

Interactive Technologies in Online Teacher Education in Africa: A Systematic Review 2014–2024

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Abstract: This systematic review investigates the integration of interactive technologies in online teacher education across Africa from 2014 to 2024. The study aims to identify the types of interactive technologies employed, the leading countries in regard to their adoption, and the outcomes of their usage on teacher training programs. Despite significant advancements, particularly in countries like Kenya and South Africa, the effectiveness of these technologies varies widely due to infrastructural, socio-economic, and policy-related challenges. The findings highlight the critical role of reliable information communication technology (ICT) infrastructure, culturally relevant content, and comprehensive training for educators in optimizing the use of interactive technologies. Additionally, the study emphasizes the need for greater policy coordination and collaboration among African nations to fully leverage these technologies. The review concludes that, while interactive technologies hold substantial potential in terms of transforming teacher education in Africa, sustained efforts are required to overcome the existing barriers and ensure equitable access to quality education across the continent.

Keywords: interactive technologies; online teacher education; digital literacy in Africa; ICT challenges and opportunities; teacher training



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1. Introduction

The advancement of science and technology has positively affected human life from all angles, including education, politics, economy, and the nature of daily interactions (social life) [1,2]. Governments around the world continue to invest considerable efforts, as, in teacher's education particularly, policies are designed to reflect the current state of technological changes [3]. In African countries, interactive technology, particularly in teacher education, has already been manifested and undergone a remarkable evolution overtime [4–6]. The outbreak of COVID-19 in 2019 significantly accelerated the integration of technology in teacher education [7]. Generally, the African continent is witnessing an incredible growth in terms of teacher education, as online teaching and interactive technology are increasingly becoming two inseparable gadgets in the industry of teacher training [8].

These country-level efforts are guided by several aims [9], such as preparing the current teacher trainees for a technologically changing workplace, making teacher training institutions (colleges) more effective and productive, and transforming the teaching process into an active process which is connected to real life [10]. The ICT in Education Policy Framework of Tanzania (2017), the ICT in Education Master Plan of Kenya (2017–2030),

the Uganda National ICT Policy (2012), the Rwanda ICT in Education Policy (2016), the National ICT in Education Strategy for Ethiopia (2018), the National Charter for Education and Training for Morocco (2015–2030), and the Digital Algeria 2013–2018 are few key policies and frameworks which are related to the integration of technology in teacher training [11–16].

The technological evolution in the field of teacher training has been remarkable over the past few decades, particularly in regard to its integration into teacher training policies that have shaped the pedagogical landscape. However, a clear gap persists, as the incorporation of interactive technology remains noticeably limited in many of these policies. Specifically, there has been little policy attention directed toward exploring the extent to which interactive technology has been adopted within teacher training frameworks, especially in African countries. The scarcity of information also extends to the types of interactive technologies employed by teacher training colleges in Africa, if they are used at all. This lack of knowledge motivates the focus of inquiry in this piece of writing. The study draws upon the existing literature to illuminate the current status of interactive technology implementation in teacher training across African countries. It explores the outcomes associated with the use of interactive technology in teacher training in these countries while offering insights into its effectiveness. Additionally, the study proposes various pragmatic strategies aimed at optimizing the integration of interactive technologies within the curricula of teacher training colleges. In doing so, it addresses this scholarly gap and contributes to the advancement of effective educational practices on the continent.

1.1. Interactive Technology in Teacher Training Through the Eyes of Constructivists

Technology and its significance in teacher education can be discussed under the framework of constructivists [17], whose focus is on knowledge (epistemology), as they specify the nature of reality, the idea of which is founded on the basis that knowledge and meaning are generated from experience [18]. From a constructivist perspective, understanding (learning) is constructed by combining prior knowledge with new information from experiences. In the context of teacher education in the African continent specifically, with the latest adopted approach of employing interactive technology in some countries [19,20], constructivists anticipate effective, active, constructive, and meaningful learning, all of which will have resulted from learners (trainees) interacting with technology. Generally, trainees' experience of interacting with technology enlarges their cognitive structure through three complimentary processes: assimilation (new information gained from the experience of interacting with technology is incorporated into prior existing viewpoints), accommodation (altering the existing schema as a result of new experience), and correction [21]. Constructivists in general emphasize the importance of instructors and peers in providing technology, language, and social context for learning (the zone of proximal development), adding that the quality of these tools (i.e., technology) plays an important role [22].

Moreover, constructivist theory underscores the importance of social interaction and collaboration in the learning process, which can be greatly enhanced through interactive technologies [23,24]. In African teacher training, virtual labs, discussion boards, and collaborative platforms provide avenues for meaningful peer-to-peer engagement and instructor support, fostering an environment where knowledge is co-constructed [25–27]. These platforms mirror the dynamics of real-world classrooms, where teachers collaborate and exchange ideas, thus promoting a deeper understanding of teaching practices. Additionally, interactive tools can provide authentic, contextualized learning experiences, such as virtual classroom simulations, which allow trainees to apply theoretical knowledge in practical, real-world scenarios [28]. This not only bridges the gap between theory and practice but also ensures that teacher trainees are better equipped to handle the complexities of their future teaching roles.

1.2. Impact of Interactive Technologies on Teacher Training Outcomes

The integration of interactive technologies into online teacher education programs across Africa has had a profound impact on teaching outcomes, particularly in enhancing digital literacy and pedagogical innovation among educators [29–31]. Studies conducted over the past decade show a marked improvement in the digital competencies of teachers who underwent training through platforms that incorporate interactive tools [32,33]. For instance, the use of Learning Management Systems (LMSs) and mobile learning apps has empowered teachers to adapt to the rapidly evolving educational landscape [34]. The introduction of AI-driven feedback systems and virtual classrooms has also improved teachers' instructional efficacy, enabling them to engage more effectively with students in both physical and digital settings [35,36]. As a result, online teacher education programs have not only increased the accessibility of professional development opportunities but have also improved the overall quality of teaching in African schools [37,38].

Despite these successes, there remain significant challenges in realizing the full potential of interactive technologies in teacher training. The impact of these technologies is often uneven, with rural and remote regions facing persistent infrastructure limitations that hinder access to online platforms [39]. Additionally, there is a critical need for sustained professional development that equips teachers with the skills to integrate these technologies into their daily practices effectively [40]. While early evidence points to positive outcomes in terms of teacher engagement and student learning, the long-term impact of interactive technologies in Africa will depend on continuous investment in infrastructure, localized content development, and the scaling of teacher training programs to reach all areas of the continent.

1.3. Challenges and Progress in ICT Integration in African Countries

The adoption of ICTs in African education systems has been the focus of numerous studies and initiatives. A report by Farrell [41] explored the early integration of ICTs in African schools, highlighting disparities in access and the uneven distribution of resources across Rwanda. Another study [42], emphasized the need for a more systematic approach to ICT integration, noting that, while numerous projects and initiatives exist, many operate in isolation with limited coordination and impact.

In Tanzania, ref. [19,43] discussed the challenges of implementing ICT in higher learning institutions, noting that, despite significant investments in ICT infrastructure, actual usage and integration into the curriculum remain limited due to a lack of training and support for educators. Similarly, ref. [44] evaluated the provision of ICT in schools across East Africa, identifying key barriers such as inadequate infrastructures, high costs, and a lack of relevant content and pedagogical support.

In contrast, countries like Kenya and South Africa have made notable progress in integrating ICT into their education systems [45]. Kenya's Vision 2030 and South Africa's e-Education policy have led to the development of comprehensive ICT strategies that include teacher training, curriculum development, and the establishment of digital infrastructures in schools. These efforts have resulted in improved access to quality education and increased digital literacy among students.

However, the literature also highlights the challenges of sustaining these initiatives. Issues such as political instability, economic constraints, and cultural resistance to change continue to hinder the widespread adoption of ICTs in education. Furthermore, the lack of a unified policy framework across the continent has led to fragmented efforts that fail to fully leverage the potential of ICTs in terms of transforming education.

1.4. Problems of the Study

The primary issue addressed in this study is the lack of a comprehensive understanding of how interactive technologies are being utilized in online teacher education within African higher education institutions. While some advancements have been reported, there are limited empirical data on the specific interactive technologies being employed, which

countries are leading in their adoption, and the measurable impacts these technologies have on teacher education programs. This gap in knowledge prevents education stakeholders from optimizing educational strategies and policies that could enhance the quality of online teacher training across the continent. Without clear evidence on which technologies work best in different contexts, there is a risk of inefficient implementation, leading to underutilized potential and wasted resources.

Gaining more detailed knowledge about the types of interactive technologies in use and their outcomes will provide actionable insights that can inform more effective policy decisions and strategic educational planning. Instead of broad or generalized approaches, education stakeholders will be able to rely on specific data-driven examples of good practices, models that work, and contextual success stories from leading countries like Kenya and South Africa. These examples can serve as benchmarks for other countries, providing a roadmap for how to adapt or replicate successful strategies. This deeper understanding allows for evidence-based improvements to online teacher training programs, ensuring that policies are tailored to the actual needs and realities of different regions, thereby enhancing the overall impact of these technologies across the continent.

1.5. Objective of the Study

The objective of this study is to investigate the adoption and integration of interactive technologies in online teacher training across African higher education institutions. Specifically, the study aims to comprehensively examine the types of interactive technologies currently being utilized, identify the country's leading their adoption, and analyze the outcomes and impacts these technologies have on teacher training programs. By focusing on these aspects, the study seeks to bridge the existing knowledge gap regarding the use of interactive technologies, which has so far hindered the development of targeted strategies and policies. This research will provide actionable insights that can inform and shape policies aimed at enhancing the quality and effectiveness of online teacher education in Africa. Furthermore, it will explore how regional clusters and collaborations between countries, as seen in East and West Africa, can serve as models for other regions to optimize the integration of these technologies, thus improving educational practices across the continent.

This study also aims to contribute to a broader understanding of the mechanisms that drive successful technology adoption, such as regional cooperation, tailored policy frameworks, and public–private partnerships. By providing detailed insights into both successful implementations and persistent challenges, the research will support the formulation of more effective and context-specific strategies to overcome barriers like infrastructure gaps and limited access in rural areas. Ultimately, the study will offer evidence-based recommendations to foster equitable, sustainable growth in the use of interactive technologies within teacher education across Africa.

1.6. Research Questions

1. What interactive technologies are higher education institutions using in online teacher education in Africa?
2. Which leading countries in Africa are using interactive technologies for online teacher education?
3. What are the outcomes of using interactive technologies for online teacher education in Africa?

2. Methods

The study employs a systematic review approach that is specifically based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework [46]. The approach is essential for its rigor in the process of identifying, selecting, and critically evaluating relevant existing studies on teacher training [47]. A systematic literature review ensures a comprehensive synthesis of existing studies on the topic, minimizing biasness and providing a reliable foundation for identifying the existing knowledge

on the topic, guiding future research, and supporting evidence-based decision-making in the discipline of teacher education. The following processes were conducted in order to examine valid, reliable, and relevant sources for our study. The search strategy yielded records from the electronic databases, and the results of the sampling procedure for this systematic literature review are summarized in Figure 1 below.

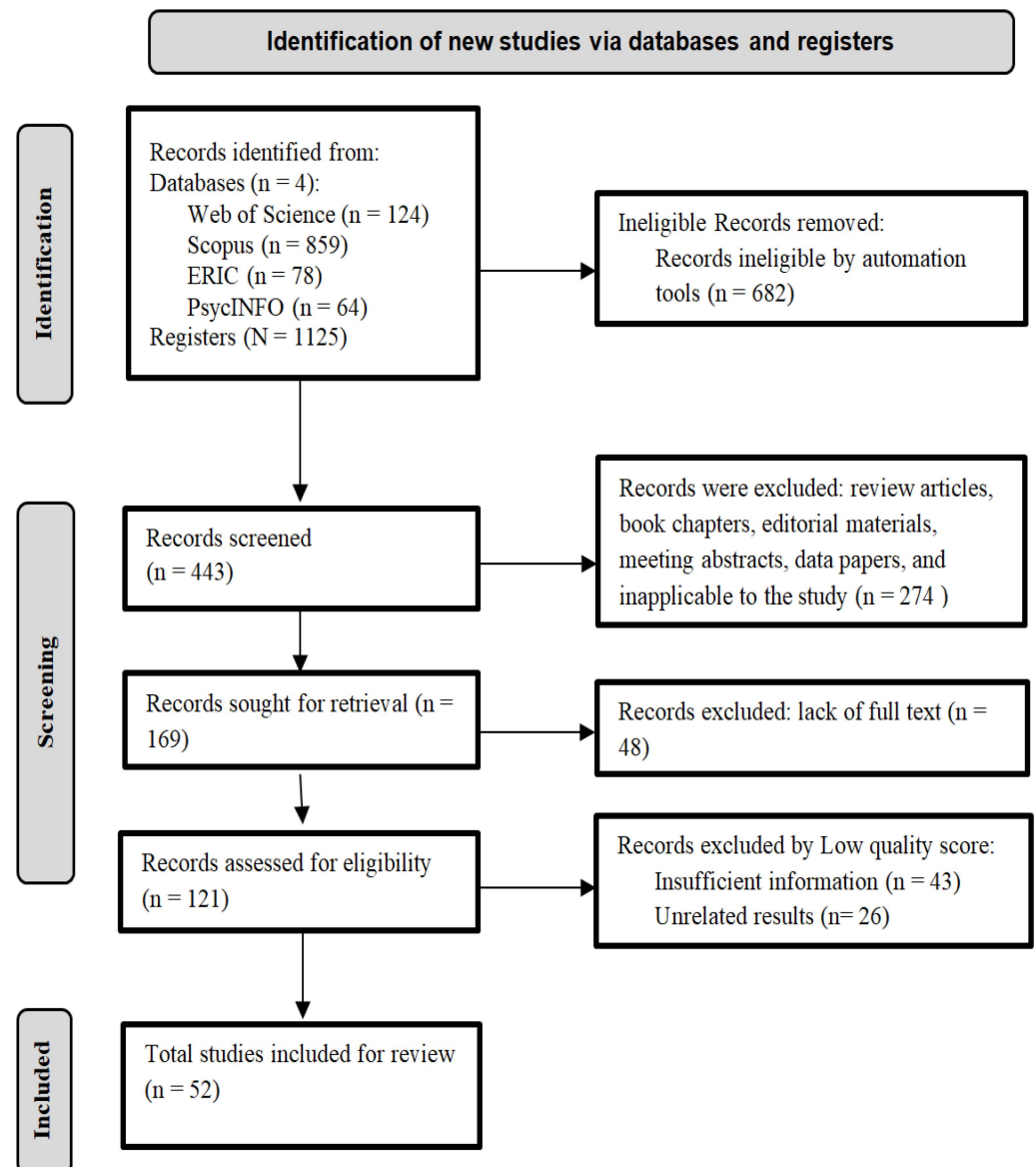


Figure 1. PRISMA flowchart for the study sampling procedure.

2.1. Eligibility Criteria

The eligibility criteria for this literature review were studies that focused on using interactive technologies in online teacher education within African higher education institutions. The included studies were those published in English, featured in peer-reviewed journals, which were available in full-text form, and which provided empirical data on the outcomes of using these technologies. Exclusion criteria included studies not relevant to the research questions, those published in non-peer-reviewed sources, and studies lacking sufficient methodological rigor [46]. Hence, the sample includes studies that met the inclusion criteria and excluded other studies, as summarized in Table 1 below.

Table 1. Inclusion and Exclusion Criteria.

Inclusion Criteria	Exclusion Criteria
Published in English	Published in any language other than English
Peer-reviewed	Non-peer-reviewed
Empirical studies	Reviews or meta-analyses, conference papers, and dissertations
Focus on online teacher education in Africa	Not focused online teacher education in Africa
Publication before 15 June 2024	Publication after the final database search on 15 June 2024
Addressed interactive technologies in teacher education in Africa	Did not address interactive technologies in teacher education in Africa
High and medium quality score	Studies judged to have low quality scores
Availability of full-text for retrieval	Non-availability of the full-text for retrieval

2.2. Data Sources and Search Strategy

The data were retrieved from four electronic databases, Web of Science, Scopus, ERIC, and PsycINFO, which published relevant research that was relevant to the goal of this systematic literature review and was peer-reviewed. Additionally, for completeness, the researchers looked through the reference lists and pertinent reviews of the included studies for other possible potential studies that would be appropriate. Manual searches of reference lists and relevant websites were also conducted. The last search was performed on 15 June 2024.

The search strategy involved using specific keywords and Boolean operators tailored to each database [48]. For example, the search string for Web of Science included terms like “interactive technologies” AND “online teacher education” AND “Africa”. Filters were applied to limit results to peer-reviewed articles published in English. Furthermore, following the PRISMA principles by [46], the search strategy included searching research titles and keywords related to interactive technologies involved in online teacher education in Africa. The Boolean operators, truncation, and wildcards were also used to increase the search’s sensitivity and specificity. Hence, the search parameters comprised the following key terms: “online teacher education”, “online teacher training, or online teacher education in Africa”, “interactive technologies in online teacher education in Africa”, “online interactive teacher education”, “interactive technologies in teacher education”, “online teacher education and interactive technologies in Africa”, and “e-learning and interactive technologies in teacher education in Africa”.

2.3. Selection and Data Collection Process

The selection process involved three researchers who independently reviewed and screened the titles and abstracts for relevance and assessed the full-text articles for eligibility. Discrepancies were resolved through discussion or consultation with a fourth researcher. Automation tools were used to remove duplicate records. Therefore, through this process, the sample includes studies that met the inclusion criteria and excluded other studies, as summarized in Table 1.

Data were collected independently by three researchers using a standardized data extraction form. The form included fields for study characteristics, participant details, the types of interactive technologies used, and the outcomes measured. Any disagreements were resolved through discussion. The authors of primary studies were contacted for clarification when necessary [11]. The data search results were exported from the electronic databases and merged into one Excel sheet. Then, data cleansing was conducted and duplicates were removed. After removing duplicates, the researchers verified the eligibility of the remaining records by looking through their titles and abstracts independently [48]. The researchers prepared the eligible records for a possible full-text screening. The differences in the independently selected studies were discussed and evaluated to reach a consensus among the researchers in line with the established eligibility criteria, which ensured a 100% interrater reliability of the inclusion and exclusion procedure [46]. Finally, data were extracted from each eligible study using a standard data extraction form, as shown in

Table 2. The researchers then entered the data into a spreadsheet and checked for accuracy and completeness to complete the selection and data extraction procedure.

Table 2. Data Extraction Form.

Study	Characteristics of Extracted Data
Author(s)	Name(s)
Year of publication	Before 15 June 2024
Title	Relevant to the aim of this study
Source	Electronic database (Web of Science, Scopus, ERIC, and PsycINFO)
Type of Study	Empirical
Aim and research problem	Objective and research questions
Sample	Studies on interactive technologies in teacher education in Africa
Setting	Online teacher education using interactive technologies
Methodology	Quantitative, qualitative, mixed method
Main findings and conclusions	Interactive technologies used, and outcomes measured
Limitations and implications	Application and recommendations

The primary outcomes sought were the types of interactive technologies used in teacher education, while the secondary outcomes were the measures of the effectiveness of the interactive technologies in teacher education.

2.4. Quality Appraisal

The quality appraisal was based on the Joanna Briggs Institute (JBI) checklist for Systematic Review and Research Syntheses, which was used to evaluate the quality of the eligible studies [49]. The JBI checklist is a critical appraisal tool designed to assess the methodological quality of studies, particularly in systematic reviews and research syntheses. It evaluates the trustworthiness, relevance, and results of published papers [50,51]. The JBI checklist consists of 11 questions that guide reviewers in evaluating various aspects of a study's design, conduct, and analysis. These questions include assessing the true randomization of participants, allocation concealment, the baseline similarities of treatment groups, blinding of participants and outcome assessors, and the reliability of outcome measurements [50,51]. Hence, it systematically addresses these questions on the quality of the studies and enables the researchers to determine the extent to which a study has minimized bias and produced reliable results. The assessed studies were assigned a quality score based on the number of JBI checklist items they met, and the studies were categorized into three levels of quality: high, medium, and low. Therefore, the data synthesis did not include studies with a weak quality score [52].

2.5. Synthesis Methods

Studies were grouped for synthesis based on the types of interactive technologies used and the outcomes measured [48]. Thus, the study synthesized the data from the included studies using the thematic procedure, as in Table 3.

Table 3. Data synthesis Procedure.

Stages of the Thematic Synthesis	
i.	Familiarizing with the data
ii.	Generating initial codes
iii.	Searching for themes
iv.	Reviewing themes
v.	Defining and naming themes
vi.	Producing the report

3. Results

The study identified key trends and outcomes related to the integration of interactive technologies in online teacher education across Africa between 2014 and 2024. The findings reveal that, while interactive technologies have been increasingly adopted, their effectiveness varies significantly across different regions and institutions due to infrastructural, socio-economic, and policy-related challenges.

3.1. Policy Frameworks Supporting ICT in Education in Africa

Table 4 summarizes key policy frameworks supporting ICT in education across various African countries, highlighting their implementation, areas of focus, and impact on teacher education. In Kenya, the ICT in Education Master Plan (2017–2030) emphasizes infrastructure development and teacher training, significantly improving ICT integration within the education system [13]. Tanzania’s ICT in Education Policy Framework (2017) focuses on curriculum integration and digital literacy, resulting in a positive impact, particularly in urban centers [11]. Ethiopia has implemented EthERNet, SchoolNet, and the ICT Business Incubation Centre (since 2001 and 2009), which collectively enhance internet connectivity and educational content delivery to schools, supporting equal learning opportunities and providing capacity-building and advisory services. Botswana aims to connect all secondary schools to the internet through initiatives like Kitsong Centers and Thuto Net, ensuring that each school is equipped with computer laboratories [33]. Uganda’s National ICT Policy (2012) focuses on access to digital resources and teacher support, showing a moderate impact with a strong emphasis on infrastructure [14]. Mozambique (2006) employs Mobile ICT Units and Provincial Digital Resource Centers to address ICT skill shortages by providing training in isolated districts [33,53]. Morocco’s National Charter for Education and Training (2015–2030) targets comprehensive digital transformation, achieving high impacts in urban areas but limited success in rural regions [16]. Mauritius runs the Universal ICT Education and Digital Youth Engagement Program, training widely recognized ICT certification courses to improve digital literacy across various demographics [33]. South Africa’s White Paper on e-Education (2004) focuses on universal access to ICT, with ongoing efforts and steady progress in terms of achieving its goals [54]. These policy frameworks reflect a concerted effort across Africa to enhance ICT integration in education, with varying degrees of success, based on local challenges and opportunities.

Table 4. Policy Frameworks Supporting ICT in Education in Africa.

Country	Policy Name	Year Implemented	Key Focus Areas	Impact on Teacher Education
Kenya	ICT in Education Master Plan [13]	2017–2030	Infrastructure development, teacher training.	Significant improvements in ICT integration
Tanzania	ICT in Education Policy Framework [11]	2017	Curriculum integration, digital literacy.	Positive impact, especially in urban centers
Ethiopia	EthERNet (Ethiopian Education and Research Network), SchoolNet, ICT Business Incubation Center [33]	2001 2009	SchoolNet provides internet connectivity as well as TV-broadcast educational content to secondary schools across Ethiopia. As such, it provides students in rural schools with access to equal learning opportunities to those in urban schools. EthERNet was launched to build and deliver highly interconnected and high-performance networks for universities and other educational and research institutions while EthioICT-Village was used to establish Ethiopia as the premier IT hub of Africa.	Provides office space, capacity building and advisory services

Table 4. Cont.

Country	Policy Name	Year Implemented	Key Focus Areas	Impact on Teacher Education
Botswana	Kitsong Centers, Thuto Net, Botswana Innovation Hub, Connecting Communities Program, and Pan African e-Network Project [33]		To link all secondary schools to the internet. As such, all secondary schools in Botswana have computer laboratories comprising about 15–20 computers.	To link all secondary schools to the internet. As such, all secondary schools in Botswana have computer laboratories comprising about 15–20 computers
Uganda	National ICT Policy [14]	2012	Access to digital resources, teacher support.	Moderate, with focus on infrastructure
Mozambique	Mobile ICT Unit, Provincial Digital Resource Centers (CPRDs) [33,54]	2006	To provide training courses in districts isolated from ICT facilities to address the problem of ICT-skilled human resources across the country. CPRDs concentrate ICT infrastructure, skills, and investment by providing a single entry point for ICT deployment and activity in the provinces.	
Morocco	National Charter for Education and Training [16]	2015–2030	Comprehensive digital transformation.	High impact in urban areas, limited in rural
Mauritius	Universal ICT Education and Digital Youth Engagement Program, Public Internet Access Points (PIAPs), and Learning Corners [33]		Training the internationally acknowledged internet and computing core certification (IC3) course to students, employees, nonemployees, and the population at large with a view of making it the benchmark for digital literacy/proficiency in Mauritius.	
South Africa	White Paper on e-Education [55]	2004	Universal access to ICT.	Ongoing, with steady progress

3.2. Interactive Technologies Across African Regions

Table 5 provides a comparative analysis of the integration and challenges of interactive technologies across different African regions, highlighting the dominant technologies, level of integration, main challenges, and opportunities in each region. In East Africa, virtual classrooms and Learning Management Systems (LMSs) are highly integrated into educational practices, with strong policy support in countries like Kenya driving this adoption. However, challenges such as limited rural access and high costs hinder widespread usage, particularly in less accessible areas. West Africa primarily utilizes mobile learning apps and virtual labs with a medium level of integration. The main challenges in this region include poor infrastructures and a lack of adequate training for educators. Nevertheless, the growing mobile connectivity offers significant opportunities for expanding the reach of these technologies. In Southern Africa, interactive content tools are highly integrated and supported by increasing investments in ICT infrastructure. Despite this, economic disparities and the high costs associated with technology adoption pose significant challenges. However, the region's commitment to expanding ICT infrastructures presents a promising avenue for overcoming these obstacles. North Africa sees a high level of integration of digital assessments and virtual labs, particularly in countries like Morocco, Egypt, and Tunisia, where government initiatives support the adoption of these technologies. However, socio-political instability and uneven adoption rates across different areas remain major challenges. Finally, Central Africa exhibits a low level of integration of basic ICT tools, largely due to significant infrastructure challenges and political instability. Despite these hurdles, there is the potential for regional collaboration to enhance the adoption and impact of interactive technologies in this region based on the integration level, and dominant interactive technologies show a stark contrast across African regions, with Central Africa exhibiting low integration and reliance on basic ICT tools compared to the more advanced, high-integration technologies in other regions such as East, North, and Southern Africa. This discrepancy suggests that Central Africa could benefit from collaborative support in technology transfer and training from neighboring regions that have developed

advanced capacities. Moreover, government initiatives in North Africa, such as those in Morocco, Egypt, and Tunisia, highlight a successful precedent for policy-driven collaboration. These initiatives illustrate that political will, alongside regional collaboration, can enhance technology access even in socio-politically complex regions.

Table 5. Comparative Analysis of Interactive Technologies Across African Regions.

Region	Dominant Interactive Technology	Level of Integration	Main Challenges	Opportunities
East Africa	Virtual classroom LMSs	High	Limited rural access, high costs	Strong policy support in countries like Kenya
West Africa	Mobile Learning Apps, Virtual Labs	Medium	Poor infrastructure, lack of training	Growing mobile connectivity
Southern Africa	Interactive Content Tools	High	Economic disparities, technology costs	Increasing investment in ICT infrastructures
North Africa	Digital Assessments, Virtual Labs	High	Socio-political instability, uneven adoption	Government initiatives in Morocco, Egypt, and Tunisia
Central Africa	Basic ICT Tools	Low	Infrastructure, political instability	Potential for regional collaboration

This comparative analysis underscores the varied levels of technological integration across African regions, each with its unique set of challenges and opportunities that influence the effectiveness and reach of interactive technologies in education.

The level of integration (high, medium, low) based on several key factors. These include the adoption rate of dominant technologies (e.g., virtual classrooms, Learning Management Systems, mobile learning apps, etc.), the presence of policy support (such as national initiatives driving technological integration), and the availability of ICT infrastructures (internet access, devices, etc.). Additionally, economic factors (such as disparities in wealth and affordability) and social conditions (like political stability and access to training for educators) are considered. Regions with strong policy backing and significant infrastructure investment tend to score higher, while those facing challenges like poor infrastructures or political instability are rated lower. Opportunities such as growing mobile connectivity or regional collaboration also influence these ratings.

3.3. Impact of Interactive Technologies on Teacher Training

Table 6 presents the impact of interactive technologies on teacher training outcomes across several African countries, using specific metrics to assess effectiveness. Digital literacy is evaluated by the percentage of teachers trained, with Kenya and South Africa showing a high impact. Studies indicate a significant improvement in digital competencies among teachers in these countries, highlighting the success of digital literacy initiatives driven by interactive technologies. Teaching efficacy is measured through student performance and teacher evaluations, with mixed results being observed in Nigeria and Egypt. While there is a medium impact overall, outcomes are notably better in urban areas, suggesting that infrastructure and access play critical roles in enhancing teaching efficacy through technology. Student engagement, assessed by attendance rates and participation, shows a high impact in Kenya and Morocco, where Learning Management System (LMS)-supported environments have led to higher levels of student engagement. This increased engagement is a key indicator of the effectiveness of interactive technologies in fostering active learning. Finally, pedagogical innovation, measured by the adoption of new teaching methods, demonstrates a medium impact in South Africa and Egypt. There is evidence of innovative teaching methods emerging in these countries, driven by the integration of interactive technologies into the educational process. Overall, the table underscores the varying degrees of impact that interactive technologies have on different aspects of teacher

training, with notable successes in digital literacy and student engagement, while areas such as teaching efficacy and pedagogical innovation show room for further development.

Table 6. Impact of Interactive Technologies on Teacher Training Outcomes.

Outcome	Metrics Used	Countries	Impact Level	Evidence from Studies
Digital Literacy	Percentage of teachers trained	Kenya, South Africa	High	Studies show significant improvement in digital competencies
Teaching Efficacy	Student performance, teacher evaluations	Nigeria, Egypt	Medium	Mixed results, with better outcomes in urban areas
Student Engagement	Attendance rates, participation	Kenya, Morocco	High	Higher engagement reported in LMS-supported environments
Pedagogical Innovation	Adoption of new teaching methods	South Africa, Egypt	Medium	Evidence of Innovative teaching methods emerging

The impact levels in Table 6 are based on specific metrics such as the percentage of teachers trained, student performance, attendance rates, and the adoption of new teaching methods. A “high” impact is observed when these metrics show significant, widespread improvements, such as in Kenya and South Africa, where digital literacy and student engagement have notably increased due to the integration of interactive technologies. In contrast, a “medium” impact reflects more uneven outcomes, as seen in Nigeria and Egypt, where teaching efficacy and pedagogical innovation show progress but are limited by factors like infrastructure and access. The distinction between high and medium impact lies in the consistency and breadth of these improvements across different regions and contexts, with high impact representing more comprehensive success in integrating technologies into teacher training.

3.4. Adoption of Interactive Technologies in Leading African Countries

The adoption of interactive technologies in leading African countries and their impact on teacher training. In Kenya, the adoption level of Learning Management Systems (LMSs) and virtual classrooms is high, leading to a significant improvement in digital literacy among teachers and an increase in teaching efficacy. This high level of adoption has positively transformed the way educators deliver content and interact with students, ensuring that teachers are better equipped to handle the demands of a digital learning environment. South Africa has also demonstrated a high level of adoption, particularly with interactive content creation tools. These tools have greatly enhanced student engagement and improved teaching outcomes, making the learning experience more interactive and effective. The country’s focus on integrating these tools into the classroom has resulted in more dynamic teaching methods and better student participation. In contrast, Nigeria has seen a medium level of adoption, particularly with mobile learning applications. While these applications have the potential to improve educational outcomes, their impact has been moderate due to ongoing infrastructural challenges. These challenges have limited the effectiveness of mobile learning technologies, hindering their full potential in teacher training. Lastly, Egypt has also exhibited a high adoption level of virtual labs and digital assessments, leading to positive outcomes in both teacher training and student performance. The integration of these technologies has provided teachers with more sophisticated tools for assessment and experimentation, thus enhancing their teaching capabilities and improving overall student achievement. Overall, Table 7 highlights the varying levels of technology adoption across these countries and the corresponding impact on teacher training, with Kenya, South Africa, and Egypt showing substantial benefits and Nigeria facing challenges that moderate the effectiveness of its technological integration.

Table 7. Adoption of Interactive Technologies in Leading African Countries.

Country	Technology Type	Adoption Level	Impact on Teacher Training
Kenya	LMS, Virtual Classrooms	High	Signification improvement in digital literacy and teaching efficacy
South Africa	Interactive Content Creation tools	High	Enhanced student engagement and teaching outcomes
Nigeria	Mobile Learning Applications	Medium	Moderate impact due to infrastructural challenges
Egypt	Virtual Labs, Digital Assessments	High	Positive outcomes in teacher training and student performance

The “level of adoption” refers to the extent to which interactive technologies (such as Learning Management Systems, virtual classrooms, mobile learning apps, etc.) have been integrated into the educational system of a given country, particularly in teacher training.

3.5. Benefits of an ICT Competency Framework for Teachers in Africa

The benefits of implementing an ICT competency framework for teachers in Africa (Table 8), emphasizing its impact on various levels of the educational system. At the systemic level, the framework fosters innovation by focusing on transformative practices in ICT integration within the educational system. This emphasis on systemic innovation leads to significant changes in the organizational and structural features of ICT course provision both in preservice and in-service teacher training. The framework’s alignment with the School Improvement Program for Secondary Education (SIPSE) further underscores its role in driving systemic transformation in education. At the classroom level, the framework promotes innovations in STEM teaching and learning by integrating technology in ways that reshape both content and pedagogy. This dual focus on what students learn and how they learn enhances the overall educational experience, making learning more dynamic and engaging. Additionally, the framework provides confidence in course materials by ensuring that all course development and materials align with agreed-upon and transparent ICT teacher competency standards. This alignment fosters trust among the Ministry of Education, partners, and other course stakeholders, ensuring that the materials are robust and effective. Finally, the framework supports policy awareness and the development of transformative teachers by embedding school, district, and national policies in ICT integration into teachers’ daily work. This integration encourages teachers to engage with students using innovative and exemplary practices, thereby reinforcing the importance of policy in shaping educational outcomes. Collectively, these benefits highlight the comprehensive impact of the ICT competency framework on improving educational practices and outcomes across Africa.

Table 8. A summary of the benefits of an ICT competency framework for teachers in Africa.

Competency Level	Advantage/Benefits
Innovation at systemic level	A competency framework in the SIPSE can focus on ICT integration in terms of transformative practices at the systemic level in education. This will lead to changes in the organizational and structural features of ICT course provision at both the preservice and in-service levels. A competency framework in the SIPSE can focus on ICT integration in terms of innovative and transformative elements.
Innovation at classroom level	Practices at the classroom level of STEM teaching and learning where technology integration changes content as well as pedagogy (e.g., what students learn as well as how they learn).
Confidence in course materials	The ministry, partners, and course stakeholders can be confident in course development and materials that are aligned to agreed and transparent ICT teacher competency standards.
Policy awareness and transformative teachers	The framework embeds school, district, and national policy in ICT integration by applying it in their daily work and engaging with students in innovative and exemplary practice standards

3.6. Challenges in the Integration of Interactive Technologies

The integration of interactive technologies across Africa faces several significant challenges that hinder widespread adoption, particularly in educational settings. Infrastructural limitations are a major barrier, with inadequate Information and Communication Technology (ICT) infrastructures being especially pronounced in rural areas of Sub-Saharan Africa and parts of Nigeria, where the availability and reliability of digital technologies are severely constrained. High costs further exacerbate the situation, as the expense of technology and the lack of affordable solutions make it difficult for many institutions in less developed regions to acquire and maintain the necessary tools for interactive learning. Compounding these issues is the lack of training, with insufficient programs being available to equip educators with the skills needed to effectively utilize new technologies, a problem that is widespread, particularly in West Africa. Additionally, socio-economic disparities, especially in rural areas, limit access to digital tools due to economic inequalities, thereby widening the digital divide and leaving economically disadvantaged regions struggling to benefit from technological advancements. These challenges (Table 9) highlight the complex and multifaceted obstacles that must be addressed to ensure equitable access to interactive technologies across Africa, necessitating targeted interventions that consider infrastructural, economic, educational, and socio-economic factors.

Table 9. Key Challenges in the Integration of Interactive Technologies.

Challenges	Description	Affected Regions
Infrastructural Limitations	Poor ICT infrastructure, especially in rural areas	Sub-Saharan Africa, parts of Nigeria
High Costs	Expensive technology and lack of affordable solutions	Across the continent, especially in less developed regions
Lack of Training	Insufficient training programs for educators on using new technologies	Widespread, particularly in West Africa
Socio-Economic Disparities	Economics inequalities that limit access to digital tools	Rural areas across Africa

4. Discussion

The integration of interactive technologies in online teacher education across Africa has been a significant development over the past decade. The study highlights that, while there has been notable progress in adopting these technologies, the effectiveness and extent of their integration vary significantly across different regions and institutions. This variation is primarily due to infrastructural disparities, socio-economic challenges, and differing levels of policy support. For instance, countries like Kenya and South Africa have made considerable strides in integrating interactive technologies into their teacher education programs, largely due to better infrastructures and more robust policy frameworks. However, in regions like Central Africa, the adoption of these technologies remains limited, reflecting broader infrastructural and socio-political challenges. It is important to illustrate how policies, technologies, and outcomes inform our understanding of the integration of interactive technologies in online teacher education across Africa. Policies such as those in Kenya and South Africa, which prioritize ICT infrastructures and teacher training, have been instrumental in enhancing digital literacy and access to technology in educational settings. These policies are foundational in terms of facilitating the broader adoption of interactive technologies, particularly through initiatives that ensure the availability of necessary infrastructures and teacher competency in using these tools.

When comparing these findings to other studies on the integration of ICT in education globally, a similar trend is observed. For example, research by [43] on ICT integration in African schools identified significant barriers, such as inadequate infrastructures and a lack of relevant content, which mirror the challenges found in this study. Additionally, studies in other developing regions, such as South Asia and Latin America, have also reported similar challenges, where infrastructural limitations and socio-economic disparities hinder

the widespread adoption of interactive technologies in education [8,22]. These comparisons indicate that, while the challenges in Africa are significant, they are not unique, suggesting that solutions implemented in other regions might be adaptable to the African context.

The effectiveness of interactive technologies in enhancing teacher education outcomes is evident in regions with better infrastructures and more substantial policy support. In Kenya and South Africa, for example, the use of Learning Management Systems (LMSs) and virtual classrooms has led to significant improvements in digital literacy among teachers and students as well as increased student engagement and teaching efficacy. These outcomes align with findings from global studies that show a positive correlation between the use of interactive technologies and improved educational outcomes [19]. However, the study also reveals that, in regions with poorer infrastructures, the impact of these technologies is less pronounced. This is consistent with the broader literature, which emphasizes that the success of ICT integration in education is heavily dependent on the availability of supporting infrastructure and adequate training for educators [41].

Despite the challenges, the study identifies several opportunities for advancing the integration of interactive technologies in online teacher education in Africa. The growing penetration of mobile technologies across the continent offers a promising avenue for expanding access to online education, particularly in rural and underserved areas. Additionally, the increasing interest in innovation hubs and living labs presents opportunities for developing context-specific solutions that address the unique challenges faced by African education systems. However, to fully realize these opportunities, there is a need for greater policy coordination across the continent, as well as increased investment in infrastructure and capacity-building programs for educators. This aligns with recommendations from other studies which emphasize the importance of a comprehensive and coordinated approach to ICT integration in education [4,10,55].

The integration of interactive technologies in online teacher education in Africa holds significant potential for improving educational outcomes. However, the success of these technologies is contingent upon addressing the infrastructural, socio-economic, and policy-related challenges that currently limit their effectiveness.

4.1. Recommendations

To effectively integrate interactive technologies into teacher education across Africa, several strategic recommendations must be implemented to overcome the current challenges. First and foremost, infrastructure development is critical for bridging the regional disparities in technology adoption. Countries like Kenya and South Africa have made significant progress due to better infrastructures, but many parts of Sub-Saharan Africa still lack basic digital access. Governments, in collaboration with international organizations, need to prioritize investments in expanding internet connectivity and reliable electricity, particularly in rural and underserved regions. These foundational resources are necessary for educators to fully utilize interactive technologies both in physical classrooms and online environments. Without adequate infrastructures, the adoption of ICT tools in teacher training will remain uneven, limiting the potential for widespread educational transformation.

Additionally, enhanced teacher training programs are essential for empowering educators to effectively integrate technology into their teaching practices. Current efforts, such as the SIPSE project in Kenya and Tanzania, have shown promise, but these initiatives need to be scaled and tailored to local contexts. Teachers require ongoing professional development that equips them with both digital literacy skills and pedagogical strategies for using ICT in the classroom. This can be achieved through blended training models that combine face-to-face workshops with online courses, ensuring that teachers in remote areas are not left behind. Moreover, the focus should be on sustainable, long-term capacity-building initiatives that continuously support educators as technologies evolve. These programs should include opportunities for teachers to collaborate and share best practices, creating networks that foster innovation in ICT use for education.

The creation of culturally relevant educational content that reflects the realities and needs of African students and teachers is also equally important. Many ICT-based educational programs are developed with a Western-centric approach which may not align with the unique cultural and social dynamics in African classrooms. Engaging local educators, researchers, and communities in the content development process is crucial for ensuring that the materials resonate with learners and address their specific challenges. This approach not only enhances student engagement but also helps to build a more inclusive and relevant education system. By promoting localization in content creation and adapting ICT tools to African contexts, educational programs can become more effective, fostering meaningful learning experiences that drive long-term improvements in teacher training and student outcomes.

4.2. Implications

The findings suggest that policy support and investment in ICT infrastructure are crucial for the successful integration of interactive technologies in teacher education. Governments need to prioritize the development of digital infrastructures and provide adequate training for educators to ensure that they can effectively use these tools in their teaching practices.

Despite these challenges, there are several opportunities for enhancing the integration of ICT in education and online teacher education in Africa. The growing mobile phone penetration across the continent presents a unique opportunity for leveraging mobile technologies for educational purposes, including the delivery of interactive online teacher training programs. Additionally, the increasing interest in innovation hubs and living labs in Africa provides a platform for developing context-specific solutions that can address the unique challenges faced by African education systems both in terms of student learning and teachers' professional development.

5. Conclusions and Future Research

In addition to the identified outcomes, it is clear that the integration of interactive technologies in teacher education is not a one-size-fits-all solution. Variations in technological infrastructure, policy support, and teacher readiness across different African nations require context-specific approaches to maximize the potential of these tools. While countries like Kenya, South Africa, and Egypt have pioneered the adoption of digital tools, other regions face substantial barriers related to internet connectivity, digital literacy, and access to devices. Therefore, future initiatives should focus on building the necessary infrastructures and fostering teacher development programs tailored to local needs to bridge these divides. Moreover, the need for continuous professional development (CPD) is paramount. Many educators, particularly in rural and under-resourced areas, lack the training to effectively incorporate interactive technologies into their teaching practices. Strengthening CPD programs that include interactive technology training will not only improve teacher competencies but also ensure that the integration of these technologies is sustainable in the long term. Investment in digital pedagogies and teacher support networks, alongside robust monitoring and evaluation frameworks, can lead to more widespread success and sustainability in digital education across Africa.

Lastly, partnerships between governments, educational institutions, and international organizations are essential for driving the next wave of technological advancements in teacher education across Africa. UNESCO-led initiatives, such as the Global Education Coalition and the "ICT Transforming Education in Africa" project, exemplify the power of collaborative efforts to overcome infrastructural and resource limitations. The Global Education Coalition, launched in response to the COVID-19 pandemic, facilitated continuity of learning through digital platforms by uniting governments, the private sector, and educational institutions. Similarly, the ICT Transforming Education project provided both infrastructures and training resources to help teachers in countries like Kenya, Namibia, and Ghana integrate digital tools effectively.

These initiatives demonstrate how cross-sector partnerships can address critical barriers in technology access and skills training, equipping African nations to embrace digital transformations in education. Through strategic collaboration, these partnerships go beyond resource sharing to foster foundational digital skills, policy support, and sustainable resource allocation, which are vital for advancing teacher education. By leveraging these partnerships, African countries can fully utilize interactive technologies to drive educational equity and improve learning outcomes on a continent-wide level.

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