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Impacts of Artificial Intelligence on Technical and Vocational Education and Training Programmes: Challenges and Prospects

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Abstract

Technical and Vocational Education and Training (TVET) constitute a fundamental mechanism for developing the skilled workforce required for sustainable of economic growth. The advent of Artificial Intelligence (AI) has introduced transformative opportunities and complexities into the design and delivery of TVET programs. This paper presents a critical analysis of the impact of AI on TVET with a focus on pedagogical innovation, skill acquisition, and alignment with contemporary labour market demands. The discussion delineates the affordances and adaptive learning environment, intelligent tutoring system, automated assessment and simulation – based training that replicate industrial processes. These technologies facilitate individualized instruction, and provide data-driven insights that support instructional improvement and institutional decision-making. However, the integration of AI into TVET is constrained by several systematic challenges. These include insufficient digital infrastructure, limited educator capacity in AI literacy and integration, financial constraints, concerns regarding data privacy and algorithmic bias and disparities in access between urban and rural institutions. Additionally, the lack of cohesive policy frameworks, and weak linkage between educational institutions and industry impede the effective alignment of curricular with technological advancements. To address these challenges the paper proposes a strategic pathway comprising targeted investment in teacher professional development, the establishment of smart laboratories and IOT- enabled training facilities, the cultivation of public – private partnership and the formulation of regulatory frameworks that promote equitable and ethical development of AI. Such measures are imperative for leveraging AI to strengthen the relevance, quality and inclusiveness of TVET in the context of the Fourth Industrial Revolution.

Keywords: Artificial Intelligence, Impact, Education, Training, Challenges, Prospects.

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INTRODUCTION

Artificial Intelligence or (AI) technology has been a topic growing interest and investigation in various field higher education inclusive. At present Artificial Intelligence technology has not only changed people's lifestyles but has also changed how people work, learn, and interact. According to Sart and FiHra (2021) the emergence of Artificial Intelligence has made it possible for various kinds of innovation to appear all the time, making human activities and work more practical and effective. Similarly, Kham and Richer (2020) posited that the development of Artificial Intelligence has also penetrated the world of education as it allows people to learn with the help of education assistants such as robots. The development of Artificial Intelligence at present requires the world of education to adopt to it in order to improve the quality of education at all levels.

According to Canbel and Zhang (2023) Artificial Intelligence (AI) represents transformative shift in the technological landscape, impacting on various sectors education inclusive. The advent of AI has opened new frontiers in the way knowledge and skills are impacted and acquired particularly in Technical and Vocational Education and Training

(TVET). As one of the educational systems in Nigeria that is primarily connected with equipping of individuals with specific skills and competences essential for the labour market, the integration of Artificial Intelligence into Technical and Vocational Education and Training programme curriculum in Nigeria at this period that the awareness on the use of technology such as AI globally is beginning to attract much attention. According to Mahama and Rexford (2019) Artificial Intelligence has the potential to revolutionalize education by personalizing teaching method to suit individual students needs, provide prompt feedback during teaching and learning process that will help. Individual has to acquire sound knowledge and skills for readiness into the world of work.

The world Economic Forum cited in Hawang and Long (2022) notes that the future of work will significantly be shared by Artificial Intelligence and automation technology is properly utilized in educational programme. As industries increasingly adopt Artificial Intelligence driven process, the demand for skilled workers who are proficient in technical and vocational skills is on the rise (Prinsho, 2021). Thus, there is urgent need for the integration of Artificial Intelligence in Technical and Vocational Education and Training programme curriculum in Nigeria as to ensure that educational curriculum of Technical and Vocational Education and Training programme remains relevant and aligned with the evolving needs of labour market which Technical and Vocational Education and Training Programme in Nigeria can offer to individual who will be willing to run programme in any of the specialized areas in Technical and Vocational Education and Training.

Concept of Technical and Vocational Education and Training (TVET)

Technical and Vocational Education and Training (TVET) according to Anaele (2023) refers to educational programmes and courses that equip individuals with practical skills, knowledge and competences necessary for specific trades, industries or professions. Technical and Vocational Education and Training as defined by UNESCO and adopted by Federal Republic of Nigeria (FRN, 2013) in her National Policy on Education is used as a comprehensive term referring to those aspect of educational process involving in addition to general education, the study of technologies and related sciences and the acquisition of practical skills, attitude, understanding and knowledge relating to occupation in various sectors of economic and social life.

Technical and Vocational Education and Training (TVET) according to Onwurah and Ejims (2019) is a programme that focuses on hand-on, realworld applications, preparing learners for direct entry into the workforce. TVET encompasses a diverse range of fields, including but not limited to Building trades, Automobile trades, Mechanical trades, Electrical/Electronic trades, Wood Work trades. In Nigeria TVET is a critical component of the educational system aimed at equipping individuals with practical skills and knowledge relevant to specific industries and trades.

Goals of Technical and Vocational Education and Training (TVET) in Nigeria

Technical and Vocational Education and Training (TVET) as enshrined in the National Policy on Education is concerned with qualitative technological human resources development directed towards a national pool of skilled and self –reliant craftsmen, technicians and technologist in technical and vocational fields that can contribute effectively to the socio-economic development of Nigeria. The goals of TVET according to Federal Republic of Nigeria (2013) shall be to:

1. provide the trained manpower in the applied science, technology and business particularly at craft, advance craft and technical level,
2. provide the technical skills necessary for agricultural, commercial and economic development, and
3. give training impact the necessary skills to individual for self-reliance economically.

The above stated goals of TVET as intended to make Technical and Vocational Education and Training proramme more practical functional and job oriented requires full integration of technology in teaching and learning process. Such technology according to Fittra and Hayanto (2023) include Artificial Intelligence that has become a vital part of the virtual world that is capable of helping human learn better and achieve educational goals more effectively.

Concept of Artificial Intelligence (AI)

Artificial Intelligence (AI) is a vast branch of computer science concerned with developing intelligent computer capable of doing tasks that typically need human intelligence. According to Alexa (2019) Artificial Intelligence is the process of modeling human thinking and designing a machine so that it can behave like humans or other terms called cognitive tasks, namely how machine can learn automatically from programmed data and information. Artificial Intelligence can also be interpreted as Artificial Intelligence or AI. Similarly, Klamma (2023) stated that Artificial Intelligence is one part of computer science that makes machines such as computer able to do work and as well as human do (Klamma, 2023). In the same vein, Oblinger (2021) posited that Artificial Intelligence (AI) is a technology whose machines can learn and understand logic like humans. This technology the author continued is said to be able to help simplicity human life which is very complex. According to Howe and Rau (2024) Artificial Intelligence in the development of computer systems that can perform tasks that typically required human intelligence such as learning, problem-solving, reasoning, and perception.

History of Artificial Intelligence (AI)

To disclose on the terms "Artificial Intelligence" it is necessary to discuss on the history of Artificial Intelligence for the purpose of sound knowledge or idea about the emergence of Artificial Intelligence. To achieve this purpose it is necessary to go back to previous dates. According to Mila (2018) in the Ancient Greek period, it is proven that various ideas about humanoid robot have been carried out. An example of this, is Daedbus who said to have ruled the mythology of the wind to try to create Artificial humans, modern artificial intelligence has began to be seen in history with the aim of defining philosophers' system of human thought. The year 1884 is important for artificial intelligence. On this date Charles Babbase was the one who worked on a mechanical machine that will exhibit intelligent behavior.

However, as a result of these studies carried out by Babbase in 1884, he decided that he would not be able to produce a machine that would exhibit as intelligent behavior as a human being, he therefore suspended his work. In the year 1950 Claude Shannan introduced the idea that computers could play chess, he therefore stated work on artificial intelligence from history officially dates back to 1956. In the year 1956, a conference artificial intelligence session at Dartmouth College was introduced for the first time. A man called Marvin Minsky was the one who started in his book "stormed search for Artificial Intelligence" that "the problem of artificial intelligence modeling within a generation will be solved". The first artificial intelligence application were introduced during the period. These applications are based on logic theorems and chess game. The programmes developed during this period in question were

distinguished from the geometric forms used in the intelligence tables; which has led to the idea that intelligent computers can be created.

Artificial Intelligence began to be used in large projects with practical application in the 1980s. The next time the daylight is passeu, the artificial intelligence has been adopted to solve real life problems. Even when the needs of users are already met with traditional methods, the use of artificial intelligence has reached to a much wider range which continue to improve up till date all over the globe. In the field of Education the use of Artificial Intelligence can be traced back to the 1970s when LOGO programme and Turtle robots were introduce to young learners. However, those tools focused more on computational thinking of programming concepts instead of AI. In 1996, a book named "Artificial Intelligence: A Modern Approach" was published and considered the most standard textbook in the field of AI for computer science undergraduates (Norvig and Russel, 2024).

Artificial Intelligence Application in TVET Programme

There are several application of Artificial Intelligence in technical and vocational education and training (TVET). These applications include content design, delivery of lesson, assessment, feedback, and support. In terms of content design (Kuleto & Elevian, 2022), Artificial Intelligence can enable someone in the designing of content which is friendly and flexible. In the same vein Miao and Sylva (2018) posited that Artificial Intelligence algorithms can scan large data to tap into the gaps thus creating content that is interesting and friendly to users. In educational programming such as in TVET AI can also be used for making content including textbooks, personalized learning materials, and interactive courses according to the target audience. Artificial Intelligence tools also enable the development of educational materials that is based on national language processing capabilities, thus ensuring material that is consistent, concise, and grammatically correct (Dasky, 2021).

In educational programmes, in terms of delivery of content AI usually enables delivery of contents more efficiently and flexible by substituting classroom instruction and providing support for students to learn from anywhere in the world at any given time. In the classroom teaching and learning process AI system have a high capability to analyze multiple sources of data and compare those data to known partering. They can also recognize the source of problems and give audience to lecturers to achieve more consistent outcomes across various classes during teaching and learning period. In other words, the AI and teachers can work together to create the best delivery method for students with maximum positive outcomes. The benefit of using AI for delivery of education content include the provision of individualize and customized learning and universal access for all students who may speak different language or have some disability such as visual or hearing impairment (Jeff and George, 2021).

In terms of assessment in education, Artificial Intelligence can enable automated assessment (Lee and Mishra, 2021). For example, AI can automate grading homeworks and test using a significant amount of time. This time could be used to work on professional development, interact with students, and prepare for class. AI can be used by tutors to personalized assessment and provide timely feedback addressing individual learning needs. The benefit of AI in assessment in education is that it can reduce human subjectivity and time for assessment. Singer and Mark (2021) suggest that AI use in education assessment increases consistency, personalization, and stability.

Impacts of Artificial Intelligence on TVET Programmes

Artificial Intelligence (AI) has emerged as a pivotal focus in transforming global systems,with education being significantly impacted. As a field traditionally reliant on human interaction and subjective judgment, education is experiencing a paradigm shift due to AI's increasing role in automating, individualizing, and scaling learning processes. Tools ranging from adaptive learning platforms to predictive analytics and automated administrative systems now permeate classroom and institutions.

At present AI holds the promise of revolutionalizing teaching and learning by improving education outcomes, enhancing access, and reducing operational burdens. Nonetheless, the adoption of Ai is not without critical concerns. These include questions of algorithmic farness, data privacy, teacher de-professionalization, and a potential overemphasis on quantifiable outcomes at he expense of humanistic education values. Inspite of all these facts AI has been reported by many scholars as a transformative force that have played positive impact on education. Some of the impacts of on education as outlined by Binns and Pane (2020) include:

1. **Enhancement of Education Programme**
   Intelligent Tutoring Systems and Automation Intelligent Tutoring System (ITS) are another crucial innovation in Artificial Intelligence –enhanced education. These systems exemplified by platforms such as squirrel AI, Century Tech, and IBM's Watson Tutor, emulate the guidance of a human tutor by offering real-time, targeted feedback based on a student's individual responses. Research has demonstrated that Intelligent Tutoring systems can deliver learning gains equivalent to one-on-one human tutoring under certain conditions.
   Again, AI streamlines administrative functions, including attendance monitoring, grading, course planning and even plagiarism detection in academic work. In education automating these labor-intensive tasks allows educators to focus more on mentorship, curriculum development, and classroom instruction.
2. **Equity and Access**
   A key promise of Artificial Intelligence in education lies in its potential to expand access to learning for underrepresented population. AI-powered platform like Duclingo, Coursera, and Khan Academy offer scalable learning solutions that can reach remote and underserved communities. Moreover, tools for real-time transition and speech recognition support learners with linguistic or physical disabilities, creating more inclusive environment.
   The deployment of AI in education assures basic digital infrastructure, stable internet connectivity, and digital literacy-resources often unavailable in low-income or rural regions. Even where technology is accessible, inequalities in low students use of AI tools (e.g for enrichment vs remendiation) may exacerbate education disparities rather than close them.
3. **Enhancing Personalized Learning**
   Artificial Intelligence's transformative contribution to education arguably lies in its ability to support personalized learning. Traditional classroom setting, structured around standard curricula and uniform pacing, often fail to accommodate the diverse abilities, learning styles, and backgrounds of students. AI-driven educational technologies such as DreamBox learning, Carnegie Learning, and Knewton use of algorithms to adjust instructional content in real-time based on a student's performance, offering an adaptive learning experience that is continuously refined. This form of individualized learning offered by AI can significantly increase engagement, motivation, and retention,

especially for students with learning disabilities or those in under-resourced schools. However, personalization through AI comes with caveats, critics have argue that the very logic of algorithmic personalization may narrow than expand learning opportunities. AI systems tend to optimize for measurable outcomes, often reinforcing patterns of behavior rather than changing students with diverse cognitive tasks.

4. **Data-Driven Decision Making**
   Artificial Intelligence driven learning analytics enable educational institutions to collect, analyze, and interpret vast quantities of data, allowing for predictive insight and informed interventions. By tracking metrics such as engagement, attendance, and assessment outcomes, these systems can identify students at risk of failing, suggest timely interventions, and customize pedagogical strategies. Predictive capacity through AI enhances institutional efficiency and students success. Predictive analytics can also foster deterministic assumption about student potential, subtly encouraging tracking and stratification.
5. **Enhanced Student Engagement**
   Artificial Intelligence – powered interactive learning experiences, such as gamification and simulations that can enhance student engagement and motivation during teaching and learning process. It can also provide virtual learning environments that can provide immersive and interactive learning experiences during teaching and learning process.
6. **Teacher Support**
   Artificial Intelligence can augment teacher capabilities, freeing up time for more critical aspects of teaching. It can also provide teachers with personalized professionalized professional development opportunities.

Challenges of Using Artificial Intelligence in TVET Programmes

As in any human activity there are challenges to realisation of the goals of using Artificial Intelligence as expected. Among these challenges includes;

1. **Digital Divide and Equity Issues**
   While Artificial Intelligence promises personalization, its benefits are not universally accessible. The digital divide – a gap in access to digital tools and the internet remains a persistent problem, particularly in low-income regions and among disadvantaged students. According to UNESCO cited in Eubanks (2019), disparities in digital infrastructure and teacher training significantly hinder the effective use of AI in educational inequality rather than bridge it unless systematic investments are made in equitable infrastructure to correct this problem.
2. **Technical and Implementation Challenges**
   Implementing Artificial Intelligence in education requires robust infrastructure, continuous technical support, and significant financial investment. Many educational institutions, particularly in the Global South, lack the capacity to adopt and maintain AI systems. Moreover, the efficacy of AI tools depends on continuous algorithmic updates, system integration, and real-time data analytic all of which present logical challenges (Luckin, 2023). There is also a need for interdisciplinary collaboration among educators, data scientists, and policy makers which is often lacking.
3. **Data Privacy and Ethical Concerns**
   One of the foremost challenges facing the use of Artificial Intelligence in education is the ethical management of student data. AI systems rely heavily on large data sets to function effectively. In educational context, this means collecting sensitive student information academic performance, behavioural patterns, and even biometric data. The potential for

misuse, data breaches, or surveillance raises serious concerns. According to Bruno and Slaver (2024), the use of learning analytics must be guided by ethical frameworks to prevent exploitation and ensure transparency. However, in many context, such frameworks are either lacking or insufficiently enforced.

Moreover, Artificial Intelligence can reflect or amplify existing biases embedded in the training data. This is particularly critical in education, where biased algorithms may disproportionately disadvantage already marginalized groups, exacerbating inequality.

4. **Teacher Resistance and Professional Displacement**

Many educators are apprehensive about the integration of Artificial Intelligence, fearing job displacement or the devaluation of their professional expertise. While proponents arue that AI can augment teachers by taking over administrative tasks, the rapid pace of technological change can create anxiety and resistance among educators, especially in systems where professional development is inadequate. As Charls and Morgan (2021) highlight, the teacher's role must be re-imagined in a way that positions them as co-designers and facilitators, not mere implementers of AI Systems.

5. **Lack of Human Interaction and Emotional Intelligence**

Artificial Intelligence lacks the detailed emotional intelligence and empathy that human educators bring to the classroom. Education is not merely about knowledge transmission; it also involves mentorship, motivation, and socio-emotional development. As Lukeman (2018) argues, AI may support teachers but cannot replace the relationship aspects of teaching that are central to students success. Over-reliance on AI tools risks reducing education to a mechanistic process devoid of human affection and contextual understanding.

6. **Pedagogical Misalignment**

Artificial Intelligence applications often adopt a "one-size-fits-all" model of learning, which may conflict with constructive or student-centred pedagogies. For instance, intelligent tutoring systems are typically designed around behaviourist models that reward correct answers without fostering critical thinking or creativity (Jones and Lia, 2023). This raises questions about whether AI can truly enhance learning outcomes or merely optimize existing potentially outdated educational practices.

7. **Ethical and Pedagogical Concerns**

Artificial Intelligence's integration into education provokes deeper philosophical and ethical inquires. One major concern is algorithmic bias – when systems unintentionally reproduce discriminatory outcomes due to skewed or incomplete training data. Such bias can lead to inequitable access, unfair assessment, and harmful profiting, particularly among students from minority or disadvantaged backgrounds.

Moreover, the pedagogical shift toward AI- driven instruction may reduce education to a transactional exchange of information. Human qualities central to learning-empathy, creativity, dialogue, moral reasoning are difficult to encode into algorithms. AI system lack the contextual judgment that teachers apply when addressing diverse classroom dynamics, behavioural nuances, and emotional needs.

Prospects of Artificial Intelligence on TVET Programme

Artificial Intelligence (AI) in education has several prospects that can enhance the learning experience for students and improve teachers' productivity. Some of the prospects of AI as outlined by Prinsho (2021) include;

1. **Tailored Learning Experience:** Artificial Intelligence can help create tailored learning experience for students, catering to their individual needs and abilities. This can lead to

improved student outcomes and increased engagement during teaching and learning process.

2. **Adaptive Assessment:** AI-powered assessment can adapt to students knowledge and skills during their training period in the school providing them with a more accurate measure of their abilities.
3. **One-on-one Support:** The use of AI in teaching and learning in Technical and Vocational Education and Training (TVET) programme can power tutoring system which will in turn provide one-on-one support to students, offering real-time feedback and guidance to the students.
4. **Automated Grading:** The use of AI in teaching and learning process can automate grading, freeing up teachers to focus on more critical aspects of teaching tasks.
5. **Inclusive Education:** AI-powered tools can help to make education more inclusive, providing support for students with disabilities and language barriers.
6. **Accessibility Features:** AI-powered features, such as text-to-speech and speech-to-text, can enhance accessibility for students with disabilities.
7. **Impaired Efficiency:** AI can automate administrative tasks in TVET programme such as attendance tracking and grading, freeing up teachers to focus on teaching. AI can also analyze large datasets, providing insights that can inform teaching practices and improve students outcomes.
8. **Future Education:** AI may charge the role of teachers, shifting their focus from traditional teaching to more facilitative and mentorship roles. AI may also enable new learning models, such as virtual and augmented reality, that can enhance student engagement and learning outcomes during teaching and learning process.

CONCLUSION

The conceptual paper discusses Artificial Intelligence and its impacts on TVET programmes: challenges and prospects. The review of previous studies shows that while AI holds transformative potential in education, its usage in educational field is accompanied by substantial challenges that must be critically addressed. Ethical concerns, pedagogical misalignment, equity gaps, and infrastructural limitations all hinder the seamless utilization of AI in educational field. Rather than a wholesale replacement of traditional education, a hybrid model that combines human pedagogical strengths with AI capabilities underpinned by rigorous ethical and policy framework, is essential for meaningful education innovation that can help in achieving education objective through Artificial Intelligence usage in education.

RECOMMENDATIONS

To tackle the challenges affecting Artificial Intelligence Application in TVET programmes, the following are some measure that could be put in place;

1. Technology such as robotics should be embraced holistically in technical training institution offering programme in TVET in order to complement the service of teachers.
2. Government should ensure that regular workshop programme are organized for teachers on the use of technologies.
3. Government and policy maker in education should ensure that the use of Artificial Intelligence in teaching and learning be enshrined into educational curriculum in Nigeria.
4. Government should ensure that teachers are regularly sponsored for further training on the use of technology such as Artificial Intelligence.

5. Adequate sensitization programme should be sponsored and organized by the government for teachers as to create awareness to them on the importance of technology in educational field.

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