Experiential learning through Virtual and Augmented Reality in Higher Education

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ABSTRACT

Educational technology can enhance learning by supporting the learning environment through various digital resources. There have been numerous emerging technologies which are able to bridge the resource gap in learning environments enabling students to get access to an abundance of resources on digital platforms. This paper presents a literature review, exploring the potential of using Mobile Augmented Reality (AR) and Virtual Reality (VR) technologies to support experiential learning in South African institutions. While there have been studies which aim to assess the use of AR and VR for educational purposes such as in mining safety education in South Africa, there is a need for studies that look at the potential of AR and VR in augmenting higher educational institutions such as universities and Technical and Vocational Education and Training (TVET) colleges which require students to complete an experiential learning component in their studies in order to complete their qualifications. The study aims to establish the potential role that AR and VR can provide in enhancing experiential learning by providing students with practical experience in various educational fields, leveraging augmented and virtual reality technologies to simulate such learning environments.

CCS Concepts

• Applied computing➜Education➜Interactive learning Environments

Keywords

Augmented Reality; Virtual Reality; Experiential Learning; mobile learning; South Africa

1. INTRODUCTION

Various South African schools as well as higher educational institutions face infrastructure challenges such as a lack of computer and science laboratories which lead to an absence of

practical learning experiences in subject areas that require such infrastructure [8]. Technology affords us the opportunity to leverage its unique offerings to augment resources in educational institutions. Much like many electronic learning (e-learning) technologies, augmented and virtual reality technologies provide lecturers with a platform to support the teaching and learning process which caters for students' various learning styles [4]. In resource-constrained environments, technology is also able to bridge the gap of resources by providing a wealth of open platforms which educational institutions can access.

Furthermore, various studies have outlined the potential of mobile and electronic devices as digital platforms which students often have access to in comparison with desktop computers in order to access learning resources ([9]; [5]). Similarly Augmented and Virtual Reality are able to provide practical virtual resource components to a teaching environment enabling students to attain practical experience as part of attaining the learning objective. This paper looks at the potential of using AR and VR in academic programs which require students to complete an experiential learning component in their education before they attain their qualifications. Higher educational institutions such as universities and Technical and Vocational Educational Training (TVET) colleges in South Africa have academic programs which require students to have a substantial experience as part of their learning component. Such programs can create challenges for both academics and students in under-resourced environments where gaining access to experiential learning infrastructure resources can be costly and at times inaccessible.

While there have been various studies which amplify the advantages of e-learning technologies in a South African context [3], the role of augmented and virtual reality in supporting experiential learning in the same context is a fairly novel concept which builds on existing e-learning use in education findings. The South African higher learning institution landscape provides a unique platform which has enabled e-learning policies and in many campuses, infrastructure and human resources to support the e-learning use by academics [14]. Through a literature review, this paper aims to analyse the potential role of augmented and virtual reality technologies in supporting experiential education particularly in fields such as dentistry where the experiential learning component is compulsory as part of the academic offerings in higher learning institutions. The paper aims to establish how AR and VR technology can be used to enhance the process of teaching and learning by leveraging on the benefits of electronic learning technologies.

2. DEFINING AUGMENTED AND VIRTUAL REALITY

Augmented and virtual reality technologies are immersive technologies which can provide real as well as virtual immersive experiences. These technologies can be accessed either through electronic devices such as mobile phones, head mounted gear or a Cave Automatic Virtual Environment (CAVE). There are various companies which manufacture AR and VR hardware platforms as well as various software companies which develop accompanying software to be used on the various hardware platforms. A CAVE is a dark room which enables people to wear AR glasses and be fully immersed in the virtual world with the dark room adding an extra effect to this virtual setting [7]. Augmented Reality (AR) is the use of mobile technologies used to overlap a real world environment by visually superimposing and connecting a present view with virtual objects ([1]; [2]). In figure 1, the Microsoft HoloLens augmented reality glasses are used to supersede reality by creating a view which allows the participant to virtually move nails from one container to the other. In this image, the student is playing an educational game which requires them to pick and place virtual nails superimposed or visible on the real nail storage boxes.

Figure 1. Microsoft HoloLens providing an augmented view of nails

Virtual Reality (VR) can be defined as the use of mobile technologies to provide a visual representation of a virtually immersed environment devoid of the external real world environment. In a virtual reality environment, the user of the mobile device is unable to view the external world thus interacting only with the virtual environments viewable through the mobile hardware such as a head mounted gear. While AR and VR provide environments which can enable students to be immersed in their learning process, they also present challenges.

The cost of various mobile head mounted devices as well as CAVE rooms, are often expensive [7]. Considering this, if educational institutions do not have a strategic perspective to use AR and VR environments to support learning, CAVE's are often expensive and allow only for a limited number of people within the room. Equally, head mounted gear such as Microsoft HoloLens are also often expensive with the 2018 price currently estimated at $3000 per set. These present an opportunity to use mobile phones as potential devices to utilize these technologies especially considering the high penetration rates of ubiquitous devices in South Africa. There are often limited software development as well technical expertise to support the development of such technologies tailored for a specific learning scenario. In considering this challenge, our study aims to use on campus experts as part of the newly established immersive skills academic programme.

3. VIRTUAL REALITY IN DENISTRY EDUCATION

Within the field of dentistry, clinical proficiency will require students to not only have theoretical knowledge, but to also have practical clinical experience. [6]. [13]. Considering the high cost of both equipment as well as human resources needed to ensure clinical competency of dental students, it is important to ensure that students complete such pre-clinical training. Coupled with recent technological advances, the realisation that the clinical setting is not always an ideal environment for skill training is leading to an increased use of computer applications in healthcare education [13]. A series of technology-based platforms and approaches have thus emerged to address these problems in recent years which include AR and VR technologies [6].

[6] conducted an extensive study on the potential use of such technologies to support experiential learning within the dentistry field, reflecting on some of these technologies:

- DentSim is a technology which enables students to gain an experiential learning component of clinical procedures on a simulated patient, which simultaneously allows the lecturer to track the student performance while being able to provide feedback to the student in their process. The simulation offers the possibility of providing practice in a realistic environment filled with detailed, frequent and objective feedback.

- The Virtual Dental Patient is a virtual reality simulated system enabling students to gain practical experience of the tooth drilling procedure. Students are able to visualize the tooth with cavity and in the process use the relevant tools to practice this procedure.

- Virtual Reality Dental Training System also uses virtual reality 3 dimensional simulation to enable students to experience restoration of procedures with related sets of dental instruments.

In providing an experiential learning opportunity for students, both virtual and augmented learning have been proven to be effective e-Learning supports. Virtual and augmented reality technologies can be used to simulate and assess clinical techniques. They provide unlimited access to practice sessions, along with the quick feedback needed for effective learning while also allowing for a standardised assessment of the skills acquired by students [6].

In conclusion, the technologies of virtual and augmented reality are well placed to introduce innovation to clinical training. VR systems overcome the limitations of phantom head systems by providing standardised cases, objective assessment and full interactivity. Moreover, VR and AR systems encourage the use of reflective forms of assessment that involve students in the self-assessment necessary to identify individual learning needs and heighten self-directed learning. In providing a new set of pedagogical tools, the more widespread use of virtual reality in dental schools would surely increase the quality of the educational process.

4. DEFINING EXPERIENTIAL LEARNING IN HIGHER EDUCATION

In this paper we identify experiential learning as an important learning theory which can be used to enable the use of AR and VR in supporting the experiential learning process. The role of technology in education cannot be realized without defining its function. Technology is often adopted in educational institutions to enhance teaching and learning process as well as ensure access to resources for students [9]. Furthermore mobile and electronic learning technology can be seen as an enabler in under-resourced environments providing access to digital resources on student's mobile phones [5]. In this paper we explore the role of augmented and virtual reality in enabling learners to attain experiential learning objectives through immersive technologies. The experiential learning theory can be defined as "the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience" ([11], p. 41). [11] proposed an experiential learning cycle of four stages are:
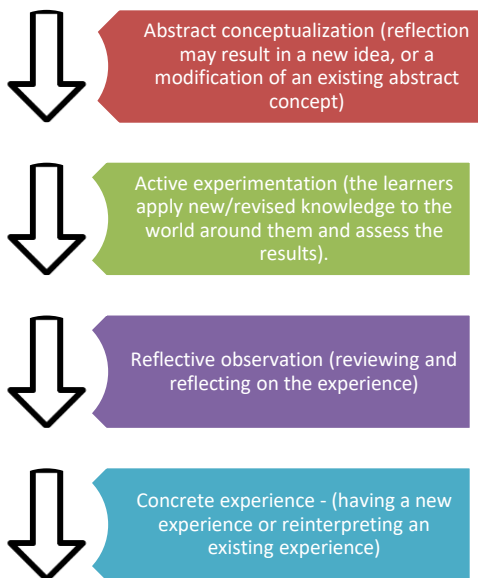
Abstract conceptualization (reflection may result in a new idea, or a modification of an existing abstract concept)

Active experimentation (the learners apply new/revised knowledge to the world around them and assess the results).

Reflective observation (reviewing and reflecting on the experience)

Concrete experience - (having a new experience or reinterpreting an existing experience)

Figure 2. Experiential learning phases [11].

In figure 2, experiential learning requires a student to be able to conceptualize, actively experience, be able to reflect as well as have reinterpret their experience. Experiential learning can further be defined by the central role which experience plays in achieving the learning outcome. A student is thus transformed or educated through a transformative process of acquiring knowledge. It provides a student with an opportunity to immerse and provide concrete experiences which enable the student to transform their perspective and approaches in the learning process [12]. There are many academic offerings in educational institutions which require students to complete an experiential component in order to attain their quantification. These include educational, mining, dentistry, medical qualifications as well as teaching qualifications. In this paper we explore the potential role of Augmented and Virtual Reality in supporting experiential learning in various fields with a focus on dentistry field. In developing the relevant VR technology, students can thus be immersed in learning environments which allow them to also gain learning experiences.

5. TOWARDS EXPERIENTIAL LEARNING WITH VIRTUAL REALITY

In this section we evaluate the intersection between experiential learning, pedagogy and potential Augmented and Virtual Reality technologies. The following section outlines figure 3:

5.1 Hardware

Head mounted gear: With the advent of advanced head-mounted gear consisting of gyroscopes and technologies that allow additivity, learning in both situated and mobile contexts has become easier with companies releasing devices such as the HTC vive, the Oculus rift and the easily accessible VR casing which allow you to use mobile phone devices within the gear casing. Furthermore, the use of sensors allowing interactions of accompanying joysticks enable the possibility to use software that allows full student interaction in the task presented to them.

Mobile phones: Developing countries have some of the highest use of mobile phones in comparison with other technologies such as laptops. There are currently many open source as well as proprietary applications developed to support teaching and learning using Augmented and Virtual Reality on mobile phones.

5.2 Software

Pedagogy: In developing software that will be enabled by adaptive technology, there is an opportunity to enable adaptive learning experiences while supporting the pedagogy outcomes set out in the student experiential learning tasks. The Visual, Aural, Reading and Kinesthetic (VARK) model [15] outlines that in considering pedagogy approaches, learning can occur in visual form, aural, reading and writing as well as kinesthetic form. These characteristics described by the VARK model enable pedagogical outcomes which can benefit from the features of AR and VR technologies as they enable software to be developed and presented in this form.

5.3 Experiential learning

As students are able to interact with the tasks presented to them, their experiences are personal in the learning process. Allowing them to construct their own learning experiences through abstract, active and reflective experience. Applications can also be developed to enable the application of concrete experiences in order to evaluate the extent of understanding of users.

Real-time interaction and real time feedback with each interaction enable students to create, reflect and apply their knowledge gained.
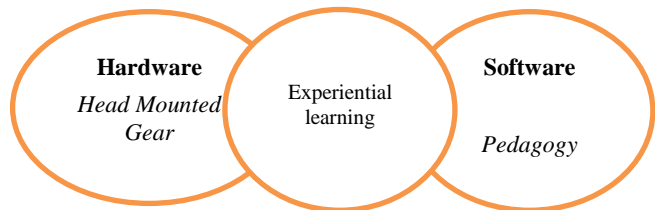
Hardware *Head Mounted Gear*

Experiential learning

Software *Pedagogy*

Figure 3. Using augmented and virtual reality to support the experiential learning process.

6. SUMMARY

This paper sought to highlight the potential of VR and AR technologies in enhancing teaching and learning at higher education institutions, with a particular focus on dentistry, a field that requires a high investment in providing appropriate resources in the training of student dentists. VR and AR technologies may

be viable alternatives to the traditional provision of physical resources including expensive infrastructure that students require to put theory to practice. In addition, these technologies show pedagogical promise of deepening students' learning experiences, allowing for more opportunity for work integrated learning experiences and reflection. They also provide for a more dynamic approach to learning rather than limiting such opportunity within the traditional confines of the lecture room, laboratory or community oral clinic. These technologies therefor align with the increased pressure on education institutions to innovate their modes of teaching to meet the demands of an ever-changing student demography that is increasingly reliant on the use of technology in learning and living. Notwithstanding the challenges that are posed by these technologies, their potential benefits are both economical as well as pedagogical in nature. In leveraging off the widespread accessibility of mobile platforms such as mobile phones which students in higher education often have access to, AR and VR provide an opportunity to enable ubiquitous experiential learning. There have been various studies which outline the use of digital technologies in enabling students to attain experiential learning during the process. One such example is the use of digital gaming technologies which are tailored to immerse the student in the learning environment enabling them to attain their learning outcomes [10]. [10] Further presents a gaming model which could potentially leverage digital technology to achieve experiential learning. In a study conducted by [9] mobile learning platform related studies found that such platforms are able to increase learner's interest in their study engagement as well as enable authentic learning. AR and VR are able to provide immersive platforms which with the relevant software technologies can be used to immerse students in practical learning environments. In under-resourced environments which require students to have a substantial experience in their qualifications AR and VR can provide a potential mobile learning platform which can achieve what is required from students before completion of their studies. In our next studies we continue to establish the possibility to using Virtual reality software and platforms to ensure students gain learning experiences.

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