Lecturers' Perceptions of Virtual Reality as a Teaching and Learning Platform

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Abstract. Virtual Reality (VR) is increasingly being acknowledged as a useful platform for education. In South Africa, however, VR is mainly recognized as an entertainment platform. Hence, the potential benefits of VR and its perceived ease of use within the South African higher education setting have not been widely investigated. Therefore, using the Technology Adoption Model (TAM), this paper investigates the perceived usefulness (PU) and ease of use (PEOU) of VR by lecturers. This paper also identifies the perceived challenges to the adoption of VR as a teaching and learning platform from a higher education perspective, and suggests how those challenges may be overcome.

Keywords: Virtual Reality · Higher education · Lecturers

1 Introduction

Education is vital for social, political and economic development of any nation. Therefore, effective teaching is essential and should be based on assisting students to advance from one knowledge level to another [26]. The evolution of technology has created interactive environments for education that now include immersive and interactive three dimensional (3D) learning platforms that are recognized as Virtual Reality [12]. According to [5], Virtual Reality (VR) may be defined as the collection of technological hardware and software that aid in the creation of immersive environments. The VR immersive environment is experienced through devices and components such as computers, head-mounted displays, headphones, and motion sensing gloves [26]. VR is increasingly being recognized as a useful platform for education [36]. VR draws on the strengths of visual representations and provides an alternative method for presenting of course-related content that could enhance teaching and learning. VR caters for students with different learning styles and hence, enhances teaching and learning [30].

South Africa (SA) has recently joined the VR revolution. Therefore, some organizations in SA are competing extensively to be recognized in the VR international market [27]. According to [27], these SA organizations produce VR

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devices for use and adoption in fashion and entertainment such as music and gaming. However, VR adoption in SA educational institutions is slow and stagnating according to [28] and research pertaining to the adoption of VR in South African higher institutions is very scarce. This paper attempts, to a limited extent, to address the research gap posed by the scanty literature on VR adoption in South African higher education. It specifically seeks to establish the perceived usefulness and ease of use of VR and the challenges to its adoption from lecturers' perspective.

2 Related Work

The applications of VR in education include, but are not limited to, the use of VR for simulation-based education in the fields of engineering, physical science, and medicine, the use of VR to assist students with disabilities, and the use of VR in gaming [21].

2.1 VR for Simulation-Based Education: Engineering and Physical Science

VR use for simulation-based education in engineering and physical science allows students to utilize equipment and machinery safely for experimental, practical and self-study projects [1,44]. According to [37], Tecnomatix Jack, RAMSIS Automotive, DELMIA Ergonomics Task Definition, SAMMIE, and Santos Human, are some of the VR systems that are used to develop prototypes in the field of engineering. These VR systems assist students in areas such as the automotive industry with the retention of information pertaining to automotive techniques [37]. Similarly, a virtual environment created by the University of Westminster for students of criminal law allowed them to hunt for clues to construct a murder case [19]. In this virtual environment, students can walk around a building and identify the type of crime committed instead of reading witness statements. Students' information retention increased because of the practical exposure in the simulated crime scene [19]. However, another study concluded that not all students are able to retain information obtained from the relevant virtual environment [43].

2.2 VR for Simulation-Based Education: Medicine

VR is utilized in medicine to train students to become nurses, doctors and or surgeons by creating a safe environment where students can practice medical procedures [2]. According to [29], in the VR environment, medical students can safely make errors; they can also gain feedback and standardized experience. A VR system, *Anatomic VisualizeR*, was developed at the University of California for medical students [17]. This VR system contains several 3D anatomic models and allows students to virtually dissect the models. A similar virtual anatomy project, 3D Human Atlas, was developed in Japan to assess students' understanding of the human anatomy [16]. According to [35], VR systems that are based on anatomy allow students to gain experience and feedback. Similarly, VR enhances medical education by standardizing training and providing students with the opportunity to repeat tasks until competency is reached [34].

2.3 VR for Assisting Students with Disabilities

People with disabilities often display limited or no skills necessary for independent living, improving cognition, and practicing social skills [3]. Studies exploring virtual environments as an aid to the acquisition of skills to support people with disabilities have looked at the aspects of grocery shopping, food preparation, orientation, crossing the road, and vocational training [40]. The following paragraphs will focus on the use of VR to assist students who have physical and/or intellectual disabilities.

Physical Disabilities. VR environments developed for people with physical disabilities enable them to develop their navigational skills [9]. For example, a virtual environment that simulates a busy street or shopping center may be used to prepare the physically disabled for a real-life setting. Similarly, physically disabled students can gain knowledge from the virtual environment on how to move around and avoid obstacles in the virtual setting before putting the knowledge into practice in the real world [39]. Food preparation is another aspect looked at to assist with the development of skills. The virtual environment described by [6] was used to teach food preparation to physically disabled students. This environment was based on an actual kitchen setting in which half of the participants were already undergoing a college training course for catering. Students showed significant improvement on the tasks they had learned in the virtual kitchen as compared to the real kitchen environment. However, [41] found no difference in improving learning between virtual and real training environments.

Intellectual Disabilities. Intellectual disabilities consist of learning and cognitive disabilities [40]. The use of VR for autism, a type of learning disability, allows autistic students to be taught road safety [31]. Both [32] and [33] suggest that there is a need to utilise virtual environments for social skills training for autistic students. Students can use the virtual environments to learn rules and basic skills which could be practiced frequently before entering a real-life setting. A VR environment called *The Virtual City* includes a procedure to teach autistic students how to use a pedestrian crossing and how to safely board a bus [11]. An evaluation of the use of VR environments for autistic students specifically showed some transfer of learning from the virtual environment to the real world [40]. VR also assists students with dyslexia, a cognitive disability [23]. Students who are dyslexic have trouble solving problems, writing and communicating [23]. VR aids in the development of virtual environments for dyslexic students, which mainly consist of visual interfaces and related sounds to enable the students to interact with virtual objects [40]. Due to the interaction with virtual objects, dyslexic students have shown improvement in their cognitive abilities [7]. However, [15] found that dyslexic students experience several challenges associated with using the VR environments including information overload if too many objects are shown simultaneously, and imperfect word processing, that is difficultly in recognizing words with similar sounds.

2.4 VR in Educational Games

Generally, VR is used for entertainment purposes such as gaming. However, a study conducted by [20] stipulated that VR in gaming is now being used for educational purposes. A VR game for safety education enhances safe training and education by allowing students to operate hazardous equipment such as a pedestal grinder in the virtual environment. The VR game was adopted to enable students to learn to control and prevent occupational injuries and illnesses caused by improper machine handling [20,38]. Another game that is used in education is *The Battle of Thermopylae*, which is a virtual gaming environment that aims to portray the historical context and importance of the battle, the warfare strategy of the battle opponents, their cultural differences and the strategic choices they made [10]. *The Siege of Syracuse* is a similar game and is used to educate students about historical events [25]. Similarly, *Heritage Key* is a VR game that also recreates history to educate students about the past, historical monuments, artefacts and archaeological discoveries [8].

Summary of Related Work. As shown in Table 1, most related work focuses on VR adoption for simulation-based education and assisting students with disabilities in various settings. However, none of the reviewed literature specifically investigates the determinants of VR adoption from a South African perspective using a theoretical framework. Thus, this project addresses this gap by investigating factors that may influence the adoption of VR by South African tertiary education using TAM as the theoretical framework.

Table 1. Summary of related work

Literature	Application context	Setting/country
[1,37,43,44]	Simulation-based education: engineering and physical science	Ecuador, Germany, Malaysia, Taiwan, UK
[2,16,17,19,29,35]	Simulation-based education: medicine and other disciplines	Japan, Malaysia, Poland, UK, USA
[3,6,7,9,11,15,23,32,33,39,40]	Assisting students with disabilities (physical and intellectual)	UK, USA
[8,10,20,25,38]	Educational games	Australia, Greece Japan, UK, USA

3 Theoretical Framework: The Technology Acceptance Model (TAM)

TAM indicates that there are two constructs that influence acceptance and use of a technology [13]. These are Perceived usefulness (PU) and Perceived ease-of-use (PEOU). The former is defined as the extent to which a person believes that a new technology will assist in performing his/her duties better compared to an existing technology. The latter is defined as a person's perception of the required effort to use a new technology. A qualitative study investigated the adoption of a Virtual Reality simulation to train nursing students to use a crash trolley during a medical emergency [14]. Findings revealed that perceived ease of use and usefulness of Virtual Reality are important factors that need to be considered for the adoption of Virtual Reality as a teaching platform. In addition, the study found that perceived innovativeness of Virtual Reality significantly influences the behavioural intention to use the Virtual Reality platform. On the other hand, [18] explored students' acceptance of Virtual Reality in medical education and found that immersion and imagination features embedded within VR applications have an impact on the perceived ease of use and usefulness of VR. Amongst five factors that were investigated in [4]—perceived usefulness, attitude, perceived cost and perceived ease of use—perceived usefulness was the only factor that significantly predicted healthcare professionals' use of Virtual Reality as a therapeutic tool. On the other hand it was found that perceived ease of use did not influence students' intention to use virtual world of Second Life (SL) to learn a chemistry concept [24].

4 Research Method

For this study we used the *exploratory design approach* to investigate lecturers' perceptions about the adoption of VR for teaching and learning. The *purposive sampling technique* was used, too. Data was collected from a sample of 21 lecturers from the discipline of Information Systems and Technology at the University of KwaZulu-Natal (UKZN). A qualitative approach was used to gain an in-depth understanding of the lecturers' perceptions about the adoption of VR as a teaching and learning platform at our university. The aim was to conduct semi-structured interviews with those 21 lecturers. However, data saturation was reached already after 10 lecturers were interviewed. Hence, we collected data from those 10 lecturers. Interviews were conducted in English and voice-recorded with the participants' permission. The recorded interviews were transcribed using Microsoft Word software. The transcribed texts were then analysed with the aid of the 'Nvivo' (version 22) data analysis tool. To this end, each transcribed text was loaded onto Nvivo and then analysed (content analysis) by grouping each participant's responses into three categories also called 'super themes'. These three categories or super themes represented the three constructs on which this project is anchored, that is: perceived usefulness, perceived ease of use and perceived obstacles to the adoption of Virtual Reality for teaching

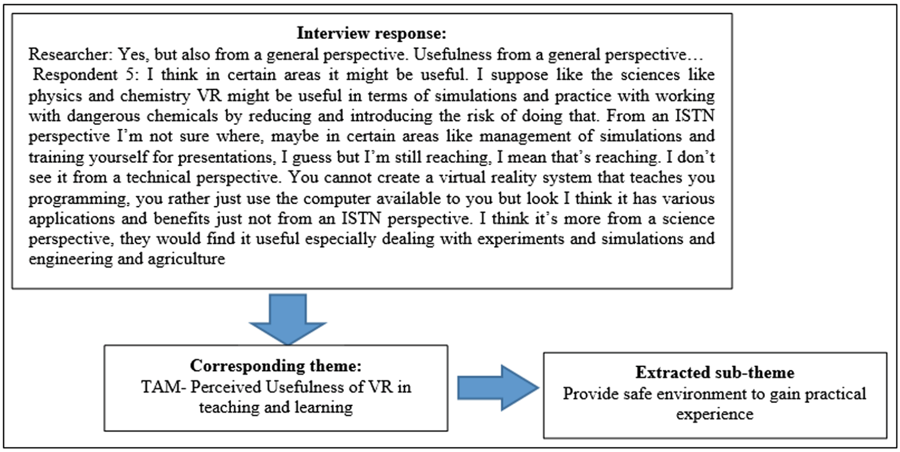

Fig. 1. Data analysis process

and learning. The participants' responses then became the sub-themes and were coded to the corresponding super-themes. The coding process entailed assigning each relevant text to a relevant theme and subsequently linking the theme to the corresponding super-theme. Figure 1 shows the data analysis process using an excerpt of an interviewee's responses.

5 Findings and Discussion

5.1 Demographics of Participants

Table 2 shows that an equal number of lecturers from two campuses (Westville and Pietermaritzburg) of our university were interviewed. Most of the interviewees had the rank of a 'lecturer'.[1] In addition, two professors and two senior lecturers were interviewed. All interviewees were employed in the discipline of Information Systems and Technology in the School of Management, IT and Governance.

5.2 Perceived Usefulness of VR for Teaching and Learning

Specific Disciplines Where VR is Most Appropriate. Most participants stated the disciplines that VR would be most relevant as far as teaching and learning are concerned. These include disciplines whereby safety is of the utmost importance. Participant 5 stated: *"In certain areas it might be useful, like in the sciences, physics and chemistry. VR might be useful in terms of the simulations. It also serves as practice for the students to work with the dangerous chemicals"*.

[1] Academic ranks in South Africa: 'junior lecturer', 'lecturer', 'senior lecturer', 'associate professor', '(full) professor'.

Table 2. Demographics of respondents

Respondent no.	Designation	Campus
1	Senior lecturer	Pietermaritzburg
2	Lecturer	Pietermaritzburg
3	Professor	Westville
4	Lecturer	Westville
5	Lecturer	Westville
6	Lecturer	Westville
7	Senior lecturer	Westville
8	Lecturer	Pietermaritzburg
9	Lecturer	Pietermaritzburg
10	Professor	Pietermaritzburg

The same participant further elaborated: *"This is because VR reduces the risk of danger in the simulated environment and it teaches students how work with the dangerous chemicals in a real-life situations*". In the context of medical practice, [2] noted that VR is utilised in medicine to train students to become medical professionals by creating a safe environment where they can practice medical procedures and experience safe exposure to dangerous chemicals. Similarly, [29] stated that in the simulated VR environment, medical students can 'safely' make errors, then gain feedback that can enhance their practice.

Moreover, participant 5 stated that VR simulations can be used to assist biology students to learn about the human anatomy by providing them with an immersive learning environment in which they can experience the course content and gain feedback from their mistakes. Similarly, [35] noted that VR systems based on human anatomy allow students to gain experience and feedback. Some participants felt that VR in the IT discipline could be used to teach abstract concepts such as programming. By contrast, participant 10 did not agree to the adoption of VR in the IT discipline: *"It would not be successful from an IT perspective*". This participant uses a combination of tutorial and practical sessions to teach course-related content. During the practical sessions, students are required to interact with a computer to complete a task. Hence, the participant believed that VR in the IT discipline would not be useful for modules that are already taught using a computer-based interactive environment.

Some of the participants (3, 4, 5, 7, 8) stated that VR could be used to study law in a courtroom simulation. Likewise, [19] had noted that students' practical exposure to a simulated crime scene or legal environment, such as courtrooms, allow them to retain more information as compared to a non-simulated environment. For example, a simulated environment such as a murder scene allows students to conduct an investigation of the type of murder weapon used, the victim, and other aspects of the crime. This promotes interest for the course and allows students to retain more information for a longer period of time.

By contrast, in a non-simulated environment, students will have to read lengthy witness statements and reports and they will therefore remember information for a short period of time [19].

Benefits of VR for Teaching and Learning. Most participants also stated the advantages of adopting VR for teaching and learning. Participant 1, for example, claimed: *"In the classroom, VR would assist with teaching and learning by creating an active environment to facilitate participation"*. Similarly, [30] had stated that VR promotes active learning and creates an engaging environment to facilitate learning. Some of our participants (2, 3, 4, 5) described the following advantages of adopting VR: *"VR platforms, e.g. second life, eliminate the language barrier and provide flexibility in terms of learning because students can learn at their own pace, hence, promoting effective learning"*. Similarly, [30] noted that VR overcomes language barriers. For example, VR environments with chat rooms and forums provide an equal opportunity for communication between students from different cultural backgrounds. Likewise, [22] had mentioned that VR platforms (such as Second Life and Minecraft) enable students' socialization via the instant messaging feature. Such socialization promotes effective learning as students can communicate with each other to share knowledge of the course work.

Participant 4 stated: *"Utilizing VR in the classroom will cater for different learning styles. Perhaps some student prefer to learn visually; then they can gain more by using VR for learning"*. Similarly, [30] claimed that the visual and interactive strengths of VR makes it suitable for various learning styles. Another participant stated that VR would be useful in modules like history by allowing students to virtually travel to destinations around the world. This assists with creating interest and motivating to learn the course content. Participant 8 further elaborated on the advantage of using VR for promoting motivation with an example: *"A lecturer can try and explain history abstractly, e.g. theoretically explaining the pyramids in Egypt. However, teaching using VR will allow students to formulate an idea on how the pyramids look in terms of the dimensions. Also, by providing the students with an immersive experience they will be more interested in learning about the history of Egypt"*.

Immersive VR environments that are specifically designed to help students to learn and experience course-related material target different learning styles; this cannot be obtained in traditional education, i.e. using blackboard teaching methods [42]. Moreover, immersive VR environments enhance learning retention by promoting interest in the module because students retain more information if they find a module or topic in the course work interesting [42]. Similarly, our participant 1 mentioned that VR depicts a shift from the traditional methods of teaching to the modern methods of teaching. This shift assists lecturers to create dynamic teaching environments to promote students' interest in the course work. Several participants (1, 2, 4, 5, 7, 8) also mentioned VR devices such as VR head-gears and VR platforms such as second life that can create virtual teaching environments to promote students interest in the course work.

5.3 Ease of Use of VR

This theme focused on the participants' reflections on the ease of using and understanding of VR systems in the context of teaching and learning. Most participants briefly explained ways in which the VR systems could be made easy to use and understand. Most participants (1, 2, 3, 4, 5, 8) suggested training as a way of introducing lecturers to VR. Some of the other participants (6, 9, 10) argued that training should continue even when VR is fully implemented. This will enable VR users to keep abreast of new developments and updates within the VR arena. One participant (5) discussed that both lecturers and students will require training to use and understand the VR systems. In addition, participant 3 stated that the UKZN needs to identify educational institutions that have already adopted VR in order to provide a foundation for the adoption of VR from a theoretical perspective. Such a theoretical foundation would enable lecturers to gain insight into changes that need to be made for the successful adoption of VR at UKZN. This would subsequently allow lecturers to understand how to use the VR systems for teaching and learning.

5.4 Challenges to the Adoption of VR and Suggested Solutions

Feasibility. Most participants (2, 3, 5, 9, 10) commented on VR adoption challenges from an infrastructural and financial perspective. They recommended that the UKZN should consider performing a cost-benefit analysis to assess the financial feasibility to adopt VR for teaching and learning. One respondent (2) alluded to the fact that *"VR adoption requires long-term planning; the university is not quite prepared for it right now in terms of the infrastructure required, but perhaps in the future the adoption of VR will be possible"*. Similarly, participant 1 recommended: *"UKZN should take as much time as is needed, no less than two years of time, to decide on the disciplines where VR will be adopted"*.

Most participants suggested a gradual adoption of VR as a solution to the challenge of current feasibility. In addition, other participants (1, 2, 3, 4, 6, 10) advocated having policies for the adoption of VR. These participants expressed that those policies should be optional in order to prevent forcing the adoption of VR to limit instances whereby lecturers would adopt VR just to adhere to the university rules instead of adopting it to its full potential. One participant stated that pilot studies across disciplines should be conducted before deciding on the adoption of VR at UKZN because this would enable the university to gain insights into the capabilities and the potential challenges of adopting VR for teaching and learning.

VR Skills. Some of the participants suggested outsourcing of VR skills to solve the issue of a lack of VR skills among the staff members. By contrast, some of the participants recommended getting VR skills by training existing staff members. Some of the participants explained that the UKZN did not have qualified staff who were familiar with utilizing VR. Training would therefore be fundamental, but it should be complemented by recruiting new staff who have skills in VR.

The recruited staff would be required to help the other staff members by sharing their VR knowledge. This would promote a pool of VR knowledge and skills at the UKZN. In this regard, remarks from the participants include *"do not outsource"* (participants 1, 2), as well as *"yes, UKZN can outsource, although that can be an issue because depending on the external people implies that there is a non-formation of internal skills. UKZN would spend money on outsourcing as opposed to using the existing people at the university"* (participants 7, 8, 9).

Resistance to Change. Resistance to change was a challenge that the participants felt needed to be addressed from an organizational perspective. One participant (2) stated the following: *"The biggest problem is resistance to change. It is really going to take time for the staff to change to newer technologies"*. The transition from old technologies such as projectors and 2D systems to more advanced systems such as 3D interactive and immersive systems like VR can sometimes cause resistance to change because lecturers are accustomed to the old technologies. This is because lecturers have adequate exposure to and experience with using old technologies as compared to their exposure and experience with using VR. The participants focused on 'PowerPoint' as a commonly used technological tool and contrasted it with VR. Most participants perceived 'PowerPoint' as a tool that could be used in conjunction with virtual environments. One participant (1) explained that 'PowerPoint' could be used to teach the theoretical sections of the coursework and it could be used to teach the complex and abstract sections of the coursework. In this way, both 'PowerPoint' and VR could be utilized in conjunction to teach a course. However, some of the participants stated that they would substitute 'PowerPoint' with VR because it would be more beneficial for teaching their modules. In particular, participant 1 stated: *"If VR is used to its full potential, such as creating multiple virtual environments, for example a classroom environment and a business environment, then there is no need for slides"*. The same participant further elaborated: *"This is because theoretical content can be taught in the classroom environment and application will be taught in the business environment, and in this way students will learn better and it will make teaching simpler"*. Some of our participants (2, 3, 4, 5, 10) expressed their concern that the UKZN would need to properly communicate the reasons for adopting VR; failure to do so would result in unwillingness to change. Some participants recommended gradually adopting VR as one of the solutions to the challenge of lack of willingness to change. Generally, people become resistant to change because of a lack of support to facilitate the change. Therefore, to prevent resistance to change, the UKZN needs to implement proper procedures and support facilities to adopt VR for teaching and learning. One participant (2) proposed the following solution: *"An effective change management process, and a clear justification of the need to adopt VR, is required"*. The same participant further elaborated that successful adoption of new technologies such as VR requires acceptance of the technology and that acceptance can only be had once the decision to adopt VR is fully understood by staff members and other relevant stakeholders.

6 Conclusion and Outlook

Several research have highlighted the possibilities and benefits associated with using Virtual Reality within the context of teaching and learning. However, related work reveals that research on the adoption of VR as teaching and learning tool in the South African (or wider African) context is very scarce. This project contributes to the scanty literature on VR adoption Africa as it investigates the perceived ease of use, usefulness of VR and challenges associated with VR as a teaching and learning platform from lecturers' perspectives in South Africa. Current literature highlights the potential use of VR from students' perspective and rarely from lecturers. This paper highlights that VR is particularly useful as it provides a safe learning environment to practice delicate or risky procedures through simulations. Lecturers also believe that VR is useful for teaching abstract concepts in an immersive learning environment. Further benefits include the fact that VR encourages students' participation in the classroom, eliminates language barrier and promotes learning flexibility, cultural diversity and student socialization. In addition, it promotes students' information retention. Lecturers mentioned that due to the evolving nature of technology, there is a need for continuous training (in the pre- and post-adoption phases) to ensure that VR is perceived as easy to use. They further mentioned that there is a need to build knowledge of VR from a theoretical perspective to gain a better understanding on how VR systems could be used for teaching and learning.

In terms of the challenges, lecturers expressed their concerns about the infrastructural and financial capabilities of the UKZN to adopt VR. Thus, they proposed a gradual approach to VR adoption, coupled with pilot studies and flexible policies that encourage voluntary adoption of VR. Some lecturers further advocated for outsourcing VR skills as a way of adopting VR while some were against it. Resistance to change is another identified challenge in the South African context. They indicated that the UKZN should adopt a hybrid approach, combining the use of existing technologies in conjunction with new ones (VR). In addition, the university should engage its academic staff on the need to move to VR systems and create a pathway for the adoption and support for VR for teaching and learning.

This paper suggests a further in-depth study of factors that may influence the adoption of VR in the South African higher education sector. Such a study should adopt more robust theoretical and methodological approach and should endeavor to capture students and lecturers' perceptions on a large scale, that is, from more than one institutions. Particularly, it would be interesting to investigate how perceptions toward VR adoption differ depending on the various types of higher institutions of South Africa (traditional, research-focused or teaching-oriented). Moreover, further studies should be conducted to assess the possibility of adopting VR in South African education in terms of the prevailing infrastructure and financial implications for the South African educational institutions as well as the educational policies put in place by the government that dictate the rules for technology adoption in South African education.

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