

# THE IMPACT OF INFORMATION AND COMMUNICATION TECHNOLOGY ON ENGINEERING PRACTICES IN AFRICA

Okechukwu Chidoluo Vitus

*Omnibus Institute of Professional Learning and Development, Lagos 42100, Nigeria.*

*Corresponding Email: [jlcmedias@gmail.com](mailto:jlcmedias@gmail.com)*

**Abstract:** This article examines the transformative role of Information and Communication Technology (ICT) in the engineering sector across Africa. The purpose of this study is to evaluate how ICT innovations are reshaping engineering practices, enhancing productivity, and fostering sustainable development within the continent. The methodology employed involves a comprehensive review of existing literature, case studies from various African nations, and interviews with industry experts. This multi-faceted approach allows for a nuanced understanding of the current landscape and the challenges faced by engineering professionals in the region. The findings reveal that ICT has facilitated significant advancements in engineering through improved communication, project management, and access to information. For instance, the use of digital tools and platforms has streamlined workflows and reduced project timelines, while also enabling remote collaboration among teams. Additionally, mobile technology has enhanced access to engineering resources in rural areas, bridging the gap between urban and rural capabilities. However, the study also identifies barriers such as inadequate infrastructure, limited internet access, and a lack of technical skills that hinder the full realization of ICT's potential. The implications of these findings are profound, suggesting that policymakers and educational institutions must prioritize investment in ICT infrastructure and training programs to empower engineers across Africa. By doing so, the continent can harness the full benefits of ICT, driving innovation and economic growth in the engineering sector. This article contributes to the ongoing discourse on technology adoption in Africa, highlighting the urgent need for strategic initiatives that promote the integration of ICT in engineering practices.

**Keywords:** Technology; Industry; Communication; Engineering; Africa

## 1 INTRODUCTION

Information and Communication Technology (ICT) has emerged as a pivotal force in the modern engineering landscape, particularly in the context of Africa. As the continent grapples with unique challenges such as rapid urbanization, infrastructure deficits, and economic diversification, the integration of ICT into engineering practices offers promising solutions. ICT not only enhances operational efficiency and project management but also enables engineers to leverage data and technology for informed decision-making. This article aims to explore the relevance of ICT in engineering within Africa, delving into how these technologies can address some of the pressing challenges faced by the continent.

The primary objective of this article is to provide a comprehensive overview of the transformative impact of ICT on engineering practices in Africa. It seeks to highlight the necessity of adopting modern technologies to foster innovation and sustainability in the engineering sector. Throughout the paper, several key themes will be addressed, including the role of ICT in enhancing communication and collaboration among engineering teams, the influence of mobile technology in bridging the urban-rural divide in resource access, and the challenges that hinder the effective implementation of ICT solutions.

Additionally, the article will examine case studies that illustrate successful ICT integration in various engineering projects across African nations. By analyzing these examples, the paper will shed light on best practices and potential strategies for overcoming the existing barriers to ICT adoption. Ultimately, this exploration will underscore the critical need for policymakers, educational institutions, and industry stakeholders to prioritize ICT investments that can empower engineers and drive sustainable development across the continent.

### 1.1 Overview of Information and Communication Technology (ICT)

Information and Communication Technology (ICT) encompasses a broad range of technologies that enable the creation, storage, exchange, and utilization of information. At its core, ICT integrates both hardware and software components alongside networks and services, facilitating effective communication and data management.

The hardware aspect includes devices such as computers, smartphones, tablets, and networking equipment like routers and switches. These tools are essential for accessing and processing information. Software, on the other hand, refers to applications and systems that perform specific tasks, including operating systems, productivity software, and specialized engineering tools. Together, hardware and software form the backbone of ICT infrastructure, enabling users to interact with technology efficiently.

Networks play a crucial role in ICT by connecting devices and facilitating data transfer. This includes local area networks (LANs), wide area networks (WANs), and the Internet, which allow for seamless communication and collaboration across various locations. Services such as cloud computing, telecommunications, and broadband internet further enhance the capabilities of ICT, providing users with the flexibility to access information and tools from virtually anywhere.

The evolution of ICT can be traced back to the advent of computers and the Internet, which revolutionized how information is processed and shared. Over the decades, advancements in technology have led to increased accessibility and affordability, making ICT indispensable in various sectors, including education, healthcare, agriculture, and engineering.

In Africa, the importance of ICT is particularly pronounced. The continent is witnessing a digital transformation that holds the potential to address challenges such as poor infrastructure and limited access to resources. For instance, mobile technology has become a game-changer, enabling communication and access to services in remote areas. This evolution not only fosters economic growth but also promotes social inclusion, paving the way for a more connected and informed society. As ICT continues to advance, its role in driving innovation and sustainable development in Africa will be critical.

## **1.2 Current State of Engineering in Africa**

The engineering sector in Africa is at a crossroads, characterized by both immense potential and significant challenges. With a rapidly growing population and increasing demands for infrastructure and services, the need for skilled engineers is more critical than ever. However, numerous obstacles impede progress in the field, including limited resources, educational deficits, and infrastructural inadequacies.

One of the foremost challenges faced by engineers in Africa is the scarcity of resources. Many countries struggle with inadequate funding for engineering projects, which often leads to delays and compromises in quality. This financial limitation affects not only large-scale infrastructure projects but also the smaller, community-based initiatives crucial for local development. Additionally, access to modern tools and technologies is often restricted, further hampering engineers' ability to innovate and implement solutions effectively.

Educational deficits also play a significant role in the current state of engineering in Africa. While there are numerous engineering programs across the continent, many face challenges related to curriculum relevance, faculty expertise, and practical training opportunities. The gap between theoretical knowledge and practical application leaves many graduates ill-prepared to meet the demands of the industry. This skills mismatch results in a workforce that is often unable to keep pace with technological advancements or the evolving needs of the market.

Infrastructural inadequacies compound these issues, as many regions in Africa suffer from poor transportation networks, unreliable energy supplies, and insufficient communication systems. These deficits not only hinder the ability of engineers to perform their tasks effectively but also diminish the overall attractiveness of the engineering profession. Inadequate infrastructure can lead to increased project costs and extended timelines, making it difficult for engineers to deliver timely and efficient services.

Addressing these challenges requires a concerted effort from governments, educational institutions, and the private sector. By investing in resources, enhancing educational programs, and improving infrastructure, stakeholders can create an environment that fosters engineering innovation and growth across Africa.

## **2 ROLE OF ICT IN ENHANCING ENGINEERING PRACTICES**

The integration of Information and Communication Technology (ICT) into engineering practices in Africa has brought about a profound transformation, enhancing efficiency and productivity across various sectors. One of the most significant advancements is the adoption of Computer-Aided Design (CAD) software, which enables engineers to create precise drawings and models with ease. This technology not only reduces the time spent on design but also minimizes errors, leading to cost savings and improved project outcomes. With CAD, engineers can explore multiple design alternatives quickly, allowing for more innovative solutions to emerge.

Moreover, project management tools have revolutionized how engineering teams plan and execute projects. Software such as Microsoft Project and Asana provides engineers with the ability to track project timelines, allocate resources effectively, and manage budgets in real-time. These tools facilitate better communication among team members and stakeholders, ensuring that everyone is aligned on project goals and deadlines. This increased transparency and collaboration are especially critical in large-scale projects, where multiple parties may be involved.

Mobile technology has also played a crucial role in enhancing engineering practices, particularly in remote areas of Africa. Engineers can access project information, collaborate with colleagues, and communicate with clients from virtually anywhere using smartphones and tablets. This mobility ensures that teams can respond quickly to challenges and make informed decisions on-site, thereby enhancing overall project efficiency.

Additionally, cloud computing has transformed data storage and access in engineering. Engineers can now store vast amounts of data online, making it easily accessible to team members regardless of their location. This capability not only streamlines workflow but also fosters innovation by allowing engineers to share and collaborate on projects without the constraints of physical proximity.

The combination of these technologies has significantly improved the way engineering practices are conducted in Africa, enabling professionals to work more effectively and creatively. Through the continuous integration of ICT, the engineering sector can further address the continent's unique challenges, fostering sustainable development and economic growth.

## 2.1 Case Studies: Successful ICT Integration in Engineering Projects

In recent years, several African countries have successfully integrated Information and Communication Technology (ICT) into engineering projects, demonstrating the potential for enhanced efficiency, innovation, and sustainability. This section examines notable case studies from Kenya, South Africa, and Nigeria, highlighting the outcomes and lessons learned from these initiatives.

One prominent example is the Nairobi-Naivasha Railway Project in Kenya, which utilized advanced ICT tools for project management and monitoring. The project incorporated Geographic Information Systems (GIS) to optimize the route selection process and ensure minimal environmental impact. By leveraging real-time data and analytics, project managers were able to make informed decisions that improved resource allocation and reduced construction delays. The successful implementation of ICT in this project underscores the importance of data-driven decision-making in enhancing project efficiency.

In South Africa, the use of Building Information Modeling (BIM) in the development of the Cape Town International Convention Centre exemplifies the transformative impact of ICT in engineering. BIM technology facilitated collaborative design processes among architects, engineers, and contractors, allowing for the visualization of the entire project before construction commenced. This integration not only minimized design conflicts but also improved communication across teams, resulting in a more streamlined construction process. The project highlighted the need for skilled personnel proficient in modern ICT tools to maximize the benefits of such technologies.

Meanwhile, Nigeria's e-Government initiative has significantly improved infrastructure development through enhanced transparency and accountability in project execution. By utilizing online platforms for project bidding and monitoring, the government has reduced corruption and inefficiencies in the procurement process. This case demonstrates how ICT can foster good governance and empower citizens by providing access to information regarding public projects.

These case studies illustrate that successful ICT integration in engineering projects can yield substantial benefits, including improved efficiency, enhanced communication, and increased transparency. However, they also highlight the necessity for ongoing investment in training and infrastructure to ensure that these technologies are effectively utilized across the continent. The lessons learned from these initiatives can serve as a guide for future projects, paving the way for a more innovative and sustainable engineering landscape in Africa.

## 2.2 Challenges to ICT Adoption in Engineering

Despite the potential benefits of Information and Communication Technology (ICT) in transforming the engineering sector in Africa, several challenges hinder its widespread adoption. Identifying and addressing these barriers is essential for leveraging ICT's full potential to enhance engineering practices.

One of the most significant challenges is the high cost associated with implementing ICT solutions. Many engineering firms, particularly small and medium-sized enterprises (SMEs), struggle to allocate sufficient funds for acquiring necessary hardware, software, and training. The initial investment can be prohibitively expensive, especially in regions where financial resources are already limited. Additionally, ongoing costs such as maintenance, software updates, and internet connectivity can strain budgets, further discouraging companies from adopting new technologies.

Training is another critical barrier to ICT adoption. A lack of skilled personnel proficient in modern ICT tools can severely impede engineering firms' ability to integrate these technologies effectively. Many engineers are not adequately trained in the latest digital tools and software, which hampers their productivity and reduces the potential benefits of ICT. Furthermore, educational institutions often struggle to keep pace with the rapid technological advancements, leading to a mismatch between the skills taught and those required in the industry.

Infrastructure inadequacies also pose significant challenges to ICT adoption in engineering. Many regions in Africa suffer from unreliable electricity supplies and limited internet access, which can disrupt operations and hinder effective communication. Without a robust infrastructure, even the most advanced ICT solutions become ineffective. Engineers need reliable access to digital tools and online resources to collaborate and execute projects efficiently.

Lastly, resistance to change within organizations can obstruct the adoption of ICT. Many professionals may be hesitant to move away from traditional practices due to fears of the unknown or concerns about the effectiveness of new technologies. This resistance can stem from a lack of awareness about the benefits of ICT or past experiences with unsuccessful technology implementations.

Addressing these challenges requires a multifaceted approach, including increased investment in infrastructure, targeted training programs, and efforts to foster a culture of innovation within engineering firms. By tackling these barriers, stakeholders can pave the way for a more integrated and technologically advanced engineering sector in Africa.

### **3 IMPACT OF MOBILE TECHNOLOGY IN ENGINEERING**

Mobile technology has emerged as a transformative force in the engineering sector, particularly in Africa, where it plays a crucial role in enhancing project management and communication among engineers. The proliferation of smartphones and mobile applications has significantly altered how engineering professionals interact, collaborate, and execute projects, leading to increased efficiency and improved outcomes.

One of the most notable impacts of mobile technology is the ability to facilitate real-time communication. Engineers can now connect with team members, clients, and stakeholders instantly, regardless of their geographical location. This immediacy is vital in fast-paced engineering environments where decisions often need to be made on the spot. Apps such as WhatsApp and Slack enable seamless communication, allowing for the rapid exchange of ideas, updates, and feedback. This enhanced connectivity fosters a collaborative atmosphere, which is essential for the successful completion of complex engineering projects.

Mobile applications have also revolutionized project management practices. Tools like Trello and Microsoft Teams allow engineers to manage tasks, set deadlines, and monitor progress directly from their mobile devices. This flexibility means that engineers can oversee projects and respond to emerging challenges while on the move, reducing downtime and keeping projects on track. Moreover, mobile technology enables better resource management, as engineers can access real-time data on equipment availability and project status, allowing for informed decision-making.

In addition to communication and project management, mobile technology has improved access to information and resources in remote areas. Engineers working in rural regions of Africa can utilize their mobile devices to access engineering databases, technical documentation, and training materials. This accessibility helps bridge the urban-rural divide, ensuring that engineers in less accessible areas are equipped with the knowledge and tools necessary to execute their projects effectively.

The integration of mobile technology into engineering practices is not without its challenges. Issues such as limited internet connectivity in certain regions, the need for training on specific applications, and concerns over data security must be addressed. Nonetheless, the benefits of mobile technology in enhancing communication and project management practices present a compelling case for its continued adoption in the engineering sector across Africa.

#### **3.1 Education and Skills Development Through ICT**

The impact of Information and Communication Technology (ICT) on education and skills development for engineers in Africa cannot be overstated. As the continent strives to cultivate a skilled workforce capable of meeting the demands of a rapidly evolving engineering landscape, ICT serves as a vital tool for enhancing educational opportunities and equipping future engineers with necessary skills.

Online learning platforms have gained significant traction in Africa, offering flexible and accessible education options for aspiring engineers. Platforms such as Coursera, edX, and local initiatives like African Virtual University provide courses that cover a wide array of engineering disciplines. These platforms enable learners to access high-quality educational content from renowned institutions worldwide, fostering a culture of lifelong learning. The ability to study remotely not only accommodates diverse learning styles but also ensures that individuals in remote areas can gain access to valuable knowledge and skills that were previously out of reach.

In addition to online courses, virtual simulations are revolutionizing engineering education by providing realistic, hands-on experiences without the constraints of physical resources. Tools like ANSYS and MATLAB allow students to engage in simulations that replicate real-world engineering challenges, promoting practical problem-solving skills. These interactive environments enhance understanding and retention of complex concepts while enabling students to experiment and innovate in a risk-free setting. The incorporation of such technologies into curricula is essential for bridging the gap between theoretical knowledge and practical application.

Furthermore, other educational innovations, such as mobile applications and collaborative platforms, are also playing a crucial role in skills development. Mobile apps tailored for engineering education facilitate self-paced learning and offer interactive resources that enhance comprehension. Collaborative platforms enable students to work together on projects, fostering teamwork and communication skills that are vital in the engineering profession.

As Africa continues to embrace ICT in education, the potential for developing a well-equipped engineering workforce becomes increasingly attainable. However, it is imperative for stakeholders, including governments, educational institutions, and private sector partners, to invest in the necessary infrastructure and training to maximize these technological advancements. By doing so, Africa can cultivate a generation of engineers who are not only adept in their fields but also capable of driving innovation and sustainable development across the continent.

#### **3.2 Impact on Sustainable Development Goals (SDGs)**

The integration of Information and Communication Technology (ICT) in engineering practices across Africa significantly contributes to the achievement of the United Nations Sustainable Development Goals (SDGs). In particular, it plays a

pivotal role in enhancing infrastructure, education, and industry, aligning with several specific SDGs aimed at fostering sustainable growth and development.

### 3.3 Infrastructure Development

SDG 9 emphasizes the importance of building resilient infrastructure, promoting sustainable industrialization, and fostering innovation. The incorporation of ICT in engineering facilitates the design and construction of sustainable infrastructure by enabling the use of advanced tools like Building Information Modeling (BIM) and Geographic Information Systems (GIS). These technologies allow engineers to optimize resource management, minimize waste, and ensure that projects adhere to sustainability standards. For instance, smart city initiatives leverage ICT to improve urban planning, transportation systems, and energy management, directly contributing to sustainable urban development.

### 3.4 Education and Capacity Building

SDG 4 focuses on ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all. ICT enhances educational access and quality, especially in engineering disciplines, by providing online learning platforms and virtual simulations. These resources allow students from diverse backgrounds, including those in remote areas, to acquire essential engineering skills and knowledge. Moreover, ICT facilitates collaboration among educational institutions, industry stakeholders, and governments, creating a holistic approach to skills development that aligns with market needs.

### 3.5 Industry Innovation

SDG 8 aims to promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all. The integration of ICT in engineering practices fosters innovation and efficiency within industries. By streamlining processes, improving communication, and enhancing project management, ICT enables businesses to operate more effectively. Furthermore, the use of data analytics and automation in engineering can lead to increased productivity and reduced operational costs, thereby stimulating economic growth and job creation.

In conclusion, the integration of ICT in engineering is a catalyst for achieving the SDGs in Africa. By enhancing infrastructure, education, and industry, ICT not only addresses immediate challenges but also lays the groundwork for sustainable development, ensuring that the continent can meet the evolving needs of its population.

### 3.6 Future Trends: The Evolution of ICT in Engineering

As Africa continues to embrace the digital revolution, the future of Information and Communication Technology (ICT) in engineering is poised for significant transformation. Key advancements such as Artificial Intelligence (AI), the Internet of Things (IoT), and big data analytics are expected to redefine engineering practices across the continent, driving innovation and improving efficiency.

AI is anticipated to play a crucial role in enhancing engineering processes. By automating routine tasks, AI can free up engineers to focus on more complex problem-solving and creative design challenges. Machine learning algorithms can analyze vast amounts of data to predict project outcomes and optimize resource allocation. In the African context, this could lead to more effective infrastructure development, as AI can help identify areas that require urgent attention and allocate resources accordingly.

The IoT is another transformative trend that will shape the future of engineering in Africa. With the increasing adoption of connected devices, engineers will have access to real-time data from various sources, enhancing their ability to monitor and manage projects. For instance, IoT sensors can provide valuable insights into the structural health of infrastructure, allowing for timely maintenance and reducing the risk of failures. This capability is particularly vital in a continent where aging infrastructure poses significant challenges.

Moreover, the convergence of ICT with sustainable practices is likely to gain traction. As countries strive to meet their climate commitments, the integration of smart technologies will facilitate the development of eco-friendly engineering solutions. For example, renewable energy projects can leverage IoT and AI to optimize energy production and consumption, contributing to sustainable development goals.

In conclusion, the future of ICT in engineering within Africa is bright, characterized by the promise of AI, IoT, and sustainable practices. These advancements will not only enhance operational efficiency but also drive innovation, positioning the continent as a leader in engineering excellence. As stakeholders come together to embrace these technologies, the potential for transformative change will be immense.

## 4 POLICY RECOMMENDATIONS FOR ENHANCING ICT IN ENGINEERING

To effectively enhance the integration of Information and Communication Technology (ICT) in engineering across Africa, a multi-faceted approach is necessary. This involves concerted efforts from governments, educational institutions, and the private sector. Here are several policy recommendations aimed at achieving this goal:

#### **4.1 Government Initiatives**

**Investment in Infrastructure:** Governments should prioritize investment in ICT infrastructure, including reliable internet connectivity, energy supply, and transport networks. Public-private partnerships can be leveraged to fund these initiatives, ensuring equitable access across urban and rural areas [1].

**Regulatory Frameworks:** Establishing regulatory frameworks that encourage innovation and investment in ICT technologies is crucial. Governments should create policies that support the adoption of emerging technologies such as cloud computing and AI in engineering practices.

**Funding and Incentives:** Providing financial incentives, such as grants and tax breaks, for companies that invest in ICT solutions can stimulate innovation. Additionally, establishing funds dedicated to research and development in engineering technology can foster local innovations tailored to African challenges.

#### **4.2 Educational Institutions**

**Curriculum Development:** Educational institutions must revamp engineering curricula to integrate ICT training comprehensively. This includes not only theoretical knowledge but also practical applications using modern tools and technologies [2].

**Collaborative Learning Platforms:** Establish partnerships with technology firms to create collaborative platforms that facilitate knowledge sharing and guest lectures. This will help students gain exposure to real-world applications of ICT in engineering [3].

**Skill Development Programs:** Implement training programs aimed at upskilling both students and current professionals in ICT tools relevant to engineering. This could include workshops, online courses, and certification programs that focus on the latest technologies and methodologies [4].

#### **4.3 Private Sector Engagement**

**Industry Partnerships:** Encourage collaborations between engineering firms and technology companies to create pilot projects that showcase the benefits of ICT integration. Such partnerships can serve as models for best practices and demonstrate tangible outcomes of ICT adoption.

**Innovation Hubs:** Support the establishment of innovation hubs or technology incubators focused on engineering solutions. These hubs can facilitate research, development, and commercialization of ICT-driven engineering technologies.

**Corporate Social Responsibility (CSR):** Encourage companies to engage in CSR initiatives that promote ICT education and resource access in underserved communities. This can help bridge the digital divide and empower future engineers with the necessary skills and tools.

By implementing these policy recommendations, stakeholders can significantly enhance the integration of ICT in engineering across Africa, paving the way for innovation, economic growth, and sustainable development [5].

### **5 CONCLUSION**

The integration of Information and Communication Technology (ICT) into the engineering sector in Africa has yielded transformative outcomes, enhancing productivity and fostering sustainable development. This article highlights several key findings that underscore the positive impacts of ICT on engineering practices across the continent. Firstly, the adoption of digital tools has streamlined workflows, enabled remote collaboration, and facilitated efficient project management, ultimately leading to reduced project timelines and improved outcomes. Additionally, mobile technology has played a crucial role in bridging the urban-rural divide, enhancing access to engineering resources in previously underserved areas [6-7].

Furthermore, the study emphasizes the significance of continued advancement and support for ICT technologies. As Africa confronts ongoing challenges such as inadequate infrastructure and limited technical skills, strategic investments in ICT can empower engineering professionals to address these issues effectively. Policymakers, educational institutions, and industry stakeholders must prioritize initiatives that enhance ICT infrastructure and provide training opportunities to cultivate a skilled workforce. The alignment of ICT integration with the United Nations Sustainable Development Goals (SDGs) also highlights its importance in achieving broader objectives, such as improved infrastructure, quality education, and economic growth.

In summary, the findings of this article reflect the critical need for ongoing investment in ICT within the engineering sector. By fostering an environment conducive to technological adoption and innovation, Africa can harness the full potential of ICT to drive sustainable development, enhance engineering practices, and ultimately improve the quality of life for its

inhabitants. Embracing these advancements will ensure that the continent remains competitive in a rapidly evolving global landscape [8].

## COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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