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The Role of Frontier Technologies in Skills-Based Education towards Future Ready Workforce: A Case of Alupe University

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Abstract
Universities are charged with the primary responsibility of developing human capital that meets the job-market demand in terms of knowledge, skills and competencies. Frontier technologies have emerged and are continuously redefining the job-market environment, transformation of traditional job roles as we know them and at the same time, generating new jobs types and roles. Although global statistics show a growing state of unemployment, there is equally a significant number of frontier technology-aligned-job opportunities that have been generated but cannot be filled because of a lack of suitably qualified personnel who fit the job requirements in terms of skills and competencies, an indication of skills-job mismatch in the graduates. The study sought to investigate the role of frontier technologies in skills-based education towards a future-ready workforce at Alupe University. The study adopted a qualitative research design where data was collected through interviews and focusgroup discussions and analyzed by extracting the dominant themes. The results showed that these technologies play seven key roles that include; equipping graduates with Knowledge, skills and competencies for the new work/job environment and emerging job roles, equipping graduates with skills and competencies that ensure entrepreneurial readiness and preparing students for expanded global opportunities; in Remote jobs and Business Process Outsourcing environments among others. These roles are defined to ensure that graduates from these programmes are equipped with knowledge, skills and competencies that address the existing challenge of skills-job mismatch.

Keywords: Frontier Technologies, Ready-Workforce, Skills-Based Education, Employability

1.0 Introduction

The Fourth Industrial Revolution (4IR) has thrustemerging frontier technologies [1], [2] to the core of global development. Technologies such as Artificial Intelligence, Machine Learning, Big Data Science and Analytics, Biotechnology, 3D Printing, Internet of Things, Drone Technologies, Virtual Reality, Augmented Reality, Simulation and Modelling, Quantum Computing, Cloud Computing, Robotics, Autonomous Systems and Blockchain, which are characterized by their disruptive, transformative and high - impact nature, are no longer futuristic concepts. There is exponential growth in the use of these technologies globally; applied in various aspects of daily life, enterprise management activities and routines, and industrial production systems [3], [4] [5]. These technologies are actively altering and redefining global approaches to service provision and goods production, rewriting job-market recruitment

determinants and dynamics, revolutionizing financial transactions in terms of security, flexibility and convenience, and profoundly impacting decision-making processes and enterprise collaborations[6], [7] [8].

2.0 Frontier Technologies: Description and Emerging Applications

Artificial Intelligence [9] is described as the technology that empowers computer systems to perform tasks that would traditionally require human cognitive intelligence such as learning, perception, language communication and deductive reasoning, continues to be applied in healthcare, cyber security, agriculture, engineering design and industrial automation and production. Some of the popular sub-domains of artificial intelligence include; machine learning, Natural Language Processing, Image recognition and computer Vision.

Cloud Computing, a distributed computing paradigm designed to provide on-demand resources that include; storage, computational power, applications and application development environment, on a pay-as-you-use model have been utilized in Banking and Finance, Large-scale data repositories, collaborative work environment and in E-Learning, to provide ubiquitous access to the resources on a 24/7 basis [10].

Internet of Things, an infrastructure consisting of a network of devices (IoT gateways, routers, network switches, firewalls and edge servers), vehicles, appliances and physical objects that are embedded with sensors, software and linked through network connectivity. When integrated with cloud computing infrastructure, IoT has been applied in real-time monitoring, capturing, processing and storage of information; environment and patient monitoring, real-time management smart cities, smart agriculture, supply chain process tracking and management and industrial automation [11], [12].

Big Data Analytics, which refers to computing technologies and processes that enable structured examination and analysis of extremely large datasets to uncover hidden patterns, trends and reveal actionable insights that can be used to automate decision - making. This technology paradigm finds application in healthcare and medicine, Finance, banking and insurance, smart cities and transport systems management and in manufacturing and supply chain systems [13].

The global security challenge, especially with regard to data and information and process transaction security, has led to the growth in adoption of Blockchain Technology. This technology enables the implementation of a decentralized, tamper-proof digital ledger infrastructure that enables secure, automated and transparent transaction management, eliminating the need for intermediaries and guaranteeing immutable transaction records [14]. It has been primarily utilized in secure financial transactions and banking, supply chain and logistics, data protection and smart contracts.

Virtual Reality (VR) is a technology that is used to generate an artificial three-dimensional computer-simulated view that mimics real objects or physical surroundings. This technology aids in training complex concepts in healthcare, the military and in demonstrating concepts that are too expensive or dangerous to execute in a real - world environment [15], [16]. Augmented Reality (AR), on the other hand, enhances a real-world environment by superimposing digital content directly onto it. It is largely applied in scenarios where contextual guidance is needed when executing a task, such as in -ray overlays during actual surgery or in guiding machine assembly or maintenance [16], [17].

Robotics and autonomous systems are intelligent physical systems that are designed, built and deployed to perform physical or computational tasks autonomously, in a contextualized environment. Utilized in manufacturing, logistics, healthcare, and exploration [18], [19].

Drone Technology integrates flight controllers, GPS, sensors, and cameras that enable remote-controlled unmanned aerial vehicles (UAVs) to perform autonomous operations. This technology finds growing application in crop health monitoring and precision spraying, medical distribution, livestock tracking, environmental science mapping and monitoring, cinematography and television, law enforcement, and search and rescue scenarios [20], [21].

3D Printing technology, also called additive manufacturing, creates three-dimensional physical objects from digital model templates, one horizontal layer at a time. It has been utilized in healthcare and the medical field to design and produce prosthetic components, bone imagery to guide metallic implants, in architecture and engineering to erect structural walls or columns, and in automotive or aerospace to design and manufacture custom components [22], [23]

3.0 Frontier technology, evolving job-market and universities' training

Frontier technologies have continued to cause disruption and evolution in the job-market environment, leading to demand for new skills and competencies for the emerging job types [24]. Higher education institutions bear the critical responsibility of equipping the next generation of professionals with advanced specialized technological skills and competencies to meet the evolving global job-market demands [25], [26], [27]. But despite this urgent global imperative, studies have pointed out that there exists a stark systemic gap between rapid technological advancement being witnessed and academic preparation, i.e. skills/competency-job [28], [29]. Institutions have either failed to integrate frontier technologies into their core academic programmes or have integrated them without clearly defining the roles that these technologies would play, towards skills-based education, in the preparation of a future-ready workforce. The inevitable outcome has been the release into the job market, graduates characterized by severe deficiencies in frontier technology skills and competencies required by modern job markets [27], [28].

The emerging job environment dictates that a modern data custodian be equipped with knowledge, skills and competencies in the application of blockchain technology to secure valuable data or transactions. A production engineer must understand the basics of machine learning, 3D printing and, robotic processes to enhance the quality and efficiency in the production or manufacturing processes. A healthcare professional would immensely benefit from knowledge and skills in the application of AI-driven or machine learning diagnostic tools, for specific health contexts. A social scientist specializing in population studies must have a working knowledge of big-data analytics that enables them to extract hidden patterns and trends from silos of data for decision-making, while an education instructor must build competencies in Augmented Reality, Virtual Reality and Generative AI technologies, to improve delivery of complex concepts in their respective areas of specialization.

4.0 Methodology

- This study utilized qualitative research design, where qualitative data was collected and analyzed, using Alupe University as a case study. The study targeted deans of faculty, chairs of departments, faculty, ICT staff, current students and alumni as respondents.
- The data collection method was through both structured and unstructured interviews and Focused Group Discussion sessions. The data was captured through interview notes and audio recordings, which were later transcribed to extract dominant thematic elements relevant to the roles of frontier technology at Alupe University.

- Ethical considerations that included; informed consent, voluntary participation by respondents, obtaining authorization from university management to carry out the study and ensuring that the data collected was utilized for the purpose of the study were fulfilled.
- The choice of Alupe University as a case study was informed by:
  1. It is a young and rapidly growing university that has deliberately incorporated some of the emerging frontier technologies such as Artificial Intelligence, Machine Learning, Data Analytics, Internet of Things among others, into its new or reviewed academic programmes.
  2. Its mission places the "element" of technology at the core of training of its graduates. The mission statement states; "Educate to empower the mind and develop competencies through teaching, research, and community engagement by integration of science and technology." The University boldly emphasizes the "integration of technology" in the training of its programmes.
  3. It is charged with the responsibility of developing human capital, equipped with skills and competencies that meet the evolving job-market needs for the nation and the global community.
- The study in anchored in three major theories:
  1. The Human Capital Theory – which views education and training as investment in personal skills [30].
  2. Skills-Based Technical Change – which demonstrates how new technology increases the demand for high-skilled workers [31], [32].
  3. Resource-Based View (RBV) of the Firm; argues that employee skills as rare and valuable organizational assets and that enterprises will have a competitive edge when staff have skills in new technologies [33].

5.0 Results and Discussion

5.1 Results:

The study identified seven roles of the frontier technologies in skills-based education towards a future-ready workforce:

- Equip graduates with Knowledge, skills and competencies for the new work/job environment and emerging job roles.
- Enables personal agility and versatility in the emerging job-market environment as opposed to the rigid traditional single skill specialization.
- Equip graduates with skills and competencies that ensure entrepreneurial readiness.
- Prepares graduates for Cross-field/Cross-specialization job environments and opportunities
- Building hands-on skills, experiences, tool familiarity and enhancing task confidence.
- Prepares students for expanded global opportunities; remote jobs and Business Process Outsourcing instances.
- Prepares students for targeted Value Chains job openings in the local context.

5.2 Discussion:

Equipping graduates with Knowledge, skills and competencies for the new work/job environment and emerging job roles

Studies [34], [35] have shown that technological advancement is among the key factors shaping employment opportunities globally and that increased adoption of emerging frontier technologies in the work environment has led to a paradigm shift, where a growing number of the traditional jobs continued to completely dissolve, while at the same time, a series of new frontier technology aligned jobs were

rapidly emerging. It has been argued [24] that the need for, and availability of new skills especially in Information Technologies and Artificial Intelligence is impacting job markets. World Economic Forum [36] report reinforces this by pointing out that emergence of new jobs aligned to frontier technologies have led to the need for; specialists in AI Integration, Big Data, Machine Learning, and Cybersecurity. Cornerstone[37] further states that global adoption of Artificial Intelligence and related technologies had led to 1.6 million positions that could not be filled because of skills deficiency, pointing at the disconnect between the traditional education systems and the emerging job market demands. This claim agrees with the position of International Labour Organization [28], on the issue of growing unemployment, which observed that increased graduate unemployment could, in part, be traced to mismatched curricula and industry job-market needs/demands.

In an attempt to equip the graduates with requisite knowledge, skills and competencies aligned with the evolving job-market, Alupe University has incorporated emerging frontier technologies in new/revised academic programmes. This is aimed at addressing the growing global concern, about the need to produce graduates whose skills and competencies align with the realities of the new job environment. Technologies such as Artificial Intelligence, Data Analytics and Blockchain have been integrated in a range of business and finance programmes, while artificial intelligence has been embedded in health science and counselling psychology programmes. Programmes such as computer science, information technology, software engineering and digital forensics programmes have mainstreamed most of frontier technology courses. Evidence from research in the Nigeria context [27] found that knowledge and skills in digital technologies were critical in positioning university graduates for employability in the emerging job market and strongly advocated for integration these technologies into the university curriculum.

Enabling personal agility and versatility in the emerging job-market environment as opposed to the rigid traditional single skill specialization.

Job agility is a critical element in the emerging job market. It has been shown [38] that being adaptive to technology, agility in learning and the ability to proactively navigate a career are critical components of agility in emerging job-market environment. A growing trend where industries are increasingly integrating Big Data Analytics and Artificial Intelligence [39] and as such, graduates are expected to have skills and expertise in the use of these technologies.

The incorporation of frontier technologies in the curriculum is a direct response the employer's growing preference for employees equipped with a range of skills and expertise that extend beyond the traditional single specialization. Competencies and skills in appropriate frontier technologies enhance the ability of the graduates to fit into multiple related or complementary job roles and enable them to easily switch between tasks or job roles in the emerging job-market. This position is informed by the fact that frontier technologies are essential ingredients that aid in overcoming the skills-constrained, traditional single-specialization training strategy [40]. For example, a graduate accountant, auditor or a predictive analyst with knowledge and expertise in how big data analytics, machine learning and AI tools can be applied in their specialization, will make a more effective employee; they can fit in both traditional roles and emerging roles [27], resulting into cost savings for the organization that would have otherwise been compelled to have two employees for these job roles; the traditional job role and the technology job role.

Equips graduates with skills and competencies that ensure entrepreneurial readiness.

The emergence of advanced technologies such as artificial intelligence, cloud computing, blockchain, and the Internet of Things has opened up numerous new possibilities for startups, which create innovative solutions which disrupt traditional industries [41]. Knowledge, skills and competencies in frontier

technologies empower the graduates with the mindset, attitude and confidence to identify and seize emerging frontier technology-aligned innovation opportunities, allowing them to conceptualize, design and launch technology startups as well as actively respond to enterprise or global innovation needs. [42], [43], [44], [45].

By incorporating frontier technologies into the curriculum, the university aims at producing graduates who are empowered to respond to the emerging innovation opportunities and contribute to the creation of employment opportunities through startups and innovative ventures. The graduates can leverage frontier technologies such as artificial intelligence, the Internet of Things, Machine Learning and cloud computing to enable quick prototyping of technology innovations/solutions and facilitate easy entry to the global market [46], [47]. This supports the arguments [48] that if Africa is to create the tens of millions of quality jobs its young people need over the coming decade, it must pivot decisively from input-driven growth to innovation-led growth powered by data and frontier technologies.

Prepares graduates for Cross-field/Cross-specialization job environments or opportunities

The university holds the position that incorporating frontier technologies in the academic programmes ensures that other areas of specializations such as; humanities, health, business or education blend with emerging trends in technology. This equips the graduates with technological knowledge, skills and competencies that enable them to competently utilize the technologies as well as guide implementation and/or adoption of these technologies in their respective areas of specialization, while adhering to ethical provisions that relate to these technologies in law [27]. This position aligns with observations made [49] where, in an increasing number of cases, employers tend to target graduates with a higher level of skills in digital technologies for employment. Furthermore, recent studies [27], [50] have shown that skills in frontier technologies are highly sought after and that a lack of skills in these emerging technologies limits the chances of securing gainful employment for graduates.

Building hands on skills, experiences and tool familiarity

The decision to incorporate these technologies in the curriculum is informed by the need to address the gaps in skills, competencies and hands-on skills needed for certain tasks, in the various fields of specialization.

Frontier technologies such as Artificial Intelligence, Virtual Reality, Augmented Reality, Cloud Computing and Internet of Things enable the mimicking of the real-world environment. This capability enables utilization of these technologies as training tools/platforms in various fields of specialization; they provide the students with a suitable practice environment that equips the students with hand-on skills, competencies and experiences, enabling; perfecting their practical skills, building their task-confidences and shaping their attitudes towards performance and management of complex tasks that require high levels of precision in execution.

Learning environment that utilize frontier technologies such as Virtual Reality and Artificial Intelligence tools provide a training platform that is free of risk, enabling the students to continuously experiment with tasks that are delicate, complex and risky[51], which perfects their levels of precision in task execution and enhances their decision making capabilities in complex and high valued job tasks such as surgery, military operations and aircraft piloting [52]. Further, these technologies enable contextualized learning, in-depth understanding of complex concepts, enhanced confidence in performing of complex tasks and appropriate application of practical skills [53], [54], [55].

Prepares student for expanded global opportunities; Remote jobs and Business Process Outsourcing environments

Growth in internet penetration coupled with digital collaborative tools and the availability of frontier technologies such as cloud computing, big data analytics, machine learning and artificial intelligence, in both developed as well as emerging economies, presents a timely platform for remote-job opportunities and Business Process Outsourcing (BPO) for graduates and global enterprises. ZipRecruiter [56] argues that AI, IoT, Cloud Computing and Blockchain are the key frontier technologies that position graduates to thrive in remote job environment. World Economic Forum[57], [58], pointed out that digital literacy and the knowledge and skills in the use of AI, Data Analytics, Cloud Computing and Desktop conferencing are key in facilitating technologies for the success of remote job roles. Skills and expertise in AI and automation tools have been found to enhance remote work [59].

By embedding frontier technologies in the academic programme, the university has made deliberate efforts towards equipping the graduates with highly portable skills that allow them to respond to remote job opportunities in the international job markets as well as take advantage of the numerous Business Process Outsourcing (BPO) opportunities.

Prepares students for targeted Value Chains.

There are documented global attempts to align education and training with specific promising economic sectors. For example, governments and large private corporations in various sectors of the economy have been observed to prioritize investing in specific frontier technologies; in robotics, promote modernized farming and livestock management, in AI-assisted big-data analytics to automate decision making such as in controlled irrigated environments and in Internet of Things for continuous monitoring and generating of intervention alerts [60], [61], [62]. The growth in financial trading financial Markets may prompt the inclusion of frontier technologies that are able to perform predictive analytics in order to guide efficient practices and accuracy of in decision making especially in fluid and dynamic environments such as financial markets, to address the need for efficiency and accuracy in decision making [63].

For example the growth of financial technology in Kenya continues to inspire institutions to include in their programmes, frontier technology courses that are tailored to produce graduates who shall fill the gaps generated by the growth of such specific value chain.

The school of Business, Economics and Human Resources Development developed an undergraduate degree programme in “finance and technology,” which aims at grounding students in traditional financial practices but at the same time equipping them with skills and competencies in frontier technologies such as Artificial Intelligence, Machine Learning and Blockchain, which enable the graduates to fit in and make significant contribution to the growing financial technology niche as experts who can build solutions, advisors who can shape decision making and/or entrepreneurs who respond to market gaps with financial technology solutions.

6.0 Conclusion

Global evidence points to a rapidly transitioning job-market environment, which requires a transformation of the approach to development of Human Capital. Institutions of higher learning must invest significantly in structures, strategies and technologies for training human resource personnel who shall be equipped with skills and competencies that address the job-market evolving needs. Appropriate skills and competencies must be defined, suitable frontier technologies identified, courses for each frontier technology developed and embedded in the academic programme and learning facilities and equipment

provided to support training in these technologies, in line with the demands of the job-market. Clearly defined roles would be a beacon that guides the training and production of qualified graduates to fill the job-market gaps.

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