



RESEARCH ARTICLE

Teachers' ICT Integration as a Catalyst for Students' 21st-Century Skills Development in Public Secondary Schools: A Review of Evidence

^aGarende Mgendi, ^bAtegwu Patrick Ogar, ^cApolinary Ndasi

^aDistrict Secretary, Tanzania Teachers' Union (TTU), Igunga District, Tabora- Tanzania

^bDepartment of Education Foundations, St. Augustine University of Tanzania

^cArchbishop Mihayo University College of Tabora

Corresponding Author

Garende Mgendi, Email: mgendigarende72@gmail.com

Author's Contributions

All authors contributed equally to this research.

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ABSTRACT

The integration of Information and Communication Technology (ICT) in teaching and learning has become increasingly important in preparing students for the demands of the twenty-first century. This review examines existing evidence on how teachers' integration of ICT can contribute to the development of students' 21st-century skills in public secondary schools. The review focuses particularly on skills such as critical thinking, creativity, communication, collaboration, problem-solving, digital literacy, self-directed learning, and information management. Evidence from the reviewed literature suggests that ICT can be leveraged in various ways by teachers to enhance their students' engagement, motivation, collaborative skills, critical thinking, creativity, access to information, and improved problem-solving ability. However, the effectiveness of using ICT in classrooms is primarily determined by teachers' level of digital competence, pedagogical knowledge, and attitudes, availability of resources, school administrative support, technical assistance, pedagogical content knowledge, and opportunities for professional development. According to recent systematic reviews, teachers' integration of ICT in instruction is usually adequate, but their level of proficiency is often insufficient in supporting students' acquisition of high-level competencies such as developing critical thinking and collaborative skills. Moreover, the review highlights that the use of ICT in education should not be regarded as an ancillary tool but as a methodological innovation that can fundamentally transform teaching practices if teachers have the right level of knowledge and confidence in employing it. Thus, the paper suggests that advancing teachers' ICT and pedagogical proficiencies and promoting the availability of relevant resources and supportive educational environments are critical to actualizing the potential of using technology to foster students' 21st-century skills in public secondary schools.

Keywords: Digital competency, Integration, Literacy, 21st century skills, Technological Pedagogical Content Knowledge

INTRODUCTION

The integration of Information and Communication Technology (ICT) into education has become increasingly important as schools seek to prepare learners for the demands of the twenty-first century (Rahimi & Oh, 2024). ICT plays a pivotal role in the

actualizations of 21st-century digital instructional delivery (Ategwu et al., 2022). It is a panacea for teacher integration of technological knowledge that aid during classroom interactions. Digital technologies can support teaching and learning by creating opportunities for communication, collaboration, creativity, critical

thinking, and problem-solving, which are among the key competencies required in the twenty-first century (Van Laar et al., 2017). Ekpo et al. (2025) advocated that digital integration into classroom situations and teachers' preparedness in the utilizations of digital tools is fundamental for the smooth running of day-to-day pedagogical implementation. The review has observed with serious dismay that the provision of ICT facilities remains a serious impediment as majority of the teachers' lacks the technological knowledge in the said concepts. However, the educational value of ICT does not depend merely on its availability or frequency of use, but on how effectively teachers integrate ICT with pedagogy, subject content, and curriculum objectives. Effective ICT integration requires teachers to combine technological, pedagogical, and content knowledge in ways that enhance students' learning experiences. Nevertheless, previous studies indicate that teachers may have positive attitudes towards ICT and possess adequate technological knowledge while using ICT mainly to support conventional teachers-centered practices rather than to promote transformative and student-centered learning (Ong & Annamalai, 2024).

The level of integration of Information and Communication Technologies (ICT) by teachers depends on teachers' knowledge, professional development, availability of infrastructure, technical support, and school leadership as well as curriculum requirements (Msambwa & Daniel, 2024). Lack of appropriate ICT facilities and infrastructures, inadequate technical support, and insufficient training of teachers have been identified as hindrances to effective integration of ICT in secondary schools in Tanzania (Kanyopa, & Mokhele 2024). While ICT has been found to enhance learning by motivating learners, engaging and facilitating collaboration among them, these outcomes do not necessarily show the development of twenty-first-century skills. The main concern is how teachers use ICT to create learning opportunities that enable learners to develop critical thinking, communication, collaboration, creative problem-solving, and creativity (Van Laar et al., 2017).

There have been studies in Tanzanian public secondary schools focusing on teachers' level of ICT competence, technological literacy, access to ICT facilities, awareness of policies, and challenges towards adopting and using ICT (Kalinga, 2024). However, there is a need to investigate how much teachers' actual integration of ICT in classrooms facilitates learners' mastery of twenty-first-century skills. This is because mere competence in using ICT by teachers or access to technological facilities does not necessarily mean that students' higher-level skills are being developed intentionally. Therefore, further investigation is required to establish whether there is a relationship between teachers' pedagogical use of ICT and learners' critical thinking, creativity, communication, and collaboration in Tanzanian public secondary schools.

Research Objectives

The reviewed paper will be guided by two research objectives:

1. To investigate the relationship between teachers' integration of ICT and the development of students' 21 st century skills in public secondary schools.
2. To establish the relationship between the availability of ICT infrastructure and students' 21st-century skills in public secondary schools.

LITERATURE REVIEW

The review will be guided by the Technological Pedagogical Content Knowledge (TPACK) framework advanced by Mishra and Koehler (2006). The framework seeks to explain how teachers can integrate technology into their pedagogy to foster content knowledge. It argues that technology integration requires a combination of Technological Knowledge (TK), Pedagogical Knowledge (PK), and Content Knowledge (CK) as well as their overlaps. The framework assumes that teachers should not only know how to use technology but also understand how they can leverage technology to enhance teaching and learning. One of the framework's strengths is that it sheds light on teachers' technological and pedagogical knowledge and explains why access to technological resources alone does not guarantee successful technology integration. It can help the study since it focuses on how teachers can use the technological facilities at hand to foster learner-centred activities that promote higher-level competencies. However, the framework is overly theoretical since the various types of knowledge often overlap, making it difficult to measure them independently. This review will focus on investigating how teachers' TK, PK, and CK facilitate meaningful technology integration and learners' development of twenty-first-century skills.

The framework's weaknesses are its inability to expound on other issues affecting meaningful technology integration in institutions such as inadequate infrastructure, ineffective technical support, and leadership. Its relevance to this study is that it guides the investigation on how learners' critical thinking, creativity, communication, and collaboration can be developed using the TPACK framework. It also supports the argument that ICT infrastructure must be accompanied by competent pedagogical use if technology is to contribute effectively to students' learning competencies.

Empirical Literature Review

This part examines studies related to this review paper. A literature review of the empirical studies is presented based on the two major themes emerging from the study objectives.

Teachers' ICT Integration and Students' 21st-Century Skills Development

Various empirical studies have shown the relationship between teachers' ICT integration and students' 21st-century skills development. Han and Ong (2024) explored technology integration in Secondary 1 and 2 Chinese as a second language classes in Singapore, with a focus on the relationships between teachers' technology-integrating practices and their beliefs and pedagogical choices. The researchers found that effective technology integration relied not only on the incorporation of technology in teaching but also on teachers' pedagogical beliefs and choices about technology integration. An outstanding aspect of this study is that it investigates teachers' pedagogical choices and beliefs about technology integration in authentic secondary-school settings. One limitation of this study is its scope: it included only four teachers and focused on Chinese as a second language, which may impact the applicability of its findings to teachers' technology-integrating practices and beliefs in other subjects and at the secondary level. Another limitation is that the researchers did not integrate the impact of technology-integrating practices on students' 21st-century skills, including their critical thinking, creativity, communication, and collaborative problem-solving abilities.

This study informs my own research by highlighting an important area to investigate: the links between teachers' use of ICT and the development of students' 21st-century skills. By identifying the role of teachers' beliefs and choices in technology-integrated pedagogy, this study helps elucidate how teachers can best foster their students' 21st-century competencies.

Rumi et al. (2026) investigated the impact of long-term one-to-one tablet-based teaching in German secondary schools. The study revealed that permanent access to tablets had significant indirect effects on students' academic achievement through increased collaboration and intrinsic motivation, although the direct effect on achievement was significant only in German. A major strength of the study is that it examined the mechanisms through which technology may influence learning rather than focusing only on technology availability. However, the study focused mainly on academic achievement and did not directly measure students' broader 21st-century skills, such as creativity, critical thinking, digital literacy, and problem-solving. Furthermore, because the study examined students' access to tablets rather than teachers' pedagogical ICT integration, it provides indirect evidence for the relationship between teachers' ICT integration and students' 21st-century skills.

Aslan and Zhu (2017) investigating factors that predicted ICT integration into teaching practices among pre-service teachers in Turkey. The study revealed that pedagogical knowledge, participation in ICT-related courses, and perceived ICT competence were

significant predictors of ICT integration, although these variables explained only approximately 17% of the variance in ICT integration. The strength of the study is that it demonstrates that effective ICT integration depends not only on teachers' technical competence but also on their pedagogical knowledge. However, the study involved pre-service teachers rather than experienced teachers in public secondary schools, which limits the generalizability of the findings to the context of the present study. In addition, the study did not directly examine students' 21st-century skills; therefore, it provides evidence about factors influencing ICT integration rather than whether ICT integration contributes to the development of students' critical thinking, creativity, communication, collaboration, and problem-solving skills.

Suzer and Koc (2024) conducted a study on teachers' digital competence using the framework of European Digital Competence Framework for Educators (DigCompEdu). Their study revealed that teachers generally exhibited an integrator level of digital competence albeit with differences according to gender, subject, educational background, location, and access to digital devices. The study's main strength is that it used an established theoretical framework for assessing teachers' digital competence rather than simply measuring the frequency of technology usage. On the other hand, the study relied on teachers' self-reported digital competence that may not accurately reflect their actual classroom ICT practices. Of greater concern, the study did not investigate students' learning outcomes or 21st-century skills raising the question on whether teachers' competence translates to effective ICT integration and the acquisition of students' critical thinking, creativity, communication, collaboration, and problem-solving skills.

Ong and Annamalai (2024) performed the study on Technological Pedagogical Content Knowledge for twenty-first-century learning skills (TPACK21cls) in teacher education in Malaysia. Their work revealed that TPACK21cls was largely absent from the planned curriculum and was never explicitly practiced in the developed curriculum with technology use mainly occurring at the level of substitution in particular for communication. The work's main strength is that it explicitly links teachers' technological and pedagogical knowledge to the development of 21st-century skills as opposed to considering ICT as a mere technical resource. However, the study focused on teacher education rather than practicing teachers in public secondary schools which limits the relevance to the present study. In addition, while the study demonstrates that technology use does not inherently result in transformative learning, it did not directly measure whether teachers' ICT integration fostered students' 21st-century skills.

Dzinoreva and Mavunga (2022) performed their research in Zimbabwe investigating the integration of

ICT into the curriculum in pre-service teacher education. The study indicated gaps in teachers' ICT competence and emphasized the need to integrate technological, pedagogical, content, and curriculum knowledge more systematically into teacher preparation. The study's main strength is that it appreciates that ICT competence should be incorporated into teacher education rather than as a stand-alone technical skill. On the other hand, the study was largely conceptual and therefore provides limited empirical information on teachers' ICT practices in secondary-school classrooms. Additionally, it did not directly focus on students' 21st-century skills meaning that while the work provides theoretical support for integration, it does not establish whether teachers' ICT use fosters students' critical thinking, creativity, communication, collaboration, and problem-solving abilities.

Mbona et al. (2026) conducted research on how teachers' preparedness, attitudes, and perceived effects of technology use in lesson delivery in selected secondary schools in Zimbabwe. Their work revealed that teachers generally exhibited positive attitudes towards technology, moderate ICT competence and believed that technology could enhance student engagement and performance albeit with inadequate infrastructure and institutional support impeding effective ICT use. The study's strength is that it focused on practicing secondary-school teachers and acknowledged the impact of teacher preparedness and institutional conditions on ICT integration. On the other hand, the study involved only 59 teachers from selected schools raising questions on whether the findings can be generalized across public secondary schools in Zimbabwe. Furthermore, the study relied largely on teachers' perceptions of student engagement and performance rather than directly measuring students' 21st-century skills, leaving uncertainty about whether teachers' ICT integration actually develops critical thinking, creativity, communication, collaboration, and problem-solving skills.

Ifinedo et al. (2019) in their study in Nigeria, investigating factors influencing technology integration among teacher educators using the TPACK and SITES frameworks. The study revealed that perceived technological knowledge, teachers' knowledge excluding technology, and knowledge for integrating technology significantly influenced technology integration, while teaching experience and class size were also associated with ICT integration. A major strength of the study is its use of Partial Least Squares Structural Equation Modelling (PLS-SEM), which enabled the researchers to examine multiple factors influencing ICT integration simultaneously. However, the participants were teacher educators rather than teachers directly teaching secondary-school students, which limits the applicability of the findings to public secondary schools. Moreover, although the study

considered technology integration, it did not directly measure students' 21st-century competencies, leaving a gap concerning whether teachers' ICT integration contributes to the development of critical thinking, creativity, communication, collaboration, and problem-solving skills.

Mwei (2020) examined teacher-related factors influencing ICT integration for instructional purposes among secondary-school teachers in the North Rift Valley in Kenya. The study revealed that factors such as voluntariness and computer experience influenced teachers' perceptions of ICT integration, while subject specialization, gender, and teaching experience had comparatively limited effects. The major strength of the study is its relatively large sample of 400 teachers from 40 secondary schools, which provides useful evidence about teacher-related factors influencing ICT integration. However, the study relied mainly on teachers' perceptions rather than direct observations of their classroom ICT practices. More importantly, it did not investigate students' 21st-century skills or determine whether ICT integration contributed to the development of critical thinking, creativity, communication, collaboration, and problem-solving abilities. Thus, the study provides evidence about factors affecting ICT integration but does not establish its relationship with students' 21st-century skills.

The study conducted by Mbabazi et al. (2022) on the integration of ICT into teaching and learning in secondary schools in the Kigezi Region, Uganda. The study revealed that ICT was inadequately integrated into teaching and learning, with insufficient ICT infrastructure and limited ICT skills among both teachers and students, while school location and school age significantly influenced ICT adoption. A major strength of the study is the inclusion of both teachers and students, which provides evidence from multiple stakeholders within the school environment. However, the study focused mainly on ICT availability, adoption, and basic competencies rather than the quality of teachers' pedagogical ICT practices. Furthermore, although the study demonstrated that infrastructure and digital competence are important conditions for ICT integration, it did not directly establish whether teachers' ICT integration contributes to the development of students' 21st-century skills.

Kagambe et al. (2024) studied the ICT integration in the implementation of the competence-based curriculum in secondary schools in Kyaka II Refugee Settlement in Uganda. The study revealed that ICT was used in fewer than 40% of observed lessons and that only 25% of teachers reported confidence in using ICT effectively, despite having received training. The study also revealed a positive relationship between ICT use, student engagement, and motivation, while inadequate equipment, poor connectivity, overcrowding, negative attitudes, and the digital divide constrained ICT integration. The main strength of the study is that it links

ICT integration to competence-based education by examining the use of ICT in actual instructional settings, thus, providing empirical evidence. Additionally, the context of this study is a refugee-settlement which might fail to be generalized to Uganda mainstream public secondary schools. Moreover, engagement and motivation are not the only 21st-century skills that students need to acquire, and there is no evidence that teachers' integration of ICT enhances learners' critical thinking, creativity, communication, collaboration, and problem-solving skills.

Kalinga (2024) carried out the research in Tanzania among public secondary schools teachers investigating their technological literacy and ICT integration into instruction in the wake of the new competence-based curriculum. The study unveiled that although the majority of teachers were knowledgeable about the national education and ICT policies, they faced a myriad of challenges implementing the policies at the classroom level; 85% of respondents indicated that they did not integrate technology as a pedagogical tool, while the majority of the respondents did not utilize online assessment. The main strength of the study is that it focuses directly on Tanzanian public secondary schools. Therefore, the research is highly relevant to the current study, since it examines directly similar setting. However, the qualitative design and sampling procedures require caution when generalizing the reported 85% figure to all public secondary-school teachers in Tanzania. More importantly, the study established the limited level of teachers' ICT integration but did not examine whether differences in teachers' ICT integration were associated with differences in students' 21st-century skills, creating an important gap for the present study.

There was a study conducted by Msambwa and Kangwa (2024) in Tanzania, reviewing existing literature on ICT integration in teaching and learning, particularly in relation to secondary education. The review revealed that effective ICT integration depends on teacher and student motivation, alignment between ICT use and curriculum objectives, maintenance of technological tools, appropriate ICT skills, and the integration of technological knowledge with pedagogical knowledge. The major strength of the study is that it synthesizes evidence from 40 studies and identifies teacher, curriculum, technological, and contextual factors that influence effective ICT integration. However, as a systematic literature review, its conclusions depend on the quality and geographical distribution of the studies included and therefore cannot independently establish a causal relationship between teachers' ICT integration and students' 21st-century skills. Furthermore, although the review indicates that ICT can support students' skills development when appropriately integrated, it does not provide direct empirical evidence from Tanzanian public secondary schools concerning the relationship between teachers'

ICT integration and students' critical thinking, creativity, communication, collaboration, and problem-solving skills

ICT Infrastructure Availability and Students' 21st-Century Skills Development

Lohr et al. (2024) examined factors associated with digital teaching and learning in German secondary schools, focusing on teachers' technology-related teaching skills, digital technology equipment, school support, internet speed, and Bring-Your-Own-Device (BYOD) practices. The findings showed that teachers' technology-related teaching skills were more strongly associated with students' active digital learning than the availability of digital equipment alone. School support and internet speed were also positively associated with collaborative learning, while the effects of BYOD varied depending on who provided the devices. A key strength of the study is its representative sample of 407 German secondary school teachers and its consideration of multiple aspects of the school digital environment. However, the study focused mainly on digital learning activities rather than the broader development of 21st-century skills, such as creativity, critical thinking, communication, collaboration, and problem-solving. Its reliance on teachers' self-reported data also presents a potential limitation. Therefore, the study leaves a gap regarding whether ICT infrastructure contributes directly to the broader development of students' 21st-century skills, which the present study seeks to address.

Majeed et al. (2021) carried out a study investigating the digital divide affecting female secondary and higher-secondary schools, particularly in relation to ICT infrastructure, electricity, internet connectivity, and access to educational information in Chitral, Pakistan. The study revealed that inadequate ICT infrastructure and unreliable electricity were major barriers to students' access to digital learning resources, while a Wi-Fi-based Content Distributor and tablet-based approach provided an alternative means of delivering educational content in settings with limited conventional infrastructure. A major strength of the study is that it addresses ICT access in an infrastructure-constrained educational context and considers practical approaches for overcoming technological barriers. However, the study focused primarily on access to and acceptance of digital technology rather than students' development of 21st-century skills. Consequently, it does not establish whether improved ICT infrastructure contributes to students' critical thinking, creativity, communication, collaboration, or problem-solving skills, which the present study seeks to investigate.

Bati and Workneh (2021) conducted their study in Ethiopia, examining the readiness of secondary schools to integrate ICT into teaching and learning, with particular attention to ICT infrastructure, teachers' ICT skills, school leadership, and institutional

preparedness. The study revealed significant challenges, including inadequate school-based ICT infrastructure, limited access to technology, weak coordination of ICT for pedagogical purposes, and insufficient capacity-building for teachers and school leaders. The study revealed that students have more access to mobile technologies beyond the classroom than to school-based technologies. The study's major strength lies in the fact that it used Design-Reality Gap Analysis to evaluate the disparity between what is expected of educational institutions in terms of ICT policies and what actually happens at school level. This study explored readiness and integration of ICT rather than students' 21st-century skills. Thus, while it demonstrates that infrastructure is an important foundation for ICT integration, it does not establish whether the availability of ICT infrastructure is associated with students' development of higher-order competencies.

Nshunguyimana et al. (2025) conducted their study in Gakenke District, Rwanda, on the utilization of digital resources and learners' academic performance in technology-enhanced secondary-school classrooms. The study revealed that the availability and utilization of digital learning resources were important components of technology-enhanced learning and were associated with learners' educational experiences and academic outcomes. A major strength of the study is its focus on actual digital-resource utilization within secondary-school learning environments rather than merely examining whether technology is available. However, the study used academic performance as the main outcome, which is not synonymous with the development of 21st-century skills. Improved examination performance does not necessarily indicate the development of creativity, critical thinking, communication, collaboration, or problem-solving abilities. Therefore, the present study can extend this evidence by examining 21st-century skills as the outcome of ICT infrastructure availability.

Ngeze (2017) conducted the research in Tanzania whose main objective was to determine the level of ICT integration and readiness among secondary schools, including the availability of ICT facilities, the level of teachers' ICT knowledge and skills and teachers' ownership of ICT devices. The study's findings indicated that there was poor ICT infrastructure in secondary schools. Most secondary schools had high student to computer ratios even if they had ICT infrastructure, but teachers had a high percentage of ownership of laptops, smartphones, or both. The study's strength was its wide coverage of the whole country which makes it very relevant for this study since it will contribute to the existing evidence in Tanzania. The study focused on determining ICT readiness in terms of the presence of ICT infrastructure and teachers' ICT knowledge and skills. However, the study does not reveal any information on whether students in

Tanzanian secondary schools have better 21st – century skills, which is the main focus of the current study. Thus, the findings of Ngeze (2017) will help respond to the first research question of the current study.

Ndume, et al. (2021) conducted a study whose objective was to assess the progress and challenges of integrating ICT in secondary schools with a focus on ICT infrastructure, accessibility to computers, and internet services and teachers' ICT skills in Tanzania. The study's findings indicated that most secondary schools in Tanzania face ICT integration challenges due to insufficient ICT infrastructure, a high student to computer ratio, low levels of ICT skills among teachers, and limited accessibility of computers and internet services in schools since about 70% of respondents said that their schools lack adequate ICT facilities and internet services. The study's strength lies in its cross-sectional survey which emphasizes the progressive nature of the qualitative study since it sheds light on the status of ICT integration in Tanzanian secondary schools between 2017 and 2019 by using statistical tests to establish relationships and prediction models. The study focused on the impact of ICT on teachers and not on students' competency. The study emphasized the challenges of ICT integration in Tanzanian secondary schools and provides an empirical basis for the current study. The study's limitation was that it did not establish whether the availability of ICT infrastructure predicts students' 21st century skills; hence it will not help answer the second research question.

METHODOLOGY

The study will use a systematic review of the evidence to generate findings. The study will employ a qualitative approach consisting of a systematic review of the literature on teachers' ICT integration, availability of ICT infrastructure, and students' 21st -century skills. The study will utilize peer-viewed journals and relevant books published between 2017 and 2025 on teachers' ICT integration, the availability of ICT infrastructure, and students' 21st – century skills. The literature will be retrieved from databases and search engines like ERIC, Google Scholar, Scopus, and JSTOR by using key terms such as teachers' ICT integration, ICT infrastructure availability, and students' 21st – century skills. The PRISMA approach guided the identification, screening, eligibility, and selection of relevant studies. The selected literature was thematically reviewed to examine evidence on teachers' ICT integration and ICT infrastructure availability and their contribution to students' acquisition of 21st =century skills, with attention to evidence from developed and developing countries, particularly Africa contexts and other Tanzania.

FINDINGS AND DISCUSSION

Teachers' ICT Integration and Students' 21st-Century Skills Development

The reviewed literature indicates that teachers' ICT integration can support students' development of 21st-century skills, particularly when technology is used to facilitate learner-centered, collaborative, interactive, and higher-order learning. However, ICT use alone does not guarantee the development of critical thinking, creativity, communication, collaboration, or problem-solving skills. Ong and Annamalai (2024) reported that TPACK for 21st-century learning was not sufficiently embedded in teacher education, with ICT integration remaining largely at the substitution level rather than being used to facilitate more transformative learning experiences. These findings suggest that the educational value of ICT depends more on how technology is integrated pedagogically than on the frequency of its use. Teachers therefore require both technical and pedagogical competencies to design activities that promote active learning, inquiry, collaboration, creativity, and higher-order thinking. Studies have identified pedagogical knowledge, ICT-related training, perceived competence, teaching experience, and contextual factors as important influences on teachers' ICT integration (Aslan & Zhu, 2017; Ifinedo et al., 2019; Mwei, 2020; Dzinoreva & Mavunga, 2022; Suzer & Koc, 2024).

The literature also indicates that teacher competencies may partly explain the association between access to Information and Communication Technology (ICT) and students' learning experiences. Access to computer devices and platforms has limited influence if teachers are incompetent to adopt and integrate the technologies into teaching and learning processes. However, most of the reviewed articles report teachers' perceptions, intentions, or competencies rather than classroom observations to establish associations between access to ICT and students' 21st-century skills. The differences in studies' contexts, objectives, and indicators also impede the possibility of comparing findings to generate concrete evidence on the relationship. Evidence reveals that deliberate teacher integration of ICT opens doors for students' 21st-century competencies. Nonetheless, teachers need continuous professional development to acquire appropriate technological, pedagogical, and content knowledge to effectively incorporate technology into their practice.

ICT Infrastructure Availability and Students' 21st-Century Skills Development

The reviewed literature indicates that ICT infrastructure availability offers a substantial basis for technology-assisted learning, but it does not automatically contribute to students' 21st-century skills development. Provision of computers, electricity, internet connection, and resources creates conditions for adopting ICT,

whereas the absence of these essentials eliminates the possibility of incorporating technology into instruction (Majeed et al., 2021; Bati & Workneh, 2021). Similarly, Van de Werfhorst et al. (2022) conclude that disparities in school digital infrastructure do not entirely account for differences in pupils' digital skills.

Findings from African contexts reveal the role of inadequate ICT infrastructure in curtailing the potential of using technology to support teaching and learning processes. For example, Ngeze (2017) and Ndume et al. (2021) associate the low adoption of ICT in African schools with a shortage of equipment, a large student-teacher ratio, weak electricity and internet connection, and insufficient ICT resources. These factors limit opportunities for students to participate in virtual research, communication, collaboration, creation, and problem-solving activities. However, the reviewed articles demonstrate that ICT infrastructure should be regarded as a facilitating rather than a limiting factor for students' 21st-century skills development. This assumption is based on the fact that infrastructure availability alone cannot guarantee learning opportunities; instead, competencies of teachers, curriculum expectations, school culture and conditions, and students' engagement with technology also play a crucial role. A major limitation of the evidence presented in the reviewed articles is the fact that infrastructure is assessed in terms of availability instead of considering its quality, accessibility, and learning support. Additionally, some studies do not directly assess students' 21st-century skills or focus on academic achievement and general learning outcomes instead of technology-specific outcomes. As a result, it is not possible to establish a direct link between infrastructure availability and students' 21st-century skills development.

ICT infrastructure availability creates conditions for technology-assisted instruction but not opportunities for students' 21st-century skills development. Evidence from the reviewed articles reveals that appropriate infrastructure, when combined with internet and electricity provision, technical support, accessibility, and relevant resources, can contribute to students' 21st-century skills development. Additionally, teachers need to receive continuous professional development to gain competence in using digital tools for instructional purposes. Therefore, the reviewed literature provides substantial evidence that can guide efforts to maximize the role of ICT in secondary education by complementing infrastructure provision with teacher training and adjusting school conditions and curriculum to enhance students' 21st-century skills development.

CONCLUSION

The reviewed literature reveals the potential of ICT to maximize learning in secondary education, but it also identifies the factors that impede its effective use. According to the reviewed articles, the success of

adopting ICT in education depends on its nature and quality and how it is integrated into the curriculum, not whether it is available. Additionally, the literature indicates that teachers need to receive professional development to gain the skills and confidence needed to use technologies to maximize students' 21st-century competencies. Although the use of ICT can increase students' motivation, participation, and performance, evidence from the reviewed articles indicates that it does not automatically result in enhanced higher-order competencies such as critical thinking, creativity, and communication. In general, the reviewed literature reveals that effective use of ICT requires professional preparation, supportive school leadership and infrastructure, appropriate policies, and meaningful learning experiences that go beyond simply operating digital devices. However, the lack of sufficient evidence on students' 21st-century skills in Tanzanian contexts constitutes a limitation in the reviewed studies, with most of them emphasizing accessibility and use of ICT rather than its quality and impact. Consequently, the reviewed literature provides an adequate foundation for exploring the role of using ICT in Tanzanian secondary education in maximizing students' 21st-century skills development.

Recommendations

In line with the reviewed study, the following recommendations can be generated: Education policymakers and administrators should invest in upgrading infrastructure, including electricity, internet connection, computer equipment, and learning materials, to support technology-assisted learning in schools. Moreover, teacher education programs should be adjusted to ensure that pre-service educators gain a comprehensive understanding of TPACK and 21st-century learning so that they can acquire knowledge about the use of technologies beyond basic operation. Additionally, teachers need to receive continuous professional development to gain the skills and confidence needed to apply ICT in promoting higher-order competencies such as analysis, synthesis, creativity, collaboration, communication, and problem-solving. This process should be practical and consider teachers' diverse needs, including subject specialization. School administrators should also offer pedagogical, managerial, and technical support to enable teachers to continuously engage in peer learning, co-planning, co-assessment, and mentoring activities to maximize the potential of using existing ICT infrastructure. The curriculum and assessment framework need to be adjusted to support technology-assisted inquiry, collaboration, creation, communication, and problem-solving processes instead of emphasizing reproductive approaches to learning.

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