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EXPLORING THE ASSOCIATION OF VIRTUAL REALITY EXPERIENCES AND CYBERSICKNESS AMONG MEDICAL STUDENTS: A COMPARISON OF STUDENTS FROM PAKISTAN AND CHINA

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Abstract
The main goal of this study was to find out differential effect and use of virtual environments on cybersickness among medical students. The population of this study was made in multinational context including Pakistan ad China's medical university students. Out of them, 200 students 150 from Pakistan, and 60 from China were selected by multistage purpose and convenient sampling technique This study was quantitative in nature and survey research design is used in this study. Standardized tools were adopted for the study, which were tri-facet validated both by expert opinion and statistically by Confirmatory factor analysis (CFA) and Cronbach Alpha. Data was analysed using frequency distribution, t-test and Analysis of Variance (ANOVA). SPSS and Smart PLS-4 were used for the data analysis. Results of the study showed that virtual reality (immersive VR, non- immersive-VR) had significant effect on cybersickness. The intensity of immersive virtual environment experiences to effect individual is greater than non-immersive environment experiences because it involves headsets that completely surrounds visual system of body. This study may help the medical professionals in developing coping mechanisms for cybersickness. In order to enhance the quality of medical education, this study may assist in identifying various technologies and equipment that have been adopted to increase student learning, engagement, and assessment.
Keywords: Virtual Reality (VR), Immersive Virtual Reality, Semi-Immersive Virtual Reality, Non-Immersive Virtual Reality, Cyber sickness.

INTRODUCTION

Digital technology has influenced every occupation, so the learning process as well i.e., various teaching tools and techniques are product or process of technology such as projectors, online resources, interactive tests, and videos are available to students that foster their interest and understanding towards achievement of educational goals. Most interesting and latest technology which is gaining fame in education is use of virtual system to mimic real-world scenarios. The virtual systems allow students to have a deep probe into the subjects via various means which other technologies cannot (Dilshad et al., 2016). For example, exploring history, or science experiments, remote learning effectively especially important during events like a pandemic (De Coninck et al., 2022). These can not only mimic real-world, rather can slow-down or speed-up the real phenomena in a convenient learning way.

Virtual reality (VR) has various forms such as augmented virtual reality (AVR), immersive virtual reality (IVR), non-immersive virtual reality (NIVR) (Information Policy Team, 2020). Another synonym used for such computer-generated information, where real life phenomena are either slower downed, fastened, or enhanced for visualization ease is called as Augmented Virtual Reality (AVR) (Izah et al., 2023).

Virtual images are being used in the computer world since 1989, but now this concept is multiplied by inoculation of 3D imaging and animations. 360° technology allows capturing surroundings from all directions, providing a realistic experience (Arshad et al., 2021). It is important to illustrate that the content which is made to be visualized on traditional TV-like screens of computers, providing virtual tours, and stimulating senses, is termed as Non-immersive VR; while the environments where head-phones or eye-lens type extensions, are used to stimulate feeling of presence with motion parallax effects, are called as semi-immersive VR (Martirosov et al., 2022; Pot-Kolder et al., 2018). On the other hand, creation of an all-round environment, where full presence and immersion of user in virtual environments is made, is called as IVR.

VR technology is getting fame very rapidly. It is becoming extension of laboratory work or sometimes even replacing that in all science subjects depending upon the availability of resources (Thorp et al., 2022). Due to its flexibility and ease of repetition without any physical harm, it is becoming dire need of life science laboratories where the extensive use of living organisms is made and sometimes various are available in too short supply to repeat or to learn manual dexterity of operations (Venkatakrishnan et al., 2020). Thus, VR is increasingly used in medicine for purposes such as medical training, surgical planning, patient education, and rehabilitation (Drazich et al., 2023).

During the course of its use, it is considered that the virtual environment is safe because it is not using real harmful chemicals or instruments in laboratories which may give physical harm to the students. But recent studies revealed that it is also not totally harmless. However, the mechanism of its harming action is different. It is linked with a series of problems which are termed as cybersickness (Chang et al., 2023; Simón-Vicente et al., 2022). This is called as common side-effect of extensive use of computerized simulations. The cybersickness issues include nausea, disorientation (Stauffert et al., 2020), and oculomotor discomfort that can last for hours or days (Hanslo, 2023). Intensity of cybersickness is directly proportional to the exposure type (related to computer interface) and time spent with the simulated environments. It is primarily focused on application aspects, rather than hardware aspects in VR (Kourtesis, Amir, et al., 2023). The study therefore, covers inter-disciplinary and least studied topic i.e., medical issues caused by VR experience. Following paragraph further narrates its study strength in various areas around the world.

Study Rationale

The study variables i.e., VR and cybersickness, remained a focus of researches in 2013-15 in USA and UK being advanced countries having rich use of technologies in education. But fewer publications were observed in Asian countries like Pakistan. The reason for this lacking behind has also been contingent to the use of technology in this area. The data regarding related work is given in figure 1.

A lack of research on the effects of virtual reality and cybersickness in medicine was observed in literature. Moreover, VR-use has been considered as topic of concern to computer sciences i.e., over 60% of papers listed in Scopus database are related to the computer sciences; while roughly 12% of visuals related to medicine; 3.2% to neurology; 3.2% to nursing training; 5% of visuals are represented in dentistry and psychology; and 24.7% is remained the topic studied under the umbrella of social sciences. Figure 2 indicates number of research papers as per subject areas.

Problem Statement

The study focuses on investigating the effect of virtual environment experiences on cybersickness among medical students. The research aims to explore dual effect of VR programs among students i.e., on enhancement of their skills and causation of medical issues among them.

Research Significance

The study may be helpful for different stakeholders in following ways:

1. The education professionals, especially science educators and medical professionals may incorporate VR in their students' practical more efficiently by getting aware of the side-effects of intensity of use and may help them to develop social and digital skills through the use VR in studies.
2. The study may provide a ground for medical institutes to develop a creative and innovative environment by using the virtual reality objects to cope with the needs of current era by controlling its harmful effects.
3. The findings may help the teachers' and university administrators to create plans and implement these action plans to reduce the side-effects of virtual reality, caused by the mismatch between vestibular and visual system in the central nervous system of the body.

Research Implications
Our quantitative analysis of cybersickness in virtual reality reveals two key findings: (1) a variety of factors, such as technology, task, and human characteristics, can cause cybersickness; and (2) users' central nervous system is affected in virtual environments and intensity depends upon the rate of presence (3) attitude and aptitude of individual is affected. The impacts of cybersickness on experience quality are shaped by several forms of adaptation, such as behavioural, cognitive, and physiological adaptation.
Research Objectives
The main goal of this study is to find out differential effect and use of virtual environments on cybersickness among medical students. From this main objective following sub-objectives were derived:
- To identify the impact of virtual reality experiences on cybersickness among medical students.
- To examine the difference in intensity of cybersickness in immersive VR and non-immersive VR environments among medical students.

Research Questions
What is the basic purpose of this research is a curious question but before arriving this question there is a base of this research, on the basis of these sub-question this study was conducted, they are as:
1. What is the effect of virtual reality environment experiences on cybersickness among medical students?
2. What is the difference in intensity of cybersickness in different virtual environments?

LITERATURE REVIEW

Although the VR concept especially in the world of computers has been emerged since last decade (Chen et al., 2024), still a lot of interest of people and literature has been found in this regard. Here, the emphasis is given to the VR use in natural science education especially among the medical students.
Improvements in computer processing power have led to the creation of more complex and realistic virtual environments. Tools like head-mounted displays (Tian et al., 2022) and Cyberglove (Caserman et al., 2021) enhance immersion and interactivity in virtual environments. Virtual reality is commonly used in entertainment, particularly in video games (Jin et al., 2018). VR technology is increasingly being utilized in education to enhance understanding and interaction in the learning process.
Features of VR
Three "I's" merged to form VR i.e., imagination, interaction, and immersion (Burdea & Coffiet, 2017 as cited by Raja and Priya (2021). The imagination refers to visualization and creation of virtual world as mimic to the reality in such a way, one can feel his presence in that environment. This imagined world manipulates one or all human senses like vision, hearing, touch or smell. Interaction refers to the human-computer interaction in 3D imagined world e.g., space ball and head-mounted device (HMD), which offer effectiveness, real-time reactivity, and human participation. This interaction with 3D virtual world makes it many times more effective than typical 2D method uses. Immersion is advanced form of interaction where a man is himself put into the virtual world like Cave etc (Kirollos et al., 2022).
Good virtual reality would replicate a real-world 3D environment to the point where the brain receives information as it would from the genuine scene. Raytracing in VR allows for the creation of photorealistic images indistinguishable from real objects, but it typically requires long rendering times (Farmani & Teather, 2020; Toet et al., 2010a).
Types of VR
Based on the computer-human interaction, there are three types of virtual reality systems: non-immersive, immersive, and semi-immersive. Non-immersive systems like desktops are less advanced and inexpensive. Immersive systems provide the most realistic experience with superior graphics and performance. Semi-immersive systems, like flight simulators, fall between non-immersive and immersive systems, offering a mix of features like expanded field of view and haptic feedback to enhance the experience(Farmani & Teather, n.d.; NATO, 2023).
These three VR environments vary in their complexity and cost from non-immersive to immersive visualization i.e., non-immersive is least costly and simplest in its formation, while the immersive is most expensive and most complex in its formation. While, the semi-immersive lies between these two.
Components of Virtual Reality System
Figure 3 indicates components of VR system
The description of these specifications of VR system here, is to explain its crucial working i.e., the specific applications, its graphic displays, and picture production processes makes it not only interesting for the users; rather the VR Engine is responsible for various tasks like calculations, generation of graphical models, object rendering, lighting, mapping, texturing, simulations, and real-time displays. The choice of the VE engine depends on factors such as the application field, user, I/O devices, level of immersion, and graphic output required (Jeong et al., 2023).
Literature indicates that the processing power of computer determines the number of senses that can be rendered in a given time. However, any computer with increased processing power can serve as VR engine as well as dispersed computer systems connected by a high-speed communication network (Chang et al., 2020). Out of

output devices the manipulation of visual and auditory senses is most common. While, smell and taste are least commonly manipulated senses in this regard. The involvement of human senses in VR technology, makes it a powerful constructivist learning tool (Mittelstädt, 2019). Under next paragraph its logic is given in detail.

VR – A Perfect Match for Constructivism

Immersive VR experiences take users to their own created worlds i.e., some backdated historical events, spaces, or even within the human body. This process of course accelerates the learning experiences much more than traditional lectures or paper-pencil work. Moreover, various different software and games of VR allow multiple users to interact with computer screens and thus develop a collaborative learning experience where students can share their ideas and solve problems in a team work (Izah et al., 2023). Literature indicates that the VR has been proved as an agent for increased engagement and motivation. Thus, it leads to improved learning outcomes. Weech et al. (2019) asserted that it gives an interface of enhanced spatial reasoning and problem-solving skills among students.

The researches made by Chang et al. (2021) and Kiryu and So (2007) elaborated that the although VR holds great promises, still it is not devoid of substantial challenges as well. They pointed out that cost & accessibility; technical issues; and ethical considerations as the potential challenges of VR. Hildebrandt et al. (2023) further added the issues of privacy, safety, and potential addiction, to ethical considerations of instruction with VR. Qionghua et al. (n.d.) asserted that in spite of its challenges, the VR technology features like personalised learning experiences, interaction, engagement and creativity, make it best route for constructivist learning approach.

Therefore, VR is main focus of the natural and health sciences in the form of simulation training, practical skills, and case-based learning activities(MacArthur & Grinberg, 2021). Among health sciences, intensive use of VR technology, is observed. Educational use of VR in natural sciences include creation of environments for new diseases, technologies assess the suitability of course material.

VR-based computer modules have been effective in undergraduate students for natural science instructions involving healthcare simulations, defined by the Agency for Healthcare Research and Quality, create a situation or environment to allow individuals to experience real health care events for practice, learning, evaluation, testing, or understanding systems and human actions (NATO, 2023). VR simulations are effective in fostering cognitive, technical, and behavioural skills. Surgical VR simulators, 3D anatomical models, and mobile VR are examples of VR simulators (Quarles, 2018). Surgical VR simulators are highly reusable and require minimal setup time, enhancing users' technical psychomotor abilities. 3D anatomical models can be studied by adjusting and rotating the model, and virtual dissection tables enable the cutting of digital models (Mousavi et al., 2013; Tiiro, 2018).

A recent study highlighted the potential of digital health education (DHE) in dermatology, highlighting its benefits such as increased learning efficacy, improved educational quality, and enhanced instructor resources. DHE includes various offline and online modalities, such as virtual patient, virtual reality environment, mobile learning, digital game-based learning, psychomotor skill trainers, Virtual Learning Environments, Learning Management Systems, and Massive Open Online Courses (Doutora, 2022; Martirosov et al., 2022; Pot-Kolder et al., 2018). It contributes to a practical and effective learning environment for students and health professionals, enhancing learning outcomes. The traditional approach to surgical education has been replaced by active and student-centred learning, with innovations like interactive three-dimensional methods enhancing anatomical knowledge. Virtual reality training has been reported to enhance learning outcomes of inpatient surgical operations (Weech, Kenny, & Barnett-Cowan, 2019). CPR instructors believe that virtual reality's fidelity, engagement, resource conservation, and memory augmentation qualities make it an ideal tool for teaching CPR to medical personnel (H. Kim et al., 2021).

But this intensive use of VR technology for the science students, is accompanied with the health challenges such as cybersickness, which includes symptoms like claustrophobia, nausea, headaches, disorientation, and discomfort. These issues are collectively known as cybersickness (Venkatakrishnan et al., 2020).

Cybersickness

Literature indicates that the simulated environment itself creates issues like dizziness, headaches, or vomiting. But if these simulations are related to computerized devices or environments, stimulates these issues three times than the situations otherwise. The reason behind these issues is primarily caused by vision focus on the digital devices which is further accompanied with the vestibular stimulations (J. Kim et al., 2023).

Cybersickness can be induced by visual stimuli, resulting from a discrepancy between movement in the vestibular environment (VE) and the lack of movement caused by sitting. This visual vs vestibular conflict causes a sensation of vection, a visually induced self-motion illusion (Gavgani et al., 2018). Further detailed issues related to the VR and cybersickness are discussed in table 1.

Further overview of the literature also indicated that different demographic factors such as the age, gender, exposure times, and nature of VR being used also influence intensity of cybersickness.

Gavgani et al. (2022) study found that motion sickness symptoms intensify with increased exposure time. Users susceptible to motion sickness may experience twice as strong effects. To reduce or eliminate simulation sickness, regular exposure to virtual settings is recommended, but longer periods are not advised (Kourtesis et al., 2024).

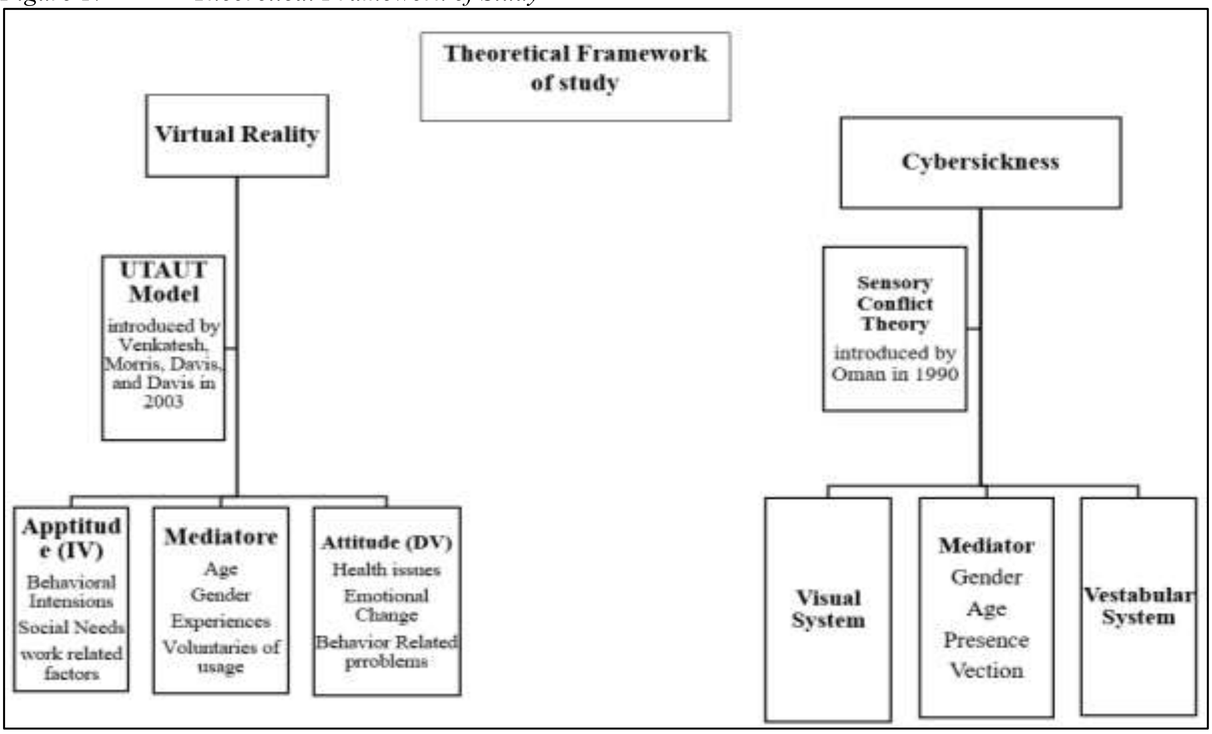
User control and navigation in a virtual environment can reduce simulation sickness rates, with walking being a more effective method than controllers for physical navigation(Holmgren, 2021). Head-mounted displays can strain the visual system due to factors like contrast, illumination, exposure time, and operating distance. Users

may experience headaches, nausea, and visual strain after ten minutes in an immersive virtual environment. Sensory conflict exacerbates these symptoms. HMDs are associated with higher motion sickness rates than desktop displays (Kourtesis, Papadopoulou, et al., 2023).
Simulation sickness can be influenced by lighting, viewing distance, and time, with ideal viewing distance of 65 cm. large screens enhance presence but do not directly cause sickness. 360-degree video technology allows students to explore a digital environment, providing a sense of presence and engaging learning (Arshad et al., 2021). However, there is a lack of research on internal medicine. VR provides a more immersive experience, allowing students to experience real-world clinical scenarios before they encounter them in their studies (Toet et al., 2010b).
Medical processes have become complex, making it essential to train medical personnel in highly sought-after skills. VR can be used in various settings, such as anatomical atlas, psychiatry, and surgical trainings. Head-mounted 3-D equipment and simulated training sessions are created to motivate subjects in a virtual environment (Qionghua et al., n.d.; Tian et al., 2022).
However, one major challenge to address is cybersickness, a collection of symptoms that occur during and after VR immersion, like motion sickness. This can pose a serious risk to performance and usability of fully immersive VR systems.

Theoretical Background of Virtual Reality and Cybersickness

This study investigates the impact of virtual reality on cybersickness among medical university students using the UTAUT (Unified Theory of Acceptance and Use of Technology) theory proposed by Venkatakrishnan et al. (2020). The theory focuses on users' intentions and usage patterns when using information systems. According to this theory, four constructs predict user approval and behaviour i.e., performance expectancy to measure job performance gains; effort expectancy to measure system simplicity/ complexity; social influence measures group influence; facilitating conditions measure the availability of organizational and technical infrastructure. Figure 4 indicates UTAUT model of the use of VR on the behaviour and performance modifications.
Taiwo and Downe's model incorporates gender, age, experience, and voluntariness of usage as moderators of interactions. Bangert and Dokter's UTAUT paradigm in medical education suggests organizations must strengthen technology adoption and culture modification. Inadequate structure, laws, politics, and user health concerns may hinder VR adoption in developing countries. Figure 5 gives further elaboration of the UTAUT Model with respect to the study.
Virtual reality can cause "cybersickness," causing nausea, disorientation, and oculomotor symptoms, potentially causing physical and psychological health issues, unlike traditional motion sickness. Figure 6 gives elaboration of cybersickness with respect to its two major issues i.e., visual and vestibular systems.
Sensory conflict theory explains cybersickness as a result of conflicting information from the visual and vestibular systems. For instance, in a driver simulator, users experience self-motion illusions, but the visual system informs them of their movement direction. Theoretical framework of the study is given in the figure 7.

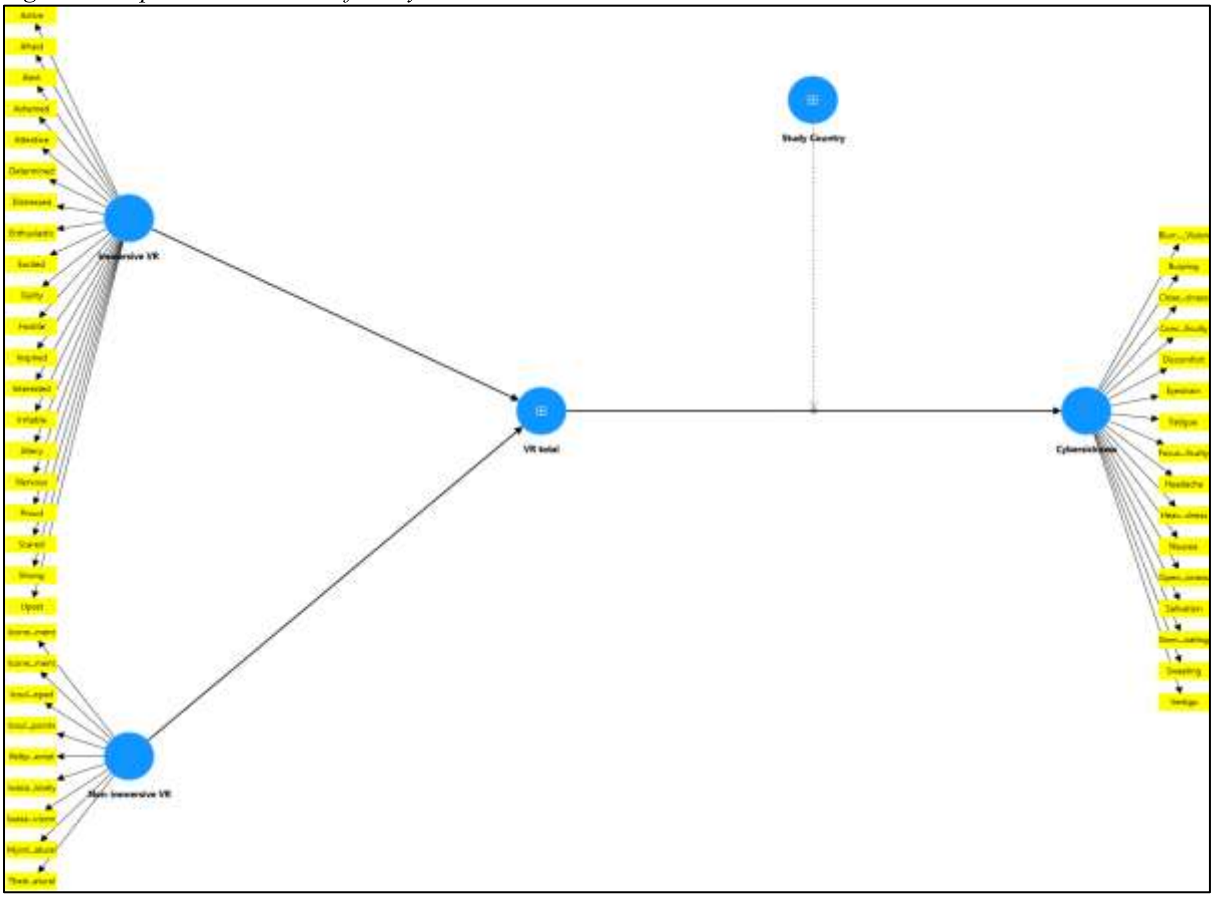
Figure 1: Theoretical Framework of Study



Conceptual Framework of the Study

The conceptual framework of the study is given in the figure 8 as follows:

Fig 8: Conceptual Framework of Study



METHODOLOGY

This study employed a survey research design to attain the desired objectives of the study. The research was conducted by examining databases such as Web of Knowledge, Google Scholar, and Scopus. A comprehensive investigation of the topic was carried out, with a focus on the results obtained from Google Scholar.

Population of the Study

The study focused on students enrolled in both public and private medical universities, including national and international institutions. The population encompassed all individuals meeting the criteria for inclusion in this group, irrespective of its size. The study was delimited to the health science students of Pakistan and China.

Sampling Technique

For this study, a multistage and convenient sampling approach was employed. In this study, multistage sampling was used at national level while convenient sampling was utilized at the international level due to practical constraints. Only Chinese students who were proficient in English were eligible to complete the questionnaire, and they were selected based on the researcher's accessibility.

Research Instrument

1. The demographic section included demographic factors include gender, age, and study level.
2. The questionnaire that measures the virtual reality was adopted from (Kourtesis, Linnell, et al., 2023)
3. To measure the active participation of individual in non-immersive virtual environment "Presence Measurement Questionnaire" was used developed by Kiryu & So (2007)
4. The cybersickness was measured by "Simulator Sickness" questionnaire by Chang et al. (2020)

Validity & Reliability

Content validity of the instrument was made by 10 experts. . As per criteria of validity, 80% of the expert agreed on the content validity criteria. Face validity of the instrument was checked by sending the questionnaire to 10 national students and 10 Chinese students who have proficiency in English language, with proper guidelines and instructions. Seven to eight students completed the questionnaire in that allocated time period. So, this tool is considered valid because the wording of the questionnaire was easy to understand, completed in given time period and their answers were related to the study. Reliability of the instrument was checked by using Cronbach's alpha and the value was found 0.890 that was considered satisfactory. Detailed description of the reliability and validity of the construct is given in table 2. Table 3 further elaborates the discriminant validity of the construct by Heterotrait-monotrait ratio (HTMT) matrix.

Ethical Consideration

Each participant in this study was given the information that participation in the study is entirely voluntary, that their identity is safeguarded by the use of a code number assigned to each response, and that their privacy and confidentiality are kept private. It was communicated to the participants that they were free to leave the study at any point, without providing an explanation.

Data Analysis

Both descriptive and inferential statistical approaches were utilized for data analysis. Descriptive statistics, including mean and frequency distribution, were computed to determine the proportion of subjects based on their demographic representation. Inferential statistics were employed to ascertain the effect of virtual reality on cybersickness among medical students. Specifically, one-way ANOVA was employed to analyse the variance in the response variable. For the purpose of data analysis SPSS and smart PLS software's were used.

Analysis to examine the Frequency of Use of VR in the Two Countries

The frequency of the use of VR in both countries was found by chi-square analysis. Association of the immersive VR levels among the students of both countries under study is given in table 4.

Table 4: Association of the Immersive VR levels among students of both countries under study

		Immersive VR			Total	Chi-square
		Low	Medium	High		
Pakistan	Count	1	25	34	60	
	Expected Count	.5	23.5	36.0	60.0	
	% within country of study	1.7%	41.7%	56.7%	100.0%	
	% of Total	0.8%	20.8%	28.3%	50.0%	
China	Count	0	22	38	60	
	Expected Count	.5	23.5	36.0	60.0	
	% within country of study	0.0%	36.7%	63.3%	100.0%	
	% of Total	0.0%	18.3%	31.7%	50.0%	.493
Total	Count	1	47	72	120	
	Expected Count	1.0	47.0	72.0	120.0	
	% within country of study	0.8%	39.2%	60.0%	100.0%	
	% of Total	0.8%	39.2%	60.0%	100.0%	

The table gives association of data related to immersive VR experience and the participant groups of two countries Pakistan and China. The chi-square values indicate insignificant association between the two variables which means that the students of both groups have no much difference at the use of immersive VR.

While observing the distribution of participants across the two countries, however it was observed that the percentage of participants is similar across all VR immersion level in both countries.

Under table 5, association of non-immersive VR experience among the students of both countries is described.

Table 5: Association of the Non-immersive VR levels among students of both countries under study

		Non immersive VR				Chi-square
		Low	Medium	High	Total	
Pakistan	Count	3	45	12	60	
	Expected Count	1.5	52.5	6.0	60.0	
	% within country of study	5.0%	75.0%	20.0%	100.0%	
	% of Total	2.5%	37.5%	10.0%	50.0%	
China	Count	0	60	0	60	
	Expected Count	1.5	52.5	6.0	60.0	
	% within country of study	0.0%	100.0%	0.0%	100.0%	
	% of Total	0.0%	50.0%	0.0%	50.0%	.000
Total	Count	3	105	12	120	
	Expected Count	3.0	105.0	12.0	120.0	
	% within country of study	2.5%	87.5%	10.0%	100.0%	
	% of Total	2.5%	87.5%	10.0%	100.0%	

The table indicates the association between non-immersive VR experience among the students of both countries. The values of chi-square indicate a highly significant relationship between the non-immersive VR experience among the students of both countries which means there exists some difference between the non-immersive VR use among the students of both countries.

Further the difference in use of non-immersive VR experience between the two countries revealed that the use of moderate level of non-immersive VR was highest among Chinese students while in Pakistan too the same was present in greater percentage than the other two levels.

Analysis to examine the intensity of cybersickness experienced by VR user students of both countries

Table 6 indicates the difference of intensity of cybersickness experienced by the VR users of both countries.

Table 6: The Difference in Intensity of Cybersickness experienced by VR users of both Countries.

		cybersickness			Total	Pearson Chi-Square
		Low	Medium	High		
Pakistan	Count	2	38	20	60	.000
	Expected Count	10.0	29.5	20.5	60.0	
	% within country of study	3.3%	63.3%	33.3%	100.0%	
	% within cybersickness	10.0%	64.4%	48.8%	50.0%	
	% of Total	1.7%	31.7%	16.7%	50.0%	
China	Count	18	21	21	60	
	Expected Count	10.0	29.5	20.5	60.0	
	% within country of study	30.0%	35.0%	35.0%	100.0%	
	% within cybersickness	90.0%	35.6%	51.2%	50.0%	
	% of Total	15.0%	17.5%	17.5%	50.0%	
Total	Count	20	59	41	120	
	Expected Count	20.0	59.0	41.0	120.0	
	% within country of study	16.7%	49.2%	34.2%	100.0%	
	% within cybersickness	100.0%	100.0%	100.0%	100.0%	
	% of Total	16.7%	49.2%	34.2%	100.0%	

The table presents data about the relationship between cybersickness and the country of study. Results of chi-square indicate a significant association between the cybersickness and the country of study. This means that there exists a difference in the victims of cybersickness in both countries.

Further percentage difference indicated that majority of the Pakistani students were facing medium level of cybersickness while, most of the Chinese students were experiencing low level of cybersickness.

Moreover, the detailed percentage of the cybersickness indicators was also found and a brief description of each of them is shown under following charts. Figure 9 indicates the difference of general discomfort faced by students of both countries.

The bar chart indicates a general discomfort found among the Pakistani students at mild level while the same was found at moderate level among Chinese students. Figure 10 indicates difference of fatigue level faced by students of both countries while using VR.

The chart indicates sever to mild fatigue level was observed among Chinese students while moderate to mild level of fatigue was observed among Pakistani students. Figure 11 indicates difference of headache faced by students of both countries

The chart indicates moderate level of headache among the Pakistani students while among Chinese students it was observed at lower ratio. Figure 12 shows difference of eye-strain level faced by students of both countries.

The bar chart indicates abundance ratio of mild eyestrain among Chinese students than that of Pakistanis. The figure 13 indicates difference of focus difficulty faced by students of both countries.

The chart indicates moderate level of focus difficulty among the students of both countries, but slightly higher ratio among the Chinese students. The figure 14 difference of increase salivation faced by students of both countries.

The figure indicates that moderate increase in salivation among Pakistani students. While this issue was almost nil among Chinese students. The figure 15 indicates difference of sweating faced by students of both countries.

The figure indicates moderate level of sweating among Chinese students, while the issue was found in little ration among Pakistani students. Figure 16 indicates difference of nausea faced by students of both countries.

The chart indicates severe nausea complaints among Chinese students while this issue was moderate among Pakistani students. Figure 17 indicates difference of concentration difficulty faced by students of both countries.

The chart indicates severe concentration difficulty level among Chinese students while among Pakistanis this issue was found at mild level. The figure 18 indicates difference of heavy headedness experienced by the students of both countries.

The figure indicates moderate level of heavy headedness among the students of both countries with slightly greater ratio among Chinese students. The figure 19 indicates difference of blurred vision experienced by students of both countries.

The figure indicates mild level of blurred vision among students of both countries but the level among Chinese students was found greater than that of Pakistanis. The figure 20 indicates the difference of dizziness with open eyes experienced by students of both countries.

The figure indicates mild level of dizziness among students of both countries but the level among Pakistanis was slightly greater than that of Chinese. Figure 21 indicates difference of dizziness with closed eyes, experienced by students of both countries.

The figure indicates that moderate level of dizziness with closed eyes, slightly greater among Chinese than Pakistanis. Figure 22 indicates difference of level of vertigo faced by students of both countries.

The figure indicates severe complaint of vertigo among Chinese students. While among Pakistanis the situation was found almost normal. Figure 23 indicates the difference of stomach bloating experienced by students of both countries.

A mild stomach bloating was found among Chinese students while the same complaint was very low among Pakistanis. Figure 24 indicates differentiated level of burping experienced by students of both countries.

The figure indicates moderate level of burping observed among Chinese students while among Pakistanis this issue was also found in little ratio.

Analysis to explore the impact of VR experience over Cybersickness via different paths

Table 7 indicates path-coefficients showing SEM analysis involving all the study variables.

Table 7: Path coefficients showing SEM analysis involving all the study variables.

Analysed paths	Mean (M)	SD	T	Sig.	Path coefficients
Immersive VR -> VR total	0.764	0.034	22.287	0.000	0.767
Non-immersive VR -> VR total	0.073	0.355	1.023	0.306	0.363
Study Country -> Cybersickness	-0.562	0.176	3.179	0.001	-0.559
VR total -> Cybersickness	0.160	0.152	0.944	0.345	0.144
Study Country x VR total -> Cybersickness	0.940	0.189	5.008	0.000	0.949

The table indicates statistical analysis of structural equation modelling examining the relationship between different study variables to experience cybersickness. The results indicated strong positive impact of immersive VR to overall VR experience; moderate positive impact of non-immersive VR over the overall VR experience. The overall VR experience has a weak positive impact on cybersickness suggesting that a higher VR experience may have little influence over cybersickness.

The moderation effect of study country along with overall VR experience had a significant impact over cybersickness suggesting that the relationship between VR experience and cybersickness is influenced by the country where the students study.

DISCUSSION AND CONCLUSIONS

The study results indicate that both countries seem to be at similar stage in terms of access to and use of immersive VR technologies. However, China appears to have more use of non-immersive VR, particularly at moderate level. This indicates that the non-immersive VR is an important part of Chinese education system.

Immersive VR was found to have insignificant effect over the cybersickness while, it was found to have strong influence via mediation of overall VR experience and cybersickness. the students of both countries found to be engaged more in the non-immersive VR experience. But it was found to have weak influence over the cybersickness that suggests that VR experience doesn't necessarily lead to cybersickness. this leads to twofold conclusions, i.e., existence of cybersickness among the students may be caused by another computer engagements or activities in addition to VR experience. It may also be concluded that the VR use is not as harmful as was theorized. So, it can be used without fear of side-effects.

Significant moderation effect of study country indicates that the cultural environment or the different instructional scenario (including availability and quality of VR technology), can have impact over the relationship of VR and cybersickness. it may also be supposed that there may be some physical environmental factor acting as extraneous factor over study (e.g., lighting, and ventilation etc.), that may influence cybersickness.

Study limitations

Some potential limitations of the study are described as below:

Limited sample size, minimizes the generalisability of the findings over large populations, although this effect was contoured by the use of PLS technique to equate variance of the data.

A detailed description of VR technology add-ons (such as head-sets, software etc.) could also give more depth to the study.

Semi-immersive VR also remained undiscussed in the study. Moreover, level of VR applications such as level of immersion, motion and cognitive demands could have more breadth to the study.

Cybersickness was estimated on the self-reported data, the involvement of medical experts could give more precise picture of the VR technology and cybersickness. In this case chance of biasness of estimation by participants was left i.e., over-estimation or under-estimation towards VR use of cybersickness.

The study was based on single time point i.e., a developmental study over time to see long term effects of VR over cybersickness might give more clarity to the findings.

Recommendations

For future researchers, work on study limitations mentioned above, can give more precise and clearer picture of the scene i.e., expanding sample size; specification of the VR technologies, and applications used to allow for

better comparisons across studies; consideration of cultural factors in VR adoption and cybersickness; longitudinal or developmental studies to observe effect of VR use over time or long-term effects; and inclusion of the medical experts to observe objective measures of cybersickness such as eye-tracking, to complement self-reported data.
For different stakeholders, the study proposes following recommendations:
For the university management, prioritization of user experience and comfort to minimize risks of cybersickness can yield more effective outcomes. This may be done by using ergonomic designs of VR add-ons such as comfortable headsets to be used for extended periods; optimization of visualization by techniques such as high resolution displays, smooth frame rates and low latency to reduce eye strains and visual discomforts; mitigation strategies to avoid or minimize motion sickness such as use of gradual transitions, smooth camera movements, and avoiding jarring movements; and use of adaptive contents which may be adjusted according to the tolerance level of users.
For educators, study may be useful in provision of clear information, to the users regarding potential risks and mitigation strategies of VR use and cybersickness to the students.
For policy-makers, the study may help to develop guidelines and SOPs regarding responsible development of VR software by the tech-companies; promoting digital literacy among the students by conducting workshops or seminars or the other public awareness campaigns.

Declaration

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Competing Interest

The authors declare that they have no competing interests.

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Availability of Data and Materials

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Author Contributions

- **Rabia Tabassum**: Conceptualization, methodology, writing – original draft.
- **Moafia Nader**: Data collection, formal analysis.
- **Qudsia Shaheen**: Literature review, writing – review & editing.
- **Farah Fida**: Visualization, supervision.
- **Saira Taj**: Validation, project administration.
- **Mahvish Fatima Kashif**: Statistical analysis, final approval of the version to be published.

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