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Research Article

Two important factors in virtual reality simulations: Nursing students' experiences of cybersickness and sense of presence

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ABSTRACT

Background: With the increasing popularity of employing virtual reality simulations in nursing education comes the need for more research examining their effects on users besides learning outcomes. This study explored nursing students' perceptions of a sense of presence and experiences of cybersickness in virtual reality simulations.
Method: A descriptive-analytic research design was employed. Between March and July 2024, 102 second-year undergraduate nursing students participated in an immersive virtual reality simulation focused on postoperative colorectal surgery care. Data were collected using the Sociodemographic Characteristics Form, the Presence Questionnaire, and the Virtual Reality Sickness Questionnaire. Student's t-test, Mann–Whitney U test, and Kruskal–Wallis test were used to compare variables.
Results: The study revealed that nursing students experienced high levels of presence and only slight symptoms of cybersickness. Additionally, a statistically significant difference was observed both between gender and the adaptation/immersion subdimension of sense of presence, and between the presence of vision problems and the disorientation subdimension of cybersickness.
Conclusions: Since virtual reality is anticipated to become the leading teaching method in future nursing education, and therefore to maximize its potential, efforts should focus on increasing the sense of presence and reducing cybersickness.

Introduction

Virtual reality (VR) is an innovative and emerging technology that uses computer technology to create an interactive three-dimensional (3D) world (Chang & Lai, 2021). VR simulation utilizes 3D features to combine physical or other interfaces, such as a computer keyboard, mouse, speech/voice recognition, motion sensors, or haptic devices, to deliver immersive and highly visual content for users (Chen et al., 2020; Teixeira et al., 2024). By presenting a unique mimic of the real world, it generates a sense of physical presence in the virtual environment whereby, through their interaction with objects and/or performing a series of actions in this digital world, participants undergo an active, interactive, and safe learning experience (Kiegaldie & Shaw, 2023). Once confined to specialized fields such as the military and medical sciences, VR has expanded into a broad spectrum of disciplines, including computer science, engineering, social sciences, sports science, insurance, and nursing. Of particular note are its applications are particularly notable in education (Bradley, 2006; Chen et al., 2020; Wohlgenannt et al., 2020). The current literature predominantly focuses on the impact of VR on learning outcomes and participants' experiences. Numerous studies have demonstrated that VR enhances users' learning outcomes while offering an enjoyable and engaging learning experience (Chang et al., 2022; Lee et al., 2022; Padilha et al., 2019; Saab et al., 2022; Teixeira et al., 2024). VR is receiving increasing interest in undergraduate nursing education and is being used not only to support the development of knowledge and clinical skills but also to teach many nursing concepts, such as leadership, communication, decision-making, and critical thinking (Chen et al., 2020). While it is natural to investigate the effects of new technology on users, other critical aspects related to VR have received limited attention. These include the sense of

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Figure. Clinical virtual simulation environment and student experiences.

presence (SoP) and cybersickness, two essential factors involved in VR implementations (Figure).

The experience of *presence* implies a sense of "realness", highlighting that feeling of "being there" (Erickson-Davis et al., 2021). Sense of Presence (SoP) is a subjective illusion in which users feel as if they have left their current physical location and are transported into the VR environment. They behave as if they are "physically present", perceiving virtual objects and individuals as real (Servotte et al., 2020). Although the VR technology used greatly influences the level of immersion achieved, the characteristics of the user also play an active role in terms of their interest in the material presented. Presence can be influenced by several factors, including the behavior of avatars (narrative, duration of interaction, characteristics), interactivity with the environment (movement, familiarity), environmental restrictions, and physical impediments, such as cybersickness and awareness of apparatus and body movement (Riches et al., 2018). Other elements that can affect presence include the user's level of interest in the subject being experienced and their ability to perceive the spatial qualities of the virtual environment (Wiepke & Heineman, 2024), as well as internal factors such as personality traits and immersion propensity (Servotte et al., 2020). Achieving high levels of SoP is possible with an optimal VR experience, which is shaped by a combination of these factors.

Cybersickness a common side effect of video games, VR systems, and driving simulators, causes symptoms such as headache, nausea, sweating, disorientation, vertigo, and, in severe cases, vomiting (Farmani & Teather, 2020). Despite advancements in VR technology, to date no fully effective solution exists to eliminate cybersickness. Researchers have explored ways to reduce its impact (Arshad et al., 2021; Chen et al., 2022; Farmani & Teather, 2020), but the problem persists. Factors contributing to cybersickness include participant demographics (e.g., experience, physical and mental attributes), hardware (e.g., screens, tracking, rendering), and software design (e.g., movement, appearance) (Rebenitsch & Owen, 2021). Minimizing cybersickness is essential for an optimal VR experience.

VR technology is constantly evolving (Wohlgenannt et al., 2020). The triggering factor for technological development is the experiences of its users coupled with the endeavor to improve the quality of the application and thus provide a better experience. Since its discovery, technological developments have much improved VR with regard to its realism and how users interact with the environment created. VR devices are currently more comfortable, lighter, easier to use, and more powerful than their previous versions (Servotte et al., 2020). In parallel with the rapid advancements in education technologies, it is essential to integrate innovative technologies within the nursing field, systematically evaluate their impact, and conduct research in this area. Plotzky et al. (2021) identified a lack of studies on immersive VR simulation, particularly with regard to the use of head-mounted displays (HMDs) in nursing education. The current nursing literature finds that nursing education is often focused on concepts such as knowledge, skills, and competence. In contrast, other essential factors, such as cybersickness and SoP, which are determinants of effective experience, are ignored. To provide better experiences, solutions should be developed that focus on reducing side effects such as cybersickness and increasing SoP in line with user experiences. Given the anticipation that VR will be used much more widely as a future educational technology, it is clear that more evidence is needed to help develop and optimize the service to be delivered using immersive VR simulation (Plotzky et al., 2021). In the nursing literature, in particular, there is a remarkable lack of research on these two factors, thus the aim of this study was to explore nursing students' experiences with the SoP and cybersickness in VR simulation.

The research questions for the present study were as follows: (a) What are the nursing students' experiences of cybersickness in immersive VR simulation? (b) What are the nursing students' experiences of SoP in immersive VR simulation? (c) Is there a significant difference between the sociodemographic data of nursing students and the findings on cybersickness and SoP findings?

Materials and Methods

Study design

A descriptive-analytic research design was used to achieve the purpose of this study.

Participants and setting

The sample consisted of second-year undergraduate nursing students from Kırıkkale University in Turkey. The undergraduate nursing education curriculum includes eight vocational courses spread over eight semesters (four years). In the fourth semester (second year), students take a surgical nursing course, where VR

Table 1
Sociodemographic Characteristics of Participants.

Sociodemographic Features	n	%
Gender		
Female	82	80.4
Male	20	19.6
Highest level of education completed		
High school	2	2.0
Local high school	75	73.5
Science high school	17	16.6
Occupation high school	7	6.9
Health occupation high school	1	1.0
Do you have a vision problem?		
Yes	52	51.0
No	50	49.0
What is your vision problem? (n:52)		
Myopia	36	69.2
Astigmatism	13	25.0
Other	3	5.8
Do you wear glasses?		
Yes	51	98.0
No	1	2.0
Do you play computer games?		
Yes	77	75.4
No	24	23.5
No answer	1	1.1
What is your gaming tool? (n:77)		
Smartphone	39	50.7
Gaming computer/tablet	27	35.0
All of them	11	14.3
Frequency of playing computer games (n:77)		
Everyday	18	23.4
1–2 times per week	36	46.7
1–2 times every 15 days	12	15.6
Once per month	7	9.1
A few times a year	3	3.9
No answer	1	1.3
Previous experience with VR (head-mounted display, virtual glasses)		
Yes	10	9.8
No	92	90.2

simulation is integrated into the teaching process. The study was conducted between March and July 2024. A total of 102 out of 112 second-year undergraduate nursing students participated. The criteria for inclusion in this study were being 18 years old and willing to participate.

Data collection tools

The following forms were used for data collection:

Sociodemographic characteristics form (SCF): This form was developed by the researchers and consisted of 18 questions covering the participants' sociodemographic features and the characteristics that related to cybersickness and SoP (see Table 1). To assess the content validity of the form, feedback was obtained from four expert faculty members. All faculty members had doctoral degrees and extensive experience in their respective fields: two in surgical nursing and simulation, one in fundamentals of nursing, and one in educational sciences.

Presence questionnaire (PQ): This form was developed by Witmer and Singer in 1998, and then Witmer et al. developed an updated version of the questionnaire in 2005 (Witmer et al., 2005). The scale was adapted to Turkish by Gökoğlu and Çakıroğlu in 2019. The PQ measures the degree to which individuals experience presence in a virtual environment and the influence of possible contributing factors on the intensity of this experience. The Turkish version of the scale consists of 29 items in five factors, including: Involvement (nine items); Adaptation/Immersion (seven items); Sensory Fidelity (five items); Interaction (five items), and Interface Quality (three items). A higher score on each factor indicated a better SoP. The validity and reliability study, it was found that the scale was highly valid and reliable, and the Cronbach alpha coefficient of the scale was 0.84. In the current study the Cronbach alpha coefficient of the scale was 0.89. Permission to use the scale was obtained from the authors.

Virtual reality sickness questionnaire (VRSQ): This questionnaire was derived from a simulator-sickness questionnaire by Kim et al. (2018). The Turkish validity and reliability study of the scale was conducted by Çetin et al. (2024). The VRSQ consisted of nine items, which are included in two components, namely oculomotor and disorientation. A higher score indicated that the participant experienced higher motion sickness symptoms. As a result of the validity and reliability study, the scale was found to be highly valid and reliable. After the first minute of VR simulation, Cronbach-α values were 0.786 for the oculomotor component and 0.753 for the disorientation component; at the 10th minute, Cronbach-α values were 0.561 for the oculomotor component and 0.694 for the disorientation component. In the current study, the Cronbach alpha coefficient of the scale was 0.609. Permission to use the scale was obtained from the authors.

Scenario

The scenario has been designed to align with the learning objectives, evidence-based practices, and guidelines (Association of perioperative Registered Nurses [AORN], 2021; INACSL Standards Committee et al., 2021; Wound, Ostomy, and Continence Nurses Society [WOCN], 2024). Following the recommendations of the International Association for Nursing Clinical Simulation (INACSL Standards Committee et al., 2021), the instructional methodology of simulation-based learning is shaped using the theoretical framework and criteria for the simulation design of the Healthcare Simulation Standards of Best Practice (HSSBP). In this scenario, a patient who has recently undergone surgery is in the patient room, requiring postoperative care until discharge. During the virtual environment immersion, participants received audio and written instructions for expected actions, such as assessing the surgical site and emptying the surgical drain. Scenario content validity was assessed by the same four experts who evaluated the SCF. The scenario was developed into a VR environment by RoT Studio (https://rotstudio.com), an immersive training technology company based in İstanbul, Turkey. Two programmers verified the VR environment's accuracy and quality before finalizing the simulation.

Data collection

Following participant recruitment, a communication group was formed using a secure messaging platform to share study-related updates and coordinate the research process. Students' available times were determined, and approximately six students participated in the immersive VR simulation daily. After attending the prebriefing session and participating in the VR simulation, each student completed the PQ and VRSQ forms before proceeding to the debriefing session. The mean duration of the sessions was as follows; prebriefing: 13.41 ± 1.18 (min:10 max:15) minutes, VR simulation: 32.07 ± 3.06 (min:30 max:35) minutes, debriefing: 38.41 ± 1.29 (min:35 max:42), and data collection lasted approximately 10 minutes. A classroom in the faculty was converted for VR simulations and equipped with devices such as a VR headset, a computer, and a TV screen. HTC's Vive Pro wired VR headset, which includes two controllers and two base stations, was used for high-resolution. The headset was adjusted to accommodate students who wear glasses. All students with glasses preferred to use a headset without removing their glasses.

Data analysis

Data were analyzed using IBM SPSS (Statistical Package for Social Sciences) 23v. software, and $p \leq .05$ was considered statistically significant. The conformity of quantitative variables to normal distribution was checked with Kolmogorov Smirnov and Shapiro Wilk tests, and it was determined that data did not have a normal distribution in the vast majority of datasets. Continuous variables were expressed as mean ± standard deviation and categorical variables as numbers (percentage). A student's t-test was used to compare variables with normal distributions between groups, while the Mann-Whitney U test and the Kruskal-Wallis tests were applied to compare variables with non-normal distributions.

Ethical statement

Ethical approval for the study was obtained from the Noninterventional Research Ethics Committee at Kırıkkale University in Turkey (reference number: 2023.11.24). After the researcher had thoroughly explained the study, written informed consent was obtained from each participant. Students were informed that participation in the study was entirely voluntary, that their decision would not impact their grades or academic evaluation, and that the subject would not be included in any examinations.

Results

A total of 112 undergraduate nursing students were invited to participate in the study, and 102 (91%) agreed to participate. The mean age of participants was 20.41 ± 1.25 (min:19 max:25). The majority of the participants were female (80.4%) and had graduated from a local high school (73.5%). Half of the participants reported having vision problems (51.0%), and nearly all of those with vision problems wore glasses (98.0%). Furthermore, a significant proportion of participants (75.4%) reported playing computer games, with 50.7% using smartphones for gaming. The majority (46.7%) played games 1–2 times per week. In addition, most participants (98.2%) had not experienced VR (head-mounted display, virtual glasses) (Table 1). The mean duration of participants' VR implementation was 32.07 minutes (SD = 3.06).

The participants' total PQ score was high (120.24 ± 11.43), and they demonstrated a strong SoP across all subdimensions. Conversely, their total VRSQ score was low (10.01 ± 8.69), reflecting minimal motion sickness symptoms (Table 2).

A statistically significant difference was observed between gender and the adaptation/immersion subdimension of PQ ($U = 516.000$; $p = .010$) and, the presence of vision problems ($Z = -2.915$; $p = .004$) and VR experience ($U = 254.000$; $p = .016$) with the disorientation subdimension of VRSQ. No significant differences were found between other demographic characteristics (Table 3).

Table 2
Participants' Mean Scores on Presence and Virtual Reality Sickness Questionnaires.

Questionnaires	Min	Max	Mean±Sd
PQ			
Involvement (9–45)	26.00	45.00	37.12 ± 4.45
Adaptation/Immersion (7–35)	19.00	35.00	28.85 ± 3.40
Sensory fidelity (5–25)	14.00	25.00	21.94 ± 2.29
Interaction (5–25)	12.00	25.00	20.17 ± 2.64
Interface quality (3–15)	8.00	15.00	12.14 ± 1.85
Total (29–145)	85.00	141.00	120.24 ± 11.43
VRSQ			
Oculomotor (0–100)	0	50.00	10.94 ± 11.54
Disorientation (0–100)	0	40.00	9.08 ± 8.78
Total (0–100)	0	35.00	10.01 ± 8.69

Note: Min-Max = minimum-maximum; Sd = standard deviation.

Discussion

This study explored nursing students' experiences with cybersickness and SoP, two key factors in VR technology, revealing notable results. Cybersickness occurs when the brain perceives the sensory and spatial integration of VR as incompatible during simulation applications. This leads to orientation problems, nausea, dizziness, and oculomotor symptoms (Nishiike et al., 2013; Simón-Vicente et al., 2024). Tursø-Finnich et al. (2023) reviewed cybersickness symptoms and identified dizziness, nausea, headache, discomfort, and eye-related issues as the most common. In the current study, participants reported low levels of cybersickness, while oculomotor symptoms (general discomfort, fatigue, eyestrain, difficulty focusing) were more frequent than disorientation symptoms (headache, fullness of head, blurred vision, dizzy [eyes closed], vertigo). This finding may be due to several factors, including fatigue from multiple lessons, underlying health issues, and sociodemographic features of the participants. This study also revealed a significant difference between vision problems and disorientation symptoms. All participants who had vision problems and used glasses preferred to wear the HMD together with their glasses. The HMD is heavy and even a slight shift in this headset causes the participant's view of the virtual environment to become blurred. Even if users adjust the HMD according to their head structure, the headset may slip during movement. Although wearing glasses did not reveal a statistically significant difference in participants' cybersickness findings, disorientation symptoms may have been experienced due to the headset's displacement during movement. In the future, it may be helpful to design studies that will take this issue into consideration while examining the difference between glasses and contact lenses.

Mareta et al. (2022) found that factors such as the speed and angle of movements, graphics quality, and bright colors/lights caused cybersickness symptoms. Previous studies suggest a direct correlation between the duration of VR simulations and the severity of cybersickness (Petri et al., 2020; Porcino et al., 2022; Risi & Palmisano, 2019). Some researchers in the literature have stated that better usability is associated with less motion sickness (Kim et al., 2018) and that the difficulty level of the target selection task and task load is a key factor related to cybersickness, with more motion sickness occurring as the task becomes more difficult (Jasper et al., 2023; Sepich et al., 2022). Although this study had a longer duration compared to those cited in the literature, it is believed that students experienced mild cybersickness symptoms due to the absence of a speed-based virtual environment. Task difficulty levels were not evaluated in the current study. However, a trainer-led teaching technique was used in the virtual simulation. Students received instructions for each application they completed, and did not encounter any problems during the application. Therefore, it was thought that the content of the virtual simulation was low in terms of task difficulty, which could explain the low cybersickness findings. Simulation scenarios in nursing education are recommended to last between 15 and 30 minutes (Bambini, 2016). Well-designed VR simulations can provide a high SoP, reducing the likelihood of experiencing cybersickness symptoms. Based on our findings and literature, this educational strategy can be effectively incorporated into nursing education by using VR with high usability and paying attention to duration, speed, task load, and difficulty level. Erbaş et al. (2024) recommend further research on virtual simulations in healthcare, focusing on the duration of VR simulation and the various factors influencing cybersickness.

Table 3
Comparison of Participants' Demographic Data With the Averages of VRSQ and PQ Scores.

Sociodemographic Features		VRSQ				PQ					
		n(%)	Oculomotor	Disorientation	Total	Involvement	Adaptation/ Immersion	Sensory Fidelity	Interaction	Interface Quality	Total
Gender	Female	82(80.4%)	50.98	52.84	51.91	37.13	47.79	51.71	51.60	52.92	50.66
	Male	20(19.6%)	53.63	46.00	49.80	37.10	66.70	50.63	51.08	45.68	54.95
	Statistic		$U = 777.500$	$U = 710.000$	$U = 786.000$	$t = 0.975$	$U = 516.000$	$U = 802.500$	$U = 811.500$	$U = 703.500$	$U = 751.00$
	analysis		$p = .710$	$p = .336$	$p = .773$	$p = .320$	**$p = .010$**	$p = .881$	$p = .942$	$p = .319$	$p = .561$
Vision problem	Yes	52(51.0%)	50.80	59.58	54.52	37.34	49.83	51.17	49.17	51.32	50.53
	No	50(49.0%)	52.23	43.10	48.36	36.90	53.24	51.84	53.92	51.69	52.51
	Statistical		$Z = -0.254$	$Z= -2.915$	$Z = 1.057$	$t = 0.505$	$Z= -0.586$	$Z= -0.115$	$Z= -0.816$	$Z= -0.064$	$Z= -0.338$
	analysis		$p = .800$	**$p = .004$**	$p = .291$	$p = .615$	$p = .558$	$p = .908$	$p = .415$	$p = .949$	$p = .735$
Wear glasses for vision problem	Yes	50(96.2%)	26.32	26.36	36.25	26.52	26.98	26.50	26.38	26.74	26.67
	No	2 (3.8 %)	31.00	36.30	32.75	26.00	14.50	24.00	29.50	20.50	22.50
	Statistic		$U = 41.000$	$U = 43.000$	$U = 37.500$	$U = 49.000$	$U = 26.000$	$U = 45.000$	$U = 44.000$	$U = 38.000$	$U = 41.500$
	analysis		$p = .655$	$p = .733$	$p = .550$	$p = .962$	$p = .251$	$p = .810$	$p = .773$	$p = .562$	$p = .686$
VR experience	Yes	10 (9.8 %)	56.00	72.10	63.10	40.25	68.05	45.10	60.65	56.90	53.25
	No	92(90.2%)	51.01	49.26	50.24	52.72	49.70	52.20	50.51	50.91	51.31
	Statistical		$U = 415.000$	$U = 254.000$	$U = 344.000$	$U = 347.500$	$U = 294.500$	$U = 396.000$	$U = 368.500$	$U = 406.000$	$U = 442.500$
	analysis		$p = .599$	**$p = .016$**	$p = .189$	$p = .204$	$p = .061$	$p = .465$	$p = .300$	$p = .538$	$p = .844$

Note: Z = Mann Whitney U; U = Mann Whitney U; t = Independence sample t-test.

The virtual environment used in this study features a patient room in a clinic, along with the devices and materials typically found in such settings. The scenario included a series of sequential steps focusing on postoperative patient care. Great attention was given to details, lighting, and coloring within the virtual environment, in an attempt to achieve the highest level of realism. These factors may have contributed to the high SoP noted by participants in the current study. High SoP levels may also have contributed to the low cybersickness findings. Servotte et al. (2020) found that nursing students in a mass casualty virtual simulation reported high SoP scores, with increased SoP correlating to reduced cybersickness symptoms. Some research has shown a statistically significant difference between SoP and factors like content type, gender (Melo et al., 2018), cybersickness, and awareness of apparatus and body movement (Riches et al., 2018). In contrast, the current study found no significant differences in sociodemographic characteristics, except for a notable difference in the adaptation/immersion subdimension of SoP based on gender. Additionally, men reported higher SoP levels than women. Previous research has examined gender differences in the SoP. Results indicate that men and women may differ in how they experience virtual environments and in the levels of presence they report. While many studies have examined the SoP in VR simulations, research on the factors that influence this sense is limited, especially in the field of nursing. Based on the literature and our findings, it is clear that minimizing cybersickness symptoms and enhancing the SoP is essential for students to have a high-quality VR simulation experience.

Conclusion

VR simulations present a promising tool for enhancing education in the field of health, offering students the opportunity to acquire knowledge and skills through innovative technology familiar to Generation Z. Our study revealed that students experienced high levels of SoP and mild cybersickness symptoms. To optimize the learning experience, the realism of the virtual environment, including factors such as color, positional changes, speed, and duration, must be thoughtfully crafted to enhance the sense of presence and reduce the risk of cybersickness. To effectively integrate this technology into nursing education, educators must consider the factors influencing the quality and effectiveness of VR simulations and conduct research to deepen their understanding of these issues.

Conflict of Interest

None.

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CRediT authorship contribution statement

Atiye Erbaş: Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Elif Akyüz:** Writing – review & editing, Writing – original draft, Validation, Methodology, Investigation, Formal analysis, Conceptualization. **Davide Giustivi:** Writing – original draft, Methodology, Conceptualization. **Daniele Privitera:** Writing – original draft, Methodology, Conceptualization.

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