

## UPSKILLING AND RESKILLING TECHNICAL AND VOCATIONAL EDUCATION FOR THE FOURTH INDUSTRIAL REVOLUTION ERA IN NIGERIA

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### Abstract

The Fourth Industrial Revolution (4IR) is rapidly transforming global industries, making it essential to reposition Technical and Vocational Education and Training (TVET) systems to meet evolving skill demands. This paper examines the critical role of upskilling and reskilling in aligning TVET with these changes. Drawing on global trends and institutional data, it underscores the growing importance of digital literacy, artificial intelligence, robotics, data analytics, and cybersecurity in preparing a future-ready workforce. Findings show that by 2025, about 60% of workers will require digital literacy, while 45% will need AI-related skills, with projections indicating that 80% of core job skills will be technology-driven between 2015 and 2030. Additionally, over 600 million people worldwide are expected to undergo reskilling by 2030 due to automation. Evidence from Nigeria, Rwanda, and Singapore highlights the effectiveness of industry collaboration, technology-driven learning, and curriculum reform. However, persistent challenges such as limited access to resources, outdated teaching methods, and policy misalignment remain. The paper concludes by advocating a collaborative, data-driven approach among governments, industries, and educational institutions to bridge skill gaps, promote lifelong learning, and reposition TVET for sustainable development in the 4IR era.

**Keywords:** Fourth Industrial Revolution, Technical and Vocational Education Upskilling, Reskilling, Workforce Development,

### Introduction

The Fourth Industrial Revolution (4IR) signifies rapid technological transformation reshaping industries, communication, and education through innovations such as AI, robotics, and IoT (Schwab, 2016). Extending this view, Brynjolfsson and McAfee (2014) note that such advancements have disrupted labour markets, displacing traditional roles and creating new ones, thereby making reskilling and upskilling essential for workforce relevance (Sullivan & Al Ariss, 2018).

In response, TVET plays a vital role in developing practical, career-oriented skills (McGrath, 2019); in Nigeria, it blends theory with hands-on training across technical and vocational fields (Okwelle, 2013), preparing learners for diverse industrial roles. Consequently, integrating 4IR technologies into curricula is imperative, as tools like BIM, robotics, drones, and simulation systems enhance training quality and workplace alignment (Azhar, 2011; Tapscott & Tapscott, 2016; Armbrust et al., 2010).

As this transformation deepens, automation shifts demand toward higher-order skills such as critical thinking and technical supervision (Bakhshi et al., 2017), requiring continuous curriculum updates and innovative teaching methods (World Economic Forum, 2020; Oketch et al., 2019). Therefore, aligning TVET with global labour trends depends on embedding digital literacy, innovation, and lifelong learning to ensure adaptability and competitiveness (Schwab, 2017; Li & Zhou, 2022).

### Redefining Pedagogical Approaches in TVET for 4IR Realities

As the global workforce structure continues to evolve under the influence of 4IR technologies, there is a pressing need for TVET pedagogies to undergo a paradigm shift. Chong et al. (2019) argue that the conventional model of instruction, where teachers serve as passive transmitters of knowledge, is no longer sufficient. Instead, TVET educators must embrace the role of facilitators who create learning environments that promote inquiry, innovation, and experiential learning. This transformation can be actualized through the intelligent application of educational technologies that empower students to explore real-world problems, develop practical solutions, and reflect critically on their learning experiences.

In adapting to these demands, TVET institutions must prioritize both technical and soft skill development. According to Makgato and Afeti (2020), in addition to equipping learners with digital skills such as AI, robotics, and data analytics, attention must also be given to cultivating soft skills—particularly critical thinking, teamwork, communication, and adaptability. These competencies are vital for success in modern, interconnected workspaces. Accordingly, TVET curricula must be restructured to reflect the dynamic expectations of the industry, with a holistic focus on producing graduates who are not only technically sound but also emotionally intelligent and adaptable.

Through the incorporation of innovative methodologies like the ACT model and by integrating lifelong learning strategies, Nigerian TVET institutions can bridge the skills gap and prepare a resilient, future-ready workforce. These reforms are not merely desirable. They are essential for national development in an era defined by rapid technological change (ACT & iLabGlobal, 2018).

**Table 1: Priority areas for Reskilling and Upskilling in TVET programs**

Sectoral Focus	Critical Requirements	Skill	Essential Technological Instruments	Authoritative Sources
Advanced Manufacturing	Expertise in robotics operation and the integration of automated systems		Computer Numerical Control (CNC) machines, Programmable Logic Controllers (PLCs), industrial-grade robotic units	Makgato & Afeti (2020)
Digital Literacy	High-level competence in the use of modern software suites and digital platforms		Microsoft Office Suite, Computer-Aided Design (CAD) software	Li & Zhou (2022)
Data Analytics	Application of statistical tools and predictive algorithms for data interpretation		R programming language, Python, Tableau data visualization software	McKinsey Global Institute (2019)
Cybersecurity	Proficiency in identifying digital threats and implementing risk management		Firewall systems, encryption, and network protection software	Frey & Osborne (2017)

	protocols		
Renewable Energy Systems	Installation and maintenance of solar and wind-based power infrastructure	Solar training kits, energy-efficient battery units	Makgato & Afeti (2020)
Artificial Intelligence	Deployment and operationalization of AI systems for problem-solving and automation	Machine learning frameworks, TensorFlow libraries	Schwab (2017)
Internet of Things (IoT)	Configuration and maintenance of interconnected smart devices	IoT-enabled sensors, real-time network monitoring utilities	McKinsey Global Institute (2019)
Virtual Reality (VR)	Use of simulation environments to support immersive, experiential learning	Virtual Reality (VR) headsets, Unity development platform	Chong et al. (2019)

Source: (Makgato & Afeti, 2020)

### Global Demand for Upskilling and Reskilling in the 4IR Era

The global trajectory of workforce development shows a sharp rise in demand for upskilling and reskilling, with the World Economic Forum (2024) projecting over 600 million people will require reskilling by 2030, highlighting the need for TVET to integrate 4IR technologies. As industries adopt automation and AI, workers must acquire new competencies to remain relevant (Brynjolfsson & McAfee, 2014).

However, Li and Zhou (2022) noted that critical skills such as AI and data analytics remain insufficiently embedded in current TVET curricula, creating a gap that threatens employability and productivity, thus reinforcing the need for curriculum reform (Schwab, 2017).

Moreover, while reskilling involves acquiring new skills and upskilling enhances existing ones, the rapid pace of technological change demands that TVET evolve into lifelong learning systems that continuously prepare workers for emerging roles (World Economic Forum, 2020).

### Statistical Evidence on Skills Deficiency and Training Imperatives

A growing body of evidence reveals a widening gap between industry-required competencies and existing workforce capabilities, driven by 4IR developments. The World Economic Forum (2020) estimates that by 2025, about 50% of workers will require reskilling due to automation and AI, highlighting the urgency for TVET reform. Similarly, the European Commission (2021) reports that many firms struggle to find digitally skilled workers, while McKinsey Global Institute (2019) projects that demand for tech talent will exceed supply by 2030, intensifying the skills gap.

Consequently, this deficit necessitates a shift from traditional skills to advanced domains such as AI, blockchain, and data science, as emphasized by Malik and Venkatraman (2020), requiring comprehensive curriculum and training reforms in TVET. In this context, the subsequent table outlines key findings on upskilling and reskilling efforts, existing gaps, and necessary reforms.

Furthermore, within the 4IR landscape, emerging technologies are reshaping labour markets and

education systems, as noted by Schwab (2016), compelling TVET institutions to adopt digitally aligned training models. In turn, the rise of AI and automation intensifies the need for continuous upskilling and reskilling, which Li and Zhou (2022) identify as essential for enabling workers and learners to adapt to evolving technological environments.

**Table 2: Synopsis of Identified Gaps in Reskilling across TVET Domains**

Skill Area	Percentage of Workforce Needing Reskilling (by 2026)	Current Coverage in TVET Programs (%)	Estimated Skill Shortage (%)
Digital Literacy	60%	30%	30%
Artificial Intelligence (AI)	45%	15%	30%
Data Analytics	50%	20%	30%
Robotics & Automation	40%	25%	15%
Cybersecurity	35%	10%	25%

Source: Adapted from McKinsey Global Institute (2019) and World Economic Forum (2024).

Table 2 makes evident the substantial misalignment between the demand for digital-era skills and their inclusion in current TVET syllabi. Notably, core skills such as Digital Literacy, Artificial Intelligence, and Data Analytics remain significantly underrepresented in existing vocational frameworks. A minimum of 30% shortfall is observable across these disciplines, revealing an urgent call to re-engineer TVET training architecture in Nigeria and other developing contexts.

**Table 3: Forecasted Skills Evolution and Strategic Recommendations for TVET**

Category	Global Statistic	Implication for TVET Development	Source
Global Upskilling Trends	600 million people projected to reskill by 2030	Need for scalable, digital-friendly training frameworks	World Economic Forum (2024)
Skill Shift Forecast	60% of skills by 2027 will differ from those of 2015	Compulsory curriculum overhaul to accommodate AI, digital tech, and smart automation	World Economic Forum (2017)
Labour Market Transformation	50% of tasks automated by 2025; human reasoning still vital	Emphasis on cognitive reasoning, creativity, and adaptability in vocational modules	Frey & Osborne (2017)
Digital Training Deficit in TVET	57% of global TVET learners lack adequate digital skillsets	Integrate robotics, Augmented Reality, and advanced tech into core courses	Li & Zhou (2022)
Automotive Sector	74% of workers require reskilling	Prioritise sector-specific technical	Reuters (2024)

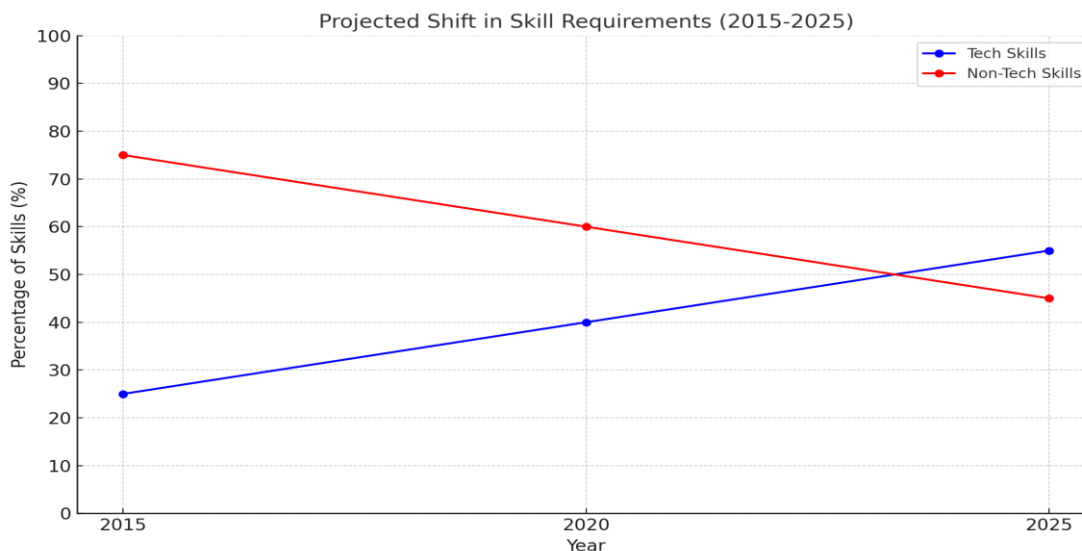
Reformation	for EVs and autonomous tech	retraining in TVET, particularly in electric vehicle systems	
STEM Workforce Deficiency	62% of employers lack access to STEM-skilled graduates	TVET must aggressively promote STEM-based learning frameworks	McKinsey Global Institute (2019)
Reskilling Disparities	Only 45% of low-educated adults pursue training	Drive inclusive policies and outreach for equitable access to reskilling opportunities	NBER (2024)

Source: Synthesised from Malik & Venkatraman (2020).

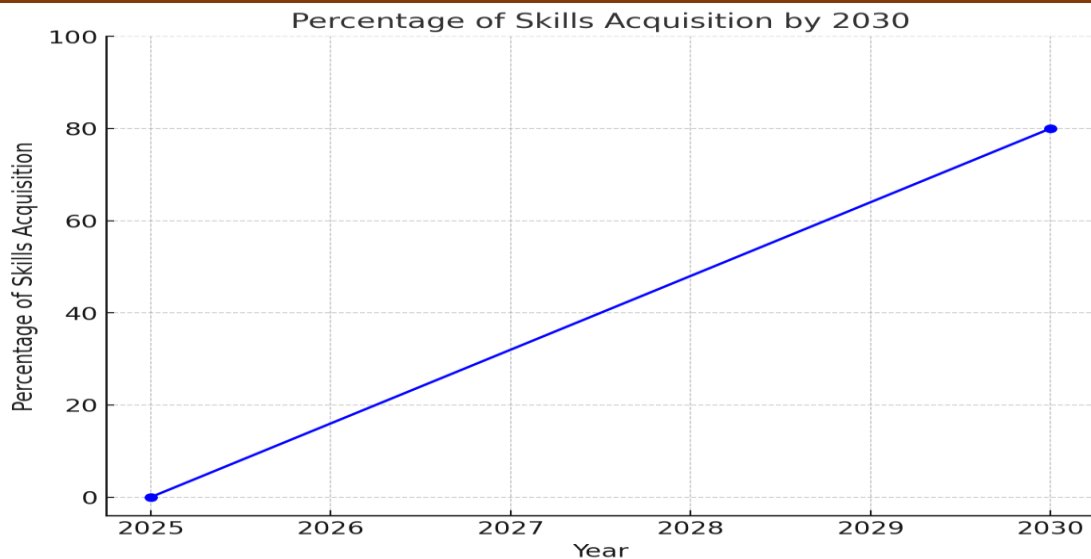
Table 3 reveals that over 600 million persons globally will undergo reskilling by the year 2030, a projection that imposes an undeniable responsibility on Nigerian TVET institutions to embed these emerging digital technologies within their curricular structures. The statistical illustrations provided further reinforce the necessity for proactive educational planning and responsiveness in the face of technological disruptions. Research conducted by Li and Zhou (2022) accentuates the fact that by 2025, a considerable portion of workforce competencies will hinge on emerging technological skills that are presently underrepresented in most TVET programs, including AI, cybersecurity, and data analytics. This observation transitions seamlessly into the discussion on redressing systemic inequalities and prioritizing digital literacy integration across all strata of TVET education.

### Graphical Representation of Evolving Skills Landscape: 2015–2030

Based on global projections, the graph below shows a steady shift in workforce skills toward technology-driven competencies. In 2015, most skills were non-technological and routine-based; by 2025, about 55% require technological proficiency; and by 2030, nearly 80% will be digitally driven, leaving traditional skills minimal. Hence, the urgent need to transform TVET into an innovation-focused technology-aligned system.



Source: Bakare & Gbenga-Arotiba, (The researchers of this current study).



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The statistical and graphical data analyses above unequivocally underscore the urgent necessity for robust upskilling and reskilling strategies within Technical and Vocational Education and Training (TVET) frameworks, particularly as Nigeria navigates the evolving realities of the Fourth Industrial Revolution (4IR). With industrial transitions being driven by disruptive innovations such as Artificial Intelligence (AI), blockchain technologies, and robotics, TVET systems in the country must be realigned to produce a workforce competent in digital and technologically dynamic sectors. Brynjolfsson and McAfee (2014) maintain that this transformative epoch mandates a deliberate re-engineering of workforce development frameworks, particularly curriculum adaptation to suit contemporary exigencies.

### **Bridging the Inequality Divide through TVET in the Age of 4IR**

The asymmetrical distribution of the economic dividends of the 4IR, as articulated by the World Economic Forum (2017), is reflective of the deepening gulf between skilled and unskilled labor globally and more pertinently within Nigeria. In response, the Nigerian TVET system must take up the mantle of promoting equitable access to advanced educational opportunities, particularly in fields such as robotics, AI, and digital entrepreneurship. Schwab and Davis (2018) emphasize that inclusive education is a sine qua non for ensuring that the benefits of technological advancement are not confined to a privileged few.

An illustrative case is the Lagos State Employability Support Project, which is strategically designed to extend training in renewable energy and digital marketing to youths from marginalized communities (Lagos State Government, 2020). Such initiatives resonate with the broader imperative of tailoring TVET programs to respond to contemporary labor market demands. Similarly, the African Development Bank's Coding for Employment initiative seeks to bridge gender and socio-economic gaps by promoting digital inclusion and skills equity (AfDB, 2019). It is, therefore, evident that TVET has a central role to play not merely as a training mechanism, but as a strategic tool for promoting socio-economic inclusion and justice in the age of the 4IR.

### **Integrating Digital Literacy and Data Ethics into TVET**

As the frontiers of education and industry continue to be reshaped by digital technologies, Nigerian TVET systems must strategically integrate digital literacy and data ethics—including privacy and cybersecurity awareness—into core curricula. UNESCO (2021) posits that this inclusion is critical

not only for developing students' technical proficiencies but also for preparing them to confront the ethical dilemmas inherent in the digital economy.

For instance, institutions like Yaba College of Technology could significantly enrich their offerings by embedding courses in ethical AI usage, responsible data management, and cybersecurity protocols—thereby preparing graduates for ethical participation in technology-centric industries (YabaTech, 2023). Similarly, the smart classroom models employed by Singapore Polytechnic serve as instructive examples of how AI and data analytics can be employed to enhance learning outcomes while upholding student data confidentiality (Singapore Polytechnic, 2022). The incorporation of these dimensions ensures that Nigerian TVET graduates are not only technically proficient but also ethically grounded in their professional engagements.

### **Cultivating Public Trust in TVET for the 4IR**

For any meaningful integration of 4IR technologies within Nigerian TVET systems to succeed, public confidence in such reforms must be vigorously cultivated. Demonstrating the tangible socio-economic benefits of technology-based education, particularly its linkages to employability can significantly bolster public trust. The Digital Bridge Institute (DBI), for example, has contributed to this endeavor by providing specialized ICT training in software development and digital marketing, thereby enhancing employability and economic mobility (DBI, 2022).

Furthermore, inter-sectoral collaborations such as the partnership between the Nigerian government and Huawei in the area of ICT development (Huawei Nigeria, 2021) serve as trust-building mechanisms that validate the relevance of TVET in national development. These collaborations also provide the needed infrastructure to ensure that ethical considerations around digital literacy and privacy are not neglected in the quest for technological advancement. By embedding transparency and ethical data use into educational technologies, Nigerian TVET institutions can firmly position themselves as credible actors within the 4IR discourse.

### **Existing Challenges Confronting Nigerian TVET in the 4IR Era**

#### **1. Curriculum Modernization**

Despite efforts by the National Board for Technical Education (NBTE, 2023), curriculum updates in Nigerian TVET remain slow and inconsistently implemented, limiting alignment with rapid technological change.

#### **2. Financial Constraints**

High costs of advanced training facilities hinder modernization; however, partnerships such as Siemens (2020) demonstrate how PPPs can ease funding gaps through equipment and technical support.

#### **3. Cybersecurity Threats**

With rising digital adoption, cyber risks are increasing, making it essential as highlighted by African Fintech Network (2022)—for TVET to integrate cybersecurity skills into training programs.

### **Harnessing Opportunities through Personalized Learning Technologies**

The advent of AI and big data offers new possibilities for enhancing teaching and learning within Nigerian TVET. AI-powered platforms such as uLesson demonstrate how technology can be employed to develop personalized learning experiences that are responsive to each student's pace and career trajectory (uLesson, 2022). The "just-in-time" learning model, as championed by Soriano (2017), allows institutions to deliver highly relevant and industry-driven content in real time. Additionally, platforms like Tuteria (2023) illustrate how on-demand tutor-learner connections can

revolutionize skill acquisition, aligning instruction with both labor market demands and individual learning needs.

### **Conclusions**

As the global labor ecosystem continues to shift under the weight of the Fourth Industrial Revolution, Nigeria's TVET institutions must rise to the occasion through strategic repositioning. This involves not only integrating cutting-edge technologies into teaching and learning processes but also forming strategic alliances, deploying personalized learning tools, and ensuring inclusivity. With deliberate policy action and sustained investment, TVET can evolve into a robust vehicle for national development, employment generation, and social equity in a digitally driven global economy.

### **Recommendations**

Recommendations for Enhancing Nigerian TVET in the 4IR

To strategically reposition Nigeria's TVET system for the demands of the Fourth Industrial Revolution, the following interventions are hereby recommended:

**Curriculum Modernisation:** Integrate 4IR technologies into TVET curricula aligned with Nigeria's key economic sectors to ensure relevance.

**Educator Capacity Development:** Provide continuous training and global exposure to equip teachers with modern technical and pedagogical skills.

**Industry Collaboration:** Strengthen partnerships with industries to offer practical training and align skills with labour market demands.

**Digital Inclusion and Innovation:** Promote digital, entrepreneurial, and blended learning approaches to expand access and enhance employability.

**Policy, Funding, and Rebranding:** Increase government support, foster PPPs, ensure inclusivity, and reposition TVET as a competitive career pathway.

### **References**

- ACT Foundation, & iLabGlobal. (2018). The ACT model for workforce readiness and skills development. ACT Foundation.
- African Development Bank (AfDB). (2019). Coding for employment: Digital skills for Africa's future. AfDB Group.
- Armbrust, M., Fox, A., Griffith, R., Joseph, A. D., Katz, R., Konwinski, A., Lee, G., Patterson, D., Rabkin, A., Stoica, I., & Zaharia, M. (2010). A view of cloud computing. *Communications of the ACM*, 53(4), 50–58. <https://doi.org/10.1145/1721654.1721672>
- Azhar, S. (2011). Building information modeling (BIM): Trends, benefits, risks, and challenges. *Leadership and Management in Engineering*, 11(3), 241–252. [https://doi.org/10.1061/\(ASCE\)LM.1943-5630.0000127](https://doi.org/10.1061/(ASCE)LM.1943-5630.0000127)
- Bakhshi, H., Downing, J., Osborne, M. A., & Schneider, P. (2017). The future of skills: Employment in 2030. Pearson & Nesta.
- Brynjolfsson, E., & McAfee, A. (2014). The second machine age: Work, progress, and prosperity in a time of brilliant technologies. W. W. Norton & Company.
- Chong, S., Pan, G., & Chen, J. (2019). Digital learning and pedagogical transformation in TVET. *Journal of Technical Education and Training*, 11(2), 1–12.
- European Commission. (2021). Digital economy and society index (DESI) 2021 report. European

Union.

- Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation? *Technological Forecasting and Social Change*, 114, 254–280. <https://doi.org/10.1016/j.techfore.2016.08.019>
- Lagos State Government. (2020). Lagos State employability support project report. Lagos State Ministry of Wealth Creation.
- Li, X., & Zhou, Y. (2022). Digital transformation and workforce skills development in the Fourth Industrial Revolution. *Education and Information Technologies*, 27, 12345–12360.
- Makgato, M., & Afeti, G. (2020). Technical and vocational education and training for sustainable development in Africa. *Journal of Vocational Education & Training*, 72(2), 1–19.
- Malik, R., & Venkatraman, S. (2020). Digital transformation in education: Implications for workforce development. *International Journal of Emerging Technologies in Learning*, 15(12), 4–17.
- McGrath, S. (2019). Vocational education and training for development: A policy in need of a theory? *International Journal of Educational Development*, 67, 12–19.
- McKinsey Global Institute. (2019). The future of work in Africa: Harnessing the potential of digital technologies for inclusive growth. McKinsey & Company.
- National Board for Technical Education (NBTE). (2023). Curriculum review report for technical colleges in Nigeria. NBTE.
- National Bureau of Economic Research (NBER). (2024). Reskilling and labor market participation report. NBER Working Paper.
- Oketch, M., McCowan, T., & Schendel, R. (2019). The impact of tertiary education on development. *World Development*, 122, 1–15.
- Okwelle, P. C. (2013). Technical and vocational education in Nigeria: Issues and challenges. *Journal of Education and Practice*, 4(25), 1–7.
- Reuters. (2024). Global automotive workforce reskilling trends in electric vehicle transition. Reuters Industry Report.
- Schwab, K. (2016). The fourth industrial revolution. World Economic Forum.
- Schwab, K. (2017). The fourth industrial revolution (Expanded ed.). Crown Business.
- Schwab, K., & Davis, N. (2018). Shaping the future of the Fourth Industrial Revolution. World Economic Forum.
- Siemens AG. (2020). Public-private partnerships in technical education: Siemens Nigeria initiative. Siemens Report.
- Soriano, D. R. (2017). *Entrepreneurship and innovation: Concepts and cases*. Routledge.
- Sullivan, S. E., & Al Ariss, A. (2018). Making sense of different perspectives on career transitions. *Human Resource Management Review*, 28(2), 123–139.

Tapscott, D., & Tapscott, A. (2016). *Blockchain revolution: How the technology behind Bitcoin is changing money, business, and the world*. Penguin.

Tuteria. (2023). *Digital tutoring and skill acquisition platform report*. Tuteria.

uLesson. (2022). *AI-powered learning in Africa: Impact report*. uLesson Education Ltd.

UNESCO. (2021). *Reimagining our futures together: A new social contract for education*. UNESCO Publishing.

World Economic Forum. (2017). *The future of jobs report 2017*. World Economic Forum.

World Economic Forum. (2020). *The future of jobs report 2020*. World Economic Forum.

World Economic Forum. (2024). *Future of jobs report 2024*. World Economic Forum.

Yaba College of Technology. (2023). *Institutional report on digital transformation in technical education*. YabaTech.