Linking Global Industrial Revolutions to Advancements of African Educational Systems: What We Learn from the Literature

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ABSTRACT

The present article explored and discussed the literature in line with the advancements and achievements of African educations systems vis-à-vis the global industrial revolutions. Specifically, the aspects of streamlining the teaching and learning processes that make ease the work of both teachers and students have been discussed. In addition, the search of the literature talked elements related to the progress made by African schools in relation to the electrification of schools, ICT in education, internet connectivity as well as the learning content digitization. Even though progress is remarkable, however, there is a need to prioritize rural areas by aligning the requirements of the fourth industrial revolution and the fulfilment of sustainable development goals.

Key words: Teachers, students, wellbeing, mental health, electricity, internet connectivity, education, digitization, quality teaching & learning, communication, computers, artificial intelligence, robotics, innovation, interconnectedness.

INTRODUCTION

From the last 10 years, governments across the continent have undertaken different educational initiatives to strategize the effective implementation of various targets as indicated in the sustainable development goals (Fleaca et al., 2018; Franco et al., 2019; Aleixo et al., 2020; Ferrer-Estevez & Chalmeta, 2021; Leal Filho et al., 2021).

In the same vein, the global industrial revolutions have played a pivotal role in shaping the trajectory of societies and economies worldwide (Morrar et al., 2017; Manda & Ben Dhaou, 2019). As the world undergoes its fourth industrial revolution characterized by digitalization and advanced technologies, it is crucial to explore how these global transformations impact the educational systems of African nations (Asghar et al., 2020; Oke & Fernandes, 2020).

The present article articulated the aspects related to the physical and mental wellbeing of teachers and students in Africa in line with the teaching practices and pedagogical innovations that contribute to the ease of teaching and learning processes. In addition, the article examined how electricity constitutes an enabling resource for quality teaching and learning processes across schools of Africa. Moreover, a thorough exploration of the achievements and challenges related to the integration of ICT in African education institutions as well as the progressive reflections on internet connectivity and content digitization have been critically evaluated from previous studies and sector assessments.

A. A flash back to the industrial revolutions
1. The First Industrial Revolution

The first industrial revolution, which began in the late 18th century, marked a profound shift from agrarian and handicraft economies to industrialized and mechanized production. Fuelled by technological advancements like

the steam engine, it revolutionized manufacturing and transportation. Crafts (2011) argued that its philosophy emphasized efficiency, innovation, and economic growth, leading to urbanization and significant societal changes. This transformative era laid the foundation for modern industrial societies and set the stage for subsequent industrial revolutions.

2. The Second Industrial Revolution

The second industrial revolution, from the mid-19th to early 20th century, was characterized by the philosophy of scientific management and mass production. Influenced by thinkers like Frederick Taylor, it emphasized efficiency and systematic production. Its main strategy included the widespread use of electricity, the assembly line, and innovations in steel production. This period saw the rise of major industries, such as automobiles and chemicals, fostering economic growth and urbanization, fundamentally transforming societies across the globe. This revolution brought new challenges and opportunities for education. Mohajan (2019) explored how technological advancements influenced the curriculum and educational methods through schools' electrification. The study provided a framework for understanding the global implications, including Africa's response to technological changes during this era.

3. The Third Industrial Revolution and Globalization

The third industrial revolution, emerging in the mid-20th century, was marked by a philosophy of digitalization and automation. Its content featured the rapid development of computer technology, the internet, and telecommunications, fundamentally altering the nature of work and communication. As Taalbi (2019) put it, its approach focuses on integrating information technology into various industries, fostering connectivity and efficiency. This era, often associated with the rise of personal computing and the internet, laid the groundwork for the interconnected and digital world we live in today.

4. The Fourth Industrial Revolution and Digital Transformation

The fourth industrial revolution, starting in the late 20th century, is defined by a philosophy of interconnected digital technologies, blurring the lines between physical, biological, and digital realms. Its main content encompasses artificial intelligence, big data, the Internet of Things, and advanced robotics. The approach involves the fusion of digital, biological, and physical systems, revolutionizing industries through smart technologies and automation. It emphasizes the transformative power of data-driven insights, machine learning, and decentralized technologies. This revolution is shaping a new era of innovation, impacting economies, societies, and the way we perceive and interact with the world.

As the world enters the Fourth Industrial Revolution, characterized by artificial intelligence and digital transformation, the implications for education are paramount. In 2018, Lamprini and Brochler emphasized the need for educational systems to adapt to the demands of a rapidly changing technological landscape. This work sets the stage for exploring how African nations are integrating digital technologies into their educational frameworks to prepare students for the future job market.

As African nations navigate the challenges and opportunities presented by these global transformations, a nuanced understanding of historical contexts and region-specific adaptations is crucial for shaping effective educational policies for the future. In addition, it is very important to examine how African education systems are advancing towards the embracement of industrial revolution developments and innovations.
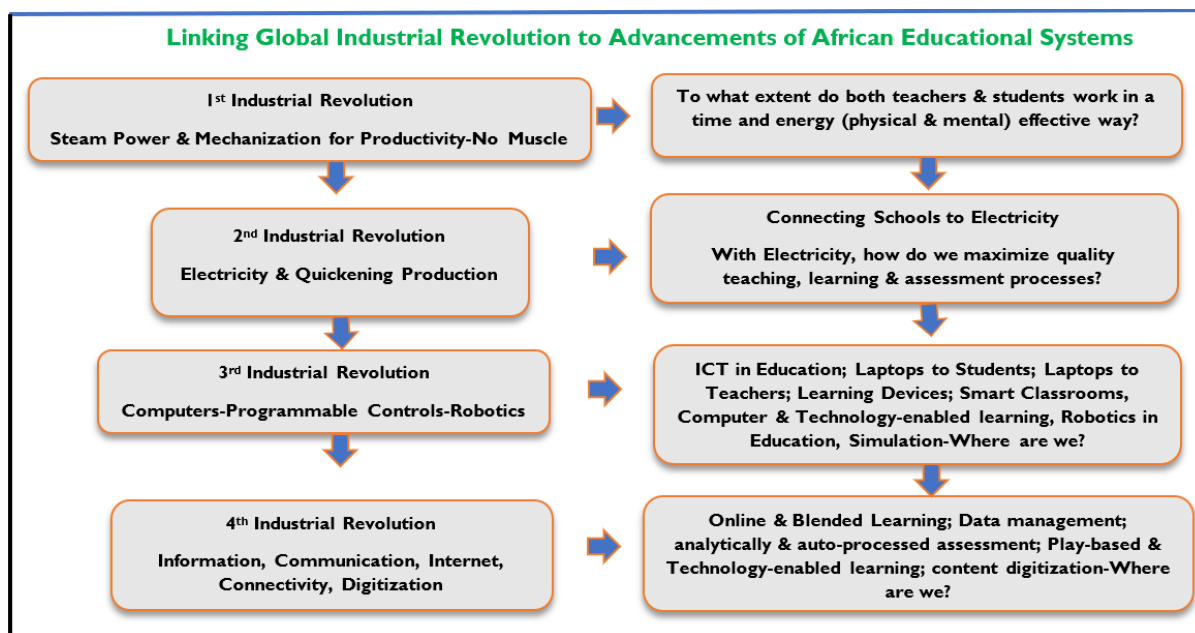
Figure 1: **A conceptual framework-linking revolutions to education initiatives**

B. Paving ways for physical and mental wellbeing of teachers and students in Africa

The physical and mental wellbeing of teachers and students in Africa is an issue that has garnered increased attention in recent years. The challenges faced in this context are diverse, reflecting the complex socio-economic, cultural, and educational landscape of the continent. However, there have been notable achievements and positive interventions aimed at enhancing the overall health and wellness of teachers and students. This literature review explored key advancements in addressing physical and mental wellbeing in the African education sector.

Considerable advancements have been made in enhancing educational infrastructure across Africa. Investments in constructing safer and more conducive learning environments are evident (Barrett et al., 2019). Authors such as Adepoju and Ige (2016) noted the positive impact of improved infrastructure on the physical wellbeing of both teachers and students. In addition, nutritional interventions, particularly school feeding programs, have gained momentum as a strategy to combat malnutrition among students (Alderman & Bundy, 2011). Such programs contribute significantly to students'

physical health and create a foundation for improved cognitive development (Gelli et al., 2015). Most importantly, the integration of health education into the curriculum is a noteworthy achievement (Achalu, 2019). This approach not only ppromoted students' awareness of health-related issues but also equips teachers with the knowledge to support their students' physical wellbeing (Naidoo & Wills, 2016).

As far as mental wellbeing is concerned, efforts have been made to address the mental health of teachers through training programs that include modules on stress management and coping mechanisms (Lufuno & Lebitsa, 2020). The recognition of teachers' mental health as a vital component of overall wellbeing signifies a positive shift in educational priorities. Moreover, the introduction of counselling services in schools is a significant step toward supporting students' mental health (Dambi et al., 2019). Trained counsellors play a pivotal role in addressing various issues affecting students, contributing to a more holistic approach to education. At community level, increased community involvement in supporting mental health is evident in various African societies (World Health Organization, 2004). Collaborations between community-based organizations and schools

reduce the stigma associated with mental health issues and foster a supportive environment.

The policy influence and policy development have taken shape in the domain of teachers' mental health. The integration of wellbeing into educational policies is a crucial achievement. Countries like South Africa have developed comprehensive policies emphasizing both physical and mental health in the education system (Department of Basic Education, 2019). This institutional commitment is fundamental for sustained efforts in promoting wellbeing. Furthermore, technological advancements have played a role in addressing wellbeing challenges. Educational technology platforms provided resources for both teachers and students on health and wellness (Kabunga et al., 2021). Telehealth services offered remote support for mental health issues, especially in remote areas with limited access to traditional healthcare services (Mutumba & Tumuhimbise, 2018).

While progress has been made, several challenges persist. Adequate funding remains a barrier to implementing comprehensive wellbeing programs, particularly in resource-limited settings (Sweetland et al., 2014). Cultural factors and stigma surrounding mental health continue to impede progress (Gureje et al., 2019).

To further advance the physical and mental wellbeing of teachers and students in Africa, sustained investment in education, health infrastructure, and teacher training is imperative (Rabbani et al., 2016). Policymakers must prioritize holistic approaches that consider the interconnected nature of physical and mental health. Collaboration between governments, non-governmental organizations, and local communities is essential to create a supportive ecosystem for the education sector (Harangozo & Zilahy, 2015).

C. Access to electricity-an enabling resource for quality teaching and learning processes-a review of studies

Access to electricity is a fundamental driver of socio-economic development, and its impact on education, particularly in Africa, is profound. This literature review explored the existing body of knowledge on how access to electricity served as an enabling resource for enhancing the quality of teaching and learning processes in the African context.

In a study by Kimaro and Nleya (2019), titled "The Role of Electricity in Enhancing Quality Teaching in Rural Schools," emphasized the pivotal role electricity plays in integrating technology into teaching practices. The study underscored how electricity serves as the backbone for the use of modern educational tools, thereby improving the overall quality of education. Moreover, Adebule (2016), investigated the correlation between electricity access and academic performance in Nigeria. The study established a positive relationship between reliable electricity and improved academic achievements, emphasizing the importance of infrastructure in educational outcomes. Furthermore, Ahmed et al. (2018) addressed the issue of educational inequality in rural areas in their work, highlighting how electricity access contributes to bridging the gap between urban and rural educational opportunities, emphasizing the need for inclusive electrification policies.

Similarly, Jimenez, and Sawada (2020) explored the broader context of infrastructure development and argued that electricity, as part of a broader infrastructure strategy, significantly influences the creation of conducive learning environments, positively impacting the overall quality of education. Furthermore, Amponsah and Marbuah (2017) contributed to the literature by investigating the impact of electricity access on teacher training and the research accentuated how electricity enhances teacher training, leading to improvements in pedagogical practices and ultimately fostering quality education.

In their study about economic dimensions of electricity access in education, Goyal and Pandey (2019) analyzed how electricity influences various economic aspects of

education, emphasizing the need for a holistic understanding of the economic implications of electrification. In a more specific way, Dinkelman (2011) provided a comprehensive case study on the effects of rural electrification in South Africa and the author explored how electrification impacts various aspects, including education and employment, offering valuable insights for the African context. Most importantly, the shift towards online learning was investigated by Zhang et al. (2020) and they delved into how electricity infrastructure forms the backbone for the expansion of online educational resources and opportunities, emphasizing the transformative potential of electrification on modern educational delivery methods.

However, Mupimpila and Ndhlovu (2019) offered a critical examination of challenges and policy implications related to electricity access. The authors emphasized the need for comprehensive policies that address electricity disparities and suggest strategic interventions to improve educational outcomes. Moreover, the United Nations Sustainable Development Goals (SDGs) have recognized the significance of electricity access for education. As highlighted in various reports and policy documents, achieving universal access to quality education (SDG 4) is closely linked to ensuring affordable and clean energy (SDG 7), emphasizing the interconnectedness of these goals.

D. Access to electricity-an enabling resource for quality teaching and learning processes-a review of key achievements

Access to electricity is a fundamental requirement for quality education. It provides power for essential school equipment, such as computers, projectors, and lighting, which are necessary for effective instruction. Electricity also enables the use of technology in the classroom, which can enhance student engagement and learning outcomes. In addition, electricity can improve the safety and security of schools, as well as the overall learning environment.

There have been significant strides in access to electricity in African schools in recent years. According to the World Bank, the share of schools with electricity access in sub-Saharan Africa increased from 24% in 2000 to 55% in 2018 (World Bank, 2022). This progress is due in part to a number of initiatives, including the electrification of rural areas whereby Governments and international organizations have invested in the electrification of rural areas, where many schools are located (World Bank, 2022); the use of off-grid solutions such as solar panels and generators, have made it possible to electrify schools in areas that are not connected to the national grid (UNESCO, 2023), and the development of innovative financing mechanisms such as public-private partnerships, have helped to mobilize resources for school electrification (African Development Bank, 2023).

Moreover, studies have shown that access to electricity has a positive impact on teaching and learning in African schools. For example, a study by the World Bank found that schools with electricity access had higher student attendance rates and test scores (World Bank, 2020). Another study, by the UNESCO Institute for Statistics, found that schools with electricity access were more likely to have computers and other technology in the classroom (UNESCO, 2022).

Despite the progress that has been made, there are still significant challenges to ensuring access to electricity in all African schools, including the high cost of electrification, especially in rural areas (World Bank, 2022); the lack of infrastructure to deliver electricity to schools (UNESCO, 2023), and the lack of maintenance of electricity systems (African Development Bank, 2023).

However, there are also a number of opportunities to further improve access to electricity in African schools, including the continued decline in the cost of solar technology which makes it a more viable

option for electrifying schools (International Renewable Energy Agency, 2023); the development of new off-grid solutions such as microgrids are being developed and could make it even easier to electrify schools (World Bank, 2022); and the increasing availability of financing to support school electrification (African Development Bank, 2023).

E. Integrating ICT in African education institutions-achievements and challenges

The integration of Information and Communication Technology (ICT) in African education institutions has been a subject of increasing interest and debate. This critical literature review aimed to analyse the achievements and challenges associated with ICT integration in the context of African educational settings. Several scholars have explored this topic, shedding light on the progress made and the obstacles faced by educational institutions across the continent.

As far as achievements are concerned, one of the notable achievements of ICT integration in African education is the improvement in access to educational resources. The works of Mbarika et al. (2009) and Ondimu et al. (2014) emphasized the role of ICT in overcoming geographical barriers, enabling students in remote areas to access educational materials and participate in virtual classrooms. In addition, E-learning platforms have gained prominence in African education. For instance, Oyelaran-Oyeyinka (2012) and Aduwa-Ogiegbaen et al. (2017) highlighted the success of various e-learning initiatives that leverage ICT to provide flexible and scalable learning opportunities. Moreover, the integration of ICT has contributed to skills development among students, aligning them with the demands of the modern job market whereby Adomi and Omodeko (2007) discussed the positive correlation between ICT integration and improved employability, emphasizing the role of digital literacy in preparing students for the workforce.

Furthermore, the establishment of digital libraries and the proliferation of Open Educational Resources (OER) have been noteworthy outcomes of ICT integration. Aduwa-Ogiegbaen et al. (2017) explored the successful implementation of digital libraries, providing students and educators with easy access to a vast array of educational materials and the utilization of OER has further democratized access to quality content, contributing to a more inclusive educational environment. Most importantly, the infusion of ICT has led to innovative changes in teaching methods. Afolayan et al. (2015) discussed how educators are leveraging technology to create interactive and engaging learning experiences. This shift from traditional teaching approaches to more dynamic methods has contributed to increased student participation and comprehension.

Again, the ICT integration has facilitated the creation of collaborative learning platforms, fostering interaction and knowledge-sharing among students. Teferra (2010) highlighted the use of ICT to connect students from different regions, creating a virtual space for collaborative projects and cultural exchange. This achievement promoted a global perspective and enhanced cross-cultural understanding. In addition, the use of ICT has empowered marginalized communities by providing them with educational opportunities. Unwin (2009) discussed initiatives that specifically target underserved populations, using ICT to bridge educational gaps. This achievement contributed to social inclusion and addresses the challenge of educational inequality.

Despite the achievements, infrastructure challenges persist in many African countries. Afolayan et al. (2015) and Teferra (2010) highlighted the inadequacies in ICT infrastructure, including a lack of reliable electricity and internet connectivity. This hinders the seamless implementation of ICT-based educational initiatives. In addition, the digital divide remains a significant challenge, with disparities in access to technology exacerbating existing educational

inequalities. Authors such as Unwin (2009) and Warschauer (2003) argued that marginalized communities, especially in rural areas, face barriers to accessing ICT resources, perpetuating educational disparities. Moreover, adequate teacher training is crucial for the successful integration of ICT in education. Several studies (Hodgkinson-Williams, 2008; Karsenti & Fievez, 2013) highlighted the insufficient training and digital literacy among educators. This lack of preparedness affects the effective use of ICT tools in the teaching-learning process.

F. Schools Internet Connectivity and Learning Content Digitization

The accessibility of the Internet and the digitization of educational content are pivotal components in shaping the educational landscape of African schools. This comprehensive literature review examined the progress made in internet connectivity and content digitization across schools in Africa, emphasizing the contributions of various scholars and the temporal evolution of these advancements.

Afolayan et al. (2015) highlighed the strides made in infrastructure development, contributing to improved internet access in African schools. According to recent statistics (World Bank, 2022), there has been a notable increase in the percentage of schools with internet connectivity. Governments and organizations have invested in laying the groundwork for reliable infrastructure, facilitating better access to online resources for students and educators. In addition, Government initiatives have played a crucial role in enhancing internet connectivity in schools. For instance, Ndemo's (2011) research in Kenya provided statistical evidence of the impact of policy interventions. Recent reports (UNESCO, 2022) indicate a positive correlation between government policies and increased internet penetration in schools, demonstrating the effectiveness of strategic planning in fostering connectivity.

Moreover, Marsden et al. (2017) shed light on the success of community-driven projects in South Africa, contributing to internet connectivity. Studies such as that of Labadi (2022) show a rise in community-driven initiatives across the continent, with communities actively involved in establishing networks and addressing local connectivity challenges. This bottom-up approach has resulted in tangible improvements in internet accessibility. Besides, Oyelaran-Oyeyinka's (2012) work emphasized the adaptability of mobile technology in providing internet access, particularly in regions with limited fixed-line infrastructure. Recent study of Alghazi et al. (2020) revealed a growing reliance on mobile internet solutions in African schools. The widespread availability of mobile devices has facilitated increased connectivity, allowing schools to leverage mobile technologies for educational purposes.

For the learning content digitization, Aduwa-Ogiegbaen et al. (2017) showcased the successful implementation of digital libraries in Nigerian higher education institutions, contributing to the digitization of learning content. A significant rise in the creation and utilization of Open Educational Resources (OER) across Africa is evident (Nyamwembe et al., 2018). Digital libraries are becoming repositories for diverse, accessible, and open content, enriching the educational experience. Moreover, Ondimu et al. (2014) highlighted the achievements of e-learning initiatives in Kenyan universities, emphasizing the role of digitized content in virtual classrooms. Recent studies (UNESCO, 2022) indicated a surge in the adoption of e-learning platforms and virtual classrooms in African schools. The statistics underscored the positive impact of digitized content in facilitating remote learning and creating interactive educational experiences. Furthermore, Wright and Park (2022) indicated a rise in the production of teacher-generated content, indicating a shift towards more personalized and context-specific learning materials. This statistical trend reflects the active involvement of educators

in the digitization process, ensuring content relevance. Similarly, statistical evidence from studies indicated an increasing trend in the integration of multimedia and interactive elements in learning materials. This statistical shift reflects a recognition of the need to cater to diverse learning styles and enhance student engagement.

However, Teferra's (2010) research on the sustainability of ICT initiatives in higher education in Africa resonated with the ongoing challenge of sustainability in internet connectivity and content digitization. Despite progress, statistical data (World Bank, 2022) indicated that sustainability and maintenance remain significant concerns. Long-term planning and investment are imperative to ensure the continued success of connectivity and digitization initiatives. Besides, Warschauer (2003) raised concerns about the quality of digitized content. However, recent assessments (UNESCO, 2022) indicated a growing awareness of the importance of quality assurance in digitized educational materials. The statistics highlight ongoing efforts to establish standards and guidelines to maintain and enhance the quality of digitized content in African schools.

G. Strategic recommendations

First, to bridge the gap between global industrial revolutions and advancements in African educational systems, strategic investments are imperative. Allocating resources for technology infrastructure, including internet connectivity and digital learning tools, is fundamental. Governments and stakeholders should prioritize the development of a robust technological infrastructure, ensuring that schools across Africa have access to the necessary tools and resources for effective teaching and learning. This investment lays the foundation for integrating emerging technologies into the educational landscape.

In addition, education policies must align with the evolving demands of the global industrial landscape. Governments should collaborate with industry experts to identify the skills and competencies required in the Fourth Industrial Revolution and beyond. This collaboration will inform the development of future-ready curricula that emphasize critical thinking, problem-solving, and digital literacy. Aligning policies with industry needs ensures that educational systems are responsive to the rapidly changing job market, preparing students for success in the digital era.

Moreover, public-private partnerships (PPPs) play a pivotal role in advancing educational systems. Collaborations between governments, private enterprises, and non-profit organizations can bridge resource gaps. Industry leaders can contribute expertise, technology, and funding to enhance educational infrastructure and curriculum development. PPPs foster innovation and create a synergy between academic institutions and industries, ensuring that educational programs are aligned with the practical requirements of the job market.

Lastly, efforts should be directed towards minimizing the digital divide and ensuring inclusivity. Policymakers should prioritize initiatives that provide equal access to technology across urban and rural areas. This includes subsidizing digital devices, expanding internet connectivity, and implementing programs that empower educators and students with the skills needed to navigate the digital landscape. By making technology accessible to all, African educational systems can harness the potential of global industrial revolutions to empower learners and contribute to socio-economic development.

H. Conclusive takeaways

- Prioritizing mental and physical wellbeing of both teachers and students creates an environment conducive to effective teaching and learning. By addressing the holistic needs of educators and students, educational institutions contribute to the development of resilient, engaged, and motivated individuals.

- Recognizing electricity as an enabling resource is pivotal. It not only powers educational technologies but also impacts the overall quality of teaching and learning processes. Governments and stakeholders should invest in electrification projects to ensure equitable access, bridging the urban-rural divide and fostering an inclusive educational landscape.

- Despite achievements, integrating ICT in African education faces challenges. Acknowledging these obstacles, such as infrastructure limitations and access disparities, is crucial. Policymakers and educators should collaboratively address these challenges to unlock the full potential of digital tools for improved learning outcomes.

- Reflecting on the progress of internet connectivity and content digitization in African schools revealed both achievements and challenges. To move forward, inclusive strategies, sustainable funding models, and continuous professional development for educators are essential. National policies, international collaborations, and research and innovation play pivotal roles in shaping the future of digitized education.

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