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Innovative Technologies in Education for Socio-Economic Development in Africa

HARRIET AKUDO AGBARAKWE[1], PROF. H. I. DIKE[2]

[1,2]Department of Curriculum Studies and Educational Technology Faculty of Education, University of Port Harcourt

Corresponding Author: HARRIET AKUDO AGBARAKWE (Ph. D),

ORCID ID (0009-0006-6957-9032)

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ABSTRACT

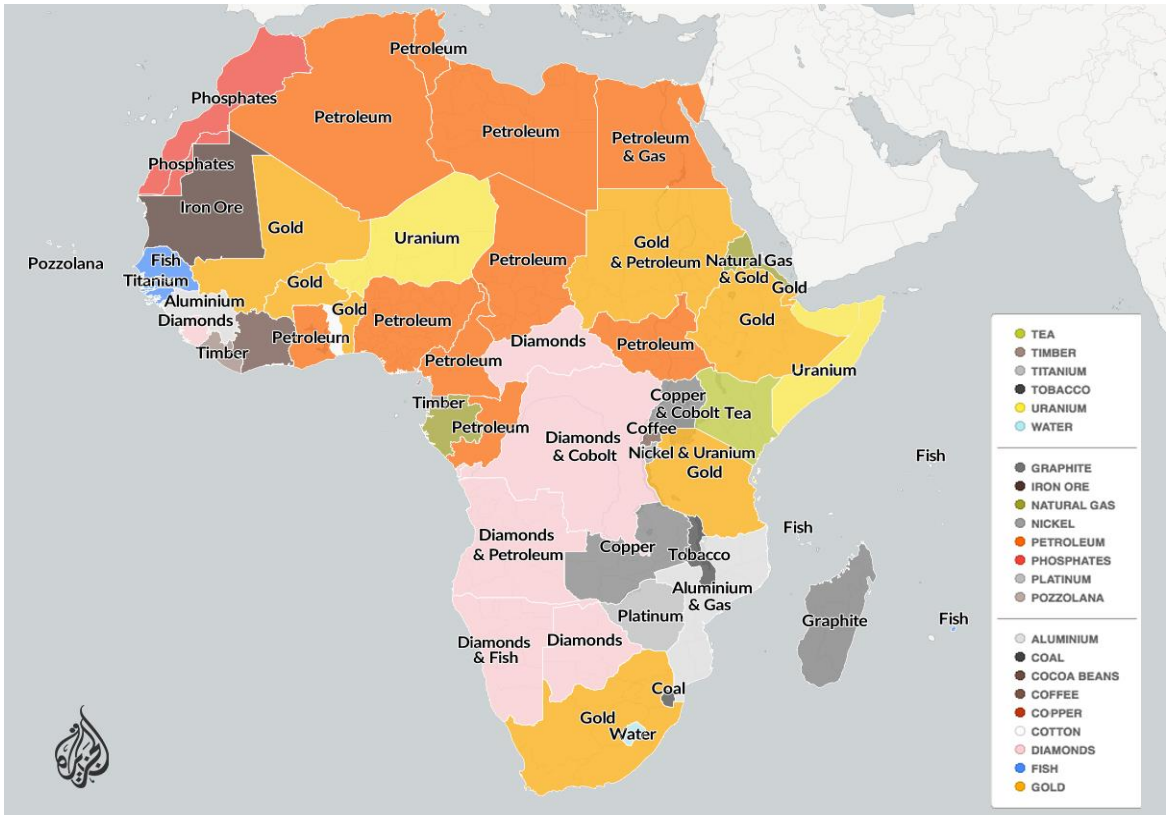
The continent of Africa faces numerous socio-economic challenges that impede her development. Despite the abundance of natural and mineral resources, Africa has over 2000 tertiary institutions, with Nigeria alone having over 200 universities, polytechnics, colleges of agriculture, and colleges of education. All these tertiary education institutes in Africa/Nigeria boast of having well over 4000 professors. In spite of all these educational establishments, only a few of these innovative technologies emanate from Africa. This paper presents a working definition of the term innovative technology and how it stands as a promising hope for addressing these challenges and fostering socio-economic development. Innovations such as e-learning platforms, learning management systems, mobile learning, virtual and augmented reality, open educational resources, blockchain for credentials, and renewable energy solutions offer potential solutions to improve educational access and quality. The successful implementation of these technologies can enhance educational outcomes, reduce poverty, and support sustainable development across the continent. This review also identifies the barriers to the full realization of these technologies, such as poor infrastructure, digital divides, and socio-economic disparities. It offers suggestions for policymakers, educators, and stakeholders on how to leverage technology for sustainable socio-economic growth. The ultimate goal is to foster an inclusive and equitable educational environment that empowers all African learners and contributes to the continent's overall development.

Keywords: Innovative Technologies, Education, Socio-economic Development in Africa.

INTRODUCTION

The African continent is gifted with rich mineral resources, including fertile agricultural lands and massive mineral deposits; it is also the world's second-largest and second-populous continent in the world. But it's disheartening to state that, presently, this continent is faced with a multitude of socio-economic challenges across its diverse regions; these challenges are reflected in their political, historical, economic, social, and educational systems. According to the World Bank, as of 2020, the extreme poverty rate in Sub-Saharan Africa was estimated at 35.2%, with over 400 million people living on less than $1.90 a day, while the African Development Bank (AfDB) reveals that the income inequality remains high in Africa, with the richest 10% of the population accounting for 41% of

total income. Africa is a continent with abundant natural resources such as oil and gas, minerals, land, sunshine, wind, and biodiversity, but it remains unbelievable that its real value is unspeakable and largely untapped. The image below shows clearly the abundance of mineral resource distribution.



Mapping of African Natural Resources
Source: https://medium.com/@ajlabs/mapping-africas-natural-resources-8fc6407ca5f9

The International Labour Organization (ILO) also reported that Africa had the highest youth unemployment rate globally, reaching 20.8% in 2020. (World Employment and Social Outlook, 2021). Underemployment rates are also significant, particularly in the informal sector, where workers often face low pay and poor working conditions. Data from the World Health Organization (WHO) indicates that Africa faces various healthcare challenges, including inadequate access to essential health services, high maternal and child mortality rates, and the burden of infectious diseases such as HIV/AIDS, malaria, and tuberculosis.

The discussion on socio-economic development in Africa is all-encompassing, and as such, infrastructural facilities are critical indicators for growth and development. The African Union's Programme for Infrastructure Development in Africa (PIDA) reports that Africa's infrastructure deficit remains significant, with only 34% of Africans having access to electricity and only 64% having access to improved water sources. (PIDA Progress Report 2019). Inadequate transportation infrastructure hampers economic development and regional integration.

The educational sector is not left out. Data from UNESCO shows that in Sub-Saharan Africa, about 87 million children of primary school age are out of school, and over one-third of children who enroll drop out before completing primary education. (UNESCO Education for All Global Monitoring Report, 2023). There is also a significant gender gap in education, particularly in secondary and tertiary levels, with girls

being less likely to attend school compared to boys. In addition, the continent also faced challenges like limited access to quality education, high dropout rates, and a shortage of skilled teachers. These issues worsened due to socioeconomic disparities, with marginalized communities suffering the most. The situation is worsened by insufficient resources, outdated teaching methods, and inadequate infrastructure, hindering educational goals and socio-economic development.

With the advent and influx of scientific and technological revolutions that are geared towards addressing socioeconomic challenges, one of which is the innovative technologies designed and developed by some Africans and the developed countries of the world to solve and enhance the gaps in African institutions of learning, especially in the developing countries, which is in line with the UNESCO Sustainable Development Goal (SDG4). The African continent can leverage these technologies and innovations to advance the course of sustainable development across all sectors, especially education. Donath, Mircea, & Rozman (2020) in Agbarakwe & Uwadia (2024) posit that using an e-learning and online learning platforms for higher education supports a learning environment that provides open and equitable access to knowledge and skills as well as fosters collaboration for shared experiences; even the SDG4 prescribes and demands access to inclusive and equitable quality education and lifelong learning opportunities for all by 2030. It is therefore expedient that there is a collective effort to actualize this goal, which will in turn bring about the desired change that will better and improve the living standards of Africans in the world, with particular emphasis on Nigeria.

Statement of the Problem

Africa has over 2000 tertiary institutions, with Nigeria alone having over 197 universities, 218 polytechnics, 27 colleges of agriculture, and 108 colleges of education (Federal Ministry of Education Report, 2020). Surprisingly, the out-of-school children with an estimated figure of 8.73 million elementary school-aged children not participating in education are recorded. Her traditional educational system still struggles to meet learners' needs and prepare them for the modern world. However, the arrival of innovative technologies offered hope, promising to transform education and address long-standing challenges. E-learning platforms, mobile apps, virtual and augmented reality, artificial intelligence, and other digital resources provided opportunities to overcome barriers, expand access to learning materials, and improve learning quality. Governments and organizations in Africa began embracing digital innovations, investing in infrastructure, and promoting technology integration in education to drive socio-economic development. Despite initial enthusiasm and investments, implementing innovative technologies in education has fallen short of expectations, revealing pressing problems. Persistent barriers threaten to widen educational disparities and hinder socio-economic progress. Challenges like poor internet connectivity, limited device access, and low digital literacy among educators and students obstruct effective technology integration. Socio-economic factors exacerbate these issues, leaving vulnerable populations disadvantaged and deepening the digital divide.

This alarming situation highlights the urgent need for attention and action to address barriers hindering innovative technology's full potential in African education. Despite increasing recognition of digital innovations, a critical research gap remains in the implementation, root causes, and way forward. Therefore, this research paper aims to provide comprehensive information on the various innovative technologies as it concerns the sub-Saharan African continent, with more emphasis on Nigeria.

Aim and Objectives of this Research Paper

The aim of this paper is to provide and analyze the various innovative technologies in education that can promote and sustain socio-economic development in Africa, with specific emphasis on:

1. Education and socio-economic development in Nigeria
2. to identify the innovative technologies that can foster and sustain socio-economic development in Africa education
3. to highlight the importance of government support, policies, and partnerships in integrating technology into education for sustainable socio-economic development.
4. the impacts of language and cultural diversity on the deployment of innovative technologies in the African continent
5. factors militating against the full actualization of innovative technologies for socio-economic growth in Nigeria
6. suggestions for the implementation of innovative technology in the educational sector for sustainable socioeconomic development:

Education and socio-economic development in Nigeria

Education is the bedrock of other sectors and so should not be overlooked. The current state of education in Africa has been average compared to other developed countries. There is a need to deploy innovative technologies for enhanced learning outcomes across learners on the African continent. It is also pertinent to state that education drives the creation of both human and non-human resources required to drive the economy, which in turn puts the nation's growth on the global map. Education plays a major role in actualizing this dream; this is because education deals with the awakening and nurturing of human potentials as well as sustaining trans-generational heritage.

For education to maximize its potential to function as a vehicle that drives sustainable development on the African continent, technologies and innovations must be deployed to meet the current demands. According to Obanya (2014), sustainable education must not be one-sided; it must stress both hard and soft skills. In today's contemporary education, any attempt to educate the head, mind, and heart without considering the nature and values of today's learner will have little or no positive impact on the economic development. This is because the type of services and skills required for today's teaming workforce are not the same as those of the past century. This can also be supported by the report from global education monitoring (GEM) at the 2023 SDG Summit on technology in education that digital technologies should be used to support education.

Innovative Technologies in Education

Below are some of the innovative technologies Nigeria and the African Continent, with their diverse cultures, languages, and socio-economic landscapes, can deploy in their educational systems to enhance socio-economic development:

i. E-Learning Platforms:

The COVID-19 pandemic made bare the importance of remote learning; e-learning platforms have become essential in Nigeria's education system. According to a report by EdTech Hub, Nigeria has seen a surge in the adoption of e-learning platforms, with an estimated 25% increase in the number of users during the pandemic. (The EdTech Hub COVID-19 Brief). Platforms like Afrilearn and uLesson have gained popularity, providing access to educational content and resources for students across the country. (TechCabal, Afrilearn, and uLesson). Other online platforms and apps that offer educational content to support remote traditional schooling include Khan Academy, Coursera, and edX. These

offer courses across various subjects and skill levels, and they are often offered for free or at a minimal cost.

ii. Mobile Learning

With the widespread adoption of mobile phones in Africa, mobile learning applications can deliver educational content directly to users' devices. These apps can provide everything from basic literacy and numeracy skills to advanced academic subjects.

iii. Virtual Reality (VR) and Augmented Reality (AR)

VR and AR technologies can create and enhance immersive educational experiences. With virtual reality, simulation-based learning, interactive 3D models used to explore complex structures, orans, and systems, as well as personalized learning where students can adapt content to individual needs and learning styles are enhanced, while augmented reality supports interactive textbooks, thereby bringing learning materials to real life with 3D models, videos, and animations. It can also promote real-life connections. In addition, learners with disabilities can be supported. Tools and platforms that can be used to achieve the above are Oculus Quest, HTC Vive, Google Expeditions, ARCore, and others.

iv. Open Educational Resources (OER)

OER are freely accessible, openly licensed educational materials that can be used for teaching, learning, and research. These resources include textbooks, lectures, lesson plans, games, and simulations, and they can help to reduce the cost of education while improving access to quality learning materials.

v. Block chain for credentials and certifications

Block chain technology can be used to securely store and verify educational credentials and certifications, making it easier for employers to validate the qualifications of job applicants by reducing fraudulent claims of educational certificates and manipulation of data. It also aids in the decentralization of identity management, provides tamper-proof records, and secures data storage.

vi. Remote work and freelancing platforms

Online platforms that connect freelancers with job opportunities can provide economic opportunities for individuals in Africa, especially in areas with limited local job markets. Platforms like Upwork, Freelancer, and Fiverr allow people to offer their skills and services to clients worldwide.

vii. Renewable Energy Solutions

Innovative technologies in renewable energy are addressing Nigeria's energy challenges and supporting socio-economic development. The Nigerian Renewable Energy Roundtable reports that renewable energy investments in Nigeria reached $42.8 million in 2020, with significant growth expected in the coming years. Access to reliable electricity is crucial for both education and socioeconomic development. Renewable energy technologies, such as solar panels and microgrids, can provide off-grid communities with affordable and sustainable energy sources, enabling schools to operate effectively and businesses to thrive as energy installation and maintenance services are required, promote local economic growth and reduction in energy cost, and, as such, promote sustainable development, job creation, and climate resilience.

viii. Agricultural Technologies

Agriculture is a significant sector in many African economies. Technologies like precision agriculture, mobile-based

agricultural advisory services, and market information systems can improve agricultural productivity, increase incomes for farmers, and enhance food security. Nigeria, with its several faculties of agriculture and research institutes, can integrate some of the innovative technologies designed to enhance the production and processing of agro-products. Platforms like Farmcrowdy and Thrive Agric are leveraging technology to connect farmers with investors, provide access to inputs and market information, and improve agricultural productivity. According to Techpoint Africa, Farmcrowdy has impacted over 25,000 farmers and facilitated the cultivation of over 16,000 acres of farmland.

Farmcrowdy is a Nigerain agritech company that enables individuals to invest in agriculture through crowdfunding. It was founded in 2016. Farmcrowdy connects farmers with investors, providing funding for farming projects and enabling individuals to sponsor crops and livestock. These AgriTech solutions contribute to food security, poverty reduction, and rural development.

ix. Financial Inclusion Technologies

Financial inclusion technologies can promote socioeconomic development through the deployment of mobile money platforms, digital payment systems, papal digital wallets, and block chain-based financial services. This inclusion can help to provide individuals and entrepreneurs access to funds. It will also assist users in managing their finances more efficiently, fostering economic growth and stability while helping to reduce poverty, increase economic growth, promote social equality, and promote economic participation and empowerment.

x. Healthcare Technologies

Improved healthcare contributes to socioeconomic development by reducing healthcare costs, increasing productivity, and improving overall quality of life. Telemedicine, mobile health apps, and health information systems can expand access to healthcare services, especially in remote areas with limited healthcare infrastructure.

xi. Entrepreneurship and Innovation Hubs:

Nigeria's growing ecosystem of entrepreneurship and innovation hubs is fostering creativity, skill development, and job creation. Hubs like Co-Creation Hub (CcHub) and Andela, which provide support to startups, offer training programs in technology and entrepreneurship, and facilitate collaboration and networking.

Also. is Disrupt Africa, a technology hub network that’s making waves in the African startup space. Disrupt Africa was founded in 2014 and has grown to become a leading platform for startup news, research, and analysis. According to a report by Disrupt Africa, Nigeria had over 400 active tech hubs and incubators as of 2020, indicating the vibrancy of its innovative ecosystem. These hubs contribute to economic growth by nurturing talent, promoting innovation, and supporting the growth of the digital economy and, as such, have the capabilities of promoting education and socioeconomic development in Nigeria by advancing its educational system, promoting financial inclusion, enhancing agricultural productivity, improving energy access, and fostering entrepreneurship and innovation.

Government Initiatives and Policies Supporting Technology Integration

Governments across the globe, including those in Africa, have recognized the transformative potential of technology in education and have undertaken various initiatives and policies to support its

integration into the education system. These efforts aim to harness the power of technology to improve learning outcomes, enhance access to education, and prepare students for the demands of the digital age. If there is no government intervention, the pros and cons and differences in attitudes between groups towards the integration of ICT in teaching and learning will never be resolved. The government needs to emphasize what is better than others (Czerniewicz, 2020).

One of the key government initiatives supporting technology integration is the provision of ICT infrastructure in schools and educational institutions. This includes the establishment of computer labs, the distribution of tablets or laptops to students and teachers, and the deployment of high-speed internet connectivity. By investing in ICT infrastructure, governments aim to create a conducive environment for technology-enhanced learning and ensure that all learners have access to digital resources and tools. According to Huang et al. (2020), the government and education providers need to stand against those who oppose the use of technology to overcome the pros and cons and ensure policy implementation.

In addition to infrastructure development, governments have prioritized training programs and capacity building for teachers to enhance their digital literacy and skills in technology integration. Professional development initiatives include workshops, seminars, and online courses designed to equip educators with the knowledge and skills needed to effectively utilize technology in their teaching practices. Yelubay (2020) and Tudor (2020) state that before ICT can be integrated effectively, teachers must be equipped with adequate training and support in the field of ICT and pedagogy. Teachers' attitudes and their willingness to apply ICT make a big difference in the lives of their students.

Furthermore, governments have implemented policies to promote the development and adoption of digital learning resources and content. This includes the creation of open educational resources (OER) repositories, the development of digital textbooks and learning materials, and the support of e-learning platforms and educational apps. By fostering the creation and dissemination of digital content, governments aim to enhance access to educational resources and promote inclusive and equitable education for all learners.

Moreover, governments have undertaken partnerships with private sector organizations, academic institutions, and international agencies to leverage resources and expertise in technology integration. Public-private partnerships (PPPs) have been established to fund technology initiatives, develop innovative solutions, and scale successful projects. Collaborative efforts between government and industry aim to leverage technology for socio-economic development and address pressing challenges in education.

Impact of Language and Cultural Diversity on the Deployment of Innovative Technologies in the African Continent

The African continent is multilingual and diverse in her culture; hence, there are bound to be some challenges in the diffusion and integration of innovative technologies. Some of which are:

i. Communication Barriers: Africa is incredibly linguistically diverse, with thousands of languages spoken across the continent. This diversity presents a challenge for the deployment of technologies such as e-learning platforms or mobile applications. Developers need to consider localization and translation efforts to ensure that their products are accessible to users in different linguistic communities.

ii. Cultural Relevance: Cultural differences across African regions influence how people interact with technology. A technology that is successful in one cultural context may not be as well

received in another. Understanding cultural norms, values, and preferences is essential for designing and deploying technologies that resonate with local communities.

iii. Digital Inclusion: Cultural and linguistic diversity can intensify digital exclusion. People who speak minority languages or belong to marginalized cultural groups may face barriers in accessing and benefiting from innovative technologies. Efforts to promote digital inclusion should consider these diverse linguistic and cultural contexts to ensure equitable access to technology for all communities.

iv. Content Creation and Curation: Developing content for educational or informational purposes requires an understanding of local languages and cultural contexts. Content creators need to produce materials that are culturally relevant and linguistically appropriate to effectively engage with diverse audiences across Africa.

v. User Experience Design: User experience design plays a crucial role in the adoption and utilization of technology. Designers must consider cultural differences in user behavior, preferences, and usability expectations when designing interfaces and interactions for innovative technologies in Africa.

vi. Trust and Adoption: Cultural factors influence trust in technology. People are more likely to adopt and use technologies that they perceive as aligned with their cultural values and beliefs. Building trust requires engaging with local communities, understanding their needs and concerns, and demonstrating the cultural sensitivity of the technologies being deployed.

vii. Socioeconomic Factors: Language and cultural diversity intersect with socioeconomic factors, such as literacy levels, access to education, and economic disparities. These factors influence technology adoption and usage patterns and must be considered in the deployment of innovative technologies across different linguistic and cultural contexts in Africa. Language and cultural diversity, to a great extent, affect the deployment of innovative technologies in Africa. To effectively deploy technologies, developers and stakeholders must recognize and navigate these complexities to ensure that technologies are accessible, relevant, and impactful across diverse linguistic and cultural landscapes.

Factors Militating against the Actualization of Innovative Technologies for Socio-economic Growth in Nigeria.

These factors encompass various aspects of the socio-economic, technological, and policies of the country. Among which are;

i. Infrastructure: Inadequate infrastructure, unreliable power supply, limited internet connectivity, and poor transportation networks hinder the deployment and utilization of innovative technologies across Nigeria.

ii. Access to quality education and skills training programs: Limited access to quality education and skills development programs inhibits the adoption and effective utilization of innovative technologies among the population. Lack of skilled workforce capable of leveraging these technologies can limit the effective deployment of these technologies.

iii. Digital Divide: Disparities in access to technology and digital literacy contribute to a digital divide within Nigeria, with urban areas and wealthier populations having better access to innovative technologies compared to rural and marginalized communities, which can lead to a digital literacy and skills gap.

iv. Regulatory Environment: Complex and restrictive regulatory environments can impede innovation and entrepreneurship in Nigeria. Unclear regulatory frameworks, bureaucratic red tape, and

inconsistent enforcement of regulations create challenges for the development and deployment of innovative technologies.

v. Access to Financing: Limited access to financing, particularly for startups and small businesses, constraints the development and scaling of innovative technologies in Nigeria. Lack of venture capital, angel investment networks, and supportive financial infrastructure inhibits the growth of the technology sector. According to the Sub-Saharan Africa Regional Economic Outlook, the growth in sub-Saharan Africa (SSA) is expected to slow to 3.6 percent as a "big funding squeeze," tied to the drying up of aid and access to private finance, which could probably lead to reduced fiscal resources for critical development like health, education, and infrastructure.

vi. Political Stability and Governance: Political instability, corruption, and governance challenges in Nigeria create an uncertain business environment that can deter investment and innovation. Weak governance structures and inadequate protection of intellectual property rights undermine confidence in the innovation ecosystem.

vii. Market Demand and Consumer Behavior: Understanding local market demand and consumer behavior is crucial for the successful deployment of innovative technologies. Failure to align technological solutions with the needs and preferences of Nigerian consumers can result in low adoption rates.

viii. Collaboration and Ecosystem Support: Limited collaboration and coordination among stakeholders within the innovation ecosystem, including government agencies, academia, private sector entities, and civil society organizations, hinder the development and deployment of innovative technologies.

ix. Cultural and social factors: cultural attitudes, social norms, and perceptions towards technology adoption and entrepreneurship can influence the acceptance and utilization of innovative technologies in Nigeria. Addressing cultural barriers and promoting a culture of innovation and entrepreneurship is essential for driving socio-economic growth.

x. Security Concerns: Persistent security challenges, including cyber threats, terrorism, and communal conflicts, pose risks to the deployment and utilization of innovative technologies in Nigeria. Ensuring cyber security and addressing physical security concerns are critical for fostering a conducive environment for technology-driven socio-economic growth.

CONCLUSION

For Nigeria to adequately address these factors and challenges listed above, a comprehensive approach involving government policies, private sector initiatives, civil society engagement, and international collaboration is required to create an enabling environment for the actualization of innovative technologies for socio-economic growth in Nigeria.

Suggestions for the Implementation of Innovative Technology in the Educational Sector for Sustainable Socio-Economic Development:

Implementing innovative technology in the educational sector can significantly promote sustainable socio-economic development. Here are some ways Nigeria and other African countries in Sub-Sahara can adopt for the successful deployment of innovative technologies in education.

1. Massive investment in infrastructure and tech hubs:
2. Ensure reliable electricity supply and internet connectivity in schools and educational institutions, especially in rural and underserved areas.
3. Upgrade and maintain ICT infrastructure to support the integration of technology in the educational sector.

4. Provide training for digital literacy and skills development, as well as integrate digital literacy training into the curriculum at all levels of education to equip students and teachers with essential digital skills.
5. Provide professional development opportunities for teachers to enhance their proficiency in using technology for teaching and classroom management.
6. Provide affordable access to technological devices such as laptops, tablets, and smartphones for students and teachers.
7. Develop and curate digital educational resources, including e-books, online courses, and educational apps to supplement traditional learning materials.
8. Policy Framework and Regulation by developing clear and supportive policies and regulations that promote the integration of technology in education while addressing privacy, security, and ethical considerations.
9. Establish standards and guidelines for the selection, deployment, and evaluation of educational technology solutions.
10. Foster collaboration and partnerships among institutions of learning and between government agencies, educational institutions, private sector stakeholders, and civil society organizations to support the implementation of innovative technology in education.
11. Encourage public and private partnerships to leverage resources and expertise for the development and deployment of technology-enabled educational initiatives.
12. Monitoring and Evaluation by designing mechanisms and implementing monitoring and evaluation of the impact of technology integration in education on learning outcomes, student engagement, and teacher effectiveness.
13. Use data-driven insights to inform policy decisions, identify areas for improvement, and optimize resource allocation.
14. Inclusive and Equitable Access: Ensure that technology-enabled educational initiatives are accessible and inclusive, catering to the diverse needs of learners, including those with disabilities and marginalized populations.
15. Bridge the digital divide by prioritizing initiatives that promote equitable access to technology and digital resources for all students, regardless of socioeconomic background or geographic location.
16. Innovation and Research: Encourage research and innovation in educational technology to develop and test new approaches, tools, and methodologies for enhancing teaching and learning outcomes.
17. Support pilot projects and experimental initiatives to explore the potential of emerging technologies such as artificial intelligence, virtual reality, and augmented reality in education.

Declaration by Authors

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