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Technological Convergence in African Higher Education: Insights from Bibliometric and Scientometric Analysis

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Abstract. The massive influx and proliferation of novel innovative technologies have characterised the fourth industrial revolution (Industry 4.0) era. These technologies have significantly revolutionised every sector, especially the education sphere in Africa. Prominent among these technologies, such as gamification, virtual reality, robotics, and augmented reality, are transforming the conventional teaching and learning approaches, promoting active learning experiences, and enhancing student engagement. Hence, this paper seeks to identify, analyse, visualise, and map emerging technology convergence research trends for T&L in the African higher education sector. A quantitative method (science mapping) was utilised to analyse the 217 bibliometric datasets (scholarly publication outputs) extracted from the Scopus database from the years 2010 to 2024. It was revealed that South Africa, Nigeria and Ghana are the top contributors to the research on emerging technology convergence for teaching and learning in the African higher education sectors. The results presented the annual publication trends, citations burst, keywords co-occurrence, document sources, cluster analysis, and scientific collaboration network. This study is a valuable addition to the growing educational technology body of knowledge, providing valuable insights for educators and policymakers seeking to leverage the use of ETs effectively. Conclusively, the study showed that adopting ETs can accelerate the achievement of United Nations Sustainable Development Goal Four by promoting equitable access to quality education and bridging the digital divide across diverse African communities and regions.

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1. Introduction

Higher education institutions (HEIs) are regarded as vital hubs driving economic development (Chatterton & Goddard, 2000). This is because they provide career-support functions through lifelong learning and more tailored educational offers, which enhance capacity development. Most significantly, the teaching and learning (T&L) approach engaged in higher education (HE) plays a fundamental role in fostering intellectual advancement and knowledge proliferation within society. Similarly, various methods, concepts, and findings of practical relevance and theoretical interest have emanated from many years of research into T&L in HE (Richardson, 2013).

The present fourth industrial revolution (4IR) era is characterised by the convergence of emerging technologies (ETs) such as artificial intelligence (AI), virtual reality (VR), robotics, augmented reality (AR), the Internet of Things (IoT), mixed reality, metaverse, blockchain, expert systems, chatbot, intelligent agents/tutors, personalised learning environments, machine learning, artificial intellgigence (AI) and 3D printing are blurring the boundaries between the physical, digital, and biological worlds, and creating new opportunities and challenges in HE and other fields.

Hence, the HE sectors globally are undergoing a profound transformation driven by the evolution, integration, and convergence of these technologies. While ET is used in this study, other terminologies such as digital technology (Brozovsky et al., 2024), advanced technology (Anozie et al., 2024), new technology (Sánchez-García et al., 2024), novel technology (Hughes et al., 2024), and disruptive technology (Locock et al., 2024) are used interchangeably in the literature, all describing the technologies that have characterised the fourth industrial revolution (4IR) era.

ETs are early-stage tools with transformative potential in various fields. These tools are characterised by their novel applications and ability to revolutionise existing practices and fields (Sembey et al., 2024). On the other hand, technological convergence or technological interoperation refers to the homogenisation of various technologies into a unified system, thereby enabling supercharged, efficient, improved, and enhanced functionalities (Brynjolfsson & McAfee, 2014).

According to Cordeiro (2021), technological convergence entails merging different technologies to collectively drive rapid innovations, advancements, and developments. It describes integrating various technologies into a unified system towards enhanced efficiencies, performance, and functionalities. The interoperability of ETs and the internet is significant, enabling the integration of online resources, multimedia presentations, and other amazing capabilities for a transformed T&L experience in the HE sector. This technological convergence has dismantled traditional T&L paradigms and structures, paving the way for novel,

interactive, and innovative approaches that can be understood through direct immersion and experiential engagement (Alam & Mohanty, 2023; Aparicio et al., 2024). The convergence has led to the eruption of blended learning models, which combine the conventional face-to-face T&L system with online components (Rossouw & Goldman, 2023). One of the notable outcomes of technological convergence is the paradigm shift from a conventional (lecture-based) instruction approach to more flexible and learner-focused pedagogies.

Artificial Intelligence-driven learning tools, mobile applications, video conferencing platforms and learning management systems (LMSs) have converged to create hybrid and fully online learning environments. These platforms allow educators to personalise content, provide instant feedback, and support a range of learning styles. This convergence is not simply about digitisation; it is about reinventing pedagogical approaches to exploit the affordances of digital ecosystems and their constituents.

The last global pandemic caused by coronavirus has seen an upward trajectory in the proliferation and adoption of ETs across disciplines. This has also exposed these technologies' numerous benefits and drawbacks in developed, developing, and underdeveloped nations. Some of the benefits of emerging technologies include enhanced connectivity, improved education, sustainable development, improved healthcare, and increased productivity. ETs can be engaged to create more engaging and interactive T&L experiences, which will subsequently help educators and students to teach and effectively learn, respectively efficiently.

These technologies have the potential to automate tasks, make better decisions, and collaborate more effectively, leading to increased productivity and efficiency in many fields. They can also be used to conserve resources, reduce pollution, and mitigate climate change, leading to a more sustainable future for the human and natural environments. These technologies can also accurately diagnose diseases, develop new treatments, and deliver personalised care, leading to better health for people globally. ETs can also aid seamless connection and communication regardless of location, thereby leading to a more engaged society.

A major positive side of ETs is their ability to foster inclusion, improve employment and education for persons living with disabilities (Talafha & Bataineh, 2025), thereby leading to the implementation of the United Nations sustainable development goal (SDG) 4 (quality education), goal 5 (gender equality), goal 10 (reduced inequalities), and goal 16 (peace, justice and string institutions). While these technologies continue to reinvent the socioeconomic space in developed countries, most African nations lag behind due to numerous factors. Technological advancement remains slow-paced in a country like South Africa, where unemployment, poverty, and the recent energy crisis are predominant.

There are several amazing and transformational benefits accrued to the integration and utilisation of ETs in the higher education space. These ETs have reinvented the T&L experiences of all stakeholders in the education sector.

According to Criollo-C et al. (2021), ETs ensure affordability and portability, availability and flexibility, provide quick support, enhance learning spaces and student behaviour, enable collaborative learning, informal and self-directed learning, motivational learning and constructivist learning. ETs also enhance communication, learning support and prompt information retrieval for a personalised T&L environment tailored to the individual needs of everyone (Samala et al., 2024).

Similarly, ETs have enabled sustainable education, learning adaptivity and transformed the conventional one-way interaction between student learning and digital content knowledge, thereby ensuring a robust interaction and connection between learners and educators/teachers (Lee & Hwang, 2022). Without compromising authenticity and security, ETs also aid data availability, data management, data verification and full transparency required when handling educational records and certifications (Bhaskar et al., 2021).

Also, ETs have been employed for adaptive learning, personalisation, evaluation, assessment, performance prediction, learner profiling, analysing student input, predicting marginal or at-risk learners, pedagogical planning, improving e-learning, increasing learners' engagement and interest, improving quality interactions, and analysing large student data (Zhang & Aslan, 2021). Hence, this study is aimed at identifying, analysing, visualising, and mapping the convergence of emerging technology (ET) research for T&L in the African HE sectors.

2. Research Methodology

The methodological approach employed in this study involved the combination of bibliometric and scientometric analysis and discussion. Using the Scopus database, this was done to gain an in-depth understanding of innovative technologies for teaching and learning (T&L) within the African higher education sphere in the pre-COVID and post-COVID era. Conventionally, the Scopus and Web of Science (WoS) databases are regarded as the most widely used for bibliometric analyses (Singh et al., 2021).

According to Mishra et al. (2021), Scopus, compared to other databases such as WoS and PubMed, is a choice citation and abstract database of scholarly articles. It is a comprehensive database that supports the conduct of bibliometric analysis because it contains a substantial number of journals compared to other databases of scientific publications (Maral, 2024; Medias et al., 2024). Figure 1 presents the research methodology flowchart for the study. The bibliometric search was done using the Scopus database, while the scientometric analysis as a science mapping tool was done using the VOSviewer application.

The search for documents on technological advancements and innovations for T&L in higher education was conducted by utilising the identified keywords and considering peer-reviewed documents published between 2010 and 2024. The keywords found to be used interchangeably in the literature include emerging technology, advanced technology, digital technology, disruptive technology, and

new technology. The datasets used for the study, as extracted from the Scopus database, include conference papers, journal articles, book chapters and books.

The key search words used were "Emerging technology" OR "Emerging technologies" OR "Digital technology" OR "Digital technologies" OR "Disruptive technology" OR "Disruptive technologies" OR "Advanced technology" OR "Advanced technologies", OR "New technology" OR "New technologies" AND "Teaching and Learning". The literature search was conducted on 20 February 2025. The initial search result revealed a total of 2940 documents. After conducting further filtering and refinement (language = English, document type = journal articles, book, chapters, and conference proceedings, country/territory = African countries) on the revealed initial 2940 documents, the process resulted in a total of 217 articles, which were extracted and adopted for use in the study.

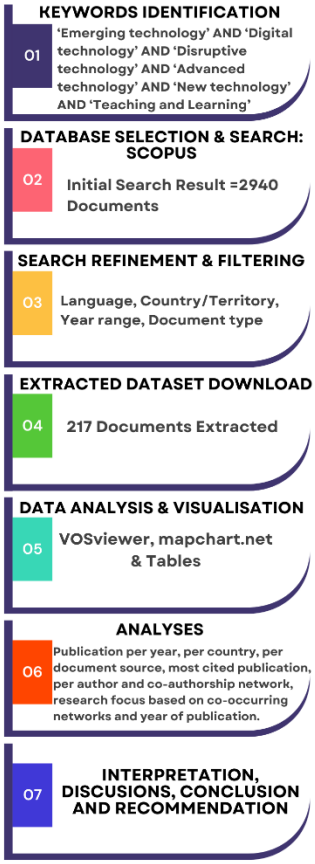

Figure 1: Research methodology framework

3. Results and Discussion

3.1 Publication Per Year

A total of 217 documents were extracted, forming the datasets for the study. From the dataset, 106 documents are journal articles, 50 are book chapters, and 61 are from conference proceedings. Based on the number of publications per year, the result showed that a total of 49 countries have contributed to the research on emerging technology (ET) convergence for T&L in the African HE sectors. The result shows a gradual and scattered rise in the number of publications from 2010

to 2024. The year 2010 recorded six (6) publications on the subject, with the number doubled (12 publications) in 2013. However, a drop can be seen in the number of scholarly outputs from 2014 (5 publications) to 2018 (5 publications). From 2019 onwards, there has been a gradual rise in the number of scholarly outputs in this area, with 2022 experiencing the highest number (41) of publications. The year 2023 saw a decline in the number of publications (34) before a slight upward trend to 37 publications in 2024. Considering the upward trend of publications from 2019 to date, it can be agreed that the COVID-19 pandemic lockdown played a significant role. Due to a lack of preparation, the pandemic also paralysed T&L activities, especially in Africa (Oguntona et al., 2021).

According to Mishrif and Khan (2023), the COVID-19 pandemic and its consequent lockdown have increased the adoption and accelerated the use of technology in various sectors. To avert closure and downturn in the event of an unprecedented pandemic, businesses turned to ETs, prompting a rush in adoption (Lashitew, 2023) and the use and proliferation of novel ones, especially for T&L purposes (Al-Maroof et al., 2023).

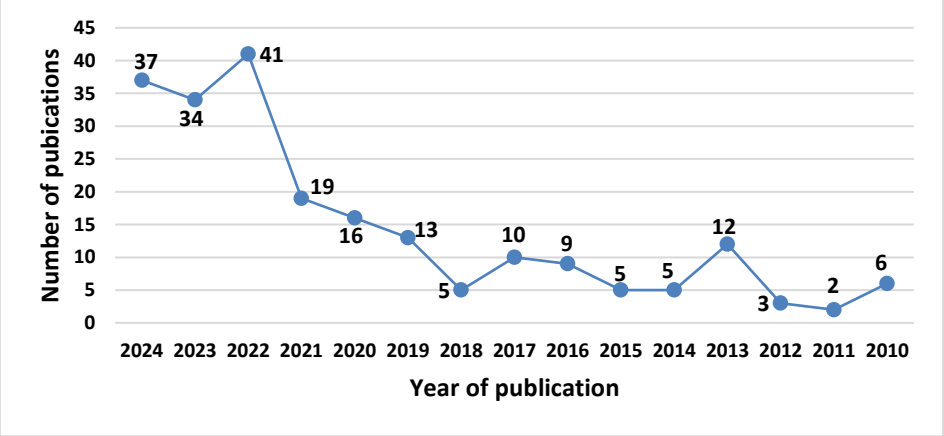

Figure 2: Number of publications per year

3.2 Publication Per Country

A total of 49 countries have contributed to the research on emerging technology (ET) convergence for T&L in the African HE sectors. The result showed that some publications have more than one affiliation with countries from within and outside Africa. Considering the publication timeline for this study (2010-2024), most African countries have produced very few scholarly outputs on the subject.

Thus, only countries with at least six scholarly outputs originating from them were evaluated. As shown in Figure 3, South Africa tops the list with a total of 134 scholarly articles with 747 citations. This is followed by Nigeria (19 scholarly articles with 57 citations), Ghana (18 scholarly articles with 66 citations), Morocco (17 scholarly articles with 358 citations), and Egypt (10 scholarly articles with 207 citations). South Africa and Nigeria are considered regional hegemons, giants of Africa and dominant state entities in their respective sub-regions (Adebajo & Landsberg, 2003; Ebegbulem, 2013). Similar studies have also shown that South

Africa and Nigeria lead in frontlining research work in the numerous fields of study across Africa (Asubiaro & Onaolapo, 2023). Research productivity from African HEIs showed that South Africa and Nigeria contribute the highest (Uwizeye et al., 2022). However, South Africa remains a dominant force in advancing knowledge in Africa. According to Zavale and Schneijderberg (2022), African higher education research endeavours will stay weak if South Africa is excluded from the research and development quest of the continent.

It is also important to note that universities from South Africa, Egypt, Morocco, Ghana and Nigeria feature in the overall top 1000 of Times Higher Education (THE) world university rankings for 2025 (Times Higher Education, 2025). These led credence to the findings of this study, which further aligns with the knowledge production coming from these countries.

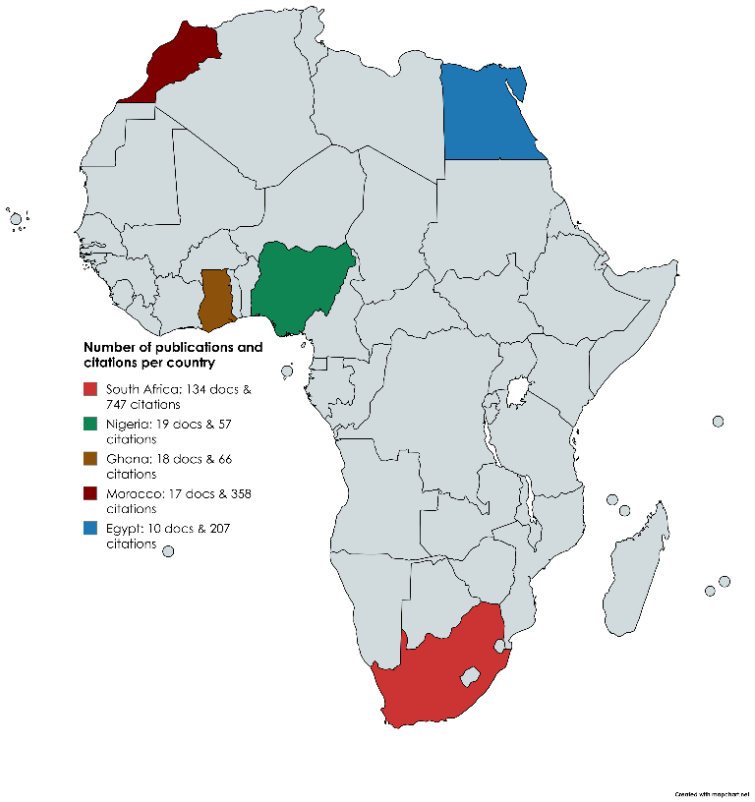

Figure 3: Number of publications per country

3.3 Publication Per Document Source

In this section, Table 1 presents the trend in research publications per document source. The bibliometric dataset utilised contains 217 documents published in journal outlets (106), conference proceedings (61) and book chapters (50). Using the criterion of document sources with at least three scholarly outputs on ET convergence for T&L in the African higher education (HE) sector, 15 sources met the thresholds, as revealed in Table 1. The British Journal of Educational Technology (BJET) tops the chart with five scholarly outputs and 137 citations. As the official journal of the renowned British Educational Research Association, published by the notable Wiley-Blackwell Publishing Ltd, BJET is the primary

source for researchers and professionals in the global digital educational and training technology field to disseminate their scholarly works. The journal has been active since 1970 and is regarded as one of the most prestigious journal outlets in the field of Educational Technology (Bond et al., 2019; Chen et al., 2020).

Hence, it is unsurprising that the journal tops the table as it is classified as a quartile 1 (Q1) in the Education and E-learning subject area, with a remarkable H-index of 119 (Scimago Lab, 2025). Education and Information Technologies journal is second on the table with five scholarly outputs and 67 citations, followed by South African Journal of Education (4 scholarly articles with 34 citations), Africa Education Review (4 scholarly articles with 32 citations), and Proceedings of the International Conference on E-Learning (4 scholarly articles with 20 citations).

Table 1: Number of publications per document source

Source Title	Documents	Citations
British Journal of Educational Technology	5	137
Education and Information Technologies	5	67
South African Journal of Education	4	34
Africa Education Review	4	32
Proceedings of the International Conference On E-Learning	4	20
Communications in Computer and Information Science	4	10
Mathematics Education in Africa: The Fourth Industrial Revolution	4	6
International Journal of Emerging Technologies in Learning	3	301
International Journal of Learning, Teaching and Educational Research	3	6
Advances in Intelligent Systems and Computing	3	3
International Journal of Technologies in Learning	3	2
Effects of Information Capitalism and Globalization on Teaching and Learning	3	1
IFIP Advances in Information and Communication Technology	3	1
Proceedings of the European Conference on E-Learning (ECEL)	3	1
Proceedings of the International Conference on Education Research (ICER 2024)	3	0

3.4 Most Cited Publication

Table 2 presents the most cited scholarly outputs on ET convergence for T&L in the African higher education sector. Based on the criterion of a minimum of 30 citations, 14 documents meet the threshold out of the 217 publications that make up the bibliometric dataset utilised for the study. It is generally agreed that assessing the quality of a scholarly publication is a daunting task involving numerous factors for consideration. However, the number of citations is the most frequently used indicator for determining the quality of scholarly outputs of researchers, research entities and HEIs, among others (Tahamtan et al., 2016). To this end, it is imperative to analyse the dataset to identify the most cited documents. From Table 2, most scholarly outputs employed the review and

survey study methods to carry out their studies. The reason for this can be attributed to the understanding that the utilisation of ETs in the African HE sectors for teaching and learning purposes is not as proliferated when compared to their counterparts in developed countries.

The scholarly article by Elmqaddem (2019) titled "Augmented Reality and Virtual Reality in education. Myth or reality?" is the most cited output on ET convergence for T&L in African higher education (288 citations). The review study discusses the potential significance of virtual reality (VR) and augmented reality (AR) technologies in education, highlighting their evolution, current capabilities, and prospects. It emphasises how these technologies can enhance learning through immersive experiences, interactivity, and visualisation of abstract concepts.

The article titled "Recent research on geometry education: an ICME-13 survey team report" by Sinclair et al. (2016) is the second most cited publication with 90 citations. The comprehensive review study covers seven major themes in geometry education research, including the role of technology, visuospatial reasoning, and teaching/learning of definitions and proofs. It provides insights into current trends and future directions in geometry education.

Table 2: Most cited publications

Publication Title	Citations	Author(s)	Method
Augmented Reality and Virtual Reality in education. Myth or reality?	288	Elmqaddem (2019)	Review
Recent research on geometry education: an ICME-13 survey team report	90	Sinclair et al. (2016)	Review
'Blended learning' as an effective teaching and learning strategy in clinical medicine: A comparative cross-sectional university-based study	73	Makhdoom et al. (2013)	Comparative cross-sectional study
Challenges, opportunities, and prospects of adopting and using smart digital technologies in learning environments: An iterative review	66	Mhlongo et al. (2023)	Review
COVID-19 and the Key Digital Transformation Lessons for Higher Education Institutions in South Africa	55	Mhlanga et al. (2022)	Content analysis
An enhanced e-learning ecosystem based on an integration between cloud computing and Web 2.0	44	Ouf et al. (2010)	Review
Effective and ineffective uses of emerging technologies: Towards a transformative pedagogical model	42	Ng'Ambi (2013)	Survey study
Students as collaborators in creating meaningful learning experiences in technology-enhanced classrooms: An engaged scholarship approach	40	Nel (2017)	Action research
Responding to user's expectation in the library: Innovative Web 2.0 applications at JUIT Library: A case study	39	Ram et al. (2011)	Survey study
Artificial Intelligent in Education	34	Hamal et al. (2022)	Review

Augmented Reality in Education: Current Status and Advancement of the Field	34	Kljun et al. (2020)	Review
New technologies for disseminating and communicating agriculture knowledge and information: Challenges for agricultural research institutes in Tanzania	34	Barakabitze et al. (2015)	Survey study
Effective or just practical? An evaluation of an online postgraduate module on evidence-based medicine (EBM)	33	Rohwer et al. (2013)	Review & semi-structured interviews
Integrating technology in teaching and learning in universities in Lesotho: opportunities and challenges	31	Turugare and Rudhumbu (2020)	Survey study

3.5 Publication Per Author and Co-Authorship Network

Regarding authorship of the scholarly outputs on ET convergence for T&L in the African higher education sector, the assessed 217 documents had 211 authors. With the minimum number of documents per author set at 2 with at least 1 citation, only five (5) are revealed to meet the threshold. From Table 3, it can be shown that the top and well-cited authors are Enakrire, R.T. (3 papers and 1 citation), Chigona, A. (2 papers and 24 citations), Ng'ambi, D.; Gachago, D.; Ivala, E.; Bozalek, V.; Watters, K. (2 papers and 15 citations), van den Berg, C. (2 papers and 8 citations), and Singh, P.; Harangee, J.; Prinsloo, T. (2 papers and 4 citations). While earlier publications by Enakrire, R.T. indicate affiliation with the University of South Africa, the latest publications and Scopus profile of the author indicate affiliation with the University of Johannesburg, South Africa.

The overlay visualisation co-authorship network in Figure 5 shows five clusters of co-authorship. According to the Figure, Ng'ambi, D.; Gachago, D.; and Ivala, E. were the earliest authors who started publishing on ET convergence for T&L in the African higher education sector. These co-authorships are indicated by the deep blue colour on the map (Figure 5) and existed from 2010 to 2012. However, the most recent authors publishing in the research field are Enakrire, R.T.; Singh, P.; Harangee, J.; and Prinsloo, T. Their publications, from 2020 to date, are represented in the yellow-coloured cluster.

Table 3: Number of publications per author

Author(s)	Affiliation	Docs	Citations
Enakrire, R.T.	University of South Africa, Pretoria, South Africa; University of Johannesburg, Johannesburg, South Africa	3	1
Chigona, A.	Cape Peninsula University of Technology, South Africa	2	24
Ng'ambi, D.; Gachago, D.; Ivala, E.; Bozalek, V.; Watters, K.	University of Cape Town, Cape Town, South Africa; Cape Peninsula University of Technology, Bellville, South Africa; University of the Western Cape, Bellville, South Africa	2	15
van den Berg, C	University of the Western Cape, Bellville, South Africa	2	8
Singh, P.; Harangee, J.; Prinsloo, T.	University of Pretoria, South Africa;	2	4

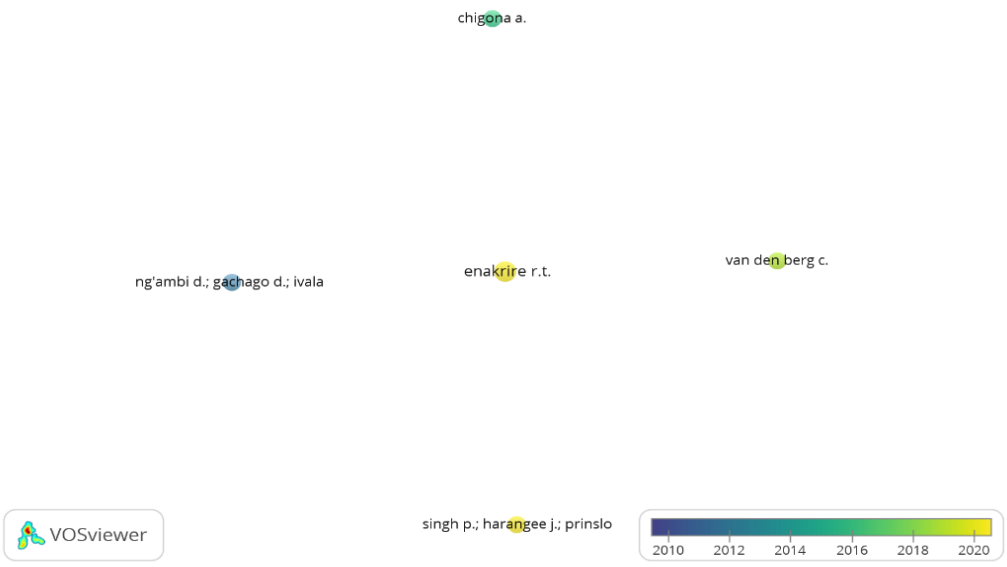

Figure 4: Overlay visualisation co-authorship network

3.6 Research Focus Based on Co-occurring Keywords

The choice and appropriateness of keywords used by authors are geared toward properly highlighting their research works. The essence of keywords in scholarly articles is for indexing purposes in library catalogues and publication databases so that the system can identify the most relevant document when a search is conducted (Corrin et al., 2022). A keywords co-occurrence network was produced using the VOSviewer application software. Keyword co-occurrence examines instances where multiple keywords appear together in each context. As Darko et al. (2020) noted, these relationships can be represented as networks where

individual keywords function as nodes and their connections are depicted as edges. The analysis was configured to examine keyword co-occurrence, using full counting as the measurement approach. The parameters included all keywords as the unit of analysis, with a threshold of at least 10 occurrences for a keyword to be considered.

A total of 20 keywords out of 1116 keywords met the threshold of 10 co-occurrences and were further grouped into three (3) clusters. Table 4 displays the 20 most prevalent keywords, ranked by their frequency of appearance and total link strength. Wuni et al. (2019) applied the Pearson product-moment correlation coefficient (r) to evaluate the connection between these two metrics, revealing a strong and statistically significant association. Their findings suggest that keywords appearing more frequently also tend to co-occur more often with other commonly used terms in research on ET convergence for T&L in the African higher education sector. Similar analytical approaches have been adopted in studies by Wang et al. (2020), Zhang et al. (2020), Oguntona (2024a), and Oguntona (2024b).

Table 4: Number of keywords co-occurrence

Keyword	Occurrence	Total link strength
Teaching	60	233
Teaching and learning	48	169
E-learning	43	176
Students	41	181
Engineering education	39	187
Digital technologies	30	110
Higher education	28	83
Education	22	73
Emerging technologies	22	71
Covid-19	21	55
Digital technology	18	34
Learning systems	17	78
Learning	16	42
South Africa	15	39
Educational technology	13	61
Online learning	12	49
Technology	12	33
Curricula	10	54
Computer aided instruction	10	50
Blended learning	10	40

As generated from VOSviewer, Figure 4 shows the network visualisation map for keywords co-occurrence and their three (3) different clusters. At the centre of the map is the "teaching" keyword to which all other keywords are linked. Cluster 1 contains 10 co-occurring keywords and is represented by the red region of the map. The keywords are blended learning, computer aided instruction, covid-19, digital technologies, e-learning, educational technology, engineering education, learning systems, online learning and students. Cluster 2 contains five (5) co-occurring keywords and is represented by the green region of the map. The

keywords are digital technology, education, learning, teaching and technology. Cluster 3 contains five (5) co-occurring keywords and is represented by the blue region of the map. The keywords are curricula, emerging technologies, higher education, South Africa and teaching and learning.

Cluster 1 (red-coloured map) is seen to consider ET convergence for e-learning and engineering education. Since the advent of technologies for educational purposes, a continuous innovative update has focused on how these technologies can best be utilised to upscale and reinvent T&L, especially in engineering education. As a field of study known for its complexities in incorporating technology for T&L, the convergence and interoperability of ETs is the panacea and way forward in STEM (science, technology, engineering and mathematics) education.

This has, therefore, seen the rise and proliferation of 3D printing, digital libraries, virtual labs, e-learning platforms, virtual and augmented reality platforms, cloud computing, the internet of things, digital twins, virtual assistants, and chatbots, among numerous others (Martín et al., 2021). Cluster 2 (green-coloured map) is seen to consider ET convergence for teaching in education. The workload of teachers has increased over the years, considering the key performance index (KPI) of employees, especially in the higher education sector.

In South Africa, for example, academic staff members are expected to engage in teaching, research, community engagement, university service, and administrative duties. Hence, the role of technologies cannot be overemphasised as they offer automation for most manual processes and procedures. ETs are therefore adjudged to be a game-changer as their adoption, incorporation, and implementation have revolutionised the educational space, especially since the COVID-19 era (Beardsley et al., 2021; Haleem et al., 2022; Timotheou et al., 2023).

These ETs have also contributed to the educational push towards achieving the Sustainable Development Goals (SDGs) as related to quality education (SDG4), among other areas (Amballoor & Naik, 2023). Cluster 3 (blue-coloured map) is seen to consider ET convergence for teaching and learning and curricula development. Through the convergence and interoperability of ETs, T&L and curricula development have seen a sharp surge. For example, these ETs have enabled the development, proliferation, affordability, accessibility, and flexibility of massive open online courses (MOOCs) globally. Teacher professional development tailored towards effective curricula, MOOC design, and enhancement of student learning has all been traceable to ETs (Bulfin et al., 2014; Vivian et al., 2014).

To further buttress the significance of ETs, countries such as the Kingdom of Saudi Arabia have made continued efforts, policies and legislations towards developing T&L curricula and methods using these novel technologies (Almuqayteeb, 2025). To also ensure all groups of people are carried along, especially people with disabilities, the convergence and interoperability of ETs remain an effective tool

to enhance interactivity, retention of learners, and reduced inequalities (SDG 10) (Bijaniaram et al., 2024; Lexman & Baral, 2024; Mohd Ashril et al., 2024).

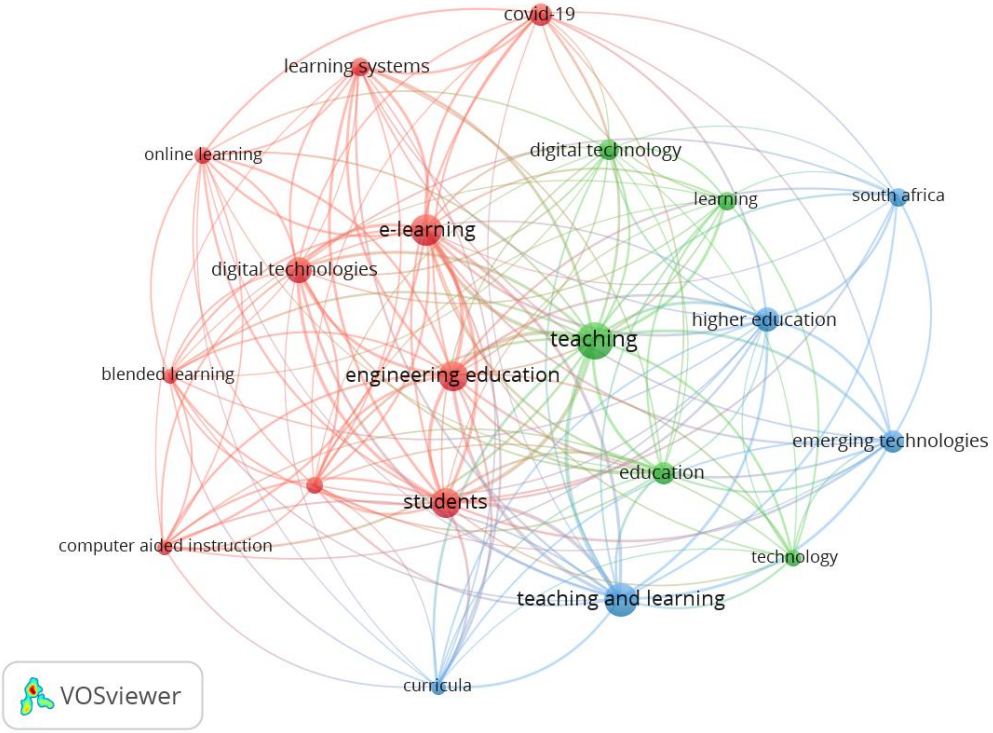

Figure 5: Network visualisation map for occurring keywords

4. Conclusion and Recommendations

This study sets out to identify research focus on ET convergence for T&L in the African higher education sector through a scientometric approach. Based on extracted Scopus-indexed scholarly publications between 2010 and 2024, the study has identified and mapped key areas of concentration in the research subject area. Drawing from the findings of the study, it can be observed that research output on ET convergence for T&L in the African higher education sector was quite low in 2010, with a gradual growth to 41 in 2022 and 37 in 2024. This increase on the African continent can be traced to the COVID-19 pandemic, which forced the adoption and use of these ETs within higher education.

While the adoption, proliferation and implementation of these ETs can be adjudged low compared to other developed countries and continents, the gradual increase in ET convergence for teaching and learning purposes is encouraging. Countries with the most publications on the subject are South Africa, Nigeria, Ghana, Morocco and Egypt, with at least six scholarly publications. Compared to the total of 54 countries on the African continent, this number is quite low, signifying the urgent and drastic need to ensure that other countries are not lagging in adopting and implementing ETs in the higher education sector. Based on the different clusters extracted, research on ET convergence for T&L has focused on e-learning and engineering education, teaching in education, and teaching and learning and curricula development.

Theoretically, the study contributes to the expanding body of knowledge on the intersection between emerging technologies (ETs) and pedagogical innovation, particularly within the underexplored African context. By identifying and visualising research clusters and trends from 2010 to 2024, a structured, evidence-based mapping of scholarly discourse that underscores Africa's evolving role in digital education transformation has been presented. The study reinforces conceptual frameworks around technological convergence, not as mere digitisation but as a systemic reconfiguration of educational ecosystems.

Furthermore, the findings extend current theoretical understanding of knowledge diffusion, revealing how geopolitical, infrastructural, and institutional disparities shape the trajectory of ET adoption across African regions. This nuanced perspective challenges universalist narratives in educational technology theory and advocates for more localised, context-sensitive models of digital integration in higher education.

Practically, the study provides critical insights for higher education administrators, policy makers, research institutions, development agencies and other relevant stakeholders seeking to bridge the digital divide. By identifying South Africa, Nigeria, Ghana, Morocco, and Egypt as continental leaders in ET-driven teaching and learning, the study presents a roadmap for regional benchmarking, collaboration, and targeted investment. The data underscores the urgent need for capacity building, digital infrastructure enhancement, and upskilling of educators in lagging African regions.

The clustering of keywords and co-authorship networks further reveals thematic and institutional gaps, offering guidance on where strategic partnerships and research funding can be most impactful and directed. Importantly, the study highlights the role of ETs in advancing Sustainable Development Goal 4 (quality education), while also intersecting with SDGs 5, 10, and 16 by promoting inclusive, equitable, and transparent educational access.

This study is a timely contribution to the body of knowledge as it shows the trend and areas of research focus on ET convergence for T&L purposes on the African continent. The findings have also mapped out the prolific authors and countries on the continent, thereby exposing a huge digital knowledge and adoption gap compared to other African countries. While the study was able to identify research focus on ET convergence for T&L in the African higher education sector from 2010 to 2024, a cautious generalisation of the results in other countries and continents should be observed, considering that the study is limited to the Scopus database, the African continent and from 2010 to 2024.

It is therefore recommended that further studies that consider the limitations of this study be conducted while using other databases or a combination of several ones to grasp the trend of the research subject area comprehensively. Strengthening cooperation and research mobility between African scholars and

international researchers is recommended to enhance the widespread acceptance and application of ETs throughout Africa.
Above all, research and development geared towards developing multilingual, innovative, African continent-specific ETs for use in higher education is recommended.

Also, to address the identified digital divide on the continent, African governments and universities should establish regional technology consortia focused on co-developing open-source educational platforms tailored to local languages and contexts. Collaborative projects with international institutions and industry partners should prioritise affordable digital infrastructure and faculty upskilling. Funding opportunities can also be leveraged through the African Union's Agenda 2063, the World Bank's Digital Economy Initiative, and the United Nations Educational, Scientific and Cultural Organisation's (UNESCO) ICT in Education programmes. Establishing innovation hubs within universities and incentivising research on inclusive EdTech solutions will further bridge disparities. Policymakers should mandate national digital strategies with targeted support for underserved regions and institutions.

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