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Virtual Reality: A Tool for Improving the Teaching and Learning of Technology Education

Onele Nicholas Ogbonna

Abstract

This work dealt with technology education, its expectations and present state, especially in developing countries. It looked at virtual reality: its development, types, uses and how it can be applied to improve teaching and learning. It also looked at different works that compared virtual reality, and other educational technology tools were reviewed. Advantages of virtual reality were highlighted; these will include both social and academic issues. Immersive and non-immersive virtual reality for education were briefly discussed, looking at the applicability of each to teaching and learning, ease of use, cost-effectiveness and health implications.

Keywords: virtual reality, technology education, virtual environment, virtual reality components, educational technology

1. Introduction

Technical Vocational Education and Training (TVET) is a globally recognized process for preparing people for dynamic engagement in occupations of functional value. It is an effective source of skilled workforce. It is an effective tool for employment generation, wealth creation and crime reduction. UNESCO [1] defined TVET as all forms and aspects of education that are technical or vocational in nature and skill oriented, provided either in educational institutions or under their authority, by public authorities and private sectors or through other forms of organised education, formal, informal or non-formal, aiming to ensure that all members of the community have access to the pathways of lifelong learning. TVET is defined as an integral part of general education which prepares its recipients for occupational fields and effective participation in the world of work. It is an aspect of lifelong learning and a preparation for responsible citizenship, which helps to promote environmentally sound sustainable development and facilitate poverty alleviation. The goal of TVET is to fight indolence, develop skills, provide knowledge and build attitudes required for entry and progressing in any chosen occupation.

However, TVET today faces huge demands globally due to high level of unemployment. Access to skill acquisition is low in relation to the potential trade. High educational entry requirements exclude the majority of youths and young adults. Female participation is relatively low in TVET and concentrated in female-dominated occupations. Geographical imbalances also exist—with low enrolments in rural and low-income areas [2]. The quality of TVET graduates has been portrayed

as extremely low, as the majority graduate without employable skills. They lacked the applied technical skills necessary for solving problems and enhancing business productivity and knowledge required by industry. Therefore, they cannot take advantage of available employment opportunities; neither can they create employment, due to gross skill deficiency [3]. Low performance of candidates on terminal examinations is symptomatic of low quality. And symptoms of faulty TVET training include mismatches between supply and demand, employer complaints and low employment rates for graduates. For TVET to achieve its envisaged objectives, it must be properly strengthened (UNESCO, [4]; United Nations, [5]).

The infrastructure needed to deliver quality and practical oriented TVET courses requires huge investment in capital. Both hard and soft infrastructure is needed to prop up the system. Challenges of attaining quality TVET programmes have been discovered to include lack of required TVET facilities, poor funding of TVET programmes and the use of obsolete facilities. Inadequate funding may have been indicted in the poor infrastructural support needed to drive quality delivery of TVET courses [3]. This limitation frustrates the integration of entrepreneurship and practical skills in TVET programmes especially in developing countries. The lack of support infrastructure and infrastructural failures results to high transaction costs which makes delivery very expensive, and since economy has not been friendly, inefficiency has prevailed.

Puyate [6] pointed out that the present state of vocational and technical education facilities is very poor; there is no planned means of maintenance of the already broken-down equipment or means of purchasing new ones, and there is little or no concern on the part of government, teachers and students for the improvement of the present state of teaching facilities. This limits effective skill acquisition by students leading to production of unskilled TVET graduates who cannot fit into gainful employment. Surveys show that only about 40% of TVET institutions of higher learning have laboratory or workshop space for technical education programmes and that the other 60% do not have laboratory or workshop space and that this reflects the low quality of technology programmes in higher institutions. He further noted that these few universities that have laboratories experience acute shortage of laboratory equipment and supplies. Puyate (4) concluded that this situation is partly responsible for the reason why it has been increasingly difficult to run experiments effectively for students and made the teaching and research in science and technology difficult, and therefore the country was producing insufficient and ill-prepared technical education graduates necessary for driving the technological and socio-economic development of this nation. Uwaifo [7] lamented that due to inadequacy of instructional facilities, only a small proportion of the students benefit from the current pedagogical system used in developing countries like Nigeria, especially in technical and vocational education. Unavailability of facilities has caused the use of ineffective methods of teaching and learning. There is dearth of ICT facilities for the training of students. Access to affordable and reliable Internet connectivity is only available in a few institutions, faculties and offices, and power fluctuations and deficient bandwidth have considerably reduced reliability of the access and made things difficult [7].

There are basically two branches of TVET: the technical and vocational areas. Effective teaching and learning of any branch of technical and vocational education can be made easier and interesting through the use of appropriate and adequately provided learning facilities as well as the adoption of the right teaching and learning methods. Inadequacies in teaching, as well as laboratory and workshop facilities, have contributed in no small measure to the diminution of the quality of technical education graduates. Uwaifo [7] lamented that only a small proportion of the students benefit from the current system used in technical and vocational education,

proving that only those who learn easily if information is in written or spoken form (verbalizers) can learn in the present situation. This calls for a more effective method in an encouraging environment. Virtual reality has been found effective for learning in different fields and for different types of learners.

2. Virtual reality

Virtual reality is a computer-generated, three-dimensional, multimedia environment. Virtual reality is an environment produced by a computer that looks and seems real to the person experiencing it [8]. It means experiencing things through computers when such things did not really exist [9]. It is a simulation of a real or imagined environment that can be experienced visually in the three dimensions of width, height and depth and that may additionally provide an interactive experience visually in full real-time motion with sound and feedback [10]. Virtual reality, therefore, is a computer-simulated, game-based learning environment, which appears real and gives learners the opportunity to interact with the learning materials and share learning experiences with both their teachers and other learners. In virtual reality, human participants can engage and manipulate simulated physical elements in the environment and interact with fictional or simulated components. Virtual reality allows the user to perform actions and observe their consequences but without penalties as experienced in real situations.

Virtual reality can be traced back to the nineteenth century. The term "virtual reality" was first used in the mid-1980s when Jaron Lanier, founder of VPL Research, began to develop the gear, including goggles and gloves, needed to experience what he called "virtual reality." But before then, some technologists were developing simulated environments. A major landmark was made in 1956 when the Sensorama was built. Morton Heilig was interested in using it for the Hollywood motion picture industry. He wanted people to get the feeling of being in the movie. The Sensorama experience simulated a real city environment, which one could ride through on a motorcycle. The rider experiences a multisensory stimulation, which provides the opportunity to see the road, hear the engine, feel the vibration and smell the motor's exhaust in the designed virtual world. In 1960, Heilig patented a head-mounted display device, called the Telesphere Mask.

In 1965, another inventor, Ivan Sutherland, built upon the foundational work of Heilig to achieve "the Ultimate Display," a head-mounted device that he suggested would serve as a "window into a virtual world." The 1970s and 1980s were a heady time in the field. Optical advances in the 1970s and 1980s produced haptic devices and other instruments that would allow you to move around in the virtual space. For example, in the mid-1980s, the Virtual Interface Environment Workstation (VIEW) system was built by NASA to combine a head-mounted device with gloves to enable the haptic interaction.

The evolution of virtual reality has provided means of carrying out experiments which would not otherwise be possible owing to availability, accessibility and cost of equipment, tools and materials, as well as safety of human and material resources. Although virtual reality does not replace real objects, it helps to carry out experiments before it is done in the real world. It has been proven to contain a feature which appeals to every faculty of learning. Virtual reality can be used to simulate a real environment for training, education and an imagined environment for interaction [9]. Virtual reality proved effective when used to augment physical facilities for learning in many fields, like teaching architecture [11]; teaching physics [12]; welder training [13]; teaching painting [14]; teaching physical education [15–18]; training in fire safety [19]; teaching safety rules [20–22]; teaching electric

power supply systems [23]; teaching biology [24]; and teaching electronic circuit construction [3], among many others. In virtual reality, students can work at their own pace to master the skills needed, get periodic feedback and have the opportunity to correct their mistakes without loss of materials, damage to equipment and injury to human beings and materials [25]. Virtual reality provides an opportunity to accurately and realistically simulate dangerous or risky situations and make them safe for learning before engaging in the real situation. Virtual reality can deconstruct complex procedures into convenient actions with each student learning at a different pace [26]. It helps in visualisation of complex concepts and theories as well as exploration of virtual scenarios in the form of real-world settings. It stimulates interaction, ensures that learning is fun and enjoyable and permits cost-effectiveness [27]. Virtual reality encourages students' participation, reduces distractions and increases attention span of students. By doing so, learning of technology education may become a more interactive process, playful and experimental—like the action-oriented approach of learning. The fondness of young people on computer games gave credence to the adoption of virtual reality as an educational tool [3, 28, 29] for teaching and learning of technology education.

There are two principal ways of using virtual reality in the classroom. The first way involves a traditional desktop set-up. This form of virtual reality is called desktop, fish tank [30, 31] or simply non-immersive virtual reality [3] and used interchangeably in this study. Desktop virtual reality is presented on an ordinary computer screen and is usually explored by keyboard, mouse, wand, joystick or touch screen [32, 33]. The second way is the immersive system. Immersive virtual reality is presented on multiple, room-size screens or through a stereoscopic, head-mounted display unit [34]. Additional specialized equipment such as a data glove enables the participant to interact with the virtual environment through normal body movements. Sensors on the head unit and data glove track the viewer's movements during exploration and provide feedback. This environment may take the form of a series of large screens or a complete cave automatic virtual reality system [35].

Desktop virtual reality is quite affordable as compared to immersive virtual reality, thereby making the choice suitable for studies in medium-income economies as experienced in developing countries. Besides, there is no overwhelmingly conclusive evidence that immersive systems are more effective in educational applications than their non-immersive counterparts [34]. Rather, the non-immersive virtual reality is much more mature and widely used in different educational areas as compared to the immersive virtual reality which is cumbersome, expensive and occupies much space [36]. Studies have shown that desktop virtual reality technology can enhance academic achievement [3, 37–40]. Moreover, there are unresolved questions relating to health and safety issues, such as motion sickness, simulator sickness and perceptual shift that arise in the use of immersive virtual reality systems [41–43]. Literature revealed headaches, nausea, balance upsets and other physical effects of head-mounted device systems. One other concern is the potential side effects and after effects of virtual reality exposure. Some other effects could include cybersickness, a type of motion sickness caused by the virtual reality experience, perceptual-motor disturbances, flashbacks and generally lowered arousal [44]. Desktop virtual reality is user friendly. Woodford [9] emphasised that desktop virtual reality is collaborative, unlike its immersive counterparts. Collaboration is a vital aspect of effective learning in skill-related fields like technology education.

Youngblut [36] conducted an extensive survey research on educational uses of virtual reality technology. Youngblut's study found unique capabilities of virtual reality in boosting academic achievement. This study showed potential educational effectiveness even for students with special needs. The role of the teacher changed from director of learning activities to facilitator. It was reported that students

enjoyed using predeveloped applications and developing their own virtual worlds. The majority of the teachers in the studies reviewed said they would use virtual reality technology if it were affordable, available and easy to use for students and teachers. Chen [45] carried out an experimental study titled "Virtual Space and Its Effects on Learning." The aim of the study was to find out how virtual reality can influence the learning of technology skills. The study showed that virtual reality is an effective tool for teaching and learning skills. However, Chen [45] asserts that although virtual reality is recognized as an impressive learning tool, there are still many issues that need further investigation including identifying the appropriate theories and/or models to guide its design and development, finding out whether its use can improve the intended performance and understanding and investigating ways to reach more effective learning when using this technology and its impact on learners with different aptitudes. Lee et al. [24] researched on learning effectiveness in a desktop virtual reality-based learning environment. The learning effectiveness was measured through three specific purposes: academic performance, perceived learning and satisfaction. There was a significant difference in the academic performance, perceived learning and satisfaction between the two groups. It was concluded that the virtual reality instructional programme positively affected the students' academic achievement and their perceived learning quality and satisfaction. The study of Lee et al. [24] helped to justify the desktop virtual reality for this study.

Onele [46] carried out a study on effects of teaching methods in virtual reality on the interest and academic achievement of electronic technology education students in Nigerian universities. It adopted a pretest-posttest quasi-experimental design. ElectricVLab designed and supplied by Quality Assurance International LLC, Massachusetts, in the USA, was used to provide the virtual learning setting for students to learn electronic technology education. The study found that student achieved high with virtual reality; there was no significant difference between the achievement of male students in demonstration and their counterparts in peer tutoring class. However, female students in peer tutoring class achieved significantly higher than their counterparts in the demonstration class. Moreover, students from both classes indicated high interest in the study of electronic technology education using virtual reality. The research identified a significant interaction effect between teaching methods.

It is true that virtual reality has existed for decades; its use is new to education, especially in developing countries. Research on applications of virtual reality technology to education is in its infancy, especially in Africa [47], and for teaching and learning in industrial-related training like technology education [3]. Such a situation presents both challenges and opportunities for instructors and researchers interested in virtual reality technology. One of those challenges is the selection of right teaching methods when virtual reality is involved. Some of the studies were on how to arrange lessons, how these arrangements affect students' behaviour, and in the long term, how they affect students' academic achievement. Yet, there does not seem to be a sufficiently conclusive and prescriptive body of research to guide the instructional method and classroom facilitation of virtual reality technologies [3, 48–51]. Researchers lamented dearth of empirical evidences to help instructors make the right choice of teaching methods in virtual reality [52–54]. Thus, researchers and educators interested in classroom uses and methods in virtual reality technologies do not yet have either a sound theoretical framework or a strong body of empirical data from controlled experiments with which to work. Anderson [55] believes that the use of virtual reality as a learning environment will require a thorough pedagogical consideration by educators in order to choose the most appropriate and suitable teaching methods, especially for teaching and learning of technology education.

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