and problem-solving. This framework has served as a reference point for guiding school-level strategies in several European Member States, illustrating how comprehensive models can inform both policy and practice. Drawing from this, the European Framework for the Digital Competence of Educators (DigCompEdu) focuses specifically on teachers' competences for integrating technologies into teaching. It identifies areas such as digital resource management, planning and orchestrating technology use to promote collaborative and self-regulated learning, using digital tools for assessment, designing personalised pathways for learners, and ensuring safe and responsible technology use by students (Caena & Redecker, 2019). These competences are defined across six proficiency levels from beginner engagement with technology to advanced innovation and peer-to-peer expertise sharing. The progression model is intended to help educators reflect on their strengths and limitations in digital teaching practices. Beyond Europe, UNESCO has established versions of the ICT Competence Framework for Teachers that incorporate dimensions like understanding ICT in education policies, curriculum integration, pedagogical applications, administration and management of digital resources, and ongoing professional learning (Phan et al., 2020). This global model has been adapted by many countries to fit national contexts. The emphasis is generally on enabling teachers to efficiently store, process, communicate information electronically, and use such capabilities strategically in education. In developing regions such as sub-Saharan Africa, disparities in technological competence among primary school teachers remain substantial. Factors influencing these gaps include limited training access, poor infrastructure for electricity and internet connectivity, inadequate availability of computers and other devices, outdated teacher training curricula that lack ICT pedagogy components, insufficient financing for continuous professional development (CPD),

and reluctance by some educators to integrate technology into their teaching. Statistics indicate very low rates of primary schools with access to electricity, only 33.8%, and similar deficits in ICT-equipped facilities in upper-secondary institutions. Even where equipment exists in urban schools or private settings, actual pedagogical use depends heavily on individual teachers' interests, awareness of ICT potential for professional growth, institutional policies on technology integration, and internet access. Some countries have implemented targeted interventions to address these barriers. Tanzania's teacher ICT framework prioritises pedagogical purposes rather than solely technical skills. While facilities may be available in certain schools, desktop computers, laptops, printers, their classroom application hinges on teachers' competencies across domains similar to those outlined by UNESCO. Such frameworks often highlight three stages: knowledge acquisition through basic ICT use; knowledge deepening via strategic integration into subjects; and knowledge creation involving collaborative application of ICT for instructional innovation (Kalinga & Ndibalema, 2023). In other contexts like Indonesia, 21st-century learning principles influence ICT deployment at the primary level. Here the constructivist view promotes shifting instruction from teacher-centred approaches toward student-centred activities bolstered by collaborative learning through technology. Teachers select appropriate instructional media aligned with curriculum content to improve engagement and reduce boredom. Their choices extend beyond presentation tools to fostering cognitive flexibility among learners by encouraging reflection and social interaction; this shift is supported by research showing positive attitudes towards collaborative learning when ICT is applied effectively (Machmud et al., 2021). Similarly structured approaches appear in literature examining NETS-T standards that assess teachers across six dimensions: mastery of technology operations; planning effective learning environments; integrating technology into curriculum delivery; diversifying assessment methods using digital tools; enhancing productivity through professional practice; and upholding ethical standards in technology use (Yieng & Daud, 2018). Globally recognised benchmarks like these enable evaluation of both successes and shortcomings in teacher preparedness. Evidence also points to persistent challenges worldwide despite policy frameworks. In science education contexts analysed by Becta (2003 & 2004), successful integration hinges upon variables such as ICT resourcing levels within schools, leadership support structures both at ICT-specific and general teaching levels, quality of initial training programmes on technology use for pedagogy, as well as adaptability to different curricula (Bingimlas, 2009). Results vary considerably between subjects or even classes depending on how technologies are applied. Ultimately current global trends show convergence toward competency-based frameworks that articulate clear domains of teacher capability with respect to technology. They also reveal divergence where infrastructural inequalities shape practical outcomes in classrooms, particularly stark between well-resourced urban systems adopting international standards like DigCompEdu or UNESCO's models versus rural systems constrained by minimal power supply or device availability (Caena & Redecker, 2019; Kalinga & Ndibalema, 2023; Phan et al., 2020).

2.2 National policies and strategies on ICT in education

At the national and regional levels, policy initiatives have sought to frame ICT integration in education through comprehensive competence-based approaches. In Europe, for instance, the adoption of frameworks like DigComp has guided school education policies by delineating the digital competence all citizens should acquire, covering domains from information literacy to problem-solving. National authorities such as Germany's Kultusministerkonferenz have refined DigComp into country-specific standards for students' digital competence. Building on this, the European Framework for the Digital Competence of Educators (DigCompEdu) focuses explicitly on educator-specific ICT competences. It has been incorporated into training courses and guidelines for teachers in some Member States and regions, including Saarland in Germany, and is planned for use in Portugal and Croatia. Spain's CRUE network intends to deploy it for continuous professional development of academic staff, while organisations such as the German Adult Education Association and the Goethe Institut seek to embed it in lecturer training. The integration process varies with national specificities, needs, and policy cycles. Translation of framework reports into target languages has supported uptake. Formal adoption at national or regional levels is not considered the sole pathway; evidence shows that policy success often depends on achieving teacher buy-in, engagement, and ownership. To address this, an online self-assessment tool aligned with DigCompEdu was developed in multiple languages to condense key ideas into practical activities relatable to teachers. Feedback is offered according to individual competence levels across 22 indicators. The tool's creation involved iterative expert consultation and piloting, adjustments for different educational audiences, and sector-specific terminology alignment (Caena & Redecker, 2019). Globally, UNESCO's ICT Competence Framework for Teachers provides another policy anchor. Its six dimensions, understanding ICT policy impacts on education; curriculum and assessment; pedagogy; digital skills; administration; and teacher development, are interlinked with

classroom management strategies that emphasise ICT-based approaches (Machmud et al., 2021). This framework outlines progression stages from knowledge acquisition to knowledge creation, encouraging collaborative engagement with ICT in pedagogical contexts. Countries such as Tanzania have adapted these principles to create their own national frameworks prioritising pedagogical use over purely technical competencies. The Tanzanian model aligns with UNESCO's dimensions but focuses strongly on ensuring teachers can integrate ICT into subject teaching rather than viewing technology solely as content delivery tools (Kalinga & Ndibalema, 2023). In Indonesia, regulatory measures like the Ministry of Education Regulation No.16 (2007) stipulate that teachers must apply information and communication technologies in learning activities. This demand reflects a broader global trend identified by UNESCO where ICT competencies are deemed essential not just locally but internationally. Implementation guidance highlights six main aspects: understanding ICT policies; curriculum integration; pedagogical practices; digital skills; administration; and continuous teacher development (Machmud et al., 2021). Such regulatory requirements aim to cultivate technological literacy within pedagogical competencies, positioning ICT as integral to creating effective teaching environments. Another example appears in Malaysia's use of NETS-T standards, developed originally by ISTE, which assess teachers across six dimensions: technology operations; planning digital-enriched learning environments; integrating technology into curricula; digital-based assessment strategies; productivity enhancement through professional practice; and addressing social, ethical, legal issues related to technology use. National programmes have applied these standards alongside targeted initiatives to close digital divides between rural and urban schools through measures like telecentres, public Wi-Fi schemes, laptop distribution programmes, and mobile internet projects (Yieng & Daud, 2018). These actions combine technical infrastructure provision with professional training requirements stipulated by ministries. Policy frameworks frequently stress both infrastructural readiness and teacher capacity building. In sub-Saharan Africa, literature indicates that disparities persist despite formal strategies due to limited electricity provision, only 33.8% of primary schools have access, and uneven internet connectivity or equipment availability. Infrastructure gaps have been compounded by outdated training curricula lacking ICT pedagogy components and inconsistent funding for continuous professional development. Even where facilities exist in some urban or private schools, their utilisation depends heavily on institutional policy support and individual teacher initiative (Kalinga & Ndibalema, 2023). The European experience further reinforces the need for stakeholder involvement during adoption phases. In DigCompEdu implementation cases, stakeholder communities were established where experts and practitioners could share deployment experiences across contexts. This participatory strategy acknowledges that frameworks must resonate with professional realities if they are to impact classroom practice (Caena & Redecker, 2019). Overall analysis of national policies reveals common structural elements: reference to established competence standards (UNESCO ICT-CFT, DigCompEdu, NETS-T); adaptation into local guidelines reflecting cultural or systemic conditions; investment in infrastructure paired with professional training initiatives; mechanisms for ongoing evaluation such as self-assessment tools or expert feedback loops; and explicit regulatory mandates integrating ICT into teacher qualification requirements (Caena & Redecker, 2019; Kalinga & Ndibalema, 2023; Machmud et al., 2021; Yieng & Daud, 2018). These strategies collectively suggest that successful ICT policy execution is contingent on coherent alignment between formal competency models, infrastructural support systems, teacher engagement processes, and context-sensitive adaptation at the national level.

3 Conceptual Framework on Teacher ICT Competencies

3.1 Defining ICT competencies for educators

3.1.1 Basic ICT skills

Basic ICT skills for educators are often framed as the foundational capabilities required to operate and utilise technology resources for pedagogical purposes. Literature identifies these skills as encompassing the ability to perform essential computer operations, manage information digitally, communicate electronically, and create content using standard office applications. Competencies in word processing, spreadsheet management, database handling, interactive presentation creation, and basic programming are highlighted as necessary components. For many teachers, understanding the functions of both hardware and software forms a prerequisite for any meaningful engagement with ICT in education; without this knowledge, implementation is often avoided entirely (Machmud et al., 2021). Evidence from international frameworks reinforces this operational dimension. The first dimension of the NETS-T standards explicitly addresses technology operations and concepts, assessing whether teachers demonstrate basic knowledge, skills, and understanding related to technology use. Mastery in this area often includes producing documents using ICT

applications, retrieving information via internet search engines, utilising multimedia in teaching contexts, and performing basic maintenance or troubleshooting tasks on ICT equipment (Yieng & Daud, 2018). These norms align with UNESCO's classification of "Knowledge Acquisition" within its ICT Competency Framework for Teachers (ICT-CFT), which is considered the baseline level of competence enabling teachers to supplement classroom practice through technology use (Lubuva et al., 2022). Studies focusing on school-level requirements underline that educators must be at ease with tools such as email platforms, file management systems, and presentation software. This is particularly relevant for instructors handling activities like data analysis with spreadsheets (e.g., Microsoft Excel), preparing lesson materials digitally, or communicating with colleagues and students using online channels. Even in contexts with limited infrastructure, such as computer labs or classrooms with restricted access to devices, teachers who possess these basic abilities can locate and deploy relevant tutorials, games, or web-based practice materials to meet curricular objectives (Ahmad & Qureshi, 2024a). The operational skill set also encompasses familiarity with broadcasting technologies used in classrooms such as radio or television where applicable (Ahmad & Qureshi, 2024b). While these may not be interactive tools in the same sense as computers or mobile devices, their integration into teaching still demands fundamental technical knowledge from educators. In regions implementing NETS-T standards alongside national initiatives, such as Malaysia's adoption combined with rural telecentre programs, technical proficiency includes the capacity to install software, configure digital environments for learning, and maintain connectivity through available infrastructure (Yieng & Daud, 2018). Empirical findings from Indonesian teacher competency assessments illustrate that most respondents already demonstrate capability in operating hardware and software relevant to ICT-based instruction. This includes applying online ICT applications for learning purposes such as accessing search engines, downloading information resources, using hyperlinks effectively within digital media presentations, and engaging in online communication tools. The acquisition of these skills has been linked both to regulatory mandates requiring ICT integration into professional practice and generational exposure to technology from an early age (Machmud et al., 2021). Basic ICT competence also involves recognising safe and ethical practice when handling digital tools. The sixth dimension of NETS-T stresses awareness of social, legal, and human issues related to technology use; educators are expected to role-model appropriate behaviour by demonstrating safe operations and respect for intellectual property laws when using digital content (Yieng & Daud, 2018). Although these ethical considerations can extend beyond technical skill per se, they form an inseparable part of effective operational ability given that many classroom tasks now rely on sourcing external materials from online repositories. Within UNESCO's competency progression model adopted by Tanzania for teachers' colleges, the "basic ICT skills" category was trained using ICDL standards between 2005 and 2008. Tutors were instructed in word processing, spreadsheets, presentations, databases, internet browsing protocols including email communication etiquette, and social media usage for educational networking (Lubuva et al., 2022). However, despite training, project evaluations documented variability in how these competencies were subsequently applied in actual classroom scenarios; this suggests that while acquisition of operational skills is achievable through structured courses, consistent pedagogical integration remains a separate challenge. National reviews further assert that these foundational abilities directly influence more advanced domains such as curriculum design or assessment diversification. Teachers who cannot navigate core applications are unlikely to engage meaningfully with higher-level digital pedagogy strategies like self-assessment tools aligned with DigCompEdu indicators or collaborative solution co-creation seen in UNESCO's "knowledge deepening" stage (Caena & Redecker, 2019). As such basic ICT capacity underpins not only lesson preparation but also participation in professional learning communities where sharing resources often relies on structured formats like digital presentation slides or spreadsheet-based datasets. In sum, research consistently defines basic ICT skills for educators through tangible operational capacities: efficiently running essential hardware/software combinations; producing documents; managing data; communicating via digital networks; integrating multimedia; conducting responsible internet searches; and adhering to ethical technological practices (Ahmad & Qureshi, 2024a; Lubuva et al., 2022; Machmud et al., 2021; Yieng & Daud, 2018). While policy frameworks globally advocate acquiring these abilities at early stages of teacher development, via mandates or structured training, they also acknowledge persistent disparities across regions due mainly to infrastructure limitations or uneven uptake after formal instruction.

3.1.2 ICT-pedagogical skills

ICT-pedagogical skills are concerned with the integration of digital technologies, resources, and methods into teaching so that they serve pedagogically meaningful purposes. International frameworks place emphasis on teachers' capacity to plan, design, and orchestrate learning activities that leverage technology to promote collaboration and self-

regulated learning processes. At the same time, such learner-led processes require guidance and support that remain the responsibility of the educator (Caena & Redecker, 2019). This means teachers not only select or create digital resources but also manage them in ways that comply with data protection regulations and copyright laws when modifying and publishing materials. In UNESCO's ICT Competency Framework for Teachers (ICT-CFT), ICT-pedagogical competencies are differentiated from basic technical proficiency. They comprise abilities to identify learning needs that require ICT intervention, select appropriate technologies in alignment with subject content, and apply these tools effectively to meet intended learning outcomes (Lubuva et al., 2022). Pedagogical use is defined as more than supplementing classroom practice; it entails integrating ICT into curriculum and assessment strategies. For example, teachers should demonstrate mastery of subject content while blending it with relevant technologies, enabling students to address complex problems within their learning contexts. Evidence from Indonesian teacher practices illustrates this integrated perspective. Teachers frequently construct ICT-based instructional media rooted in national curriculum standards, enabling them to facilitate learners in achieving basic competencies (Machmud et al., 2021). This practice includes selecting media according to classroom conditions and student characteristics such as age, cognitive level, and socioeconomic status. Appropriate media selection is viewed as effective for delivering material, engaging motivation, and accommodating learners who cannot acquire personal devices, some choosing mobile phones or shared projection systems as alternatives. The same approach applies in assessment: the use of ICT provides options for diversifying measurements of student understanding by integrating feedback mechanisms or self-assessment tools. Frameworks like DigCompEdu isolate "Teaching and Learning" as a core area focused on integrating digital methods into pedagogical practice. Here, educators at higher proficiency levels experiment with innovative complex technologies and develop new pedagogical approaches alongside advanced assessment strategies. This progression implies moving from occasional technology use toward consistent pedagogical embedding across subjects and contexts. Teachers in these levels actively share their expertise with peers, indicating that pedagogical ICT competence extends into collaborative professional domains. Research underscores that the orchestration of learner experiences with technology requires balancing differentiation and personalisation. Educators create activities targeting varied levels and speeds of learning, establish individual pathways, and set objectives tailored to learners' needs (Caena & Redecker, 2019). Equal access to technologies is also a stated priority, teachers are expected to ensure that digital participation opportunities do not exacerbate existing inequalities between students. This aligns with broader principles in frameworks such as NETS-T where technology integration in curriculum delivery aims at maximising student learning through creative environments enriched by innovation. In Malaysian applications of NETS-T standards, teaching-learning dimensions evaluate whether instructors integrate curriculum plans using technology strategies suited for subject delivery (Yieng & Daud, 2018). Teachers are trained to make efficient use of virtual learning environments provided by ministries, for instance Frog VLE, and accompanying digital devices such as tablets or smartphones for both students and teachers. Such training supports compliance with policies mandating the integration of ICT in instructional contexts while stimulating adoption through resource availability combined with skill development. Pedagogical competencies also involve ensuring learners develop digital competence themselves. In DigCompEdu's "Empowering Learners" area, technology serves as a means to differentiate instruction while promoting active engagement through personalised digital activities (Caena & Redecker, 2019). Similarly, UNESCO's "knowledge deepening" stage reflects an expectation for collaborative problem-solving using ICT within subject areas (Lubuva et al., 2022). This requires educators to act not merely as facilitators but, as described in related literature, as activators who creatively choose strategies matched to context and learner profiles (Caena & Redecker, 2019). The Tanzanian adaptation of UNESCO's framework integrates pedagogy with six domains of professional practice including curriculum mastery, varied instructional strategies by learner level, active participation in knowledge co-creation communities, preparation of physical environments conducive to ICT use, and sustainable professional learning habits supported by evolving technologies. Within this model, pedagogy is inseparable from organisational capability, for example setting up facilities that bridge physical classrooms with virtual environments enhances collaborative opportunities directly relevant to instructional goals. ICT-pedagogical skill also involves engagement in professional networks for exchange of innovative teaching strategies using technology (Lubuva et al., 2022). Participation extends beyond individual classrooms into collective knowledge sharing contexts which can generate refined approaches applicable across disciplines or school levels. In action research contexts like PALM projects described elsewhere in literature, motivated teachers acquired most higher-level computer skills during classroom activities alongside pupils, a situated cognition model showing how pedagogical application reinforces technical skill development when embedded directly within teaching scenarios (Mumtaz, 2000). To summarise within the constraints given by policy frameworks and empirical accounts: ICT-pedagogical skills consist of aligning

technological tools with curricular objectives; tailoring activities based on learner diversity; using digital means for diverse forms of assessment; ensuring safe usage compliant with legal standards; participating actively in collaborative professional contexts; preparing environments supportive of interaction between physical and virtual spaces; and adopting ongoing reflective practice for continuous innovation (Caena & Redecker, 2019; Lubuva et al., 2022; Machmud et al., 2021; Yieng & Daud, 2018). Unlike basic ICT skills covered in Section 3.1.1, these competencies embed technology deeply into the act of teaching itself, turning devices and software from supplementary aids into essential components of the educational process according to established international frameworks.

4 ICT Tools for Teaching and Learning

4.1 Categories of ICT tools

4.1.1 Hardware resources

Hardware resources in educational contexts are generally understood as the physical technological equipment and devices that enable implementation of ICT-supported teaching and learning. These can range from basic computing systems to more specialised apparatus tied to subject-specific needs. Evidence highlights that when schools possess appropriate hardware resources, teachers are more able to integrate ICT effectively into instructional activities. Conversely, lack of such resources is repeatedly identified as a barrier. In surveys of primary and secondary teachers, major obstacles include insufficient computers, inadequate quality hardware, poor access to devices, and absence of suitable educational equipment for classroom purposes (Bingimlas, 2009). ICT hardware in schools often includes desktop computers, laptops, peripherals like printers and scanners, audiovisual systems such as projectors or interactive displays, and other elements like telephones or tablets (Kalinga & Ndibalema, 2023). In some cases, specific initiatives have provided richer technology packages. The Apple Classrooms of Tomorrow (ACOT) programme, for instance, equipped schools with computers, printers, scanners, laser disc players, videotape players, modems, CD-ROM drives and an extensive selection of software titles to support pedagogical innovation (Mumtaz, 2000). Such comprehensive provisioning allowed participating teachers to progress over years from initial technical challenges toward deeper integration of technology into pedagogy. Reports on Tanzanian school facilities show substantial variation between private primary schools and public secondary institutions in urban areas versus rural locations. Where available, hardware resources may comprise desktop computers and laptops along with calculators, video cameras and similar devices. Yet their actual use for teaching depends notably on teachers' skills and interest levels as well as institutional policy backing. Accessibility is further influenced by infrastructure factors: data indicate low availability of electricity in many sub-Saharan African primary schools (only 33.8% have access) which directly constrains the operation of hardware even where it exists (Kalinga & Ndibalema, 2023). In certain national frameworks for ICT competence, such as those derived from UNESCO's ICT-CFT, the category covering technological equipment recognises educators' capacity not only to operate existing hardware but also to apply peripheral devices attached to computer systems in multi-dimensional interactive environments. Teachers are expected to be able to use new technology equipment competently within instructional design (Phan et al., 2020). This extends beyond basic operation toward purposeful integration with learning activities. Technical support structures play a critical role in maintaining the functionality of hardware resources. Literature indicates that without reliable assistance programs or maintenance contracts in place at school level, breakdowns or technical faults may discourage teachers from using ICT devices during lessons. Common problems include malfunctioning computers, printers failing to operate properly, or connectivity interruptions for networked devices, each disrupting planned instruction. Provision of ongoing technical support can mitigate these disruptions by ensuring regular maintenance of equipment (Bingimlas, 2009). Some initiatives supporting teacher ICT adoption explicitly involve upgrading or expanding school hardware inventories. For example, professional development projects like PALM facilitated action research where teachers experimented directly with classroom computer use alongside pupils; here adequate access to functioning machines was necessary for the approach's success. Similarly, Stager's interventions in Australia included not just training components but attention to ensuring on-site familiarisation with school-specific hardware configurations (Mumtaz, 2000). Teachers reported benefits from working within their own classrooms using familiar equipment rather than solely relying on off-site training centres with different device setups. Beyond standard computing units and their peripherals, some contexts incorporate broadcasting technologies, radio or television, into educational practice. Using these forms demands a different kind of operational skill set but still relies on hardware presence within the teaching environment (Ahmad & Qureshi, 2024b). Hardware versatility here relates closely to subject delivery modes; knowing how to integrate such equipment into lesson planning

can broaden the scope of ICT-mediated learning experiences available to students. Hardware quality and suitability also influence motivation among educators toward ICT integration. Poor choices in resource procurement, selecting low-quality devices or ones ill-suited for classroom teaching, have been observed as contributing factors diminishing teacher enthusiasm for integrating technology (Bingimlas, 2009). Recommendations emerging from studies advise procurement policies that align device capabilities with pedagogical objectives so that hardware does not limit instructional possibilities due to performance deficits or incompatibility with curriculum-related software applications. Ultimately the literature portrays hardware resources as both enablers and potential bottlenecks depending on their availability, appropriateness for curricular needs, maintenance status, and supporting infrastructure like electricity supply (Bingimlas, 2009; Kalinga & Ndibalema, 2023). Comprehensive strategies addressing this dimension typically encompass provision of adequate quantities and types of devices; alignment of procurement decisions with intended pedagogical uses; establishment of technical support systems; investment in resilient infrastructure for consistent operation; and recognition within competence frameworks that effective ICT usage includes skilled engagement with diverse technology equipment (Mumtaz, 2000; Phan et al., 2020). This perspective situates hardware not merely as static assets but as active components whose operational readiness shapes educators' capacity for meaningful ICT-based instruction.

4.1.2 Software applications

Software applications in educational settings encompass a wide range of tools used by teachers to prepare, deliver, and assess learning. These include both general-purpose software and subject-specific applications. Studies show that teachers frequently rely on commonly available platforms such as Microsoft Office for tasks including word processing, spreadsheet calculation, database management, and interactive presentations. Search engines like Google remain popular for retrieving information resources, while hyperlink media embedded in digital materials supports navigation within learning content. Online communication tools, email services and messaging platforms, are also widely employed to facilitate interaction between teachers and learners. In some contexts, video-sharing sites such as YouTube function as educational resources providing real-world examples to illustrate concepts. This aligns with reports identifying YouTube as the second most favoured software application among teachers after office productivity suites. Teachers integrate such media into classrooms for visual engagement, sometimes compensating for learners' inability to acquire personal devices by projecting content during lessons. However, only a smaller proportion of respondents regularly use learning management systems (LMS) like Google Classroom or Edmodo for organising instructional activities (Machmud et al., 2021). Frameworks based on UNESCO's ICT Competency Framework for Teachers highlight teachers' ability to use specialised software according to professional or industry characteristics. Educators are expected to integrate IT application products into teaching, manipulate outputs from specialised programs effectively, and incorporate them into multi-dimensional interactive environments. Furthermore, competencies extend to using utility software for exploiting and managing digital resources, searching, editing, updating documents, and operating assessment-related tools such as digital test banks and examination software (Phan et al., 2020). Specific applications support creativity and multimedia integration in teaching and learning processes. These include audio editing software like Audacity for creating instructional clips; graphics editing tools such as Photoshop or Paint for producing visual materials; video editing programs like Movie Maker; and simulation or animation-based software for interactive content creation. Similarly, games designed for educational purposes can enhance student creativity by embedding subject-specific problem solving into gameplay experiences. Teachers also demonstrate skills in using online libraries to access and share digital content relevant to learning goals. File-sharing services like Dropbox or Google Drive make it possible to distribute materials efficiently among students or colleagues (Lubuva et al., 2022). Online support forums complement these sharing platforms by enabling educators to request and exchange teaching resources with peers. LMS platforms provide additional functionalities including course administration, live collaboration spaces, file submission systems, grading modules, communication forums, and calendar tools, all supporting structured virtual classroom environments (Phan et al., 2020). Evidence indicates varying levels of competence across different categories of software use. For instance, score data from tutor competency assessments reveal higher proficiency in creating learning activities using LMS platforms than in producing multimedia content from scratch via editing tools. Similarly, female tutors reported slightly lower mean scores than male tutors in tasks involving graphical and video creation (Lubuva et al., 2022), which may suggest discrepancies in specialised software familiarity even when general-purpose application usage is widespread. The adoption of these applications depends not only on teacher competence but also on external conditions affecting their operation. Obstacles cited include unstable internet connections and electricity supply issues that can

disrupt access to cloud-based or online-only solutions. A lack of ICT-related training further limits awareness of advanced functionalities beyond basic operations in familiar programs like Microsoft Word or Excel. Limited time for preparing materials reduces opportunities for mastering more sophisticated platforms (Machmud et al., 2021). In contexts with constrained access to school computer laboratories or restrictive hardware inventories, as noted elsewhere, the diversity of software usage is often narrowed accordingly (Kalinga & Ndibalema, 2023). In professional development programmes focusing on ICT integration, instructional design processes have leveraged multiple types of software according to pedagogical models such as cognitive science principles or concerns-based adoption approaches. These ensure that resources align with both lesson objectives and learner needs during implementation. By integrating behaviourism-inspired drill-and-practice applications alongside constructivist collaborative tools (e.g., CMC platforms), educators address differentiated learning strategies within the same technological ecosystem (Rahimi & Yadollahi, 2011). Overall patterns suggest that while office productivity suites dominate regular classroom use due to familiarity and ease of access, there is growing incorporation of diverse multimedia editing applications, subject-specific game-based tools, online repositories, file-sharing services, LMS platforms, and collaborative forums (Lubuva et al., 2022; Machmud et al., 2021; Phan et al., 2020). The combination expands the possibilities for lesson delivery, assessment diversification, resource sharing, and student engagement with authentic tasks through interactive formats. Yet disparities in training quality, infrastructure reliability, institutional policy support, and individual teacher initiative continue to influence how fully these applications are embedded into pedagogical practice across different regions (Kalinga & Ndibalema, 2023).

5 Teachers' Competencies in Ileje District

5.1 Current state of ICT competency among teachers

Evidence from relevant studies indicates that the most proficiently practiced level of ICT competencies among tutors trained in Tanzanian teachers' colleges is basic ICT skills, whereas ICT-pedagogical competencies intended to innovate teaching and learning remain less consistently applied in classroom contexts. Basic skills, such as word processing, spreadsheets, presentations, databases, internet browsing, email use, and social media engagement, were embedded into training initiatives like the ICT Project using ICDL standards. These capabilities formed part of tutors' regular work culture and were frequently used in their professional activities. However, evaluations revealed that although tutors acquired theoretical knowledge of how to employ ICT in education, practical application in their teaching was largely optional and at the discretion of individual staff members. The gap between theoretical competence development and pedagogical implementation appears influenced by several factors. Reports highlight a lack of strong emphasis within institutions to encourage daily use of ICT-pedagogical strategies outside subjects explicitly linked with ICT or ICS curricula. This situation meant that non-ICT subject tutors often did not view integrating digital tools into their lessons as a responsibility. Consequently, advanced competencies such as mapping web resources with subject content, creating multimedia lesson presentations, or conducting e-learning through platforms like Moodle were rarely demonstrated. A probable contributor to this limited uptake was insufficient balance between hands-on practice and theoretical instruction during training sessions. Initiatives frequently treated ICT skills and subject pedagogy as separate domains rather than integrating them seamlessly, a complexity noted in related literature on TPACK frameworks where successful integration depends on concurrent engagement with subject content, pedagogical approaches, and technology use (Lubuva et al., 2022). Further evidence points towards infrastructural and contextual constraints impacting competency levels. In sub-Saharan African settings similar to Ileje District, digital gaps among teachers are driven by under-qualification, minimal ICT training exposure, low familiarity with digital learning environments, poor electricity supply in many primary schools (only 33.8% have access), limited availability of computers and internet connectivity for pedagogical use, absence of effective ICT strategies or policies at institutional levels, high poverty rates affecting remote communities, insufficient leadership support for ICT pedagogy guidelines, inadequate CPD financing, outdated training curricula lacking digital integration components, shortage of teacher trainers with requisite digital proficiency, and reluctance by some educators to adopt new technologies. Even when facilities such as desktop computers, laptops, printers or video cameras are present in certain urban schools within Tanzania's Songwe Region context, actual utilisation for instructional purposes depends heavily on teachers' interest levels, awareness about digital tools' potential for self-directed professional development, institutional policy frameworks supporting technology adoption, and consistent internet access. Studies assessing teacher competence with respect to UNESCO's Knowledge Acquisition (basic skills), Knowledge Deepening (strategic integration), and Knowledge Creation (innovative collaborative

problem-solving) stages reveal that many educators operate primarily at the basic level. Performance at KD or KC stages is challenging due to required creativity in applying ICT across curriculum areas, skills which current training has not fully cultivated. Similar findings emerge from assessments showing moderate self-reported confidence in Technological Pedagogical and Content Knowledge (TPACK); while teachers can handle personal digital activities competently, implementing curriculum with integrated technology remains less common. Variations are also observed when competencies are examined against demographic indicators. For example, male teachers often report slightly higher technological competencies than female peers in using digital devices for enhancing teaching and learning; however this trend is inconsistent across all studies. Some findings show gender having no effect on overall competence while others suggest female educators outperform males in certain pedagogical technology applications. Education level correlates more strongly: teachers holding bachelor or master degrees tend to demonstrate higher technological competencies compared to those with lower qualifications because of more frequent computer use both at school and home settings. An additional factor influencing application is attitudes toward ICT usage. Teachers with positive perceptions are more likely to exhibit higher competence levels than those with negative viewpoints, yet attitude alone does not guarantee implementation if contextual barriers persist (Kalinga & Ndibalema, 2023). In some studies involving English language instruction contexts relevant to Tanzanian educational practice comparisons, an inverse correlation was found between computer anxiety and classroom ICT usage; skill levels emerged as stronger predictors for integration patterns than either anxiety or attitude measures (Rahimi & Yadollahi, 2011). This aligns with observations from broader reviews where low technological knowledge and skills directly reduce the likelihood of successful pedagogical adoption despite outward willingness to try new tools (Kalinga & Ndibalema, 2023). Overall available data portray a scenario where Ileje District's primary school teachers likely mirror national trends captured in these cited reports: they possess functional basic ICT abilities learned through formal training initiatives but show limited progression into complex pedagogical integration stages due to infrastructural deficiencies, insufficient practical reinforcement during training programmes, institutional policy gaps regarding technology use outside specialised subjects, lack of targeted CPD addressing integrated competencies, variable confidence across demographics such as gender and education level, and persistent disparities between urban-access contexts versus rural constraints (Kalinga & Ndibalema, 2023; Lubuva et al., 2022).

5.2 Training and professional development opportunities

Teacher training initiatives focused on ICT in education have been framed around developing both foundational digital skills and competencies for pedagogical integration. Reports indicate that in Tanzanian teachers' colleges, large-scale projects, the ICT Project (2005–2008), National ICT Programme (NICTP), ICT Competence Standards for Teachers (ICT-CST) implementation, and subsequent initiatives, trained hundreds of tutors in basic ICT skills following the ICDL standard, covering word processing, spreadsheet use, presentations, databases, internet access, email communication, and social media engagement. Between 2005 and 2011, these programmes expanded to include ICT-pedagogical competencies aimed at enabling tutors to apply technologies within subject teaching. However, evaluations conducted in 2014 revealed that the most proficiently practiced skills were the basic operational ones; pedagogical competencies remained low in application. Literature suggests a key reason for this imbalance lies in the way training packages were structured. ICT competence development often treated subject content and pedagogy separately from technology-related instruction. This separation meant tutors did not consistently practice integrating digital tools with curriculum or instructional strategies during training (Lubuva et al., 2022). Studies aligned with the TPACK framework caution that successful adoption depends on concurrent development of technology knowledge, pedagogical approaches, and subject content familiarity. Without such integration, even well-developed technical proficiency may fail to translate into classroom ICT use. In contexts comparable to Ileje District, multiple barriers influence professional development outcomes. Findings indicate lack of appropriate leadership and administrative support for implementing ICT pedagogy guidelines; limited financing for continuous professional development (CPD); outdated training curricula lacking embedded digital components; shortages of trainers with sufficient digital skills; and reluctance among some educators to adopt technology for teaching (Kalinga & Ndibalema, 2023). Infrastructure deficits, poor electricity supply affecting a majority of primary schools, insufficient computer availability, and unreliable internet connectivity, also impact training effectiveness by limiting opportunities for practical exercises during or after formal courses. International frameworks recommend structured CPD efforts extending beyond one-off training events. For example, UNESCO's ICT-CFT model emphasises stages from Knowledge Acquisition through Knowledge Deepening to Knowledge Creation. Advanced stages require teachers to identify learning needs demanding technological solutions, select relevant tools aligned with subject matter, and collaboratively apply them in solving instructional problems (Lubuva et al., 2022).

Achieving these competencies calls for regular practice within supportive environments as well as access to resources. The Tanzanian adaptation of this framework incorporates six domains of professional practice where pedagogy interacts directly with organisation of physical learning environments conducive to ICT use. Evidence from sub-Saharan Africa underlines disparities in teacher competence linked to minimal training exposure. In Nigeria, poor policy backing combined with inadequate connectivity and high poverty levels are cited as drivers of digital gaps (Kalinga & Ndibalema, 2023). For teachers in remote areas without reliable facilities, CPD structures must address not only skill enhancement but also strategies for resource adaptation, choosing technologies feasible under local conditions. Where facilities are available in urban schools, desktop computers, laptops, printers, their use depends heavily on teacher interest and institutional encouragement. Examples from other countries highlight possibilities for more engaging professional development models. In Australia's PALM project, action research was used as a strategy for sustaining teacher motivation while building both technical and higher-order computer skills. Teachers experimented with computers alongside pupils in their own classrooms, supported by project officers who provided educational and technical backup. This situated cognition approach demonstrated that higher-level skills could be acquired through classroom-based practice rather than isolated workshops. Similarly, the ACOT programme supplied extensive hardware resources coupled with multi-year support including software training, planning time, peer observation opportunities, and gradual progression through instructional phases, from grappling with technical issues toward full pedagogical integration (Mumtaz, 2000). Reports focusing on individual factors influencing uptake stress that attitudes toward ICT utility in education affect CPD impact. Teachers who perceive technology positively tend to report higher competence levels than those with negative viewpoints (Kalinga & Ndibalema, 2023). However attitude alone is insufficient if infrastructural or policy barriers remain unaddressed. Professional development planning therefore needs to account for contextual factors identified in literature: adequate equipment and technological infrastructures; human resources for technical support; curricular integration mechanisms; leadership at school board or national policy levels; incentives for project participation; continuous education systems; quality pedagogical content provision; observatories of innovative practices; and alignment between ICT goals and national curricular visions (Peralta & Costa, 2007). Some summaries advise coupling professional development with measures providing sufficient classroom time for teachers to implement new technologies, such as reducing lesson loads or extending daily lesson periods, to ensure application opportunities (Bingimlas, 2009). Self-training is also recognised as a supplement where institutional courses are lacking; teachers are encouraged to seek private sessions or engage independently with available resources like user guides or online tutorials. Maintenance of self-organisation skills is highlighted as beneficial when conducting classes that rely on technology. Ultimately the experiences documented across Tanzanian contexts indicate that while initial competency acquisition through formal programmes has been widespread at the basic level (Lubuva et al., 2022), sustained CPD designed around integrated pedagogy-technology-content interaction remains limited. Enhancing such structures would involve consistent hands-on practice linked directly to subject teaching during training sessions; addressing infrastructural constraints post-training; establishing institutional policies mandating broader application across subjects; providing accessible technical support; ensuring curriculum updates reflect current technological realities; and encouraging participation in learning communities where educators share strategies for innovative technology uses (Kalinga & Ndibalema, 2023). These measures collectively emerge from empirical findings as pathways through which professional development can move primary school teachers, especially those in districts like Ileje, beyond basic operational skills into richer pedagogical applications of ICT tools.

6 Factors Affecting ICT Competency Development

6.1 Institutional support and leadership

Institutional support and leadership emerge in the literature as determining factors shaping teachers' ability to integrate ICT into pedagogical practice effectively. Studies indicate that leadership roles within schools, as well as national and regional policy backing, play an equally important part in influencing responses to ICT innovation. The absence of comprehensive policy frameworks, or fragmented approaches across government departments, can create barriers to coordinated adoption. For instance, in South Africa, the lack of an integrated ICT policy has been described as potentially leading to a digital divide where access to quality communications services and content risks becoming a privilege for a select few rather than a right for all. Such structural weaknesses underscore the importance of unified policy direction at institutional and governmental levels in promoting equitable ICT integration. Leadership engagement at the school level is repeatedly cited as instrumental for successful ICT uptake. Reports emphasize that individual

school leadership can shape teacher attitudes, motivation, and confidence towards technology usage by ensuring access to equipment, providing guidance on pedagogical adoption, and modelling innovative practices (Mathevula & Uwizeyimana, 2014). School administrators are also advised to support technology adoption by purchasing necessary hardware. However, due to high costs associated with infrastructural development, many schools remain without adequate ICT resources (Ahmad & Qureshi, 2024b). This points to the role of leaders not only in advocating for resource allocation but also in planning strategically for sustainable integration aligned with available budgets. In contexts such as sub-Saharan Africa, including Tanzania, analysis shows that inadequate leadership support on guidelines and training related to ICT pedagogy is among the challenges affecting implementation (Kalinga & Ndibalema, 2023). Institutional leadership must therefore address both infrastructural readiness and capacity-building among staff through continuous professional development (CPD). Frameworks like UNESCO's ICT Competency Framework for Teachers highlight that progression from basic knowledge acquisition to knowledge creation requires enabling environments supported by leadership commitment (Lubuva et al., 2022). Leaders are expected to facilitate these environments by ensuring that physical spaces are conducive to digital learning, arranging collaborative opportunities among teachers, and integrating ICT goals into broader curricular visions. Other literature identifies specific contextual factors connected to institutional support: equipment provision; technological infrastructure setup; human resources dedicated to technical and pedagogical assistance; software availability; integration of ICT into curricular projects; active initiative from teachers encouraged by leadership; board-level decision-making aligned with national policy; network infrastructure maintenance; incentives for project development; partnerships with industry; systems of continuous education and professional development; quality pedagogical materials and support services; observatories tracking innovative practices; and explicit vision statements incorporating ICT into curricula (Peralta & Costa, 2007). Schools demonstrating these characteristics often report higher levels of teacher engagement with technology in instructional settings. The role of institutional leadership extends beyond provisioning resources, it includes motivational aspects. Evidence from the PALM project indicates that when leaders facilitated sustained action research within classrooms, teachers were more likely to build advanced computer skills alongside their pupils (Mumtaz, 2000). Similarly, initiatives like ACOT paired extensive hardware supply with structured planning time, peer observation schedules, and managerial oversight, enabling participants to gradually move from technical problem-solving toward full integration of technology into pedagogy over several years. In Nigeria's case studies, lack of appropriate strategies or policies from school governance bodies has been directly linked with poor internet connectivity, insufficient electricity supply, and limited device availability. Such deficits hinder teachers' capacity for self-directed professional growth using digital tools (Kalinga & Ndibalema, 2023). Leaders who promote unfettered access to relevant training opportunities can counteract these obstacles, Obonyo's assertions highlight how this correlates strongly with successful computer use in classrooms (Ahmad & Qureshi, 2024b). Conversely, weak leadership commitment results in fragmented ICT application even where individual teachers express willingness. The European DigCompEdu experience illustrates another facet of leadership support: stakeholder communities composed of experts and practitioners were established during tool development so experiences could be exchanged across contexts. Institutional leaders played roles here by enabling participation from their staff, thereby aligning framework deployment with actual teaching realities (Caena & Redecker, 2019). This participatory model reinforces that ownership among educators, and by extension their institutions, enhances the sustainability of competence development initiatives. Infrastructure challenges themselves often link back to governance priorities. For example, large disparities between urban and rural facilities reflect varying degrees of investment directed by local or national authorities. In South African programmes like the Teacher Laptop Initiative managed by the Education Labour Relations Council, governance structures facilitated monthly allowances for teachers' purchase and connectivity costs toward laptops meant for educational use (Mathevula & Uwizeyimana, 2014). Without comparable schemes in regions with limited funding allocations, institutional aims for digital competency improvement may falter regardless of teaching staff enthusiasm. In sum, evidence consistently connects effective ICT integration with strong institutional leadership defined by strategic visioning, adequate resource provision, infrastructural investment, supportive policy formulation, incentives for project involvement, continuous skill enhancement systems, fostering collaborative networks among educators, compliance with broader national curriculum goals, and openness toward participatory design processes in framework adaptation (Ahmad & Qureshi, 2024b; Kalinga & Ndibalema, 2023; Mathevula & Uwizeyimana, 2014; Peralta & Costa, 2007). Leadership acts not merely as an administrative backdrop but as an active driver orchestrating the conditions under which teachers can progress beyond basic technical proficiency into sophisticated pedagogical uses of technology. Weak or absent leadership undermines these prospects by failing to

bridge gaps between technical acquisition during training and sustained classroom application, an issue intertwined with institutional priorities detailed throughout Section 5.2.

6.2 Availability of ICT infrastructure

The literature indicates that availability of ICT infrastructure is fundamental to enabling teachers to apply both basic and pedagogical digital competencies within their instructional practice. Evidence from sub-Saharan Africa, including Tanzania, shows marked disparities in infrastructure provision across regions, with poor facility access constraining classroom use despite teacher training. UNESCO-UIS statistics report that only 33.8% of primary schools in the region have electricity, while 57.2% of upper-secondary schools are similarly supplied. This lack of reliable power directly impacts the operation of ICT devices and limits opportunities for sustained integration in lesson delivery. Where infrastructure exists, such as desktop computers, laptops, printers, scanners, calculators and video cameras in certain urban public secondary schools or private primaries, practical use often depends heavily on individual teachers' interest levels, knowledge, institutional policy support for technology adoption, and internet connectivity. In rural contexts like those similar to Ileje District, inadequate network connectivity and insufficient equipment are frequently cited as reasons for low application rates in teaching. Studies highlight poor internet access and a shortage of computers as structural barriers preventing regular ICT use for pedagogical purposes (Kalinga & Ndibalema, 2023). These limitations affect teachers' capacity to engage in self-directed professional development using online platforms or to implement collaborative and interactive lessons aligned with frameworks such as UNESCO's Knowledge Deepening or Knowledge Creation stages (Lubuva et al., 2022). Within school-level environmental factors identified by Peralta and Costa's analysis, availability of ICT infrastructure encompasses physical equipment and technological systems needed to facilitate digital teaching. Their list includes hardware provisioning; network infrastructures; software tools, both general productivity applications and pedagogical programs; and technical support to maintain operational capability (Peralta & Costa, 2007). Without such components functioning cohesively, integration into curricular projects is impeded even where teacher competence levels are adequate. For example, ICT resourcing quality influences readiness: procurement decisions that result in poor-quality or incompatible devices reduce teacher motivation to initiate technology-based instruction (Bingimlas, 2009). Hardware resources extend beyond standard computing units to include peripherals like printers and scanners which support lesson material preparation (Mumtaz, 2000). In initiatives such as ACOT, comprehensive hardware packages provided participants with robust capacity, computers coupled with printers, scanners, audiovisual devices, networking equipment, allowing multi-year progress toward fully integrated pedagogy. Conversely, many Tanzanian educational contexts lack similar breadth of equipment; infrastructural gaps in Ileje's district schools likely mirror national patterns where device availability is limited outside specialised ICT labs (Kalinga & Ndibalema, 2023). Reports from Bingimlas identify resourcing among five key factors influencing successful ICT learning opportunities: adequacy of hardware allocation per student group; leadership supporting ICT usage; trained staff capable of handling devices; integration into standard teaching practices; and alignment with broader curriculum goals (Bingimlas, 2009). Under-resourced schools fail to meet these criteria uniformly due to insufficient budgeting for technology acquisition or maintenance contracts. Technical faults, malfunctioning machines or unstable network connections, further discourage usage; without repair services or replacement plans administered at institutional level these issues persist. Internet connectivity remains a recurrent determinant of infrastructure effectiveness. Komba and Mwakabenga's findings note that reliable internet access enables teachers to participate in communication networks for learning material exchange. Weak or inconsistent connections hinder access to digital content repositories or collaborative tools vital for modern instructional practice. In Nigeria's case studies focusing on remote communities, unavailable connectivity combined with high poverty levels exacerbated digital gaps despite presence of some devices (Kalinga & Ndibalema, 2023). Availability also involves software infrastructure: licensing appropriate educational programs ensures compatibility with curricular objectives. UNESCO's ICT-CFT recognises tools tailored according to professional requirements as part of infrastructure, alluding to managing outputs from specialised applications alongside general productivity software integration (Phan et al., 2020). Without access to current versions suited for subject-specific delivery, teachers may revert solely to generic tools unsuited for complex teaching tasks. Leadership-driven procurement policies can improve infrastructure quality when aligned with pedagogical needs (Ahmad & Qureshi, 2024b). Yet high costs remain challenging for many districts; strategic planning is advised to maximise available budgets towards sustainable installations rather than sporadic purchases. School boards additionally influence infrastructural stability through partnerships with industry providing devices or maintenance support (Peralta & Costa, 2007). In professional development contexts such as PALM interventions in Australia, working with familiar equipment within

one's own classroom was valued by teachers for confidence building (Mumtaz, 2000). Transposing this insight suggests that in Ileje District schools where infrastructure differs between training settings and actual classrooms, familiarity gaps may impede transfer of learned skills into practice if the provided devices are absent locally. Overall evidence positions the availability of ICT infrastructure as a core enabler determining whether trained competencies can translate into active classroom use. Adequacy covers electricity supply reliability; sufficient quantities of compatible hardware devices; functioning network connections; licensed relevant software; maintained technical support structures; leadership support integrating these resources into school policy frameworks; and procurement strategies mindful of curriculum alignment (Bingimlas, 2009; Kalinga & Ndibalema, 2023; Peralta & Costa, 2007). Where shortcomings occur across these elements, as documented widely in sub-Saharan Africa, they significantly constrain progress beyond basic operational skills into richer pedagogical deployment identified in Section 5.2.

7 ICT Integration in Classroom Practices

7.1 Innovative teaching strategies using ICT

7.1.1 Project-based learning with ICT

Project-based learning (PBL) approaches that utilise ICT are characterised in the literature as strategies where teachers integrate technology into real-world tasks or authentic activities, thereby enhancing learner engagement and developing competencies required for contemporary workplaces. These tasks are often designed to provide phenomena that reflect professional contexts students may encounter in future careers. Evidence indicates that implementing ICT for authentic and situated learning activities can help learners understand content more deeply by connecting theoretical material to practical scenarios. The concept reflects principles identified by scholars such as Oliver and Herrington, who describe ICT-enabled learning as aligning with situated learning strategies that encourage active participation through realistic contexts. Teacher practices in contexts like Indonesia illustrate how project-based approaches with ICT involve selecting instructional media compatible with curriculum content. This compatibility ensures learners receive appropriate information levels while maintaining relevance to their educational objectives. For example, when creating a PBL unit focused on environmental science, teachers might utilise multimedia resources, including videos of local ecosystems, embedded within national curriculum standards. Such media not only convey factual content but also serve as triggers for student projects involving observation, reporting, and proposing solutions to identified issues. Research further underscores the role of authenticity in stimulating motivation. Authentic activities integrated into PBL serve to prepare learners for conditions likely found in vocational or professional environments. For instance, presenting students with a real-world case, such as urban planning challenges, and requiring them to develop digital presentations or simulations aligns classroom objectives with tangible societal problems. In these scenarios, ICT tools become central: students might use spreadsheet software to analyse population data, graphic editors to design layouts, and communication platforms to coordinate group work. The integration of authentic, problem-solving elements into project tasks parallels demands from workplace skill reports which list critical thinking and complex problem solving among top competencies projected for 2025 employment markets. Consequently, PBL units in an ICT-rich environment often embed situations requiring learners to activate prior knowledge and apply reasoning strategies alongside digital tool use. Teachers report promoting problem solving and critical thinking by incorporating real cases into activities, these could range from analysing climate change impacts using online datasets to designing public health awareness campaigns via multimedia content creation. However, evidence points out that while many educators attempt such integrations frequently, others only do so occasionally due to constraints like limited preparation time or incompatibility between certain subject matter and problem-based formats (Machmud et al., 2021). This suggests that sustained adoption of PBL with ICT may require institutional support addressing workload management and provision of adaptable curricular materials. ICT applications in PBL are diverse. Within DigCompEdu's pedagogical dimensions, project work would involve careful orchestration of technology use across phases: planning resources (selecting suitable digital content), facilitating collaborative environments (using shared online workspaces or LMS discussion boards), guiding self-regulated progress (embedding formative assessment tools), and ensuring equitable participation through differentiated access measures (Caena & Redecker, 2019). UNESCO's "knowledge deepening" stage captures similar intentions, educators identify subject-specific needs for ICT intervention during projects, choose tools best suited to those needs, and employ them strategically toward resolving complex inquiries (Lubuva et al., 2022). Examples from Malaysian applications of NETS-T also demonstrate how project-oriented strategies benefit from structured ICT integration. Teachers were trained to harness virtual learning environments like Frog VLE during projects, supporting student-

centred inquiry where groups might collect data via internet research, compile findings into shared documents, and present conclusions using interactive media (Yieng & Daud, 2018). In such models, technology is embedded at all stages rather than merely providing supplementary presentation capability. Participation in professional networks can enhance PBL quality when educators exchange design ideas and resources for ICT-infused projects. Tanzania's adaptation of the UNESCO framework promotes tutors' active involvement in knowledge co-creation communities (Lubuva et al., 2022), which can be applied toward refining project scaffolds, ensuring alignment with both curricular targets and technological possibilities available locally. For instance, collaborative teacher forums might share templates for science investigation projects utilising online simulation software or case study repositories accessible via national education portals. The learner empowerment dimension within DigCompEdu stresses personalisation during ICT project work. Teachers can differentiate roles within group projects according to students' skill levels, one learner may handle digital research compilation via search engines while another manages content creation with video editing software, ensuring each pathway fosters competence development tailored to individual starting points (Caena & Redecker, 2019). Equal access remains essential; without adjusted resource allocation some students may be unable to participate effectively if lacking devices or connectivity during off-class hours. In practice-based accounts such as those summarised above (Machmud et al., 2021), project designs benefiting most from ICT integration often combine multi-media inputs (graphics, audio clips), collaborative tools (shared drives), analytical programs (data visualisation), and dissemination platforms (websites/blogs). The coherent linking of these tools within a defined problem-solving cycle distinguishes effective PBL from fragmented digital activity. Outcomes include heightened motivation through tangible outputs, publishable online reports or community presentations, which reinforce both content mastery and transferable skills. In summary, documented implementations show that successful project-based learning with ICT hinges on deliberate selection of compatible instructional media rooted in curriculum standards; embedding authenticity through real-world cases; structuring opportunities for critical thinking and problem solving; integrating technology consistently across stages from planning through assessment; leveraging collaborative networks for design enhancement; personalising participation pathways while safeguarding equal access; and focusing on producing outputs meaningful beyond classroom boundaries (Caena & Redecker, 2019; Lubuva et al., 2022; Machmud et al., 2021; Yieng & Daud, 2018). These elements align closely with international competency frameworks yet remain contingent on teacher preparedness, availability of resources detailed in Section 6.2, and institutional support discussed in Section 6.1.

7.1.2 Blended learning approaches

Blended learning approaches combining ICT with traditional classroom instruction have been described in the literature as involving the facilitation of learning both within and across subject areas, merging face-to-face teaching with digital environments. Frameworks such as those adapted from Kozma's classification identify stages like "infusing," which explicitly refers to facilitating blended learning across subject boundaries (Bariu et al., 2022). This stage moves beyond basic productivity tools toward interactive platforms able to deliver lessons that integrate online and in-person components. In this model, ICT competencies at higher levels contribute to creating usable knowledge through combined modalities, benefiting both the individual teacher and wider societal objectives. National adaptations of UNESCO's ICT-CFT, such as Tanzania's ICT Competence Standards for Teachers, reflect an emphasis on pedagogical uses of technology in blended contexts. Knowledge Deepening within these frameworks encourages collaborative solution co-creation for subject-specific problems, while Knowledge Creation aims for lifelong capabilities in generating innovative instructional designs that draw on both physical and virtual learning spaces (Lubuva et al., 2022). The organisation and administration domain explicitly includes preparing ICT facilities so they can be used to bridge classroom and virtual environments. This preparation encompasses arranging collaborative group work in digital spaces alongside traditional class structures, maintaining continuity between modes. Evidence from Indonesian practice shows teachers crafting instructional media aligned with national curriculum standards while integrating online elements into lesson delivery (Machmud et al., 2021). Teachers reported applying online ICT tools, such as search engines for information gathering, hyperlink media within presentations, and remote communication applications, to extend learning beyond the classroom. This hybridisation allows material presentation and delivery through both direct instruction and mediated digital platforms. The stated aim is to promote meaningful learning by engaging students with authentic activities facilitated through situated strategies that combine physical presence with ICT-supported inquiry. Malaysia's application of NETS-T standards offers further examples of blended models where educators employ virtual learning environments (e.g., Frog VLE) provided by ministries (Yieng & Daud, 2018). In these cases, teachers integrate curriculum plans using technology to maximise student learning opportunities in creative settings enriched by

innovation. Students work at times independently through the online environment, asynchronous access to materials, and at other times collaboratively under teacher guidance during in-class sessions. Digital devices such as tablets or smartphones are used across both modes to interact with content and peers. The assessment dimension here often involves gathering student submissions through LMS tools while conducting formative evaluations during face-to-face phases. Blended arrangements also take into account differentiated access needs through equal participation measures outlined in DigCompEdu's Empowering Learners area (Caena & Redecker, 2019). Educators ensure that offline alternatives or adjusted scheduling are available for learners who cannot access devices outside school hours. Activities might be designed so that tasks initiated online can be continued during in-person meetings using shared resources or printed materials derived from digital sources; this helps maintain inclusivity without undermining the integration strategy. In professional development contexts comparable to Tanzanian initiatives, cultivating blended learning competence means training teachers not only in individual ICT skills but also in structuring instruction that alternates or intertwines different delivery formats (Lubuva et al., 2022). However, evaluations indicate that while basic operational skills are widely practised, integrated pedagogical competencies, including blended approaches, are less consistently applied due to institutional constraints or insufficient balancing of theory and practice during training phases. Addressing this requires embedding technology use directly into curriculum planning rather than treating it as a supplementary activity after face-to-face lesson design is complete. The "infusing" stage described by Kozma corresponds closely with UNESCO's Knowledge Deepening concept when applied to blended environments: it utilises technology for complex problem-solving supported by group collaboration across modes (Bariu et al., 2022; Lubuva et al., 2022). For example, a science project might involve students gathering experimental data physically in school laboratories yet analysing it using simulation software accessible via an LMS; discussions could be facilitated through in-class seminars intertwined with forum postings evaluated by the instructor. Such arrangements rely on competency frameworks that combine knowledge about technologies with domains of practice directly linked to pedagogy. Blended strategies often benefit from participation in professional networks which allow educators to exchange templates or guidelines for hybrid projects (Lubuva et al., 2022). Collaboration extends into designing assessments suited for blended settings, for instance, ensuring alignment between synchronous classroom evaluations and asynchronous digital task submissions. In Malaysian NETS-T guided programmes (Yieng & Daud, 2018), productivity and professional practice dimensions support teacher collaboration electronically (e.g., sharing resources via LMS), mirrored by physical meetings where materials are contextualised according to local requirements or class-specific dynamics. Despite these models' potential advantages, implementation challenges remain prominent in sub-Saharan Africa contexts like Ileje District due to infrastructure deficiencies noted previously, limited electricity supply, hardware shortages, connectivity gaps, which restrict consistency between online and offline lesson segments (Kalinga & Ndibalema, 2023). UNESCO-UIS data confirm low percentages of schools with necessary facilities; thus even trained teachers face barriers sustaining blended methods over time without institutional investment in reliable infrastructure (Lubuva et al., 2022). In remote communities within Nigeria studied under similar conditions, poor connectivity combined with policy gaps inhibited widespread adoption despite educators' interest (Kalinga & Ndibalema, 2023). In summary, documented examples across different national contexts demonstrate that effective blended learning approaches require competency at strategic integration levels, aligning ICT tools with curricular aims across synchronous and asynchronous formats; designing activities flexible enough for varied access capacities; preparing facilities linking physical classrooms with virtual spaces; participating actively in collaborative networks refining hybrid strategies; and maintaining assessment coherency between modes (Caena & Redecker, 2019; Lubuva et al., 2022; Machmud et al., 2021; Yieng & Daud, 2018). These practices depend not only on individual teacher skill but also on supportive institutional frameworks capable of addressing infrastructural constraints discussed earlier while reinforcing pedagogical integration as a primary objective rather than optional adjunct to traditional teaching formats.

8 Measurement and Evaluation of ICT Competencies

8.1 Assessment frameworks for teacher ICT skills

Assessment frameworks for teacher ICT skills described in the literature are frequently based on established international standards and adapted for specific educational contexts. UNESCO's ICT Competence Framework for Teachers (ICT-CFT) version 3.0 provides a widely used model comprising six dimensions: understanding ICT in education policy; curriculum and assessment; pedagogy; application of digital skills; organisation and administration; and professional learning (Phan et al., 2020). This framework includes progression stages from Knowledge Acquisition,

basic technological proficiency, to Knowledge Deepening, which entails collaborative solution co-creation in subject areas, and finally Knowledge Creation, focusing on lifelong capability to generate new usable knowledge relevant to real-life problems (Lubuva et al., 2022). Each stage corresponds to teacher capacities for identifying learning needs, selecting appropriate technologies, and applying them effectively to achieve pedagogical aims. Tanzania has adopted these levels into its national ICT competence standard for teachers, alongside the six domains of professional practice set out by UNESCO. Frameworks such as DigCompEdu further detail educator-specific digital competence, structuring it into six principal areas and twenty-two individual competences. Areas cover topics including Digital Resources, Teaching and Learning, Assessment, Empowering Learners, Facilitating Learners' Digital Competence, and Professional Engagement. The competence descriptions incorporate actions like selecting or creating digital educational resources with awareness of copyright and data protection regulations; integrating technology to promote collaborative and self-regulated learning processes; using digital tools for assessing learners' performance; providing targeted feedback; differentiating learning pathways according to student needs; and ensuring safe technology use that fosters media literacy. Importantly, the DigCompEdu framework measures proficiency along six cumulative levels from A1 through C2. Beginners (A1–A2) operate technology in limited ways and recognise its potential; intermediate practitioners (B1–B2) integrate technologies broadly across their teaching contexts; advanced educators (C1–C2) share expertise with peers, experiment with complex technologies, and develop innovative pedagogical methods. In some cases, assessment tools aligned with such frameworks have been developed to facilitate self-evaluation by teachers. For DigCompEdu, an online self-assessment instrument has been produced in multiple languages. The tool condenses key concepts into practical activity statements relatable to educators' daily practice. For each competence indicator, twenty-two in total, the respondent selects among five answer options representing increasing mastery levels mapped to the framework progression scale (Caena & Redecker, 2019). Development of the instrument involved iterative expert consultations, pre-piloting, item revision, sector-specific terminology adjustments, and tailoring versions for different educational audiences such as school teachers versus higher education lecturers. Targeted feedback is provided based on self-assessment results to guide improvement according to identified strengths and weaknesses. Other recognised standards include ISTE's National Educational Technology Standards for Teachers (NETS-T), which organise evaluation under six dimensions: Technology Operations and Concepts; Planning and Designing Learning Environments and Experiences; Teaching, Learning, and the Curriculum; Assessment and Evaluation; Productivity and Professional Practice; and Social, Ethical, Legal and Human Issues. These dimensions allow assessors to examine whether teachers demonstrate attitudes, skills and knowledge relevant to technology use; plan effective environments accommodating diverse student abilities; integrate digital strategies into curriculum delivery; use technology in varied ways for measuring learning outcomes; improve productivity through ICT-enhanced professional activity; communicate digitally with stakeholders; and role-model safe technology practices. Assessment exercises applying NETS-T may also capture contextual differences between urban and rural schools by evaluating how infrastructure availability impacts performance across dimensions. Documentation shows that government programmes incorporating NETS-T have sometimes been coupled with rural access initiatives like telecentres or village Wi-Fi schemes to address gaps detected during evaluations (Yieng & Daud, 2018). Measurement processes can also be embedded within course design assessments for online teaching contexts. One study referenced in this literature assessed competencies using a 7-point Likert scale derived from Bigatel et al.'s identification of key factors influencing online teaching success. These include encouraging student–faculty contact, promoting cooperation among students, encouraging active learning, giving prompt feedback, emphasising time on task, communicating high expectations, respecting diverse talents in learning modes. The alignment between such criteria and frameworks like UNESCO's or DigCompEdu underscores how assessment models often integrate pedagogical practice indicators alongside technical skill metrics. Evaluation data from experimental studies demonstrate how implementing an ICT competence framework can be measured through performance outcomes. In one reported case involving EC classes operating under an ICT competence framework versus CC classes without it, average scores differed notably: EC averaged 8.54 while CC averaged 7.71, calculated through score distribution formulas for each group. Distribution charts revealed higher proportions of good or excellent grades (B or above) among EC students compared to CC peers. This result was interpreted as evidence supporting both feasibility and effectiveness of teaching according to ICT development approaches when assessed against framework criteria (Phan et al., 2020). In Tanzanian teacher training evaluations conducted during competency development projects from 2005 onwards (Lubuva et al., 2022), assessments distinguished between basic skills, word processing, spreadsheets, presentations, and pedagogical competencies like integrating e-learning platforms into subject teaching. Separate metrics were applied to gauge frequency of application in work settings versus theoretical knowledge retention

from training courses. These distinctions reflect how assessment frameworks can weight practical implementation alongside acquisition measures in order to highlight gaps between formal instructional outcomes and classroom realities. Comprehensive assessment models are often constructed from multiple bases including UNESCO's ICT-CFT theoretical structure, TPACK integration principles that unite technological knowledge with pedagogy and subject content (Phan et al., 2020), ISTE's skill standards via NETS-T dimensions (Yieng & Daud, 2018), national IT laws or regulations governing technology application in teaching, output standards for student graduation competencies at pedagogical universities, characteristics of online learning models suited for evaluation benchmarks, technology factors recognising infrastructural constraints at school level, plus exemplar research-derived frameworks used internationally in comparable settings. The synthesis of these sources forms rubrics guiding measurement across component competencies, each linked to descriptive criteria enabling rating against expected proficiency expressions, and facilitates expert advisory input before finalising framework structures for consistent evaluation use across institutions or regions (Phan et al., 2020).

8.2 Indicators for effective ICT integration

Effective ICT integration is reflected in a set of measurable indicators drawn from international frameworks and empirical studies that examine both technical capacities and pedagogical applications. Within UNESCO's ICT Competence Framework for Teachers (ICT-CFT), the progression from Knowledge Acquisition through Knowledge Deepening to Knowledge Creation serves as one composite indicator system. At the basic stage, teachers demonstrate proficiency in using technology to supplement classroom activities, competencies here involve operating hardware, managing digital information, and performing essential software tasks. Moving into Knowledge Deepening, indicators include the ability to identify subject-related problems requiring ICT solutions, select appropriate technological tools, and integrate these tools strategically into curriculum and assessment processes (Lubuva et al., 2022). The highest stage, Knowledge Creation, is characterised by generating new usable knowledge for real-life issues using ICT collaboratively; this indicator focuses on sustained innovation and transferable skill development beyond immediate instructional contexts. Frameworks such as DigCompEdu extend these classifications by providing twenty-two competence descriptors arranged across six thematic areas. Indicators within "Digital Resources" measure skills in selecting, creating, modifying and managing digital teaching materials while respecting copyright and data protection laws. "Teaching and Learning" indicators capture planning and orchestration of digital methods to promote collaboration and self-regulated learning; they also assess the balance between learner autonomy and teacher guidance (Caena & Redecker, 2019). In "Assessment," effective integration is indicated by using ICT for comprehensive performance analysis and providing timely feedback. "Empowering Learners" encompasses differentiation measures, allowing varied learning speeds, pathways, objectives, and active student engagement in digital environments with equitable access guarantees. The area "Facilitating Learners' Digital Competence" includes promoting safe use of technologies, media literacy development, enabling communication and cooperation through digital tools, and guiding learners in problem-solving with ICT. ISTE's NETS-T standard offers a parallel suite of indicators across six domains. These include demonstrating attitudes, skills, and knowledge about technology operations; planning effective environments incorporating ICT; executing curriculum plans enriched with ICT strategies; diversifying assessment via digital tools; enhancing productivity through ICT-supported professional practice; and modelling ethical use of technology (Yieng & Daud, 2018). Evidence from Malaysian implementations shows specific measurable outputs such as frequency of Frog VLE utilisation for teaching activities or incorporation of ministry-provided tablets in lesson delivery. In such cases, indicators are not only skill-based but also activity-based, counting instances of technology engagement aligned with curricular objectives. Experimental evaluation methods further inform indicator design. In one documented study, comparison between classes applying an IT competence framework versus those without showed differences in average scores (8.54 vs 7.71). Distribution metrics revealed greater proportions of high-achieving students (grade B or above) in framework-aligned classes. Here effective ICT integration indicators included improved learning efficiency metrics, average scores accompanied by variance data, and increased representation of higher achievement levels attributable to structured technological application. Other research-derived frameworks embed pedagogical practice criteria into indicator sets. Bigatel et al.'s online teaching success factors adapted for competency measurement incorporate encouraging active learning through ICT tasks; giving prompt feedback via technology-mediated channels; communicating high expectations online; fostering cooperation among students digitally; allocating clear timelines for task completion within e-learning systems; respecting diverse learning modes supported by varied technology uses; and maintaining consistent content quality across modalities (Phan et al., 2020). These demonstrate how behavioural

measures combine with technical skill indicators to represent effective integration holistically. Indicators also take contextual constraints into account. In sub-Saharan Africa settings where infrastructure gaps limit device availability or connectivity (Kalinga & Ndibalema, 2023), effectiveness may be measured relative to resource adaptation: for example, using shared projection systems when personal devices are not feasible still aligns with integration if linked to curricular goals (Machmud et al., 2021). Professional engagement metrics within DigCompEdu include active participation in educator networks sharing digital teaching strategies, frequency of contributions or uptake of peer-shared resources can serve as practical indicators here. Assessment instruments tied to these frameworks often operationalise indicators through self-report scales mapped to proficiency stages or competency descriptors. For DigCompEdu's tool, each indicator is expressed as an activity statement relatable to daily practice with five possible mastery levels matching A1–C2 progression (Caena & Redecker, 2019). Respondents select their level for each competence area, producing targeted feedback on strengths and weaknesses, application frequency becomes an embedded metric. Indicators for effective integration thus span several categories: technical proficiency validated by usage frequency or output quality (e.g., document creation rates); pedagogical embedding evidenced through lesson plans integrating ICT methods consistently; learner outcome enhancements shown via comparative score distributions under framework-guided instruction; equity measures ensuring all students can participate regardless of device possession; ethical compliance assessed through adherence to content licensing norms; collaborative engagement tracked by participation volumes in professional networks or virtual learning communities; infrastructural adaptability demonstrated through creative deployment of available resources toward curriculum fulfilment (Caena & Redecker, 2019; Lubuva et al., 2022; Phan et al., 2020; Yieng & Daud, 2018). These diverse measures collectively provide a means to evaluate whether teachers are operating beyond basic technological use into substantive pedagogical adoption that aligns with both international competency models and observable classroom impacts.

9 Broader Implications of ICT Competency in Primary Education

9.1 Contribution to educational quality improvement

Research in multiple contexts shows that teacher ICT competencies contribute directly to quality improvement in education by enhancing teaching processes, expanding learning opportunities, and addressing gaps in existing instructional methods. Documented benefits from the utilisation of ICT in teaching and learning include motivating pupils, providing instructional variety, compensating for language deficiencies, encouraging active participation, reinforcing learning, increasing application possibilities, and improving the applicability of learning content to individual needs. These enhancements lead to greater student autonomy as digital tools allow learners to exert more choice over study approaches, requiring less direct instruction. ICT integration also aligns with a shift in the teacher's role from director to guide or moderator, supporting learners in navigating resources and constructing understanding rather than passively receiving information. Studies conducted in primary and secondary education contexts report measurable improvements when students engage with ICT-based activities. For example, primary school pupils using tutorial software for reading scored higher on reading assessments; very young students composing stories with computers achieved higher reading skill scores; and science learners utilising simulation software recorded improved results (Mathevula & Uwizeyimana, 2014). Such outcomes indicate that ICT can act as an agent for change in educational reform, aiding transitions from traditional lecture formats toward more innovative and effective approaches. Shared digital resources within schools promote collaboration among learners and teachers and can reduce costs while improving quality, especially important in under-resourced settings. Empirical evaluation of ICT competence frameworks further supports their effectiveness in improving educational quality. In one experimental assessment comparing classes operating under an ICT framework with those without it, average learner scores were higher in the framework group ($X_{EC} = 8.54$) compared to the control ($X_{CC} = 7.71$), with a greater proportion of students achieving grades of B or above (Phan et al., 2020). This was interpreted as evidence that structured use of ICT aligned with competence development can increase both teaching efficiency and student performance quality. Teacher competencies also influence educational quality through professional reflection and innovation. Frameworks such as DigCompEdu encourage educators to integrate digital methods into teaching practice not only for delivery but also for personalised learning pathways, differentiated instruction, targeted assessment feedback, safe technology use, media literacy promotion, and fostering collaborative problem-solving among students (Caena & Redecker, 2019). By enabling teachers to plan and orchestrate technology-rich environments suited to varied learner needs, and ensuring equal access, the outcomes encompass both cognitive gains and socio-emotional development. Integration of social networks and

online platforms into distance education offers further opportunities for competency growth among teachers while maintaining continuous feedback loops with learners (Sydorenko et al., 2020). Data show substantial increases in usage rates of platforms like Twitter during periods of heightened demand for remote learning, driven by quarantine measures, illustrating how ICT-enabled communication supports adjustment of educational processes in real time. Such environments facilitate lifelong professional improvement for educators while ensuring timely curriculum modifications based on ongoing interaction with pupils. ICT-enhanced instruction is linked with developing multi-literacy capacities among students: information literacy (finding, evaluating, synthesising information), technology literacy (using multimedia tools productively), visual literacy (communicating through images), global literacy (interpreting messages from a global perspective), and digital literacy (communicating within broad online communities) (Robin, 2023). Teachers competent in these domains help create classrooms where students' diverse abilities are addressed through multimodal instruction that connects them with broader societal contexts. Improved educational quality also results from ICT supporting collaborative work beyond individual classrooms. Educators participating in professional networks share digital resources, lesson designs, or project outlines that sustain best practices across institutions (Lubuva et al., 2022). This collective exchange strengthens instructional strategies while reducing duplication of effort at local levels. Similarly, capacity-building initiatives such as action research demonstrate how teachers acquire advanced skills by using ICT alongside their students during actual lessons, promoting situated cognition where computer proficiency develops organically within authentic teaching scenarios (Mumtaz, 2000). In contexts facing infrastructural challenges like Ileje District analogues, implementing adapted frameworks such as Tanzania's version of UNESCO's ICT-CFT improves organisation of physical environments conducive to technology use while embedding digital pedagogy across subjects (Lubuva et al., 2022). Evidence underscores that when competencies extend beyond basic operational skills into pedagogical integration, planning differentiated activities, aligning resources with curricular goals, the resulting instructional practices produce more meaningful learning experiences. Literature also emphasises quality improvements gained through blended learning models combining face-to-face interaction with virtual environments. Teachers trained under competence standards design course structures that leverage both modalities effectively, for instance using LMS platforms for asynchronous research tasks complemented by synchronous classroom discussion, and maintain coherent assessment systems across delivery modes (Yieng & Daud, 2018). This flexibility increases student engagement while accommodating varied access capabilities noted in infrastructure studies (Kalinga & Ndibalema, 2023). In sum, documented contributions of teacher ICT competency to educational quality improvement span tangible academic achievements (score gains in experimental groups), enhanced literacy across multiple modalities, enriched instructional diversity permitting personalised pathways, strengthened collaborative exchanges among educators via digital networks, sustained adaptability through real-time platform feedback mechanisms (Sydorenko et al., 2020), transformation toward learner-centered methodologies supported by frameworks like DigCompEdu (Caena & Redecker, 2019), and facilitation of innovative blended arrangements tailored to infrastructural realities. These findings consistently link well-developed teacher competencies directly to both measurable student performance outcomes and qualitative enhancements within the overall learning environment (Mathevela & Uwizeyimana, 2014; Phan et al., 2020; Robin, 2023).

9.2 Future prospects for ICT-enhanced teaching

Evidence across multiple frameworks and empirical studies points to structured pathways for advancing ICT-enhanced teaching, with prospects closely linked to the consolidation of teacher competencies into sustained pedagogical integration. Building from models like UNESCO's ICT Competence Framework for Teachers (ICT-CFT), the sequence from Knowledge Acquisition, through Knowledge Deepening, toward Knowledge Creation provides a roadmap for progressive capacity development. The potential trajectory involves moving educators from basic operational skills, using technology to supplement instructional delivery, toward embedding ICT strategically in curriculum and assessment, and ultimately toward generating new usable knowledge through collaborative technology-enabled problem solving (Lubuva et al., 2022). Future prospects are thus aligned with enabling teachers to operate confidently across these stages by institutionalising opportunities for practice within environments equipped for digital learning. The DigCompEdu framework offers additional refinement of such progression by defining six thematic areas with twenty-two competence descriptors. Higher proficiency levels (C1–C2) envisage educators sharing expertise with peers, actively experimenting with complex technologies, and developing innovative pedagogical methods (Caena & Redecker, 2019). Reaching these levels depends on targeted professional development that interlinks technology use with subject pedagogy and learner engagement strategies. The availability of an online self-assessment tool in multiple languages facilitates ongoing evaluation and personalised feedback, allowing teachers to plan competence growth

intentionally according to identified strengths and weaknesses. Measured improvements under framework-aligned instruction suggest tangible benefits that can inform long-term adoption. In one experimental comparison, classes applying an ICT competence model averaged $X_{EC} = 8.54$ against $X_{CC} = 7.71$, indicating enhanced learning efficiency under structured technological guidance. Distribution data showing greater proportions of high-achieving students in EC groups support the feasibility of scaling such approaches (Phan et al., 2020). These outcomes imply that expanding framework-based instruction could yield broader academic gains if coupled with infrastructural readiness. Prospects also include embedding blended learning approaches where physical classrooms are bridged with virtual spaces as described in national adaptations of UNESCO's ICT-CFT and NETS-T standards. In Malaysia's application of NETS-T, productivity and professional practice dimensions encourage teacher collaboration electronically while maintaining curriculum contextualisation in face-to-face sessions using ministry-provided devices (Yieng & Daud, 2018). Similarly, Indonesia's classroom practices integrate online search engines, hyperlink media, and communication tools alongside direct instruction to promote meaningful learning through authentic activities (Machmud et al., 2021). Scaling such hybrid models will require sustained infrastructure investment noted earlier in Section 6.2, ensuring equitable access so learners can participate across modalities without resource barriers. Another element shaping future directions is participation in educator networks. Tanzania's adaptation of UNESCO's framework includes active involvement in knowledge co-creation communities (Lubuva et al., 2022), which can be leveraged to exchange project templates, digital lesson plans, or strategies for differentiated learning using ICT. Professional engagement indicators within DigCompEdu measure such activity volumes, providing a means for institutions to incentivise collaborative dissemination of digital teaching practices (Caena & Redecker, 2019). Looking ahead, institutional leadership will remain central to enabling these advancements. Strong leadership support, through procurement aligned with curricular needs, maintenance systems for hardware and software, policies integrating ICT into all subject areas, and incentives for teacher participation in CPD, forms the backbone for translating competence frameworks into classroom reality (Peralta & Costa, 2007). Without this vision and resource coordination, prospects may stall at basic skill acquisition rather than progressing toward integrated pedagogy. ICT-enhanced teaching also has scope to expand multi-literacy capacities among students when competencies are effectively applied. As documented by Robin (Robin, 2023), promoting information literacy, technology literacy, visual literacy, global literacy, and digital literacy enriches learner readiness for diverse communicative contexts. Teachers proficient across these literacies can design multimodal instructional sequences that connect classroom learning with broader societal discourse, an outcome particularly relevant for preparing pupils to function productively in future workplaces (Bingimlas, 2009). Capacity-building through situated cognition models suggests another feasible prospect: embedding skill development within actual teaching scenarios rather than isolated workshops. In the PALM project context, teachers acquired higher-level computer skills working alongside their pupils in classrooms supported by educational and technical backup (Mumtaz, 2000). Extending similar experiential learning opportunities could facilitate transitions into Knowledge Deepening or Knowledge Creation stages organically during daily instruction. Framework indicators such as those within DigCompEdu's "Empowering Learners" area highlight the importance of differentiation and equitable technology access. Future-oriented strategies must ensure that expansion of ICT use does not exacerbate inequalities among students; activities should accommodate varied access conditions through offline alternatives or adjusted scheduling so all learners benefit from digitally enriched tasks. Finally, continuous evaluation through self-assessment instruments offers a sustainable mechanism for guiding teacher progression over time. Iterative expert consultations informing tool design, as seen in DigCompEdu's development, show the value of adapting descriptors and terminology for sector-specific relevance (Caena & Redecker, 2019). Embedding such evaluative cycles within CPD programmes promises prospects where competency gains are monitored and adapted dynamically according to shifting technological landscapes and pedagogical requirements. In combination, these elements depict a forward path grounded in established frameworks: advancing teacher proficiency levels mapped by models like UNESCO's ICT-CFT and DigCompEdu; expanding blended learning integration across curricula; strengthening collaborative professional networks; ensuring leadership-driven infrastructural support; cultivating multi-literacy competencies; adopting situated cognition approaches; safeguarding equity in participation; and institutionalising continuous assessment-feedback systems (Caena & Redecker, 2019; Lubuva et al., 2022; Machmud et al., 2021; Yieng & Daud, 2018). Under these conditions ICT-enhanced teaching holds substantial potential to amplify both instructional quality and learner achievement outcomes observed in empirical studies.

10 Conclusion

The integration of ICT in primary education presents both promising opportunities and persistent challenges that require comprehensive attention. Evidence indicates that while foundational digital skills among teachers have been widely developed through structured training programs, the translation of these skills into effective pedagogical practices remains limited. This gap is influenced by factors such as insufficient practical reinforcement during training, infrastructural deficiencies including unreliable electricity and limited access to devices, and a lack of institutional policies encouraging consistent use of technology across all subject areas. Moreover, disparities in competence levels are observed across demographic lines and geographic locations, with rural schools facing additional constraints due to inadequate connectivity and resource scarcity.

Advancing teacher competencies beyond basic operational abilities demands integrated professional development approaches that combine technological knowledge with subject pedagogy and learner engagement strategies. Models like UNESCO's ICT Competency Framework for Teachers and the European DigCompEdu framework provide structured pathways for progression, emphasizing stages from initial skill acquisition to innovative application and collaborative knowledge creation. Embedding ICT into authentic instructional strategies such as project-based and blended learning can enhance student motivation, critical thinking, and personalized learning experiences. However, successful implementation of these approaches depends heavily on supportive institutional leadership, adequate infrastructure, and ongoing access to technical and pedagogical resources.

Assessment frameworks aligned with international standards offer valuable tools for measuring teacher ICT skills and guiding targeted improvements. Self-assessment instruments and performance evaluations can help identify strengths and areas needing development, facilitating continuous professional growth. Additionally, participation in professional networks and knowledge-sharing communities contributes to the dissemination of effective practices and collective problem-solving.

The contribution of well-developed ICT competencies to educational quality is evident through improved student outcomes, enriched instructional diversity, and expanded opportunities for learner autonomy and collaboration. Digital literacy across multiple modalities prepares students for future societal and workplace demands, while enabling teachers to adapt instruction to diverse learner needs. Future efforts should prioritize creating enabling environments that support sustained pedagogical integration of technology, ensuring equitable access for all learners, and institutionalizing continuous evaluation mechanisms.

Ultimately, the advancement of ICT-enhanced teaching in primary education hinges on coordinated strategies that address infrastructural challenges, strengthen teacher training with integrated pedagogical components, and cultivate leadership committed to embedding technology within curricular frameworks. Such comprehensive approaches hold promise for transforming instructional practices and elevating student achievement in contexts similar to those examined, including regions facing resource limitations.

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