Drivers of Users' Embracement of 3D Digital Educational Spaces in Higher Education: A Qualitative Approach

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ORIGINAL RESEARCH

Drivers of Users' Embracement of 3D Digital Educational Spaces in Higher Education: A Qualitative Approach

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Abstract
Three-Dimensional Virtual Worlds (3DVW) have significant promise for the development of teaching and learning environments. Educational communities have become interested in such virtual platforms, and this technology has widely benefited educational settings. This study aims to identify the factors that drive the acceptance of 3DVWs as means for distance learning by higher education students, and provides a taxonomy of such drivers. A qualitative approach was employed for data collection to enable a detailed exploration. Two data collection instruments were used in the experiment: a virtual synchronous focus group and an open-ended question. One hundred twenty-one students participated in 13 virtual focus groups, and 124 students responded to the open-ended questions. Thematic analysis was used to analyse data, and as a result, 26 factors were identified as antecedents to the acceptance of 3DVW in higher education. Those factors are then classified into 12 categories based on their definition and similarities. Twenty-one out of the 26 factors impact the user acceptance of 3DVW positively, and five factors impact it negatively. The findings of this study indicate advances in theory, methodology, and pedagogical practice.

Keywords Three-dimensional virtual world · User acceptance · Higher education · Distance learning · Qualitative research · Immersive environments

1 Introduction

A 3DVW often refers to a three-dimensional web-based, simulated, and graphical environment and users of these platforms use 'avatars', which are animated, graphical, and digital self-representations that they can inhabit and communicate with. (Boulos et al., 2007). Most of the popular 3DVW platforms have millions of users, and they are built based on a host

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of innovative features emphasising immersion, interactivity and user-driven content (Huang et al., 2008). Increased internet access and the introduction of more efficient computers for daily use, on the other hand, are reviving the popularity of 3DVWs. Nowadays that virtual technologies are increasingly available for everyone, individuals from all walks of life are beginning to use them for a wide range of purposes.

Online teaching has become a popular teaching method as the use of technology in education has grown (Pei & Wu, 2019). The education sector has a variety of technologies available for teaching their learners synchronously and asynchronously. Instructional management systems, Web conferencing software, Web 2.0 technologies, and 3DVWs are some examples of educational technologies available for teaching and learning in an online environment (Stone, 2009). In both academic and corporate environments, 3DVWs are successfully used as online platforms for educating students (Riley, 2008; Stone, 2009), and as one of the forefront technologies in academia, They represent a paradigm change away from the traditional in-person and face-to-face classroom and towards a modern approach to teaching and learning (Brown et al., 2009).

Despite the advent of this ground-breaking technology in higher education and its rising number of users and applications, little research is done evaluating user adoption of the 3DVW technology from various perspectives. More specifically, there is a scarcity of qualitative research that looks for factors impacting user acceptance. This research fills this gap by conducting qualitative research which explores factors that students' adoption of technology in the higher education industry as a virtual platform for distance learning.

The purpose of this study was to identify factors and elements that drive higher education students' acceptance of 3D virtual worlds as a platform for distance learning. This study identifies various factors impacting user acceptance of 3DVW technology in higher education students. These results will provide educators and educational institutions with possible solutions to students' perception of the technology and introduce different crucial constructs for designing and applying virtual technologies in the teaching and learning programmes. Determining the factors that may contribute to a higher level of user acceptance will assist developers in creating more effective forms of online platforms so that they can be permanent alternatives to the traditional form of education. It may fill the gap by providing instructional designers with valuable information about different parameters that positively or negatively influence the way students adopt and use the new technology. Especially for educators and trainers, this study provides insights for instruction delivery, integration of instructional contents, and implementation of an educational environment where students feel more engaged. Designing an acceptable teaching and learning environment for students can contribute to increased academic accomplishment.

To achieve the current study's objectives, a multi-user learning environment was developed and implemented in Second Life (one of the widely employed virtual world platforms), and it was used in a reasonably large undergraduate subject delivered in an Australian university.

The following is the remainder of the document. The literature review is explained after the introduction section. Following that, the research methodology is clarified, accompanied by the research findings. Finally, there is a discussion of the results and findings.

2 Literature Review

Bell (2008) defined virtual worlds as "a synchronous, persistent network of people, represented as avatars, facilitated by networked computers" with three components: synchronous communication, persistent presence, and avatars.

In comparison to traditional media, 3DVWs provide the functionality to administrate several parts of education and provide a higher level of interactivity for collaboration and communication. These immersive platforms may construct sophisticated and highly dynamic learning environments using in-world features like programming, modelling, and scripting. 3DVWs also enhance teaching and learning beyond what Web presentation tools can provide (Second Life Education, 2011).

3DVWs are currently regarded as a teaching tool with tremendous promise for the future generation of educational settings and online learning. They are increasingly being used as a sophisticated platform for distance learning by educational systems all over the world. A growing quantity of universities, colleges, schools, and other educational communities throughout the globe are focusing increasingly on the teaching and learning tools that 3DVWs can bring. 3DVW teaching and learning programmes are devised and developed by a variety of higher education industries all around the world (Dale & Lane, 2007; De Lucia et al., 2009; Hsu, 2011, 2012; Robinson, 2011). 3DVWs have been used by educational communities from many backgrounds to enhance teaching and learning during the last decade (Chow et al., 2012).

Only a few studies in higher education have looked explicitly at the facilitators and drivers of the embracement of 3DVWs. Chen et al. (2008), for example, in a quantitative study, investigated the impact of several aspects on students' intentions to use the 3D Virtual environment for educational requirements. In a tourism course, Singh and Lee (2009) investigated the influence of three factors on the perceptions of Second Life among students.

Because there is a scarcity of comprehensive qualitative research on the antecedents of 3DVW's user acceptance in higher education, this paper utilises a qualitative approach to examine the factors that influence higher education students' acceptance of 3DVWs in higher education. The main research question for this study as well as two sub-questions are provided below.

Main Research Question. What are the factors affecting students' acceptance of 3DVW?
RQ1. What factors have a positive effect on the student acceptance of 3DVW?
RQ2. What factors have a negative effect on the student acceptance of 3DVW?

The answers to the above questions are provided and discussed in Sect. 5 of the article.

3 Research Design

Qualitative research aims to accomplish a comprehensive understanding of a specific event rather than a cursory examination of a broad population sample (Creswell, 2005). Qualitative research is a kind of exploratory approach. This type of research is employed to understand the underlying reasons, opinions, and motivations. Qualitative research can provide knowledge about the topic contributing to the development of ideas or hypotheses for future quantitative research. This approach also uncovers patterns in

thoughts and opinions and helps to understand the problem deeper (Wyse, 2011). The main reason for selecting a qualitative approach in the current research is the focus on discovery and exploration. This qualitative study utilised inductive techniques to obtain a deeper understanding of higher education students' acceptance of 3DVWs. The study aimed to find the possible factors influencing user acceptance of 3DVWs to provide a taxonomy and a big picture of the antecedents.

'Second Life', at the time of the research, was one of the most evolved and promising three-dimensional platforms suitable for educational purposes. As a result, Second Life was the selected platform for creating the virtual campus and conducting the study. In the current study, '3DVW', refers to Second Life. A virtual land was rented for a period of one year within Second Life to implement a virtual teaching and learning environment. The aim was to build a realistic virtual university campus that would replicate an educational atmosphere to engage students in a distance learning programme using their avatars and remotely attend the learning experience.

Figure 1 shows sample snapshots of the main area of the virtual campus, a running virtual computer laboratory, and some other parts of the learning environment. In the virtual campus, four main areas were developed: computer laboratories, resource rooms, discussion rooms, and lecture theatres.

Fig. 1 Sample snapshots of the virtual campus

3.1 Collecting Data

Undergraduate students enrolled in a first-year elective subject from different disciplines at an Australian university were chosen as participants for this research. Two data collection instruments were employed in this experiment: The first instrument was an online synchronous focus group, and the second one was an open-ended question, and these two were the only data sources utilised in this study. The reason to employ two data collection methods for the research was to generate a thorough understanding of 3DVW acceptance in a real-life context. The Human Research Ethics Committee approved this study. The following section outlines each of these two data collection methods used in this study.

3.1.1 Virtual Focus Group

Virtual Focus Group (VFG) was one of the main methods of collecting the data for the study and was applied to obtain insights into factors impacting the acceptance of the technology by higher education students. VFG is an Internet-based research method utilising online environments to bring spatially dispersed participants together in a group discussion that is based on text communication (Adler & Zarchin, 2002; Turney & Pocknee, 2005). For the purpose of the study, VFGs were hosted within Second Life meeting sessions. The main reason for selecting Second Life for this purpose was based on all students being familiar with the technology and the environment and knowing how to use it. Communication was carried out through a chat messenger via Second Life. The chat tool is a public messenger, such that every participant can type messages and see others' messages in real-time. There was a possibility of recording the whole discussion as text log files. Altogether, 13 VFG sessions were held as students were grouped into 13 groups (depending on the tutorial class they were enrolled in), and altogether, 121 students who permitted the research team to incorporate their responses in the study data participated in the VFG. Each session took about one hour, and in each session, a maximum of 15 students participated in the VFG to describe their understanding and experiences of using 3DVW technology in their course. After completing each focus group session, the discussion, including all answers and comments stream, was recorded into a text log file by a facilitator and delivered to the research team.

3.1.2 Open-ended Question

The second method of data collection for the qualitative study was an open-ended question. The question was about how 3DVW can be accepted to use for higher education. Students were asked to discuss the topic from various perspectives and to describe how they will advise professionals in the higher education field to use 3DVW. They responded to the question by addressing various aspects of utilisation of 3DVWs by students and the factors influencing the technology's acceptance. Overall, 124 students agreed that their responses could be used in this study.

3.2 Analysing Data

After completing the data collection phase, all log files of the VFG sessions and all responses to the open-ended question were imported into a Microsoft Word document.

Following the data collection, data analysis was carried out. Thematic analysis by Braun and Clarke (2006) was selected for analysing the data. The inductive thematic analysis approach was appropriate in order to address the research questions due to the exploratory and qualitative nature of the current study; particularly, limited research is conducted on the acceptance of 3DVWs in higher education, and this form of analysis allows flexibility and are not limited to any existing theoretical framework. Furthermore, thematic analysis is flexible since it allows both theoretical viewpoints and data-derived ideas to be combined, which can enrich the analysis (Braun & Clarke, 2006). The plan for data analysis in this study was to systematically identify, analyse and report patterns of meaning, otherwise known as 'themes', across the collected data, which reflected the perception of the students about the use of the technology. Therefore, thematic analysis was adopted to conceptualise the findings from transcribed data. Thematic analysis is comprised of six phases as follows.

In the first phase, data was read and reread by the research team to become familiar with the data set. In this phase, the initial ideas and patterns in the dataset were noted.

In the second phase, based on the research question and according to the patterns of the dataset, initial codes and labels were generated and applied to the dataset. In order to categorise data for efficient analysis, data reduction and data compilation took place in this phase. Some of the generated codes were reviewed, some were combined, some codes were deleted, and some new codes were generated. This phase was conducted several times.

In the third phase, searching for themes in the dataset was carried out. The codes to identify meaningful and potential themes in accordance with the objective of the study were examined. Codes were collated into themes that precisely represent the data. At the end of this phase, a list of candidate themes describing factors impacting user acceptance of 3DVW was extracted for further analysis.

In the fourth phase, reviewing and refining the main themes as well as identifying the sub-themes were performed. The identified themes and sub-themes were revised and refined, and the initial set of themes was divided, combined or discarded. In this phase, where the analysis seemed incomplete, the reviewing process was repeated until accurate themes were extracted.

In the fifth stage, a detailed analysis of each theme and identification of a full story and their significance in answering the research questions were provided. A clear definition and names for each theme were generated in this phase. Meaningful categories were generated by grouping themes featuring similar content as well.

In the final phase, the process of writing up the final report based on the latest themes and categories was carried out, and straightforward and clear data according to the theme classification were provided. Due to the gap in empirical studies in the literature, there was no potential framework for data interpretation. Therefore, an inductive analysis of the data was undertaken. The frequencies of various thematic occurrences

Fig. 2 The process of thematic analysis— adapted from Braun and Clarke (2006)

are used in all of the above phases. Figure 2 depicts the steps in the process of thematic analysis carried out in the current study.

Studying previous and similar research in the literature and matching the identified themes with similar themes in other studies in the field was very helpful in the proper naming of the themes. Next, after identifying the themes and reviewing and naming them, similar themes were classified into certain categories. For this example, as playfulness is always accompanied by enjoyment, they were both categorised into the same category.

4 Research Findings

4.1 Descriptive Statistics

As described earlier, two data collection methods were used in this qualitative study: VFG and an open-ended question. Altogether, 121 students participated in VFG, and 124 students answered the open-ended question; therefore, the response rates were 49.95% and 48.4%, respectively. VFG participants were 36.30 per cent female and 63.70 per cent male on average. Similarly, males made up 57.9% of respondents to the open-ended question, while females made up 42.1%. The participants ranged in age from 17 to 24. After eliminating the invalid and missing data, the total number of the collected data samples through VFGs and the open-ended question was 245. Table 1 demonstrates the participants' demographics in the sample.

Figure 3 represents the big picture of factors influencing user acceptance of 3DVWs as a graphical depiction of the thematic analyses' findings. As the taxonomy demonstrates, 26 factors impacting the user acceptance of 3DVW were identified. These antecedents were classified into twelve meaningful categories: infrastructure, attractiveness, cost efficiency, self-efficacy, sense of presence, virtual environment, ease of use, usefulness, accessibility, enjoyment, convenience, and interaction. Some of the antecedents impact user acceptance positively, and others impact it negatively. Below, the sections present the extracted factors, explain each factor with a definition and provide sample quotes.

4.2 Categories and the Construct Definitions

Classified into twelve categories, the identified factors impacting acceptance of 3DVW by higher education students are introduced in the current section, the theoretical background and a definition for each factor are provided, and some sample quotes from the qualitative data are presented.

Table 1 Participants' demographic information

	Total number of students enrolled	Participated students	Female participants	Male participants
Virtual focus group	250	124	45	79
Open-ended question	250	121	51	70

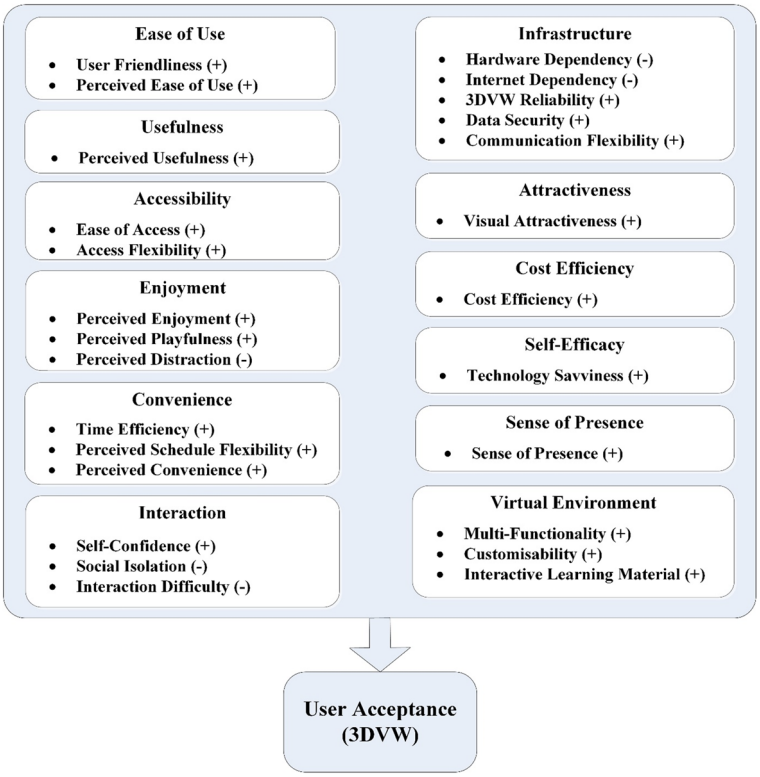

Fig. 3 Taxonomy of the factors impacting students' acceptance of 3DVW

4.2.1 Ease of Use

Two factors comprised the category 'Ease of Use': 'perceived ease of use' and 'user-friendliness'. According to Davis (1989), perceived ease of use was defined as *'the degree to which students believe that using the 3DVW in their education would be free of effort'*. User-friendliness was defined for this study as *'a characteristic of a 3DVW-based environment such that any student can use it without having extensive computer experience or training'*. The majority of the participants believed that the 3DVW-based environment was user-friendly and easy to use and reported that they prefer to apply it in their education due to these characteristics.

Overall, 27 participants in the VFG and the open-ended question reported that the technology was easy to use. Similarly, three participants mentioned that the technology was user friendly. According to the results, the adoption of the 3DVW among students was favourably impacted by both 'user friendliness' and 'perceived ease of use'. Table 2 summarise all factors in this category.

Table 2 Summary of ease of use

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Perceived ease of use	The degree to which students believe that using the 3DVW in their education would be free of effort	Positive	27	*"Second life is easy to use as it requires only basic computer knowledge and is fairly self-explanatory. Due the simplicity of the program, if training were needed it would be minimal."* *"With easy to use features, Second Life allows students to spend time and thought on their responses to class discussions, developing their skills in critical thinking."*
User friendliness	A characteristic of a 3DVW-based environment such that any student can use it without having extensive computer experience or training	Positive	3	*"Second life, as an example, has a user friendly interface, is simple to use and set up, has good graphics and allows for the creation of your own individual avatar with a variety of attributes available."*

4.2.2 Accessibility

Two factors comprised the category 'Accessibility': ease of access and flexible access. Miller and Khera (2010) defined 'ease of access' as 'the degree of ease experienced by a user in locating the TEEAL system'. In line with this definition, ease of access was defined for the purpose of this study as *'the degree of ease experienced by a student in having access to a 3DVW*'. 3DVW is considered an easy to access technology for higher education students due to its accessibility requiring only a computer and an Internet connection. As home access to computers and the Internet has expanded dramatically over the last years, students, especially higher education students, are able to have easy access to this technology both on the university campus and at home. Overall, 20 participants in the qualitative study stated that 3DVWs are easy to access, and therefore, they would like to apply this technology in their educational programmes. This factor will have a positive impact on the technology's acceptance in higher education.

Access flexibility is defined as '*the user's ability to run 3DVW technology on various digital devices*'. Based on the specification of 3DVWs, the technology can be easily accessed and run through desktop computers, laptop computers, tablets and other smart devices, increasing the flexibility of the technology. Due to a wide range of users of this technology, the developers have provided the possibility of running it on various operating system platforms and different hardware configurations. Fourteen participants reported the technology was flexible regarding accessibility through different types of digital devices. This factor has a positive effect on the technology's consumer acceptance. Table 3 shows the summary of factors in this category.

Table 3 Summary of accessibility

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Ease of access	The degree of ease experienced by a student in having access to a 3DVW	Positive	20	*"2nd Life is a good way to support the learning in this subject as it can be accessed virtually everywhere in the world."* *"An advantage is that if you do have the Internet connection and second life software it is very easy to access and use."*
Access flexibility	The ability of users to run 3DVW technology on various digital devices	Positive	14	*"Nearly every home has access to some form of technology, usually a smart phone or a laptop. Making a virtual university accessible as long as you are connected to some form of Internet; now this would make studying easier for people who have busy lifestyles."*

4.2.3 Infrastructure

Five factors comprised the category 'Infrastructure': hardware dependency, Internet dependency, 3DVW reliability, data security, and communication flexibility. Hardware dependency was defined as *'the extent to which the technology requires computer hardware for running*'. Since the technology has been developed as computer software, it is impossible to run or use it without having appropriate computer hardware such as a desktop/laptop computer or a smart device with minimum requirements. On the other hand, launching the technology and establishing a virtual environment requires a computer device with appropriate specifications in terms of processor, graphics and memory, etc. Due to a possible limitation in access to decent computer hardware, the use of this technology can not be possible for every student or in every location. Thirty-four participants in the study mentioned that due to the limitations in accessing appropriate computer hardware, it is hard for everyone to take advantage of the technology in their education. They believed that this factor has a negative effect on technology's acceptance among users in the field.

Internet dependency was defined as *'the extent to which the technology requires Internet access for running'*. This technology is an Internet-based technology and runs on the Internet and has a client/server structure. Without having a high-speed Internet connection, using the technology is impossible. Despite the significant increase in Internet connectivity for students in higher education, many students still have restricted access. Therefore, this is a considerable issue that can negatively impact the user acceptance of 3DVW. Overall, 38 participants in this study stated that not having access to high-speed Internet is a barrier to using the technology.

When a hardware configuration of a computer system is established, the system reliability is mainly dependent on the software (Shatz et al., 1992). Lyu (1996) defined software reliability as 'the probability of failure-free software operation in a specified environment for a specified period of time'. In the current study, 3DVW reliability was defined as *'the probability of failure-free operation of the software for a duration of a normal class'*. Software bugs, technical difficulties, operation speed, and glitches are considered the major issues that decrease the reliability of 3DVWs. According to the participants, the reliability of the technology in such an application should relate positively to use for distance learning.

Thirty participants in the qualitative study believed that the system lacked reliability. They reported that if the technology was more reliable, they would more likely intend to use it. Thus, 3DVW reliability is considered to affect the acceptance of 3DVWs in higher education positively.

Jing et al. (2007) defined data security as 'the protection of data from accidental or intentional disclosure to unauthorised persons and from unauthorised modification or destruction'. Data security should be an important area of concern for everyone, especially in educational systems, and personal information should not be made available or may be made available only to those specifically authorised by the owner. 3DVW, as a multipurpose technology, has not been exclusively designed for educational purposes; therefore, the data security of this technology needs to be one criterion considered in its application. There should be a higher level of security measures taken by the developers of the technology in comparison with other distance learning tools such as Blackboard. In line with Jing et al. (2007), data security is defined for the current study as '*the protection of student data from accidental or intentional disclosure to unauthorised persons*

and from unauthorised modification or destruction'. Six participants listed data security as a key antecedent in the acceptance of technology. They believed that the system lacked data security, and if it was more secure, they would likely intend to accept and use it. It is believed that having data security in a 3DVW-based learning environment affects its user acceptance positively.

Communication flexibility was defined as *'the degree to which students are able to communicate with others by using 3DVWs*'. Communication is the biggest asset within the new technological world in which 3DVW is a leading technology communication-wise. Communication via text, voice and online video is simply just a click of a button to talk to anyone who is on the same platform. It is great for education due to the unique collaboration tool, where students are able to make connections with those who share the same interests from not only the university but around the world. Having no geographical and technical boundaries makes it easier to work with peers and teachers, which essentially supply a better source of education to all students. Students can easily link real-world operations to real-world information resources. Fifty-nine participants pointed out that the communication flexibility of 3DVWs is a very important factor contributing to the user acceptance of this technology. The summary of factors in the 'Infrastructure' category is shown in Table 4.

4.2.4 Usefulness

Perceived usefulness was defined in the study of Davis (1989) as 'the degree to which a person believes that using a particular system would enhance his or her job performance'. Based on the above definition, perceived usefulness was defined for the purpose of the current study as *'the degree to which a student believes that using a 3DVW would enhance his or her performance in education'*. Upon encountering a 3DVW, students attempt to assess the match between their study goals and the outcome of applying the technology. Overall, 27 participants found this technology a very useful means for their educational programme, which positively impacted its acceptance. Table 5 summarises this category.

4.2.5 Attractiveness

Perceived visual attractiveness of a website is defined as 'the degree to which a person believes that the website is aesthetically pleasing to the eye. And that aesthetics plays a role in the decision to use an information system and an especially important role in the decision to use a website' by Van der Heijden (2003). In line with the definition, visual attractiveness was defined as *'the degree to which a person believes that a virtual environment is aesthetically pleasing to the eye'* (Ghanbarzadeh & Ghapanchi, 2020). This factor pertains to the virtual world's visual effects and elements, as well as its graphical structure, colours, patterns, and general appearance. It is believed to have a significant part in the adoption of this technology. Nineteen participants reported the environment to be attractive. According to the students, the visual attractiveness of the 3DVW encouraged them to spend more time with various parts of the environment and focus more. They claim that this aspect influenced their adoption of the technology in a positive way. Table 6 presents a summary of this category.

Table 4 Summary of infrastructure

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Hardware dependency	The extent to which the technology requires computer hardware for running	Negative	34	*"Furthermore, SL software has technological requirements, and some students may not have computers that meet these requirements."* *"Those who have poor access to technology are at disadvantage, they would s till have to go to third party places to access second life anyway, negating advantages."*
Internet dependency	The extent to which the technology requires Internet access for running	Negative	38	*"… many have found many difficulties with accessing second life due to poor internet communications"* *"A disadvantage is that if there is an issue with your internet or computer, you wouldn't be able to attend the class"*
3DVW reliability	The probability of failure-free operation of the software for the duration of a normal class	Positive	30	*"I think its poor for presenting information as it takes a long time to get onto the program as you need the viewer"* *"If the speed of second life was increased, then it would already make the program better"*
Data security	The protection of student data from accidental or intentional disclosure to unauthorised persons and from unauthorised modification or destruction	Positive	6	*"There will always be a risk of hacking or viruses when working online, no matter how advanced it gets"* *"a disadvantage of the program is that if someone's details were stolen, they could log on and cause harm"*
Communication flexibility	The degree to which students are able to communicate with others using 3DVWs	Positive	59	*"The advantages of second life are that it is an easy way to interact with the tutor or students."* *"The advantages of it has been that it is an easy way of communicating so that everyone doesn't have to be in the same room."* *"Microphones can be used in the virtual classes, meaning that conversations will not have to be typed constantly and questions can be asked just by speaking."*

Table 5 Summary of usefulness

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Perceived usefulness	The degree to which a student believes that using a 3DVW would enhance his or her performance in education	Positive	27	*"3d virtual world technology would be advantageous for students' educations whilst at university as it is a useful tool that offers many benefits to its users."* *"…Second Life works well and is very beneficial for students"*

Table 6 Summary of attractiveness

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Visual attractiveness	The degree to which a person believes that a virtual environment is aesthetically pleasing to the eye	Positive	19	*"The visualisation of the classroom produces the 3D virtual world and encourages students to actively participate."* *"I found it more attractive than any other program used in education"*

4.2.6 Enjoyment

Three factors comprised the category 'Enjoyment': perceived enjoyment, perceived playfulness, and perceived distraction. Venkatesh (2000) adapted perceived enjoyment from Davis et al. (1992), which defined it as 'the extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system use'. Based on the above definition, and according to Ghanbarzadeh and Ghapanchi (2020), perceived enjoyment was defined as *'the extent to which the activity of using 3DVW technology is perceived to be enjoyable for students'*. Due to the attractiveness of the virtual environment as well as the variety of activities within this environment, users find it to be a kind of entertaining and exciting tool. When the 3DVWs are considered a fun and pleasing technology by students, they are intrinsically motivated to use it. Sixty participants mentioned that they found the technology fun and pleasing. This factor positively impacts user acceptance.

Fang et al. (2005) defined perceived playfulness as 'the degree to which a person believes that using a particular system would make him or her joyful'. Perceived playfulness was also defined by Han and Windsor (2013) as 'the degree to which a smartphone user believes that he or she could get intrinsic enjoyment when playing mobile games on the smartphone'. Based on the above definitions, perceived playfulness was defined as *'the degree to which students believe that they could get intrinsic enjoyment while navigating their avatar in the virtual environment'*. A virtual environment is designed in a way that resembles online computer games. Although a 3DVW has most of the characteristics of a three-dimensional game, it is not a game. Nineteen students found the technology to be more playful than other learning and teaching tools. This factor positively influences the acceptance of 3DVW.

Perceived distraction was defined as *'the degree to which a student's attention is being diverted away from the study*'. Working with 3DVWs, due to the entertaining characteristics of this technology, can be distracting for students in educational settings. Students who are interested in computer games or habitual game players, in general, are more likely to concentrate on the environment and be involved in entertaining activities within the virtual environment while they study. Distractions are a key element that needs to be discussed when considering implementing this technology in education. Twenty-eight participants considered the technology distracting. This factor can negatively impact the 3DVW's user acceptance. Table 7 shows the factors in the category 'enjoyment' along with some sample quotes from the data.

4.2.7 Cost Efficiency

Athanassopoulos et al. (1999) defined cost efficiency as 'the minimum level of economic resources which must be consumed to produce a desired level of output'. On the basis of this definition, cost efficiency was defined as *'the minimum level of economic resources that must be consumed to provide the desired level of educational service using 3DVW technology'*. Using 3DVW technology for educational purposes decreases a wide range of costs for both the institution and students. Costs of establishing and maintenance of a 3DVW-based learning and teaching programme are very low compared to a real-life in-person classroom programme. As an online distance learning technology, 3DVW can be considered a cost-effective tool for communication, collaboration, and teaching and

Table 7 Summary of enjoyment

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Perceived enjoyment	The extent to which the activity of using 3DVW technology is perceived to be enjoyable for students	Positive	60	*"The 3D virtual world of second life is a fun, exciting and interactive way of learning."* *"I have enjoyed using second life. Having a different approach to learning is the best thing about it."*
Perceived playfulness	The degree to which students believe that they could get intrinsic enjoyment while navigating their avatar in the virtual environment	Positive	19	*"Virtual worlds can adapt to any situation you need when you try to perform an example to your employees and also role-play and operating simulated equipment for businesses."* *"I find it actually more playful than in class during face to face"*
Perceived distraction	The degree to which students' attention is being diverted away from the study	Negative	28	*"A disadvantage of second life is its distracting. Because for example, all I want to do is fly around this island."* *"I don't think 2nd life can properly hold a student's attention because it is more or less a game."*

Table 8 Summary of cost efficiency

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Cost efficiency	The minimum level of economic resources which must be consumed to provide a desired level of educational service using 3DVW technology	Positive	98	*"It would be cost effective for the university to run, as it does not cost much money to run and can accommodate for a large amount of students."* *"3D Virtual Worlds represent a low cost, low labour promotional tool to help show prospective students what university life would be like."* *"About being online from home, this eliminates travel and parking costs which is big contributing factor to uni[versity] students."*

learning as the institution would generate long term savings in resources such as labour, energy, regular classroom maintenance, educational material such as computers and so on. The budget cuts and rising costs force educators to creatively do more with less by using this technology for teaching, learning, communication and collaboration to accommodate economic constraints.

As for students, costs such as travel costs will be reduced as well. Overall, 98 participants in the VFG and the open-ended question reported this technology to be cost-efficient and considered this characteristic as a factor contributing to the use of technology. Therefore, this factor is considered to affect user acceptance of 3DVWs positively. The 'Cost efficiency' category is summarised in Table 8.

4.2.8 Sense of Presence

Adapted from the study of Bystrom et al. (1999), the sense of presence was defined by Kim (2005) as 'the degree to which participants subjectively feel that they are somewhere other than their actual physical location because of the effects of a computer-generated simulation'. In accordance with this definition, the sense of presence was defined as *'the degree to which students feel that they are on campus while they are in their actual physical location because of the effects of 3DVW'*. Visual realism is one of the basic characteristics of the virtual environment. Many studies proved a direct relationship between visual realism and the sense of presence. For instance, Barfield and Hendrix (1995) and Hendrix and Barfield (1996) found that visual realism is linked to a greater sense of presence. According to the findings, two major characteristics of a virtual campus create a sense of presence among higher education students: being realistic and resembling a physical campus. Within the virtual campus, when students encounter a realistic environment, buildings, classrooms, and objects, they usually feel there. Similarly, when the virtual environment resembles their real campus, and they find replicated objects of their campus, as they already are familiar with the buildings, rooms and overall campus area, they feel as though they are on the real campus. In total, 51 participants cited a sense of presence in the virtual classroom as a factor in their own adoption of 3DVW technology. Therefore, this factor positively impacts the user acceptance of technology. Table 9 presents a summary of the sense of presence.

4.2.9 Self-efficacy

Technology savviness comprised the category 'self-efficacy'. Adapted from AAUW (2000), Lewis (2008) defined technology savviness as *'the ability to apply information technology in sophisticated, innovative ways to solve problems across disciplines and subject areas; to interpret vast amounts of information with analytic skill; to understand basic principles of programming and computer science fundamentals; and to continually adapt and learn new technologies as they emerge in the future'*. The current study used the same definition for the 'Technology Savviness' construct. Technology savviness affects the way young people utilise and adopt new technologies. Currently, the majority of university students tend to consider themselves as technology savvy, and this universal use of technology seems to encourage the young generation to practise new technological innovation, and 3DVW is no exception in this regard. Having the basic knowledge of using a new technological tool can increase the intention to use that. Overall, nine students stated that the majority of the students are technology savvy and should be able to use the technology with no major problems. This element, they claimed, may impact accepting this technology

Table 9 Summary of sense of presence

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Sense of presence	The degree to which students feel that they are on campus while they are in their actual physical location because of the effects of 3DVW	Positive	51	*"Second Life can be designed to reflect the exact layout of the university which creates the feeling of being on campus."* *"… having the virtual world created allows students to imagine actually being in the classroom which keeps a structure to the class period that having no avatar would not"*

Table 10 Summary of self-efficacy

Factor	Definition	Impact on user acceptance	Number of Participants	Sample quote
Technology savviness	The ability to apply information technology in sophisticated, innovative ways to solve problems across disciplines and subject areas; to interpret vast amounts of information with analytic skill; to understand basic principles of programming and computer science fundamentals; and to continually adapt and learn new technologies as they emerge in the future	Positive	9	*"Although, as technology advances, it could be assumed the technology-savvy generation will keep up. Hence, the majority of students should be able to easily log onto Second Life."* *"Especially for the younger generation who have grown up around technology and are proficient in using computers, this can be a more effective way to educate the younger generation who see a computer screen more"* *"our generation and future generations are becoming more and more technologically advanced, so I think it would be ignorant to not take advantages of the benefits of platforms like second life"*

in higher education significantly. The summary of factors in the category 'Self-efficacy' is shown in Table 10.

4.2.10 Convenience

Three factors comprised the category 'Convenience': time efficiency, perceived schedule flexibility, and perceived convenience. Time efficiency was defined as *'the amount of time that can be saved by using the 3DVWs in an educational programme compared to a traditional classroom setting'*. The use of 3DVW technology as a means for education has allowed students to experience a distance learning programme and connect online and access all the learning material while they are not physically on campus. This helps them to save a large amount of time compared to the traditional classroom, such as transportation time and the time they waste on the campus and so on. Sixty-five students mentioned 3DVW as a time-efficient technology. They believe that this characteristic of the technology has made a huge impact on the interest in the technology to be used in education. This factor affects the user acceptance of 3DVWs in higher education positively.

Banff et al. (2006) defined perceived schedule flexibility as 'the amount of flexibility respondents perceive they have over their work hours and their work location'. Based on this definition, perceived schedule flexibility was defined as *'the amount of flexibility students perceive they have over their education programme time schedule'*. The ability to access the course material and educational resources through the virtual environment anywhere and anytime contribute to a flexible time schedule for students. They break down the constructs of a typical classroom environment, where users can access the application any day at any time. Thirty-three participants reported that using this technology brings them flexibility in their daily study routine; therefore, they would prefer to use it. This factor also has a positive impact on higher education users' acceptance of this technology.

Perceived convenience was defined as *'the degree to which students believe that application of a 3DVW technology in their educational programme would give them flexibility and efficiency in location, effort and accessing the classroom and material remotely'*. 3DVWs such as Second Life help to provide a unique experience where a student has the opportunity to learn in their own personal location, whether it be on campus, in a computer lab, or in the comfort of their own home. It provides students with an autonomous environment where they can access the content, and it will stimulate group activities without having to be physically present. For the traditional classroom setting, students have to travel to the campus to attend lectures, tutorials, workshops and computer laboratories, whereas by using this technology, we can take most of this travelling out. Students can attend their classes within the virtual environment from the comfort of wherever they are. Remote access to educational material also helps students to multi-task while they are doing their studies. One hundred ninety-five participants in both the VFG and the open-ended question considered this technology as a very convenient way of learning and teaching and mentioned that for this reason, they highly prefer to use it in their educational programme. This factor affects the user acceptance of this technology positively. Table 11 shows the summary of factors in the category 'convenience'.

4.2.11 Interactions

Three factors comprise the category named 'Interactions': self-confidence, interaction difficulty, and social isolation. Sander and Sanders (2006) defined academic self-confidence as

Table 11 Summary of convenience

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Time efficiency	The amount of time that can be saved by using the 3DVWs in an educational programme compared to a traditional classroom setting	Positive	65	*"Second Life saves time, money and effort because it is online and simple to use."* *"it saves the time of having to travel to and from uni[versity] and I think a lot of students would actually prefer it over an in class discussion"*
Perceived schedule flexibility	The amount of flexibility students perceive they have over their education programme time schedule	Positive	33	*"It gives me flexibility in my personal schedule for example if I have a work commitment at the same time as a lecture"* *"The ability to access the classroom anywhere meant that it has a very flexible schedule for that day."*
Perceived convenience	The degree to which students believe that using a 3DVW technology in their educational programme would give them flexibility and efficiency in location, effort and accessing the classroom and material remotely	Positive	195	*"Advantages of using second life is that students and tutors can talk to each other from home or wherever is most convenient for them and not have to meet in person but still be able to talk about whatever they need to"* *"It also provides flexibility in that whether a student is learning from home, work or even a café it gives them the ability to join class and work asynchronously on the same project as it can be accessed from anywhere with a reasonable internet connection"*

'the extent to which [students] have a strong belief, firm trust, or sure expectation in their ability to respond to the demands of studying at the university'. Inspired by this definition, self-confidence was defined as *'the degree to which students believe in their own ability to interact with the instructor and other students by using 3DVW technology'*. As the technology creates a virtual barrier between students and instructors and reinforces through user anonymity, it assists and encourages introverted and shy students to participate in class activities and discussions and socially interact with others. Therefore, this provides benefits to the individual and the class as a whole, as students who may normally lack the confidence to express valuable ideas in the physical classroom can perform better. Students who usually do not prefer to be at the centre of attention, who are shy and do not like to speak up in front of the class, can now participate as much as the others without feeling ashamed. This technology will help them increase their self-confidence, reduce anxiety in a traditional classroom, and express criticism, especially for isolated students. The arena that 3DVW provides as a platform for learning that eliminates the element of judgement enables students to interact freely and without inhibition in regard to class content. The virtual world could be more effective at facilitating interactions during tutorials, as students will be more confident to ask questions and participate in discussions than they would be when physically in a room. Fifty-eight participants in the qualitative study reported 3DVW could increase students' self-confidence and increase student involvement in the course. Thus, this factor positively impacts 3DVWs' user acceptance.

Adapted from Dean (1960, 1961), Tomeh and Petrasek (1978) defined social isolation as 'the degree to which the individual feels alone, anonymous, and detached from others in society'. In accordance with the preceding definition, social isolation was defined as *'the degree to which a student feels alone, anonymous, and detached from classmates and other students of the university'*. Many students believe that 3DVW technology can break down their personal communication skills. They believe that by having virtual communication, they lose a realistic conversation with someone standing right in front of them; therefore, it can lead to social isolation and loss of communication skills. Sixty-six students believe that by implementing 3DVW-based learning, they will become socially impaired unable to converse and interact face to face.

Interaction difficulty was defined as *'the barriers arising in communication when the interaction is not face-to-face'*. 3DVW-based classes eliminate the human interaction that a traditional classroom environment provides. Unlike a face-to-face classroom, within the virtual classroom, educators are not able to gauge students' mood, involvement and engagement in the course, and they mostly cannot adapt the course material and presentations based on students' reactions. On the other hand, instructors in face-to-face classrooms usually use body language to build rapport and create relationships and communication with students. This can contribute to feeling safe and supported in the classroom, and at the same time, they transfer presentations and course material in the best way possible. This is lost in a virtual class setting. Avatars do not have human feelings, facial expressions, or the real-life appearance of a person; therefore, although students and instructors interact virtually, the interaction is limited. Additionally, certain courses cannot be supported by a virtual class setting. Transferring material that depends on the physical interaction between instructor and students is impossible for a virtual classroom to replicate. Instead of being able to form study groups face to face, students in virtual classrooms rely primarily on video, voice, text, and avatar expressions to interact with others. Overall, 20 students reported the interaction difficulty as a factor negatively impacting the user acceptance of 3DVWs. Table 12 shows the summary of factors in the category 'Interaction' with selected sample quotes extracted from the qualitative data.

Table 12 Summary of interaction

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Self-confidence	The degree to which students have a belief in their ability to interact with the instructor and other students by using the 3DVW technology	Positive	58	*"A 3D virtual world would avoid 'awkward' discussion as some students may be shy to contribute face to face or in a classroom full of 30 students or more."* *"… It is also beneficial to shy students who are scared to speak up in class and gives them the opportunity to give input in another way"* *"An advantage of second life is it allows people who are shy to have their opinion without the confrontation of public speaking"*
Social isolation	The degree to which a student feels alone, anonymous, and detached from classmates and other students of the university	Negative	66	*"the disadvantage is we felt like just talking and learning from a machine"* *"the disadvantage of the 2nd life is we are not really enjoy the real life of study and the real communicate with our classmate"* *"Lack of face to face communication promotes anti-social behaviours and lack of social skills which can lead to other complications."*
Interaction difficulty	The barriers arising in communication when the interaction is not face-to-face	Negative	20	*"In a face to face lecture you get a real response, through body language and tone of voice whereas things can be misinterpreted through messaging"* *"And another point to bring up just about second life in general is that you cannot read others body language or their emotions as you would having a normal face to face conversation."* *"You simply do not have the same connection with people online as appose to in person"*

4.2.12 Virtual Environment

Three factors comprise the category 'Virtual environment': multi-functionality, customisability, and interactive learning material. Adapted from Hoehle and Scornavacca (2008), Chang Lee et al. (2013) defined multi-functionality for a mobile device as 'the diversity of functionalities performed by a mobile device'. Based on the above definition, multi-functionality was defined as *'the diversity of functionalities provided by a 3DVW technology in a higher education setting'*. Within a virtual learning environment, it is possible to design a variety of functions integrated into one place that students can virtually access. As an immersive and multipurpose technology, a 3DVW offers excellent opportunities for students to participate in distance learning programmes. Online courses, tutorials, workshops, consultations, seminars, labs, meetings, and discussion boards can all be conducted with ease, and students and educators from all over the world can visit the virtual venue. Additionally, activities such as field trips, simulation, gaming, course material, curricular services, and a wide range of other student activities could be embedded inside a single virtual learning environment contributing to a multi-functional, educational and recreational experience for both learners and educators. 18 participants in the study stated that this multi-functionality of the 3DVWs is a positive antecedent of its user acceptance.

Sharma et al. (2009) defined software customisability as 'the ability to modify a component as per the application requirement'. Based on this definition, for the current study, customisability was defined as *'the ability to modify a component in a virtual environment as per the application requirements'*. As a customisable technology, 3DVWs allow designers to specify a set of extensions or changes to the core capabilities of the educational environment based on the requirements of the students and teaching course. Various aspects of the virtual space and activities can be easily extended, changed, modified, and re-organised. This technology is very versatile regarding how it can be used and can suit any learning requirements, and it allows even students to customise different parts of the environment and develop new features for themselves. The customisability of the 3DVWs has a positive impact on its acceptance, according to 26 participants in the study.

Interactive learning material was defined as *'the digital learning material that requires the student to complete a series of related activities to learn a specific concept'*. Provided course material for students can be designed and offered within 3DVWs in an interactive manner so that they will work through the content at their own speed and on their own terms. For instance, the material can be designed in a way that the next step in learning resources becomes available for the students only if they successfully answer a question or pass the previous step. Similarly, the designed material can use some intelligent methods and algorithms to determine students' knowledge and learning level to present various pieces of resources to better suit the student's needs. The three-dimensional graphic design possibility in 3DVWs has created the opportunity for instructors to provide another means of accessing material other than traditional hard copies or plain text files, or two-dimensional image files. Sixty-three students mentioned that accessing the interactive learning material within 3DVWs will positively impact its acceptance. Table 13 shows the summary of factors in the category 'virtual Environment' with selected sample quotes extracted from the qualitative data.

Table 14 summarises the identified categories, and factors in each category, and represents a quantitative elaboration of the data and the frequency of themes in each sample group: the data collected from the virtual focus groups, and the data collected through the open-ended question.

Table 13 Summary of virtual environment

Factor	Definition	Impact on user acceptance	Number of participants	Sample quote
Multi-functionality	The diversity of functionalities provided by a 3DVW technology in a higher education setting	Positive	18	*"there are many possibilities within second life, for both education and recreational purposes"* *"In a 3D virtual world, it is possible to have everything in one place, which students can access online. All of the course materials and lecture notes, as well as virtual rooms where lectures or tutorials can be held"*
Customisability	The ability to modify a component in a virtual environment as per the application requirement	Positive	26	*"This technology is very versatile on how it can be used and can suit any learning requirements."* *"Second life … has an unlimited foundation of possibilities within the learning experience"*
Interactive learning material	The digital learning material that requires the student to complete a series of related activities to learn a specific concept	Positive	63	*"The use of course material online in a virtual world provides us with another means of accessing the material other than hard copies"* *"Students can also stay up to date and find useful information by using the never-ending avenues of interactive course material"*

Table 14 Quantitative representation of the collected data and the frequency of identified themes

Category	Factor	Impact on User Acceptance	Frequency of themes in data		
			*VFGs (124 samples)	Question (121 samples)	Total
Ease of use	Perceived ease of use	+	13	14	27
	User friendliness	+	1	2	3
Accessibility	Ease of access	+	10	10	20
	Access flexibility	+	10	4	14
Infrastructure	Hardware dependency	–	31	3	34
	Internet dependency	–	33	5	38
	3DVW Reliability	+	26	4	30
	Data Security	+	5	1	6
	Communication flexibility	+	34	25	59
Usefulness	Perceived usefulness	+	15	12	27
Attractiveness	Visual attractiveness	+	8	11	19
Enjoyment	Perceived enjoyment	+	33	27	60
	Perceived playfulness	+	7	12	19
	Perceived distraction	–	22	6	28
Cost efficiency	Cost efficiency	+	42	56	98
Sense of Presence	Sense of presence	+	23	28	51
Self-efficacy	Technology savviness	+	6	3	9
Convenience	Time efficiency	+	35	30	65
	Perceived schedule flexibility	+	9	24	33
	Perceived convenience	+	103	92	195
Interactions	Self-confidence	+	27	31	58
	Social isolation	–	62	4	66
	Interaction difficulty	–	19	1	20
Virtual Environment	Multi-functionality	+	5	13	18
	Customisability	+	1	25	26
	Interactive learning material	+	26	37	63

*Virtual Focus Groups

5 Discussions and Conclusions

This section discusses the findings and provides answers to the research questions. The current research employed a qualitative approach to examine factors affecting higher education users' embrace of 3DVW. The two sets of qualitative data were collected through the virtual focus group and the open-ended question using a 6-phase thematic analysis. As a result, a big picture representing antecedents of user acceptance of 3DVWs in the higher education context was provided. After a thorough analysis of the data, the answers to the research questions are summarised as follows.

Answer to the main research question: What are the factors affecting students' acceptance of 3DVW? In order to answer the main research question, 26 factors impacting the user acceptance of 3DVW were identified. The identified factors are shown in Fig. 3 and Tables 15 and 16. These factors were classified into twelve meaningful categories:

Table 15 Antecedents of user acceptance of 3DVWs in higher education (with positive effects)

Antecedents with a positive effect	Brief implication
* User friendliness	A user-friendly learning environment enables students with little or no technical background to easily navigate within the environment with no difficulty and helps them establish an immediate relationship with technology
Perceived ease of use	Designing an easy-to-use environment and including simple options in the virtual learning environment help students immediately learn the features of the new technology
Perceived usefulness	When students believe that using a 3DVW would enhance their performance in education, they will be encouraged to accept the technology
* Ease of access	3DVW is easily accessible through a computer and an Internet connection. This characteristic contributes to increased user acceptance of this technology in higher education
* Access flexibility	Students can easily access the learning environment through a wide range of electronic devices. This characteristic has a positive impact on user acceptance of the technology
* Visual attractiveness	When the visual effects and elements, graphical structure, colours, patterns, and overall view of a virtual learning environment is aesthetically pleasing to students, they intend to accept and use the technology
* 3DVW reliability	Creating a 3DVW-based learning environment with minimum software bugs, technical difficulties, operation issues, and glitches will have a positive impact on user acceptance of the technology
* Data security	A higher level of data security for the virtual learning and teaching environment is one of the major concerns of students using this tool for their education
* Communication flexibility	Various communication tools embedded in 3DVWs have increased the flexibility of communication among students and educators and positively impacts user acceptance of the technology
Perceived enjoyment	When a 3DVW is considered a fun and pleasing technology, students are intrinsically motivated to accept and use it
* Perceived playfulness	Students could gain intrinsic enjoyment while navigating their avatars in the virtual learning environment. This characteristic has a positive impact on user acceptance of 3DVW technology
* Cost efficiency	3DVW is a cost-efficient technology to be used in the field of education, and the use of the technology reduces a large number of expenses for both students and educational institutions
* Time efficiency	Students can save a large amount of time that they would usually spend when they have a traditional classroom
* Perceived schedule flexibility	3DVW technology provides access to the activities, course materials and lectures online and 24/7, which gives students a flexible study schedule
* Perceived convenience	3DVW-based learning allows students to learn in the comfort of their own place, without travelling to the campus, which is considered a convenience for them
* Multi-functionality	The diversity of functionalities that 3DVW platforms present have made this technology a multipurpose and multi-functional environment for distance learning
* Customisability	3DVWs allow designers to specify a set of extensions or changes to the core capabilities of the educational environment based on the requirements of the students and teaching course

Table 15 (continued)

Antecedents with a positive effect	Brief implication
* Interactive learning material	Course material can be designed and offered within 3DVWs in an interactive manner, and students can go through the material independently based on their own pace of learning and understanding
* Technology savviness	Technology-savvy students are encouraged to use new tools in their educational programmes, and 3DVW is no exception
* Sense of presence	In order to enable students' immersion into the virtual learning space, the environments must be created so they are similar to the real-world teaching and learning environment
* Self-confidence	3DVW technology leads to increased self-confidence in interactions, and self-confidence significantly impacts students' acceptance of the technology

* The factor has not been identified or examined previously in the literature

Table 16 Antecedents of user acceptance of 3DVWs in higher education (with negative effects)

Antecedents with a negative effect	Brief implication
* Hardware dependency	This technology requires appropriate hardware specifications to run and perform
* Internet dependency	This technology requires a high-speed internet connection to run and perform
* Perceived distraction	The entertaining characteristic of this technology can be a distraction to students learning
Social isolation	Distance learning reduces face-to-face interactions among students as they lose real conversations and relationships and can contribute to social isolation
* Interaction difficulty	There is a lack of body language, eye contact, facial expressions, postures, gestures, and proximity in the virtual world, which creates a communication barrier between students and instructors and students themselves, thus contributing to interaction difficulties

* The factor has not been identified or examined previously in the literature

infrastructure, attractiveness, cost efficiency, self-efficacy, sense of presence, virtual environment, ease of use, usefulness, accessibility, enjoyment, convenience, and interaction.

To answer the research sub-questions, the identified 26 factors were investigated further in terms of their positive or negative impact on user acceptance.

Answer to RQ1: What factors have a positive effect on the student acceptance of 3DVW? 21 out of the 26 factors positively affect user acceptance, meaning that they have a significant impact on the acceptance of 3DVWs as a means for teaching and learning for higher education. Table 15 demonstrates the positive factors. Therefore, Table 15 summarises the answer to the first research sub-question.

Answer to RQ2: What factors have a negative effect on the student acceptance of 3DVW? The remaining factors, 5 out of 26, are considered negative factors, meaning that they negatively impact the acceptance of 3DVWs in the higher education setting. Table 16 shows the negative factors with their brief implication. Thus, Table 16 summarises the answer to the second research sub-question.

Tables 15 and 16 also provide a brief implication of each of the introduced factors. To the best of our knowledge, the factors indicated by * are new and have not been identified or examined in the same context previously.

5.1 Implications for Theory, Methodology and Pedagogical Practice

This study aimed to learn more about the user acceptance of 3DVWs in a higher education setting, and it has implications for theory, methodology and Pedagogical Practice.

5.1.1 Implications for Theory

Theoretically, the current study introduces the factors and constructs that influence higher education students toward adopting three-dimensional virtual worlds as a distance learning and teaching platform. The findings offer insight by highlighting constructs that can help higher education better understand how 3DVWs can be designed, implemented, adopted, and used to deliver effective teaching and learning. The findings also provide an in-depth understanding of various aspects of 3DVW and its advantages, limitations, and efficiency in higher education. The introduced factors can be employed by educational institutions to evaluate higher students' perception of 3DVWs and can be used to drive pedagogical development decisions. The finding emphasises the importance of the design aspect of virtual learning environment toward the acceptance of 3DVWs, showing that ease of use, usefulness, attractiveness, and enjoyment of the virtual content, as well as the sense of presence within a 3D virtual learning environment, significantly impact the adoption of this technology in higher education. The findings indicate this technology's essential infrastructural and accessibility requirements and their relationship with the adoption of 3DVWs in the higher education setting. Besides, this study indicates that there are factors associated with higher education students' personal and social capabilities that can influence their perception towards acceptance of this technology. The findings also emphasised the economic impact of the use of 3DVWs in higher education. The study provides theoretical support to determine the relationship between the constructs and the acceptance of 3DVWs. It also provides a taxonomy of antecedents of technology adoption in the higher education context.

Some of the identified constructs have already been examined by other theories, and the current study's findings are consistent with them. As an example, the relationship between 'Perceived ease of use' and 'Perceived usefulness.' and acceptance is in accordance with Technology Acceptance Model (TAM) (Davis, 1989) and TAM2 (Venkatesh & Davis, 2000). Similarly, the relationship between 'Perceived enjoyment', which is an additional motivational determinant of acceptance, and acceptance is also consistent with the findings of Davis et al. (1992). Overall, the study provides support for the Technology Acceptance Model. The study's findings as well as the provided big picture of effective factors will help future researchers understand various elements impacting the user acceptance of 3DVW technology in education. This can also assist scholars in the educational technology and information systems fields in developing new theories. The new factors discovered in the study can be investigated further in future studies using different or similar technologies in various virtual teaching and learning environments. Similarly, the relationships between user acceptance and positive outcomes can be measured by considering these factors.

5.1.2 Implications for Methodology

In this study, the application of 3DVW technology can be seen as empirical evidence about the role of immersive virtual environments in the implementation of distance learning programs for higher education. Future studies could explore the relationship between user acceptance and personal parameters such as age, gender, exposure to technology, familiarity with technology, cultural and psychological factors, etc. Future studies will be able to accurately examine the newly identified factors by using statistical research methods to determine the significance of each factor. Many studies in the literature, including the current study, implemented limited and short-term instructional programmes on 3DVW-based environments, which were a part of a course or, at most, one-term courses. New research could expand the duration of the educational programme to a longer-term, such as more than one term, if not more than one year. Researchers can better study how students' and educators' impressions of this technology change during long-term studies.

Although there are some studies in the literature on the social aspects of 3DVWs, future research is expected to delve deeper into the various social and cultural factors that influence the use of these technologies by higher education students, particularly by studying the application of the technology within various cultural contexts. Studies are required to investigate the issues and barriers associated with employing the technology in higher education. Since the current study encountered several unsatisfactory experiences and limitations in using Second Life for educational purposes, improvements are required for Second Life to become an effective means for distance learning. The majority of the studies in this area have mostly focused on the benefits and positive elements of 3DVWs in higher education. Thus, these technologies must be investigated in terms of application, and implementation complexity, efficiency, compatibility, students behaviour, data security, implementation cost, and so on. This study looked at the adoption of 3DVW only from the students' perspective. New studies can also examine adoption from other users' points of view, e.g. instructors, lecturers, tutors, and so on.

5.1.3 Implications for Pedagogical practice

The current study has a number of contributions to pedagogical practice. The higher education community, which is considerably active in the use of virtual learning environments, can use the approach, outcome and findings of the current study in order to implement and offer effective virtual distance learning programs. This section provides some practical implications and informed directions for scholars who are interested in learning more about the pedagogical possibilities of 3DVW technologies and are willing to offer more engaging virtual learning experiences for higher education learners. Some of the potential capabilities of the technology in the context of higher education are discussed as follows.

Implications for Teaching Staff and Course Designers Educators and course organisers may use 3DVW technology to expand novel and effective teaching and learning methods in an innovative, effective, and productive way. The current subsection provides implications for various stakeholders of the technology.

Initial orientation sessions play a crucial role to assist students' transition to the 3DVW-based learning environment. Prior to starting educational sessions in the virtual world, students should be provided with guidelines and an overview of the environment. They should

be familiarised with the technology and learning space, as well as the possible activities within the 3DVW-based learning environment. Creating accounts, designing and personalising avatars, navigation within the virtual worlds, teleportation, and communication are the major activities students should learn before starting an actual teaching and learning programme in 3DVW. Additionally, students should be provided sessions to use the technology practically to become familiar with the developed virtual area and to practise available options within the environment. These orientation sessions reduce students' anxiety about the new technology, teach them the basic operations, and give them an overview of what they will use in the real teaching and learning sessions.

Despite the rich communication facilities provided in virtual world platforms, there are some limitations in interactions between students and instructors. 3DVW-based training eliminates face-to-face interactions, and therefore, delivering the material might not be as perfect as in a traditional classroom. The technology is very mature and rich in presenting learning material, and the capabilities of the technology enable instructors to represent the contents in a variety of creative ways such as videos, animations, presentations, interactive learning material and spatially structured tasks. Students may need assistance to use the material, and very detailed guidelines are required.

The findings can raise awareness of the significance of the environment and its contents' purposeful design. 3DVWs, as a multipurpose platform, enable educators and teachers to create interactive learning environments and their contents on the basis of their current teaching and learning methodologies and theories to offer lessons to higher education learners. Several previous studies have implemented various instructional methodologies and learning theories in virtual worlds.

When students are in a remote location, and there is no supervision, many distractions can interfere with a student's learning as they may not be fully engaged in the task at hand. Therefore, teachers' strict supervision, management, and guidance encourage the students to be more disciplined in their activities.

Implications for Curriculum Designers and Developers The implications of this study should also be shared with practitioners and designers of curriculum and educational contexts. The design of the virtual learning environment is worthy of consideration. This study's results revealed several factors relevant to the virtual space design that impact 3DVW technology's acceptance in higher education.

Students learn new technology features faster when the platform is designed to be simple to use, and simple features and options are included in the interactive learning environment. This contributes to technology acceptance. A user-friendly learning environment enables students with little or no technical background to easily navigate within the environment with no difficulty and helps them establish an immediate relationship with technology. The current study's results indicated that ease of use is a significant factor in a 3DVW-based learning environment and should be taken into account when developing such environments and implementing educational experiences.

The visual attractiveness of the virtual learning environment is another significant factor playing a crucial role in the adoption of 3DVWs. Designers of virtual learning environments for higher education can make aesthetic development choices in order to attract students by creating an attractive learning atmosphere. Visual effects, graphical layout, interactive functionality, colours, patterns, and the overall look of the learning environment are all critical in creating a visually appealing virtual learning environment. For instance, using lively and exciting colours, including natural perspective viewpoints in the environment such as water, oceans, trees, flowers, and so on, can be considered examples of visual

attractiveness in the virtual environment. The more attractive the look of the virtual teaching and learning environment is, the more positive the outcome for students engaged in the technology.

Another significant specification of the three-dimensional virtual learning environment is the sense of presence, which plays an important part in achieving learning effects. In order to enable students' immersion into the virtual learning space, the environment, the surroundings, and the objects inside the environment must be designed in a way that they are quite close to the teaching and learning environment in the real world. Users should feel emotionally and cognitively involved in the virtual environments (Mantovani & Castelnuovo, 2003). The 3DVW-based learning experience should be very realistic and built in a way that helps students feel like they have attended a real-life classroom or university campus environment to achieve better teaching and learning outcomes.

Hedonic outcomes such as enjoyment and happiness are intrinsic motivators for the adoption of a system (Venkatesh & Brown, 2001). In actuality, information and communication technology innovations hold incredible potential to enhance the way individuals learn. ICT-based technologies have become a significant part of educational systems. One of the most significant benefits of incorporating these innovations into education is that learning can be viewed as enjoyable and entertaining. Students who participate in enjoyable activities gain a fresh outlook on learning (Okan, 2003). Bloom and Hanych (2002) stated that students do not learn if they are not having fun when it comes to learning as entertainment. This study's findings also reveal that when students see the learning programme in 3DVWs as enjoyable and interesting, they are more likely to employ and adopt the technology. Incorporating game-like experiences into the learning platform, designing game-based learning so that students play the game to understand the concepts, and outfitting the environment with activities that maximise excitement, fun, and playfulness all contribute to higher education students' acceptance of technology.

Implications for Higher Education Institutions The current study also shares implications with higher education institutions, such as universities, colleges, polytechnics, etc.

Unlike the traditional education system, one of the main advantages of using 3DVWs in education is the faster delivery time. It reduces travel time for educators and students, and for the most part, There is no squandering of time at the start or end of the sessions. For students, as they learn at their own pace, there is no time wasted due to the pace of the entire class. This technology is a cost-efficient tool for communication, collaboration, and teaching and learning as the institution generates long-term savings in resources such as labour, energy, regular classroom maintenance, educational materials, and so on. The budget cuts and rising costs force educators to creatively do more with less by using this technology for teaching, learning, communicating and collaborating in ways that accommodate economic constraints. Therefore, having 3DVW-based e-learning as an option is highly recommended for higher education institutions.

The amazing potential of this technology to offer users a virtual presence within a virtual environment is one of the key reasons for its popularity in education, specifically in lecturing and delivering courses. Users feel a virtual presence in a virtual classroom or a lab space by controlling an avatar from a remote place. The use of visual effects allows students to touch and see everything virtually.

The experience of conducting computer lab discussion sessions and weekly meetings and discussion sessions during the experiment showed that this technology was successful in being used for virtual meetings and online discussions and can be an alternative for in-person meeting sessions.

Businesses have been forced to look more closely at green options as their awareness of environmental problems has grown. It is a directive for organisations, governments, and educational groups all across the world. Universities can mitigate the environmental impact of a large number of carbon footprints by implementing e-learning programmes.

5.2 Research Contribution

As stated earlier, this study focused on investigating 3DVW technology's user acceptance in higher education. In order to answer the research questions, a virtual teaching and learning environment was created in a 3DVW platform and was employed to conduct a distance learning program for the period of one semester for an undergraduate subject. After the experiment was completed, two forms of data collection, focus groups and open-ended questions, were used and overall, 245 data samples were collected, which is a rich sample size for a qualitative study of this kind compared to similar qualitative studies in the field. This study used a qualitative approach to gain an in-depth understanding of the participants' views about the technology. After the data collection and analysis was completed, significant findings were achieved. The findings provide critical information regarding the use and acceptance of 3DVWs in higher education. This paper contributes to the literature in the following ways:

- The study provides a big picture of various aspects of the adoption of 3DVWs in higher education. It identified multiple factors which influence the acceptance of 3DVW technology. To the best of our knowledge, this is the most comprehensive study identifying and introducing 26 antecedents of user acceptance of 3DVWs in higher education.
- This study introduces 22 new constructs that have not been examined in the field. Based on the results of the literature review conducted for this research, a limited number of studies looked at the user acceptability of the technology in higher education; and the majority of them have focused on a small number of constructs that are mostly different to the findings of the current research.
- In addition to the factors that have a significant and positive impact on technology's adoption, this study introduces another category of factors that negatively impact the user acceptance of the technology in higher education.
- In addition to the strengths of 3DVWs for higher education, the current study also highlights the technology's critical issues and limitations that affect its application in higher education and the learning effectiveness.
- The study provides constructive implications for theory, methodology, and pedagogical practice, with design solutions to the educational communities such as higher education institutions, teaching staff, course designers, curriculum designers and developers, and the higher education research community.

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Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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