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Incorporating Smart Technologies into Electrical/Electronic Training Programmes in Nigeria

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Abstract

The rapid advancement of smart technologies has transformed industrial operations and created new demands for technical skills in the modern workforce. This paper examines the incorporation of smart technologies into Electrical/Electronic training programmes in Nigeria. It highlights the importance of technologies such as Artificial Intelligence (AI), Internet of Things (IoT), robotics, automation systems, simulation software, and digital learning platforms in improving technical education and skill acquisition. The paper discusses the benefits of integrating smart technologies, including enhanced practical learning, improved employability, innovation, entrepreneurship development, and alignment with Industry 4.0 requirements. It also identifies major challenges affecting implementation, such as inadequate funding, obsolete facilities, shortage of skilled instructors, poor infrastructure, and limited technological resources. Furthermore, the study outlines strategies for effective integration, including curriculum modernization, government investment, teacher retraining, industry collaboration, establishment of smart laboratories, and improved internet and power supply. The paper concludes that integrating smart technologies into Electrical/Electronic training programmes is essential for producing competent graduates capable of supporting Nigeria's industrialization, technological advancement, and sustainable economic development.

Keywords: *Smart Technologies, Electrical/Electronic Training, TVET, Industry 4.0, Artificial Intelligence, Nigeria*

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Introduction

The twenty-first century has witnessed unprecedented technological advancement driven by digital innovation and the emergence of smart technologies across various sectors of the global economy. The integration of Artificial Intelligence (AI), Internet of Things (IoT), robotics, cloud

computing, cyber-physical systems, big data analytics, virtual reality, and automation technologies has significantly transformed industrial operations and workforce requirements (Schwab, 2016; Saleem et al., 2017). Modern industries now rely heavily on intelligent systems and automated processes to improve productivity, efficiency, quality control, and operational safety (Fuller et al., 2019). Consequently, the electrical and electronics sector has experienced remarkable transformation through the adoption of smart grids, embedded systems, programmable logic controllers, intelligent sensors, and digital communication technologies (Abrahamsen et al., 2021).

The current era of Industry 4.0 has introduced new dimensions in manufacturing, engineering, and technical operations, thereby redefining the competencies required in the labour market (Lasi et al., 2014). Industry 4.0 emphasizes digitalization, automation, machine learning, real-time data exchange, and interconnected production systems (Kagermann et al., 2013). As a result, workers in the electrical and electronics field are expected to possess advanced technological skills, digital literacy, problem-solving abilities, creativity, and adaptability to emerging technologies (Fatokun & Gumbo, 2024). This transformation has created increased pressure on educational institutions, particularly Technical and Vocational Education and Training (TVET) institutions, to modernize their training systems in order to remain relevant in the digital age (UNESCO, 2021).

Technical and Vocational Education and Training (TVET) plays a vital role in national development by equipping individuals with practical competencies, technical knowledge, and employable skills needed for industrial growth and economic sustainability (Okorie, 2001). TVET programmes are designed to bridge the gap between theoretical knowledge and practical application, thereby producing skilled manpower for various sectors of the economy (Ayonmike, Okwelle, & Okeke, 2015). In Nigeria, Electrical/Electronic training programmes offered in technical colleges, polytechnics, colleges of education, vocational centres, and universities are aimed at preparing learners for careers in electrical installation, industrial maintenance, telecommunications, electronics servicing, automation systems, renewable energy technologies, and power systems management (Agbo, 2022).

Despite the importance of Electrical/Electronic training programmes to national industrialization, many Nigerian training institutions continue to face numerous challenges that hinder effective skill acquisition and technological advancement. These challenges include inadequate funding, obsolete workshop equipment, poor infrastructural facilities, unstable electricity supply, shortage of qualified instructors, and outdated curricula that fail to reflect current industrial realities (Eze, 2023; Muoghalu & Ahmad, 2026). In many institutions, teaching methods remain largely conventional and teacher-centred, with limited utilization of digital instructional technologies and simulation-based learning tools (Afeez, 2017). Consequently, many graduates lack sufficient practical competencies and digital skills required by modern industries, leading to unemployment, underemployment, and reduced industrial productivity (Odu, 2011).

The growing dependence on smart technologies in industries has therefore made it necessary to integrate these innovations into Electrical/Electronic training programmes in

Nigeria. Smart technologies provide opportunities for interactive learning, virtual experimentation, remote access to instructional materials, intelligent simulations, and automation-based practical experiences (Sallati, de Andrade Bertazzi, & Schützer, 2019). Technologies such as virtual reality and augmented reality enable students to safely simulate hazardous electrical operations, troubleshoot circuits, and practice industrial procedures in controlled environments (Radianti et al., 2020). Similarly, Internet of Things (IoT) devices and embedded systems allow students to acquire hands-on experience in smart automation, smart homes, intelligent energy management, and industrial monitoring systems (Saleem et al., 2017).

The incorporation of Artificial Intelligence into Electrical/Electronic training also supports personalized learning, intelligent tutoring systems, predictive maintenance training, and automated assessment processes (Holmes et al., 2019). Furthermore, simulation software such as MATLAB, Proteus, AutoCAD Electrical, Multisim, and PLC programming applications improve students' understanding of complex electrical concepts and industrial automation processes (Onyesolu & Ezeani, 2012). These technologies enhance learners' critical thinking abilities, creativity, innovation, and problem-solving skills required in the twenty-first-century workforce (Partnership for 21st Century Skills, 2019).

Globally, several developed nations have successfully integrated smart technologies into TVET systems to improve workforce preparedness and industrial competitiveness (OECD, 2020). Countries such as Germany, China, South Korea, and Singapore have modernized their technical education systems through digital laboratories, smart workshops, robotics training, and industry-driven curricula (UNIDO, 2022). Nigeria must therefore adopt similar strategies to ensure that its Electrical/Electronic graduates can compete effectively in the global labour market and contribute meaningfully to national development.

Furthermore, the integration of smart technologies into Electrical/Electronic training programmes aligns with Nigeria's national policies on technological advancement, entrepreneurship development, youth empowerment, and economic diversification (Federal Republic of Nigeria, 2013). The modernization of TVET programmes can significantly reduce unemployment by equipping graduates with relevant digital and technical competencies required for self-employment and industrial productivity (Uwaifo, 2010). It can also encourage innovation, research, sustainable energy development, and the establishment of technology-driven enterprises in the country.

However, despite the numerous benefits associated with smart technologies, their integration into Nigerian TVET institutions remains limited due to inadequate technological infrastructure, insufficient funding, poor internet connectivity, lack of technical support, and resistance to change among some educators and administrators (Yakubu & Dasuki, 2019). Addressing these challenges requires collaborative efforts among government agencies, educational institutions, industries, private organizations, and international development partners.

Therefore, incorporating smart technologies into Electrical/Electronic training programmes has become an essential strategy for improving the quality of technical education, enhancing employability, promoting innovation, and achieving sustainable

technological development in Nigeria. The successful integration of these technologies will not only modernize teaching and learning processes but also strengthen Nigeria's capacity to compete in the rapidly evolving digital economy

Concept of Smart Technologies

Smart technologies refer to advanced digital systems and intelligent technological tools that utilize automation, artificial intelligence, connectivity, data analytics, and computational intelligence to perform tasks with minimal human intervention (Schwab, 2016). These technologies are designed to collect, process, analyze, and exchange information in real time in order to improve efficiency, productivity, accuracy, and decision-making processes across different sectors of the economy (Fuller et al., 2019). Smart technologies combine hardware, software, communication systems, and intelligent algorithms to create interconnected environments capable of adaptive and autonomous operations (Saleem et al., 2017).

The concept of smart technologies emerged prominently with the development of Industry 4.0, which emphasizes cyber-physical systems, digital manufacturing, intelligent automation, cloud computing, and machine-to-machine communication (Kagermann et al., 2013). Smart technologies enable devices and systems to interact with one another through network connectivity, thereby facilitating seamless communication, monitoring, control, and optimization of industrial and educational processes (Abrahamsen et al., 2021). In the educational sector, especially in Technical and Vocational Education and Training (TVET), smart technologies are transforming traditional teaching methods into interactive, learner-centred, and technology-driven instructional systems (UNESCO, 2021).

In Electrical/Electronic training programmes, smart technologies provide opportunities for practical skill acquisition, virtual experimentation, intelligent simulations, automated troubleshooting, and digital learning experiences (Fatokun & Gumbo, 2024). These technologies expose students to modern industrial practices and help bridge the gap between classroom learning and real-world applications (Sallati, de Andrade Bertazzi, & Schützer, 2019). The integration of smart technologies into training programmes also enhances creativity, innovation, problem-solving abilities, and technical competence among learners (Holmes, Bialik, & Fadel, 2019).

One of the major smart technologies relevant to Electrical/Electronic training is Artificial Intelligence (AI). AI refers to computer systems capable of performing tasks that normally require human intelligence, such as learning, reasoning, problem-solving, and decision-making (Russell & Norvig, 2021). AI-powered systems can support intelligent tutoring, predictive maintenance training, automated fault diagnosis, and adaptive learning processes in technical education. AI also enhances personalized learning by analyzing students' performance and recommending suitable instructional materials (Holmes et al., 2019).

Another important smart technology is the Internet of Things (IoT). IoT refers to a network of interconnected physical devices embedded with sensors, software, and communication technologies that enable data collection and exchange through the internet (Saleem et al., 2017). In Electrical/Electronic training, IoT enables students to develop

competencies in smart home systems, intelligent energy management, industrial automation, remote monitoring systems, and smart metering technologies. IoT-based learning environments also support real-time monitoring and practical experimentation (Ashton, 2009).

Robotics and automation technologies are also significant components of smart technologies. Robotics involves the design, construction, and operation of programmable machines capable of performing tasks automatically or semi-automatically (Groover, 2019). Automation systems are widely used in industries to improve productivity, precision, and operational efficiency. Integrating robotics into Electrical/Electronic training exposes students to industrial control systems, programmable logic controllers (PLCs), mechatronics, and automated manufacturing processes (Lasi et al., 2014).

Smart sensors constitute another critical aspect of smart technologies. Smart sensors are intelligent devices capable of detecting physical conditions such as temperature, pressure, motion, voltage, and current, while also processing and transmitting data for analysis and control purposes (Mayer & Främling, 2020). These sensors are commonly applied in smart grids, industrial automation systems, and electronic control systems. Their integration into training programmes helps students understand modern monitoring and control technologies used in industries.

Smart grid technology is also increasingly important in Electrical/Electronic education. Smart grids are digitally enhanced electrical power systems that utilize communication technologies, intelligent sensors, and automated controls to improve electricity generation, transmission, distribution, and consumption (Abrahamsen et al., 2021). Smart grid systems support efficient energy management, renewable energy integration, and real-time fault detection. Exposure to smart grid technologies prepares students for careers in modern power systems and sustainable energy development.

Virtual Reality (VR) and Augmented Reality (AR) technologies are transforming technical education through immersive learning experiences. VR creates computer-generated simulated environments that enable users to interact with virtual objects and systems, while AR overlays digital information onto real-world environments (Radianti et al., 2020). In Electrical/Electronic training, VR and AR allow students to simulate electrical installations, troubleshoot circuits, and practice hazardous industrial operations in safe and controlled environments. These technologies improve students' understanding of complex technical concepts and enhance practical learning experiences.

Computer-Aided Design (CAD) software is another important smart technology used in Electrical/Electronic training programmes. CAD applications enable students to create, modify, analyze, and optimize engineering designs using computer systems (Groover, 2019). Software such as AutoCAD Electrical helps students design circuit diagrams, electrical layouts, and industrial control systems accurately and efficiently.

Simulation software also plays a major role in smart technological applications within technical education. Simulation tools such as MATLAB, Proteus, Multisim, and PLC simulation software allow students to model, analyze, and test electrical and electronic systems virtually before physical implementation (Onyesolu & Ezeani, 2012).

These applications improve conceptual understanding, reduce equipment damage, and provide opportunities for repeated practice without safety risks.

Embedded systems and microcontroller technologies are equally important in modern Electrical/Electronic training. Embedded systems are computer-based systems integrated into larger devices to perform dedicated functions (Marwedel, 2021). Technologies such as Arduino, Raspberry Pi, and microcontrollers are widely used in automation systems, robotics, smart devices, and industrial applications. Training students in embedded systems equips them with practical skills required for modern technological innovation and product development.

Cloud computing is another emerging smart technology influencing technical education. Cloud computing refers to the delivery of computing services such as storage, databases, software, and networking over the internet (Mell & Grance, 2011). Cloud-based learning systems enable students and instructors to access educational resources remotely, collaborate online, and utilize virtual laboratories regardless of geographical location.

Digital learning platforms also constitute an essential component of smart technologies in education. Platforms such as Learning Management Systems (LMS), virtual classrooms, e-learning applications, and online collaboration tools facilitate remote instruction, digital assessment, and flexible learning opportunities (Yakubu & Dasuki, 2019). These platforms support blended learning approaches and improve accessibility to educational resources.

Overall, smart technologies are revolutionizing Electrical/Electronic training programmes by enhancing instructional delivery, promoting practical learning experiences, and preparing students for the demands of modern industries. Their integration into Nigerian TVET institutions is essential for improving technical competence, innovation, employability, and national technological development.

Overview of Electrical/Electronic Training Programmes in Nigeria

Electrical/Electronic training programmes in Nigeria constitute an important component of the Technical and Vocational Education and Training (TVET) system aimed at producing skilled manpower for industrial, technological, and economic development. These programmes are designed to equip learners with practical knowledge, technical competencies, and professional skills required for the installation, maintenance, operation, troubleshooting, and management of electrical and electronic systems in various sectors of the economy (Okorie, 2001). The programmes contribute significantly to the development of competent technicians, technologists, engineers, and artisans needed in industries such as manufacturing, telecommunications, construction, energy, transportation, and information technology (Uwaifo, 2010).

Electrical/Electronic training programmes are offered at different levels of the Nigerian educational system. Technical colleges provide foundational vocational training that prepares students for employment as craftsmen and technicians in electrical installation and maintenance works (Federal Republic of Nigeria, 2013). Polytechnics and colleges of technology offer National Diploma (ND) and Higher National Diploma (HND)

programmes focused on advanced technical and industrial competencies in electrical and electronic engineering technology (NBTE, 2020). Colleges of Education (Technical) prepare technical teachers and instructors for vocational institutions, while universities provide degree programmes in electrical and electronic engineering with broader theoretical and research-oriented content (Ayonmike, Okwelle, & Okeke, 2015).

In addition to formal educational institutions, Electrical/Electronic training is also provided through vocational centres, industrial training institutes, private skill acquisition centres, and apprenticeship systems. The apprenticeship model remains common in Nigeria, particularly among artisans and informal sector technicians who acquire practical skills through on-the-job training under experienced professionals (Agbo, 2022). These multiple training pathways collectively contribute to the supply of technical manpower required for national industrialization and technological advancement.

The curricula of Electrical/Electronic training programmes in Nigeria are structured to develop competencies in several specialized areas. One major area is electrical installation, which involves training students in domestic, commercial, and industrial wiring systems, electrical safety procedures, cable jointing, conduit installation, and maintenance of electrical equipment (Eze, 2023). Students are also trained in power systems, including electricity generation, transmission, distribution, protection systems, transformers, and power system maintenance. Knowledge in this area is essential for supporting Nigeria's energy infrastructure and industrial operations.

Electronics maintenance is another core aspect of Electrical/Electronic training programmes. Learners are equipped with competencies in assembling, servicing, troubleshooting, and repairing electronic devices such as radios, televisions, amplifiers, computers, and communication equipment (Odu, 2011). With the rapid advancement in digital electronics, modern training also involves exposure to microprocessors, embedded systems, and programmable devices used in contemporary electronic systems.

Industrial automation has become increasingly important in Electrical/Electronic education due to the growing adoption of automated systems in industries worldwide. Students are trained in programmable logic controllers (PLCs), control systems, industrial instrumentation, robotics, and mechatronics applications used in automated manufacturing environments (Fatokun & Gumbo, 2024). Automation training helps learners understand modern industrial processes and prepares them for Industry 4.0 environments characterized by intelligent manufacturing systems and digital production technologies.

Telecommunication systems also form an important component of Electrical/Electronic training programmes. This aspect focuses on communication technologies such as wireless communication systems, fiber optics, satellite communication, networking, and mobile communication technologies (Saleem et al., 2017). As the global communication sector continues to evolve rapidly, technical training institutions are increasingly expected to expose students to modern telecommunication technologies and digital communication systems.

Another emerging area in Electrical/Electronic training is renewable energy technology. Due to the increasing global emphasis on sustainable energy solutions, students are now

introduced to solar energy systems, wind energy technologies, inverters, battery management systems, and energy efficiency practices (UNIDO, 2022). Renewable energy education is particularly important in Nigeria because of the country's persistent energy challenges and the growing need for alternative power sources in rural and urban communities.

Instrumentation and control systems constitute another important aspect of Electrical/Electronic training. Students learn how to operate, calibrate, maintain, and troubleshoot industrial instruments and control devices used in manufacturing plants, power stations, and industrial facilities (Groover, 2019). This area also involves exposure to sensors, transducers, process control systems, and monitoring devices essential in modern industrial operations.

Fault diagnosis and repairs remain fundamental competencies in Electrical/Electronic programmes. Students are trained to identify faults in electrical circuits, electronic devices, power systems, and automated systems using modern diagnostic tools and testing equipment (Onyesolu & Ezeani, 2012). Practical troubleshooting skills are critical for ensuring equipment reliability, safety, and operational efficiency in industries and households.

Despite the strategic importance of Electrical/Electronic training programmes in Nigeria, many institutions face numerous challenges that affect the quality and effectiveness of training delivery. One major challenge is inadequate workshop and laboratory facilities. Many technical institutions lack properly equipped workshops, modern laboratories, and functional practical equipment necessary for effective hands-on learning (Ayonmike et al., 2015). In several institutions, available facilities are insufficient to accommodate the growing number of students enrolled in technical programmes.

Another serious challenge is the use of obsolete equipment and outdated instructional materials. Some training institutions still rely on old machines and analog devices that no longer reflect current industrial realities (Muoghalu & Ahmad, 2026). As industries increasingly adopt smart technologies, automation systems, and digital devices, graduates trained with obsolete facilities often struggle to meet labour market expectations.

Inadequate funding also affects the quality of Electrical/Electronic training programmes in Nigeria. Insufficient government funding limits the procurement of modern equipment, maintenance of workshops, provision of internet facilities, and acquisition of simulation software and digital learning technologies (Uwaifo, 2010). Consequently, many institutions experience poor infrastructural development and limited technological innovation.

Another challenge is the shortage of qualified and technologically competent instructors. Some teachers and trainers lack adequate exposure to emerging technologies such as robotics, artificial intelligence, Internet of Things (IoT), renewable energy systems, and industrial automation (Fatokun & Gumbo, 2024). This limits their ability to effectively train students in modern technical competencies required in contemporary industries.

Furthermore, there is limited integration of digital technologies and smart learning systems into many Electrical/Electronic training programmes. Traditional teaching

methods dominated by theoretical instruction continue to prevail in some institutions, with minimal use of simulation tools, virtual laboratories, e-learning platforms, and computer-aided instructional technologies (Yakubu & Dasuki, 2019). This situation affects students' practical exposure and digital skill development.

Poor collaboration between industries and educational institutions also contributes to skill gaps among graduates. In some cases, curricula are not regularly updated to align with industrial trends and labour market demands (Eze, 2023). Consequently, many graduates often lack employability skills, practical competencies, and technological adaptability required in modern workplaces.

The inadequate exposure to emerging technologies has contributed to increasing unemployment and underemployment among graduates of Electrical/Electronic programmes in Nigeria (Odu, 2011). Employers frequently complain that many graduates lack practical competence, innovation skills, critical thinking abilities, and experience with modern industrial equipment and automation systems. This mismatch between training outcomes and industrial expectations highlights the urgent need for curriculum modernization and integration of smart technologies into Electrical/Electronic training programmes.

Therefore, improving Electrical/Electronic training programmes in Nigeria requires significant investment in modern workshop facilities, smart laboratories, digital learning technologies, curriculum reforms, teacher retraining, and stronger industry partnerships. Such improvements will enhance practical skill acquisition, technological competence, employability, and national industrial development.

Need for Incorporating Smart Technologies into Electrical/Electronic Training Programmes

The rapid transformation of industries through digitalization, automation, and intelligent systems has created an urgent need for Technical and Vocational Education and Training (TVET) institutions to modernize Electrical/Electronic training programmes. The integration of smart technologies into training systems is no longer optional but essential for producing competent graduates capable of functioning effectively in the modern industrial environment (Schwab, 2016). Smart technologies improve instructional delivery, practical skill acquisition, innovation, and workforce preparedness, thereby enhancing the quality and relevance of technical education in Nigeria (Fatokun & Gumbo, 2024). The following are major reasons for incorporating smart technologies into Electrical/Electronic training programmes.

1. Alignment with Industry 4.0

One of the major reasons for incorporating smart technologies into Electrical/Electronic training programmes is the need to align technical education with the demands of Industry 4.0. Industry 4.0 refers to the fourth industrial revolution characterized by automation, cyber-physical systems, artificial intelligence, Internet of Things (IoT), robotics, cloud computing, and smart manufacturing systems (Kagermann, Wahlster, & Helbig, 2013). Modern industries now operate with intelligent machines and digitally interconnected production systems that require workers with advanced technological competencies (Lasi et al., 2014).

Electrical/Electronic students must therefore acquire practical skills in automation systems, programmable logic controllers (PLCs), embedded systems, robotics, artificial intelligence, and IoT technologies in order to remain relevant in the contemporary labour market (Groover, 2019). Traditional teaching methods and outdated workshop equipment can no longer adequately prepare students for highly automated industrial environments. The integration of smart technologies into training programmes ensures that students develop competencies required for smart manufacturing, industrial automation, and intelligent electrical systems (Fuller et al., 2019).

The industrial sector increasingly demands technicians and technologists who can install, program, troubleshoot, and maintain smart devices and automated systems (UNIDO, 2022). Therefore, aligning Electrical/Electronic education with Industry 4.0 enhances graduates' employability and supports Nigeria's industrial modernization efforts.

2. Enhancement of Practical Learning

Smart technologies significantly improve practical learning experiences in Electrical/Electronic training programmes. Technical education is highly practical in nature and requires students to develop hands-on competencies through experimentation, demonstration, and repeated practice (Okorie, 2001). However, inadequate workshop facilities and obsolete equipment in many Nigerian institutions often limit students' practical exposure (Ayonmike, Okwelle, & Okeke, 2015).

The integration of simulation software, virtual laboratories, augmented reality (AR), and virtual reality (VR) technologies enables students to practice electrical and electronic operations in safe and interactive environments (Radianti et al., 2020). Simulation applications such as MATLAB, Proteus, Multisim, and AutoCAD Electrical allow learners to design, test, and troubleshoot electrical circuits virtually before physical implementation (Onyesolu & Ezeani, 2012). This improves conceptual understanding and reduces the risk of damaging expensive equipment during practical exercises.

Virtual laboratories also provide opportunities for repeated practice and experimentation without geographical or time limitations (Yakubu & Dasuki, 2019). Students can perform practical tasks multiple times until mastery is achieved, thereby improving competence and confidence. Smart technologies also simplify the teaching of complex concepts such as industrial automation, power system analysis, microcontroller programming, and intelligent control systems.

Furthermore, immersive technologies such as VR and AR create realistic industrial environments that expose students to hazardous or complex operations safely (Radianti et al., 2020). This enhances experiential learning and bridges the gap between theoretical instruction and industrial practice.

3. Development of Employability Skills

The modern labour market requires graduates who possess not only technical competencies but also digital literacy, critical thinking abilities, creativity, communication skills, innovation capacity, and adaptability to technological changes (Partnership for 21st Century Skills, 2019). Smart technologies

contribute significantly to the development of these employability skills among Electrical/Electronic students.

The use of digital learning platforms, simulation software, automation systems, and collaborative technologies helps students develop analytical thinking and problem-solving abilities required in modern workplaces (Sallati, de Andrade Bertazzi, & Schützer, 2019). Students learn how to analyze data, identify faults, troubleshoot systems, and develop technological solutions to practical industrial problems.

Artificial Intelligence (AI) and IoT-based learning systems also encourage independent learning, adaptability, and innovation (Holmes, Bialik, & Fadel, 2019). Through project-based learning and practical technological applications, students develop entrepreneurial competencies that enable them to establish technology-driven businesses and create employment opportunities for themselves and others.

Moreover, industries increasingly prefer graduates who can operate modern industrial equipment, utilize digital technologies, and adapt to rapidly evolving technological environments (UNESCO, 2021). Therefore, incorporating smart technologies into Electrical/Electronic training enhances graduates' competitiveness and employability both locally and internationally.

4. Improvement of Teaching and Learning

Smart technologies improve the quality of teaching and learning processes in Electrical/Electronic training programmes. Traditional teacher-centred instructional methods are gradually being replaced by learner-centred and technology-driven approaches that promote active participation, collaboration, and interactive learning experiences (Yakubu & Dasuki, 2019).

The use of smart boards, multimedia presentations, projectors, e-learning platforms, online instructional videos, and virtual classrooms enhances instructional delivery and facilitates effective communication between instructors and students (Afeez, 2017). Digital instructional materials make learning more engaging, interactive, and understandable, particularly in technical subjects that involve diagrams, circuit designs, simulations, and practical demonstrations.

Learning Management Systems (LMS) and online educational platforms also provide students with access to lecture notes, assignments, practical tutorials, and digital resources beyond the classroom environment (OECD, 2020). This promotes flexible learning and supports blended learning approaches that combine face-to-face instruction with online learning activities.

Artificial Intelligence-based educational systems can also support personalized learning by monitoring students' academic progress and recommending suitable instructional materials based on individual learning needs (Holmes et al., 2019). Such intelligent systems improve learning outcomes and encourage self-directed learning among students.

Additionally, digital technologies facilitate communication and collaboration between institutions, industries, instructors, and students through virtual meetings, online workshops, webinars, and digital project collaborations (UNESCO, 2021). This broadens students' exposure to global technological practices and industrial experiences.

5. Promotion of Innovation and Creativity

The incorporation of smart technologies into Electrical/Electronic training programmes promotes creativity, innovation, and technological problem-solving among students. Modern industries require innovative individuals capable of designing smart solutions to societal and industrial challenges (Schwab, 2016).

Exposure to technologies such as robotics, embedded systems, IoT devices, artificial intelligence, and automation systems encourages students to develop innovative projects and prototypes (Marwedel, 2021). Students can design smart home systems, automated security systems, renewable energy devices, intelligent irrigation systems, robotics applications, and industrial control systems.

Project-based learning involving smart technologies also stimulates critical thinking and experimentation (Sallati et al., 2019). Students are motivated to explore creative approaches to solving engineering and technological problems using modern digital tools. This culture of innovation is essential for entrepreneurship development and national technological advancement.

Furthermore, participation in technological competitions, innovation exhibitions, hackathons, and research activities enhances students' confidence and creativity. Smart technologies therefore create opportunities for learners to become inventors, innovators, and technology entrepreneurs capable of contributing to industrial growth and economic development.

6. Preparation for Global Competitiveness

Globalization and technological advancement have transformed the labour market into a highly competitive environment where technical skills and digital competencies are essential for career success (OECD, 2020). Incorporating smart technologies into Electrical/Electronic training programmes equips Nigerian graduates with internationally relevant competencies needed to compete effectively in the global workforce.

Countries with advanced technical education systems have already integrated smart technologies into their TVET programmes to improve industrial productivity and workforce development (UNIDO, 2022). Therefore, Nigerian institutions must modernize their training systems to align with global technological standards and industrial expectations.

The integration of smart technologies exposes students to modern industrial equipment, digital communication systems, automation processes, and intelligent technologies commonly used in developed countries (Abrahamsen, Ai, & Cheffena, 2021). This enhances graduates' adaptability and increases their opportunities for international employment, professional certification, and global collaboration.

Furthermore, globally competitive graduates can contribute significantly to national development by introducing innovative technologies, improving industrial productivity, and supporting economic diversification (Federal Republic of Nigeria, 2013). Smart technology integration also strengthens Nigeria's capacity to participate effectively in the global digital economy and technological revolution.

the incorporation of smart technologies into Electrical/Electronic training programmes is essential for improving practical learning, employability, innovation, instructional quality, and global competitiveness. It

provides students with the technological competencies required to function effectively in modern industries and supports the overall modernization of technical education in Nigeria.

Smart Technologies Applicable to Electrical/Electronic Training Programmes

Artificial Intelligence (AI): AI systems can support intelligent tutoring, predictive maintenance training, automated troubleshooting, and data analysis. AI-based learning platforms personalize instruction and improve learning outcomes.

Internet of Things (IoT): IoT enables interconnected devices to communicate through networks. Students can learn smart home automation, industrial monitoring systems, smart metering, and remote-control technologies.

Robotics and Automation: Robotics training exposes students to programmable systems, industrial robots, and automated manufacturing processes widely used in industries.

Virtual Reality (VR) and Augmented Reality (AR): VR and AR technologies provide immersive learning environments where students can simulate electrical installations, troubleshoot circuits, and practice hazardous operations safely.

Smart Grid Technology: Smart grids involve intelligent electricity distribution systems that use sensors, communication technologies, and automation to improve power management and efficiency.

$$P=VI$$

The relationship between electrical power, voltage, and current remains fundamental in smart grid and intelligent energy management systems.

Simulation Software: Applications such as MATLAB, Proteus, Multisim, AutoCAD Electrical, and PLC simulation software help students practice circuit design, system analysis, and industrial automation.

Embedded Systems and Microcontrollers: Students can learn programming and interfacing of Arduino, Raspberry Pi, and microcontroller systems used in automation and smart devices.

Benefits of Incorporating Smart Technologies into Electrical/Electronic Training Programmes

The incorporation of smart technologies into Electrical/Electronic training programmes offers numerous educational, industrial, and economic benefits. Smart technologies enhance the quality of teaching and learning, improve practical skill acquisition, increase employability opportunities, and prepare students for the rapidly evolving digital economy (Schwab, 2016). As industries increasingly adopt automation, artificial intelligence, robotics, Internet of Things (IoT), and digital communication systems, technical education institutions must integrate these technologies into their programmes to produce competent and industry-ready graduates (Fatokun & Gumbo, 2024). The following are some major benefits of incorporating smart technologies into Electrical/Electronic training programmes in Nigeria.

Improved Skill Acquisition

One of the major benefits of integrating smart technologies into Electrical/Electronic training programmes is improved skill acquisition among students. Technical education is fundamentally practical in nature and requires

learners to develop hands-on competencies through experimentation, demonstration, and repeated practice (Okorie, 2001). Smart technologies such as simulation software, virtual laboratories, automation systems, and embedded technologies provide students with opportunities to gain practical digital competencies relevant to modern industries (Onyesolu & Ezeani, 2012).

Simulation applications such as MATLAB, Proteus, AutoCAD Electrical, and Multisim enable students to design, analyze, and troubleshoot electrical circuits virtually before physical implementation. These tools improve conceptual understanding and reduce the risk of equipment damage during practical activities (Groover, 2019). Students also acquire competencies in programmable logic controllers (PLCs), robotics, microcontrollers, smart sensors, and industrial automation systems that are widely used in contemporary industries.

Furthermore, smart technologies expose learners to real-world industrial practices and technological applications, thereby bridging the gap between theoretical instruction and practical implementation (UNIDO, 2022). Through repeated interaction with digital tools and intelligent systems, students develop confidence, technical competence, and operational efficiency required in the workplace.

Enhanced Student Engagement

Smart technologies significantly improve student engagement and participation in the learning process. Traditional teaching approaches that rely mainly on lectures and textbook instruction often reduce students' interest and active involvement in technical subjects (Afeez, 2017). However, interactive technologies such as multimedia presentations, smart boards, virtual reality (VR), augmented reality (AR), and simulation software create more engaging and learner-centred instructional environments.

The use of visual demonstrations, animations, interactive diagrams, and virtual simulations helps students understand complex electrical and electronic concepts more effectively (Radianti et al., 2020). These technologies stimulate curiosity, improve concentration, and encourage active participation during classroom and laboratory activities. Students become more motivated to learn when they can interact directly with digital tools and observe real-time outcomes of their practical activities.

Virtual and augmented reality technologies also provide immersive learning experiences that make technical training more exciting and realistic (Radianti et al., 2020). For instance, students can simulate industrial operations, electrical installations, and fault diagnosis procedures in safe virtual environments. Such experiences increase learners' enthusiasm and improve knowledge retention.

In addition, online collaboration platforms and digital communication tools encourage teamwork, interaction, and collaborative learning among students and instructors (Yakubu & Dasuki, 2019). This enhances students' communication skills and promotes cooperative learning experiences.

Increased Employability

The integration of smart technologies into Electrical/Electronic training programmes improves graduates' employability and competitiveness in the labour market. Modern industries increasingly demand workers who possess digital literacy, technological

adaptability, problem-solving abilities, and competencies in automation and intelligent systems (OECD, 2020).

Graduates trained with smart technologies are more likely to possess practical knowledge of industrial automation, IoT systems, robotics, embedded systems, renewable energy technologies, and digital communication systems (Saleem et al., 2017). Such competencies make them valuable to employers in sectors such as manufacturing, telecommunications, energy, construction, and information technology.

Furthermore, exposure to modern technologies enables graduates to adapt easily to workplace technological changes and industrial innovations (Sallati, de Andrade Bertazzi, & Schützer, 2019). Employers often prefer candidates who can operate digital equipment, analyze data, troubleshoot automated systems, and work effectively with modern industrial technologies.

The incorporation of smart technologies also prepares students for global employment opportunities by aligning training programmes with international technological standards (UNESCO, 2021). Consequently, graduates become more competitive in both local and international labour markets.

Better Problem-Solving Abilities

Smart technologies contribute significantly to the development of analytical thinking, critical reasoning, and problem-solving skills among Electrical/Electronic students. Technical occupations require individuals who can identify faults, analyze systems, troubleshoot equipment, and develop innovative solutions to practical problems (Partnership for 21st Century Skills, 2019).

Simulation tools, intelligent systems, and digital learning platforms expose students to real-life industrial challenges and encourage them to apply logical reasoning in solving technical problems (Holmes, Bialik, & Fadel, 2019). Students learn how to diagnose faults in electrical circuits, optimize system performance, interpret data, and implement corrective measures using digital technologies.

Artificial Intelligence (AI) and automation technologies also support predictive maintenance training, intelligent fault detection, and system analysis, thereby improving students' troubleshooting abilities (Fuller et al., 2019). Through project-based learning and practical experimentation, learners develop creativity, innovation, and decision-making competencies necessary for modern industrial environments.

Additionally, repeated practice using simulation software enables students to experiment with different technical solutions without fear of damaging equipment or causing safety hazards (Onyesolu & Ezeani, 2012). This promotes confidence and independent problem-solving abilities.

Flexible Learning Opportunities

Another important benefit of smart technologies is the provision of flexible learning opportunities for students and instructors. Digital learning platforms, e-learning systems, cloud computing technologies, and virtual classrooms support remote, self-paced, and blended learning approaches (Yakubu & Dasuki, 2019).

Students can access lecture materials, practical tutorials, instructional videos, assignments, and simulation tools online regardless of geographical location or time constraints (OECD, 2020). This flexibility is particularly

beneficial in situations where physical attendance is difficult due to distance, financial limitations, health challenges, or infrastructural problems.

Cloud-based learning systems also facilitate collaborative learning and information sharing among students, instructors, and institutions (Mell & Grance, 2011). Learners can participate in online discussions, webinars, virtual workshops, and digital projects using internet-enabled technologies.

Furthermore, self-paced learning allows students to learn according to their individual learning abilities and preferences (Holmes et al., 2019). Students can revisit digital instructional materials multiple times until they fully understand complex concepts and practical procedures.

Flexible learning opportunities provided by smart technologies therefore improve accessibility, inclusiveness, and continuity in Electrical/Electronic education.

Industrial Relevance

The incorporation of smart technologies ensures that Electrical/Electronic training programmes remain relevant to current industrial practices and technological trends. Industries worldwide are rapidly adopting automation systems, smart manufacturing technologies, artificial intelligence, and digital communication systems as part of Industry 4.0 transformation (Kagermann, Wahlster, & Helbig, 2013).

Training students using obsolete equipment and outdated instructional methods creates a mismatch between educational outcomes and labour market requirements (Ayonmike, Okwelle, & Okeke, 2015). Integrating smart technologies into training programmes helps institutions align their curricula with modern industrial standards and employer expectations.

Students become familiar with modern industrial tools such as programmable logic controllers (PLCs), robotics systems, industrial sensors, renewable energy technologies, and intelligent control systems commonly used in industries today (Groover, 2019). This industrial relevance improves graduates' workplace readiness and operational efficiency.

Furthermore, collaboration between industries and educational institutions can be strengthened through smart technology integration. Industries can support institutions with modern equipment, industrial attachments, internship opportunities, and curriculum development initiatives (Eze, 2023). Such partnerships enhance practical learning and ensure that training programmes remain responsive to industrial changes.

Entrepreneurship Development

Smart technologies also promote entrepreneurship development among Electrical/Electronic students. Modern economies increasingly require innovative entrepreneurs capable of developing technological solutions to societal and industrial challenges (Schwab, 2016). Exposure to smart technologies encourages students to design and develop innovative projects such as smart home systems, automated security devices, renewable energy systems, robotics applications, and intelligent monitoring systems.

Technologies such as embedded systems, IoT devices, microcontrollers, and automation platforms provide opportunities for students to create technology-driven products and

services (Marwedel, 2021). Through project-based learning and practical experimentation, students develop entrepreneurial skills including creativity, innovation, risk-taking, and business problem-solving abilities.

Smart technologies also support digital entrepreneurship through online platforms, e-commerce systems, and remote technological services (UNIDO, 2022). Graduates can establish businesses in areas such as solar energy installation, automation systems design, electronics maintenance, software development, smart device production, and industrial control solutions.

Moreover, entrepreneurship development contributes to poverty reduction, job creation, and economic diversification in Nigeria (Uwaifo, 2010). Graduates who possess technological and entrepreneurial competencies are better positioned to become self-reliant and employers of labour rather than job seekers.

the incorporation of smart technologies into Electrical/Electronic training programmes provides numerous benefits including improved skill acquisition, enhanced student engagement, increased employability, better problem-solving abilities, flexible learning opportunities, industrial relevance, and entrepreneurship development. These benefits are essential for improving the quality of technical education and preparing Nigerian graduates for participation in the modern digital economy.

Strategies for Effective Integration of Smart Technologies

The successful integration of smart technologies into Electrical/Electronic training programmes in Nigeria requires comprehensive planning, policy support, infrastructural development, and collaboration among relevant stakeholders. Smart technologies such as Artificial Intelligence (AI), Internet of Things (IoT), robotics, automation systems, simulation software, and digital learning platforms can only achieve meaningful educational impact when adequate implementation strategies are adopted (Schwab, 2016). Effective integration will improve the quality of technical education, enhance students' employability, and strengthen Nigeria's technological and industrial development (Fatokun & Gumbo, 2024). The following strategies are essential for effective integration of smart technologies into Electrical/Electronic training programmes.

Curriculum Modernization

One of the most important strategies for integrating smart technologies into Electrical/Electronic training programmes is curriculum modernization. Many technical education curricula in Nigeria remain outdated and do not adequately reflect current industrial trends and technological advancements (Ayonmike, Okwelle, & Okeke, 2015). Therefore, educational authorities such as the National Board for Technical Education (NBTE), National Universities Commission (NUC), and other regulatory agencies should revise existing curricula to incorporate emerging technological areas.

Modern Electrical/Electronic curricula should include courses and practical training in Artificial Intelligence (AI), Internet of Things (IoT), robotics, automation systems, embedded systems, cloud computing, cybersecurity, smart grid technologies, renewable energy systems, and digital communication technologies (Kagermann, Wahlster, & Helbig, 2013). Curriculum

reforms should also emphasize practical, project-based, and competency-based learning approaches that encourage innovation and technological problem-solving (UNESCO, 2021).

In addition, industrial trends and labour market demands should guide curriculum development processes to ensure that graduates possess relevant technical and digital competencies required by industries (OECD, 2020). Regular curriculum review is therefore essential for maintaining the relevance and quality of Electrical/Electronic training programmes.

Government Investment

Adequate government investment is critical for successful integration of smart technologies into technical education programmes. Many Nigerian TVET institutions face challenges related to poor funding, obsolete equipment, inadequate workshops, and insufficient digital infrastructure (Uwaifo, 2010). Without adequate financial support, institutions cannot procure modern equipment or establish smart learning environments.

Government at federal, state, and local levels should allocate sufficient funds for the development of smart laboratories, digital workshops, virtual learning environments, and technological infrastructure in technical institutions (Federal Republic of Nigeria, 2013). Investment should also focus on the procurement of automation systems, simulation software, robotics kits, computers, smart boards, internet facilities, and renewable energy equipment.

Furthermore, government should provide grants and intervention funds specifically targeted at promoting technological innovation and digital transformation in TVET institutions (UNIDO, 2022). Adequate funding will improve the quality of technical education and enhance students' exposure to modern industrial technologies.

Teacher Training and Retraining

The integration of smart technologies into Electrical/Electronic training programmes requires competent instructors who possess modern digital and technological skills. However, many technical educators in Nigeria have limited exposure to emerging technologies such as robotics, AI, automation systems, IoT, and virtual learning platforms (Fatokun & Gumbo, 2024).

Continuous professional development programmes should therefore be organized to train and retrain instructors on the use of smart technologies in teaching and practical instruction (Afeez, 2017). Workshops, seminars, industrial training, certification programmes, and digital literacy courses should be provided regularly to update teachers' technical competencies and pedagogical skills.

Teacher retraining programmes should also focus on modern instructional strategies such as blended learning, simulation-based teaching, virtual laboratories, and project-based learning approaches (Yakubu & Dasuki, 2019). Exposure to industrial environments through industrial attachments and professional collaborations will further improve instructors' practical knowledge and teaching effectiveness.

Competent instructors are essential for effective implementation of smart technology integration because they serve as facilitators, mentors, and technical guides for students.

Industry Collaboration

Strong collaboration between industries and educational institutions is essential for effective integration of smart technologies into Electrical/Electronic training programmes. Industries possess modern technological facilities, practical expertise, and real-world industrial experiences that can support technical education development (Eze, 2023).

Partnerships between industries and training institutions should be strengthened to provide modern equipment, industrial attachment opportunities, internship placements, curriculum support, and technical mentorship programmes (UNESCO, 2021). Industries can also support institutions by donating automation systems, industrial machines, robotics equipment, and digital tools used in contemporary workplaces.

Industrial collaboration enables students to gain practical exposure to real industrial operations and emerging technologies, thereby improving their employability and workplace readiness (Sallati, de Andrade Bertazzi, & Schützer, 2019). Such partnerships also help institutions align their curricula with labour market needs and industrial expectations.

Furthermore, collaboration with technology companies and engineering organizations can facilitate access to modern software applications, technical certifications, and professional development opportunities for both instructors and students.

Establishment of Smart Laboratories

The establishment of smart laboratories and modern technical workshops is another important strategy for integrating smart technologies into Electrical/Electronic training programmes. Smart laboratories provide students with opportunities to interact directly with digital technologies, automation systems, and intelligent devices used in modern industries (Groover, 2019).

Institutions should establish workshops equipped with robotics kits, programmable logic controllers (PLCs), simulation software, smart sensors, embedded systems, virtual reality devices, industrial automation systems, and renewable energy technologies (Onyesolu & Ezeani, 2012). Such facilities support practical experimentation, simulation-based learning, and project development activities.

Smart laboratories also encourage innovation, creativity, and technological research among students and instructors (Holmes, Bialik, & Fadel, 2019). Learners gain hands-on experience in operating and troubleshooting modern industrial systems, thereby improving their technical competence and confidence.

In addition, institutions should ensure regular maintenance and upgrading of laboratory facilities to keep pace with rapidly evolving technological changes.

Improved Power Supply and Internet Access

Stable electricity supply and reliable internet connectivity are essential for effective integration of smart technologies into Electrical/Electronic training programmes. Most smart technologies depend heavily on uninterrupted power supply and internet-enabled communication systems for proper operation (Abrahamsen, Ai, & Cheffena, 2021).

However, many Nigerian institutions experience unstable electricity supply, poor internet services, and limited digital infrastructure, which negatively affect technology-based teaching and learning activities (Yakubu & Dasuki, 2019).

Government and institutional administrators should therefore invest in alternative power solutions such as solar energy systems, inverters, and standby generators to ensure uninterrupted electricity supply.

Reliable internet access should also be provided in classrooms, laboratories, and libraries to support online learning, virtual collaboration, cloud computing, and access to digital educational resources (Mell & Grance, 2011). Improved internet connectivity will enhance communication, research activities, and remote learning opportunities for students and instructors.

Public-Private Partnerships

Public-private partnerships (PPPs) are essential for supporting the integration of smart technologies into Electrical/Electronic training programmes. Due to limited government resources, collaboration with private organizations, industries, NGOs, international agencies, and development partners can provide additional financial and technological support for TVET development (UNIDO, 2022).

Private sector organizations can contribute through funding, donation of equipment, sponsorship of training programmes, and establishment of innovation centres within institutions. International organizations and donor agencies can also support technical education through grants, capacity-building programmes, technical assistance, and infrastructure development projects.

Public-private partnerships encourage shared responsibility for educational development and strengthen institutional capacity for technological innovation (OECD, 2020). Such partnerships also promote sustainability and long-term development of smart technology initiatives in technical education institutions.

Promotion of Research and Innovation

Research and innovation are critical for successful technological advancement and sustainable development. Therefore, institutions should encourage students and instructors to undertake innovative projects, technological research, and practical problem-solving activities involving smart technologies (Schwab, 2016).

Students should be motivated to develop projects related to automation systems, renewable energy technologies, robotics, smart homes, intelligent security systems, and IoT applications (Marwedel, 2021). Project-based learning and innovation competitions can stimulate creativity, critical thinking, and entrepreneurship development among learners.

Institutions should also establish innovation hubs, research centres, and technology incubation programmes to support students and instructors in developing commercially viable technological solutions (Holmes et al., 2019). Research collaborations with industries and international institutions can further enhance innovation and technological advancement.

The promotion of research and innovation contributes to technological self-reliance, industrial growth, and national development.

Implications for National Development

The integration of smart technologies into Electrical/Electronic training programmes has significant implications for Nigeria's technological, industrial, and economic development. One major implication is the

production of a highly skilled workforce capable of supporting industrialization and digital transformation in the country (UNESCO, 2021). Graduates equipped with competencies in automation, AI, IoT, renewable energy, robotics, and digital systems can effectively contribute to modern industrial operations and technological innovation.

Smart technology integration also supports the development of indigenous technological capacity and reduces dependence on foreign technical expertise (UNIDO, 2022). Skilled graduates can design, install, maintain, and troubleshoot modern industrial systems locally, thereby improving industrial productivity and national technological advancement.

Another important implication is employment generation and entrepreneurship development. Graduates with modern technological competencies are better positioned to secure employment opportunities or establish technology-driven businesses in areas such as renewable energy installation, automation systems, smart devices, and electronics maintenance (Uwaifo, 2010). This can contribute significantly to poverty reduction and youth empowerment in Nigeria.

Furthermore, integrating smart technologies into Electrical/Electronic training programmes enhances Nigeria's competitiveness in the global economy. Countries with technologically competent workforces are more likely to attract foreign investment, promote industrial growth, and participate effectively in global technological markets (OECD, 2020).

The integration also contributes to sustainable development through the promotion of renewable energy technologies, energy efficiency, smart infrastructure, and environmentally friendly industrial practices (Saleem et al., 2017). Therefore, effective integration of smart technologies into Electrical/Electronic training programmes is essential for achieving sustainable technological and economic development in Nigeria.

Conclusion

The integration of smart technologies into Electrical/Electronic training programmes in Nigeria is essential for improving the quality and relevance of technical education in the digital age. Technologies such as Artificial Intelligence (AI), Internet of Things (IoT), robotics, automation systems, and simulation software are transforming industries and creating demand for technologically skilled graduates (Schwab, 2016).

Despite challenges such as inadequate funding, obsolete facilities, shortage of skilled instructors, and poor infrastructure, the incorporation of smart technologies offers significant benefits including improved practical skills, enhanced employability, innovation, entrepreneurship, and industrial relevance (Fatokun & Gumbo, 2024).

Effective integration requires curriculum modernization, government investment, teacher retraining, industry collaboration, establishment of smart laboratories, and improved internet and power supply (UNESCO, 2021).

Therefore, integrating smart technologies into Electrical/Electronic training programmes will help Nigeria produce competent graduates capable of supporting industrialization, technological advancement, and sustainable economic development.

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