

A Review of Virtual Reality Applications in an Educational Domain

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Abstract—The use of virtual reality (VR) applications has grown tremendously in recent years. This paper focuses on the review of existing virtual reality applications in higher educational institutions. The VR applications are still not widely used although it helps students learn and enhances their performance. Moreover, some factors that lead to the limited use of virtual reality are lack of communication, delay in technology development, weak acquisition of knowledge, etc. This paper provides a comprehensive overview of virtual reality applications in educational institutions. The reviewed articles are taken from databases such as Science Direct, Ebscohost, and Scopus. Furthermore, the reviewed eighteen articles are published between 2016 and 2021. The study analyzed the reviewed articles based on different factors such as fields, purpose, targets, methods, citations, factors, and limitations. The findings revealed that virtual reality applications could play an essential role in the education domain. The reviewed articles highlighted the significant contribution of virtual reality applications in the education domain and their impact on the students' performance. Moreover, the study revealed the critical factors used in VR environments, such as ease of use, efficiency, interactive environments, effectiveness, and learning environments.

Keywords—virtual reality, higher education, learning environment, student performance

1 Introduction

A new computing platform is born every 15 years. All are ready to integrate and experience the new coming platforms to fine-tune the future. The most exciting futuristic platform revolves around a vision to create enhanced and immersive experiences. When you wear goggles, you are entering a fully immersive computer-generated environment, a virtual world through which the person can interact with the virtual environment.

Virtual Reality (VR) stands for computer machinery to artificially create real-world properties and scenarios [1]. Virtual reality applications have grown tremendously in almost all domains and thus have shown a remarkable impact on various sectors

like learning, teaching, attitude, and community skills [2]. Virtual reality applications are computer applications that allow users to experience 3D sound and visual stimuli. According to [28, 36, 14, 15, 39], virtual reality applications enable users to be engrossed in the 3D world, in which they interact with virtual objects and explore the virtual environment [3].

The main scope of this research work is the educational domain. The characteristics of VR hold many applications within primary education to create new opportunities, increase participation, and enhance student learning in higher educational institutions [4]. The main goal of this research work is to highlight the importance of using VR in higher education institutions to increase the level of student's intrinsic motivation, participation, understanding, and confidence in learning [6, 1]. Thus, the recent trends of VR application in the field of education have had a significant influence, which has become a means to enable the student to acquire information, thus improving the learning process.

The students are not fond of just the traditional mode of teaching and learning methods alone. The environment has to be enriched with the efficient utilization of technology. To develop, succeed, and utilize this technology and upgrade the quality of education, there is a need to activate the VR usage; besides, proper training must be provided and ensured for both the teachers and the students [1, 2, 7].

New technologies are used to improve learning. The intention of using VR applications as advanced technology is the same as using a 2D program in the initial stages of technology-enhanced learning [4]. VR applications determine the critical factors of education by enhancing the professional development of the teacher's experience, practical simulations, and innovations, and thus the new environment attracts the students and their curiosity and participation [1, 8, 9, 5].

Some tools are related to virtual reality, such as interactive learning environments that enrich ease of use, flexibility, and effectiveness. Besides, various learning activities are offered to the students who take the courses to illustrate how they interact with these events [9, 10]. Interaction in the learning environment is a vital element and is directly tangible to student performance, same as [29, 2]. There are collaborative educational environments that involve four elements of the course: teaching, society, teacher assessment, and student evaluation [11]. These factors can be considered as essential factors that lead to the VR application acceptance and use. Constructivism plays a crucial role in the development of educational applications. The employment of virtual reality applications stretches the student's opportunities exclusively to build and enhance knowledge [9, 10].

The foremost hindrance in education is the conceptual theories with no simulation, making education neither easy nor understandable. However, Virtual Reality environments enable us to create a model or simulation of reality that makes things familiar and transparent [7, 6]. Besides, VR applications provide three-dimensional (3D) perceptions of the chosen system. Students can thereby learn the principles and theories of the systems in a quicker, effective, and enjoyable way by interacting and traversing the environment created for such a system [11]. This study focus on the following questions:

- Q1. What is the purpose of using VR applications in educational projects?
- Q2. What is the primary system/model and method used?
- Q3. What is the main contribution to knowledge used in VR applications?
- Q4. What are the main target groups and the citations of each study?

This paper is organized into several parts. It begins with a literature review that collects research articles related to VR systems from several open-access databases. A summary of selected publications is represented in a table to determine each study's problems, methods, and knowledge contributions. It is followed by a methodology section that encompasses the processes and impacts of the technologies currently used. Furthermore, results and discussion are included, followed by the conclusion and references.

2 Literature review

In this section, a literature review of different studies related to education, engineering, physics, neuropsychology, etc., is presented. Each study was analyzed based on their method of using VR systems. Students all over the world are nowadays more engaged in online learning [11]. VR is riding the development of online education administration systems and amplifies the focus of the educational brand more significantly. This section selected 18 articles related to the study purpose and explained them in Tables 1 and 2 to answer all the questions of this study.

Regarding the respondents' opinion on the position of VR in growing academic cognizance of the brand and as the educational sector developed to use VR as an assistance tool of the learning process, most respondents (72%) agreed that VR tools permit more extensive engagement on an implied target market online or with students' interest through e-learning models [9, 12, 20]. [1] presented a VR research related to the use of 3D in university for student's learning process. The method was to build a model utilizing VR technology to make the learning process easier. The contribution to knowledge statistically shows significant differences; improvement in student achievement in the sample who studied using the 3D lab [10].

In the engineering field, [12] examined the effect of four different methods in the engineering field to assess the students' learning outcomes and feedback. The primary purpose was to examine the VR systems validity among other types of learning. The results compared the scores of the students after each test monitored. The study showed that Virtual reality systems enhance students' achievements in engineering education [12]. The results were incredible, emphasizing that VR applications can be exploited to simplify students learning evolution.

[7] highlights some factors that can impact rehabilitation, such as perceived behavior, self-efficacy, and facilitating conditions [7, 16, 20]. The results revealed the positive influence of these factors to improve the educational process. Furthermore, in the educational process, VR technology's effect on students who face problems in the shift from the information age to the experience age is unbelievable as e-learning modules, hands-on workshops, practical experiences, etc. can be provided [17]. VR is particularly valuable for giving a few openings: expanding understudy commitment; giving constructivist, legitimate encounters to affect understudy character; taking into account new points of view taking and sympathy [18]; furthermore, supporting imagination and the capacity to envision troublesome models. An essential purpose behind using VR as a learning instrument is to meet youthful understudies in a way that they like. [17, 22].

[6] focused on animation usage among universities to increase students engagement. The whole animation model by VR application was utilized to make a simple vision for students. Using unique models of testing and validating data as learning

theory depending on sampling and questionnaire administration disclosed the influence of effort expectancy and students' performance [18, 21]. Moreover, VR applications have also given a significant opportunity for people with disabilities who do not have the linguistic or physical ability to reach the natural world and experience the educational experiences of the truth. Sometimes a VR application becomes a requisite to make the system tangible and avoid mistakes that may occur in the practice of the existing system, which abolishes or causes impairment, thereby leading to unintended financial losses. Thus, VR applications become mandatory for teaching and providing training, thereby introducing a prototype of the natural system [12, 19].

[8, 5] said that fast developments in technology had created distance education straightforward. Education is considered a necessity for society, just as Covid 19 has affected the education sector, which led to the transformation of the educational approach entirely via the Internet. The research discusses the importance of distance learning and how to address the challenges of e-learning. The purpose was to improve education and new skills that lead to lifelong learning and know the pros and cons of innovation and development. Furthermore, to solve technical difficulties- download difficulties, software installation problems, sign-in and audio problems by pre-registering for video lectures and there must be a Plan B for teaching. Similarly, courses should be flexible, interactive, and essential training [8, 25, 21, 47].

The e-learning system of Kazakhstan was investigated in [9]. According to the writer, distance education is divided into two important sections: the student and the teacher. The research also stressed the importance of starting e-learning in all regions because of its countless benefits. Some of its benefits are that students can learn and develop themselves independently, encourage them to solve problems themselves, and improve their knowledge. In addition, we should investigate and research different teaching methods to improve education and provide a better understanding for students. We should know that E-learning is an ongoing educational project for long-term use. We should expect more benefits from it in the future too, and we should keep in mind that students are our counters and society [26, 41].

[10] aims to see the academic pressures and fears experienced while studying and during exams during the COVID-19 crisis. The survey conducted by university students showed that pressures and fear increase during the final examination period because the grades are higher since the introduction of distance learning for the Covid-19 crisis and the lack of experience in using the study site [45, 42, 9]. In addition, the students who are intense users gain knowledge and perform the tests comfortably. The challenging course material, which has practical, the creation of training and trial programs for students, student account problems, poor signals, etc., are some of the problems faced by the students. All these reasons will affect students' performance and are required to adapt to e-learning [27, 47, 46].

On the other side, [39] determined some difficulties with VR applications, especially in the education process. One of the impediments that the teacher has to face is using these VR applications to motivate them to communicate with the students interestingly to take advantage of educational programs and encourage them to access the virtual experience. Some of the essential elements of virtual reality applications and technology are the manufacturers, the devices manufactured, their quality, the working of the virtual application, how it portrays the system, and how the application improves the level of the students during the educational process [20~27].

Table 1 shows the summarized studies of twelve related topics and determines the problem, method, and contributions.

Table 1. Summarized studies

Ref.	Problem	Purpose	Method	Contribution to Knowledge
[1]	Achievement of the students learning	Build a VR technology-based model to make the learning process easier	Experimental method	Metacognitive abilities in science, significant differences in student achievement
[8]	COVID-19 affected student learning methods	Address the challenges of e-learning	Survey	Teachers and students should guide on how academic institutions exploit educational resources and curricula.
[29]	Student's performance	Address the challenges of e-learning	Survey	Directly tangent to the student performance
[12]	Achievement of the students	Examine the VR system validity among other types of learning	Experimental difference method	A valuable option for clinical assessment and retraining restricted major
[7]	The analyst observed behavior mechanism	Identify developed technology, most integrated into collaborative networks	Many-sided information translation intervention	Increase the interactive exercise rehabilitation
[18]	Struggling in identifying the learner's needs in their lives	Increase imagination and communication abilities amongst learners	Interactive simulations	VR developed in new technology to support the learner's needs
[5]	Less collaboration	Determine the factors of VR	Experimental method	Underlines the advantages of the VR application and recognize the VR innovation abilities to build the scholarly brand mindfulness
[36]	Learners' attitudes	Increase the imagination level	Experimental method	Identify the effects of force feedback haptic using VR
[41]	Perspectives of receiving of information technology	Determine the suitable factors of VR applications	Experimental method	Effectiveness of head-mounted HMDs in learning
[39]	Behavioral intentions of using virtual reality in learning: perspectives of acceptance of information technology and learning style	Increase the dimensions of VR	Experimental method	Energize head-mounted HMDs in learning for VR engineers and instructive foundations
[2]	Achievement of the students	Build a VR technology model to make the learning process easier	Experimental method	Students' creativity and reasons related to creativity, such as meditation, flow, and attention, are amplified.

(Continued)

Table 1. Summarized studies (*Continued*)

Ref.	Problem	Purpose	Method	Contribution to Knowledge
[6]	Imagination and communication abilities amongst learners	Increase the dimensions of VR	Sampling and questionnaire administration	Increase imagination and communication abilities amongst learners
[40]	Imagination in particular creative methods	Examine the VR systems validity among other types of learning	Experimental method	Increase individual's creative performance and observer's attention plus movement state by a reminder and encouraging feedback that is based on electroencephalography
[11]	Create (3D) perceptions into the organizations	Developing online studying administration systems	Experimental method	Interacting and traversing the environment created for such a system

Table 2. Summarized details of construction stage, target, dimension, field and factors

Reference/ Citation	Construction Stage	Target	Dimension	Field	Factors
[14]/106	Design	Students	3D, 5D, 7D	Education	Effectiveness
[37]/15	Design	Students	3D	Education	Ease of use
[39]/29	Design	Students	3D	Education	Efficiency
[11]/65	Operation & management	User Managers	3D, 6D	Collaboration	Interactive environments
[28]/211	Operation & management	Users	3D, 4D, 6D	Constructed safety	Learning environments,
[40]/54	Design	Users	3D	Collaboration Constructed Design	Efficiency, Effectiveness
[1]/16	Review	Students	3D	Education	Ease of use
[29]/97	Design	Students	3D, 6D	Education	Ease of Use
[12]/176	Design	Students	3D, 4D	Education	Learning environment
[7]/47	Operation & management	Users	3D, 4D, 6D	Education, Collaboration	Ease of use, Effectiveness
[18]/111	Design	Students	3D, 4D, 6D	Education	Interactive Environment
[5]/4	Design	Students	3D, 6D	Education	Effectiveness
[36]/20	Design	Students	3D, 4D	Education	Efficiency
[41]/29	Operation & management	User Managers	3D	Collaboration	Interactive environment, Effectiveness
[14]/73	Design	Students	3D	Education	Efficiency
[2]/16	Operation & management	Users	3D, 4D, 6D	Collaboration	Ease of use
[6]/9	Design	Students	3D, 4D, 6D	Education	Ease of use
[38]/22	Operation & management	User Managers	3D, 6D	Collaboration	Learning environment

3 Methodology

Recent articles available on open-access database system are reviewed, and articles based on virtual reality applications which are effective and shows a significant impact on learning and academic performance are selected in this research work. The Analysis and retrieving procedure was performed using three keywords “VR application,” “VR application in Learning,” and “VR application in academic Performance.” Firstly, virtual reality applications aim at numerous features that help like estimation, study, psychology, medication, and treatment. Secondly, the uses of virtual reality applications in the education and learning fields and their impact on enhancing academic performance. It is a significant factor that the study is limited to articles on educational performance. The studies were checked and filtered based on years of publication and selected papers in a specific period from 2016 to 2021. The search was applied in three databases, namely SCIENCE DIRECT, EBSCOHOST, and SCOPUS, as shown in Table 2. The keywords used in this search engine were virtual reality applications to enhance students’ achievement, virtual reality applications to increase academic performance and the virtual environment’s effectiveness.

The result of the search included thousands of deference topics of virtual reality. The papers were excluded based on repetition, posters, books, thesis, and magazines. Besides that, the topics related to medicine, physiology, science were omitted and included only the issues associated with virtual reality in the education and learning sectors (see Figure 1). Table 3 shows the available matched articles in open-access databases such as SCIENCE DIRECT, EBSCOHOST, and SCOPUS. The reports are based on the virtual reality applications factor- the total reached articles were 34236 papers. All the selected articles used in the literature review section were used from 2016 to 2021 to use the latest updated topics related to VR. The method used to analyze the articles to find the target, purpose, citation, construction stage, the method used, field, factors, and limitations distributed between the two tables of Table 1 and Table 2, respectively.

Table 3. Open access database

Database Name	Field	Years (2016–2021)	Totals
SCIENCE DIRECT	VR applications	15300	21648
	VR applications in learning	3499	
	VR applications in academic performance	2849	
SCOPUS	VR applications	9832	10625
	VR applications in learning	757	
	VR applications in academic performance	36	
EBSCOhost	VR applications	1830	1963
	VR applications in learning	111	
	VR applications in academic performance	22	
Total = 34236			

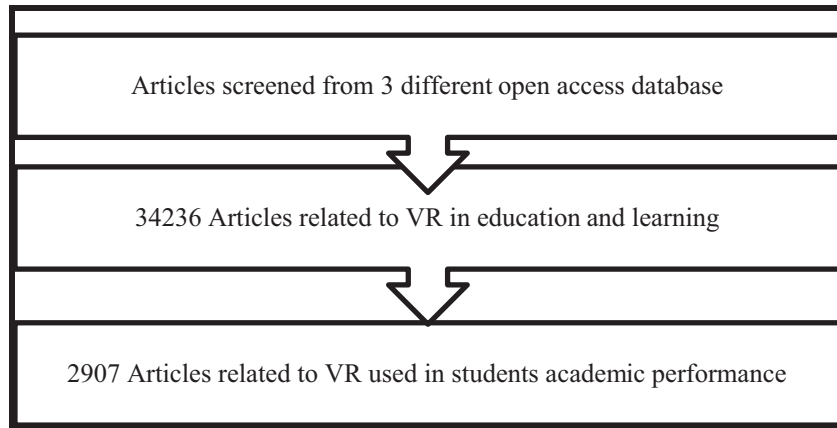


Fig. 1. Extracting relevant publications

4 Result and discussion

In this small-scale research, we found that the usability of VR applications in higher education institutions increased the academic performance factor. It increased dramatically, evident in each year's increased look-alikes and additional [24]. We found nearly three thousand papers related to academic performance, as shown in Table 3, and used six pieces to discuss virtual reality's importance in the learning area. It focuses on and discusses VR use in learning and the need for new methods and assessments to enhance and increase understanding. For this intention, it is clear that the VR application is critical in any higher educational institution.

The study came out with the core factors used in VR applications. As mentioned in Table 2, the five factors include interactive, learning, efficiency, effectiveness, and ease of use. Table 2 mentioned the field used, dimensions like 3 D, 4D, 5D, and 6D.

The results of the review are:

- Consuming any VR system radically progresses the students' performance.
- An effective VR system development can effectively utilize the information age benefits to those with CNS impairments dysfunction.
- The animation usage behavior of students increased students' innovation.
- Studies also showed students' positive attitudes towards 3DL teaching. Improvements in logical and visual thinking were also detected.

5 Conclusion

The conclusion of this review can be comprehended in the following phrase: "There is a lack in the student's academic level in the traditional model of education. The use of virtual reality applications influences the engagement and performance of the learners".

Virtual reality applications have their place in education and play a vital role and prove their importance from the results of the reviewed articles of this study. There is a broad scope for this topic in research. It will be interesting to see more and more learning systems based on virtual reality in the future. We can also connect virtual phones as well as will be able to create more realistic images and graphics to simulate reality. Virtual reality applications can be used in the educational area and also in day-to-day activities and work environments. The authors recommend 3DL in Omani schools and emphasize the need to conduct more research on different virtual labs in science education at higher education institutions. Furthermore, VR systems are very beneficial to medical students too. The future is virtual reality applications, and its benefits will remain countless and immeasurable.

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