VIRTUAL SIMULATOR IN ONCOLOGY FOR TEACHING CATHETER CARE FULLY IMPLEMENTED FOR NURSING STUDENTS: EXPERIMENTAL STUDY

Simulador virtual em oncologia para o ensino de cuidados com cateter totalmente implantado para estudantes de enfermagem: estudo experimental

Simulador virtual en oncología para la enseñanza del cuidado de catéteres implementado íntegramente para estudiantes de enfermería: estudio experimental

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ABSTRACT

Background: the virtual simulator emerges as an effective technological tool in the teaching-learning process. **Objective**: to compare the effectiveness of two teaching strategies in training nursing students in oncology, focusing on catheter insertion and care for fully implanted central venous catheters. **Methodology**: an experimental, controlled, and randomized study conducted with 55 nursing students. Participants were divided into two groups - control and experimental - and underwent different educational interventions with identical content. Statistical analysis included hypothesis testing and regression, with a significance level set at 5%. **Results**: the sample included 55 students (mostly women, aged between 21 and 23). Both groups showed improvement in learning after the intervention, but without statistical significance. However, the experimental group showed a significant improvement (p=0.003) in managing fully central venous in relation to adverse events. No significant differences were observed concerning sociodemographic profile, education, or digital fluency. **Conclusion**: the training program using virtual reality simulation proved as effective as the face-to-face course combined with a virtual learning environment, with better outcomes in knowledge about adverse events for the experimental group.

Keywords: continuing nursing education, virtual reality, nursing students, learning health system

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RESUMO

Enquadramento: o simulador virtual surge como uma ferramenta tecnológica eficaz no processo de ensino-aprendizagem. **Objetivo**: comparar a eficácia de duas estratégias de ensino na formação de estudantes de enfermagem em oncologia, com foco na inserção de cateteres e nos cuidados com cateteres venosos centrais totalmente implantados. **Metodologia**: estudo experimental, controlado e aleatorizado, realizado com 55 estudantes de enfermagem. Os participantes foram divididos em dois grupos — controlo e experimental — e submeteram-se a diferentes intervenções educativas com conteúdo idêntico. A análise estatística incluiu testes de hipóteses e regressão, com um nível de significância fixado em 5%. **Resultados**: a amostra incluiu 55 estudantes (maioritariamente mulheres, com idades entre os 21 e os 23 anos). Ambos os grupos apresentaram melhoria na aprendizagem após a intervenção, mas sem significância estatística. Contudo, o grupo experimental mostrou uma melhoria significativa (p=0.003) na gestão de cateteres venosos centrais totalmente implantados em relação a eventos adversos. Não foram observadas diferenças significativas no que diz respeito ao perfil sociodemográfico, à formação académica ou à fluência digital. **Conclusão**: o programa de formação utilizando simulação em realidade virtual mostrou ser tão eficaz quanto o curso presencial combinado com um ambiente de aprendizagem virtual, com melhores resultados no conhecimento sobre eventos adversos para o grupo experimental.

Palavras-chave: educação continuada em enfermagem, realidade virtual, estudantes de enfermagem, sistema de aprendizagem em saúde

RESUMEN

Marco contextual: el simulador virtual surge como una herramienta tecnológica eficaz en el proceso de enseñanza-aprendizaje. **Objetivo**: comparar la efectividad de dos estrategias de enseñanza en la formación de estudiantes de enfermería en oncología, centrándose en la inserción de catéteres y en los cuidados de los catéteres venosos centrales totalmente implantados. **Metodología**: estudio experimental, controlado y aleatorizado realizado con 55 estudiantes de enfermería. Los participantes se dividieron en dos grupos —control y experimental— y recibieron diferentes intervenciones educativas con contenido idéntico. El análisis estadístico incluyó pruebas de hipótesis y regresión, con un nivel de significancia establecido en el 5%. **Resultados**: la muestra incluyó 55 estudiantes (mayoría mujeres, con edades entre 21 y 23 años). Ambos grupos mostraron mejoría en el aprendizaje después de la intervención, pero sin significancia estadística. Sin embargo, el grupo experimental mostró una mejora significativa (p=0.003) en la gestión de los catéteres venosos centrales totalmente implantados en relación con los eventos adversos. No se observaron diferencias significativas en cuanto al perfil sociodemográfico, la formación o la fluidez digital. **Conclusión:** el programa de formación utilizando simulación en realidad virtual resultó tan efectivo como el curso presencial combinado con un entorno de aprendizaje virtual, con mejores resultados en el conocimiento sobre eventos adversos para el grupo experimental.

Palabras clave: educación continua en enfermería, realidad virtual, estudiantes de enfermería, aprendizaje del sistema de salud

INTRODUCTION

The global incidence of cancer is rising significantly, with an estimated 28.4 million cases by 2040 (Sung et al., 2020). This increase highlights the importance of training qualified professionals to ensure high-quality, safe care, especially in oncology. This study aims to evaluate the impact of a virtual simulator on the management of totally implanted catheters, emphasizing its role in enhancing nursing education and improving patient outcomes.

In recent years, international nursing education has increasingly focused on maintaining high standards of excellence and safety (Hong & Wang, 2023). In Brazil, educational guidelines emphasize innovative methods to enhance practical skills and critical thinking (Pfeifer et al., 2024).

Nursing students are integral contributors to the progression of nursing practice. They are pivotal facilitators in fostering the expansion and enhancement of the profession, thereby representing a vital element of the healthcare workforce (He et al., 2017; Lessmann et al., 2012). To achieve this objective, education must furnish professionals with comprehensive training encompassing knowledge, skills, and critical-reflective reasoning (Hang & Wang, 2023).

Chemotherapy constitutes a prominent modality in the treatment of cancer, necessitating a profound understanding and expertise to manage this type of therapy. An integral aspect of the procedures and support afforded to individuals undergoing this therapeutic regimen involves the management of fully implantable long-term central venous catheters, which are commonly utilized to administer these pharmaceutical agents (Damacena et al., 2020).

This device comprises a catheter composed of silicone or polyurethane and a titanium camera encased by a pierceable silicone septum, necessitating surgical insertion. The catheter insertion procedure is conducted in the Surgical Center under the expertise of a medical team, with the puncturing task performed by a nurse utilizing a designated needle. This type of catheter offers benefits including reduced infection risks and enhanced longevity. Notwithstanding, the effective utilization of this device mandates that the nurse possesses appropriate education and training to adeptly manage the device, accounting for its distinct attributes (Damacena et al., 2020).

Understanding the optimal practices for catheter utilization enhances its longevity, thereby the occurrence of negative events and complications, including but not limited to infection, obstruction, extravasation, dislocation, and localized pain (Elfagi et al., 2022).

The significance of incorporating the field of oncology into undergraduate nursing curricula is underscored by the necessity to impart understanding of procedures intrinsic to this specialized area of healthcare. Consequently, institutions facilitating practicum opportunities for graduating nursing students are called upon to establish initiatives aimed at equipping them with the requisite expertise and skill set for managing a fully implanted catheter (Ximenes et al., 2020).

This demand to prepare future nurses drives and determines the search for efficiency in training processes, with the adoption of various educational strategies supported by technological resources, which have the potential to address the challenges (Fischer et

al., 2021; Matsubara et al., 2016). These resources contribute to the training and education of new healthcare professionals, thus minimizing adverse events when caring for people with cancer (Pfeifer et al., 2024; Cavalcante et al., 2022).

In the field of health, the quality of education is important, with the advancement of new technologies and improving their use to provide innovative education (Bezerra, 2020). The search for materials and methods that allow for broader instructions with prepared and committed professionals generates reflection in the teaching-learning process, in a conception of knowledge in which students and teachers actively participate, replacing techniques of memorization and fragmented transfer of knowledge in a vertical way, with encouragement for student participation, being called active methodologies (Costa et al., 2015).

The simulation with virtual reality is characterized as an active methodology, based on a real event based on a real event to do, learn, evaluate, or understand situations, grounded in Problem-Based Learning (PBL), which allows the student to be an active character, with the learning of concepts, understanding, and problem-solving, while the teacher remains as the facilitator (Costa et al., 2015).

In this way, the mobile simulator with virtual reality emerges as a viable technological tool to integrate into the teaching-learning process, as it facilitates the connection between theory and practice, contributing to enhancing knowledge and understanding. Furthermore, it can evoke emotions and influence students' attitudes and values (Pfeifer et al., 2024). This is a device that simulates real situations, providing students with an immersive experience that replicates scenarios from clinical practice. These simulations, although artificially created, are perceived by the senses in a similar way to the physical environment. The technology enables access to high-definition synthetic and immersive environments, allowing for real-time decision-making practice (Pfeifer et al., 2024).

In this case, given that the changes brought about by digitalization in the professional field impact training in the health areas, and that recent advancements in universities show a growing trend of combining in-person and online methods, as well as the adoption of technological resources to support the development of skills (Darmann-Finck et al., 2016; Dörner et al., 2022). A comparative evaluation was sought between the learning outcomes of conventional teaching and the use of a mobile simulator with virtual reality. The objective was to compare the effectiveness of the teaching strategy employed in the training program for nursing undergraduates in oncology on puncture and care of the totally implanted catheter in two groups. One group received conventional teaching, including in-person classes and content available in a virtual learning environment, while the other group had conventional teaching combined with the use of a mobile simulator with virtual reality.

METHODOLOGY

Design and Participants

This experimental, controlled, and randomized study was conducted at a "Cancer Center" in São Paulo, SP, Brazil. It involved nursing graduates enrolled in the oncology internship program from February 2023 to

February 2024. The study aimed to compare two educational interventions on puncture and care of fully implanted catheters: one utilizing a mobile simulator with virtual reality in conjunction with face-to-face classes and content available in the Virtual Learning Environment (Portuguese: *Ambiente Virtual de Aprendizado* - AVA), and the other employing the conventional method, which included face-to-face classes and AVA content. The experimental design adhered to the recommendations of CONSORT (Consolidated Standards of Reporting Trials) (Gewandter et al., 2019).

Procedure

Participants were invited to join the study after approval by the Research Ethics Committee of the Antônio Prudente Foundation, with protocol number 55320521.3.0000.5432. The date for data collection occurred during the same period. All 55 invited participants provided written informed consent. The eligibility criteria were being nursing students participating in an oncology internship program at the institution where the study was conducted in August 2023 and February 2024, who agreed to participate. Upon recruitment, participants were randomized into two groups: the experimental group (EG) and the control group (CG). The allocation to the study arms was determined through a completely random process using a draw with envelopes (single draw in a bag with all names included), conducted by the study researchers. The instructors approached the undergraduates in the training room during class time, in the period allocated for the theoretical program, in August 2023 and February 2024. Participants completed surveys regarding sociodemographic and digital fluency characteristics and then took a pre-test to assess their knowledge. Following this, all participants were provided with instructional content through an AVA and underwent practical training for catheter puncture, each session lasting four hours. Undergraduates randomly assigned to the EG engaged in training utilizing a virtual reality simulator developed by the Brazilian company Xeduca (www.xeduca.com.br). This training session, lasting approximately 30 minutes, involved the application of concepts with mediation and support from the researchers. Both groups then completed a post-test to evaluate their knowledge.

Questionnaire

We collected sociodemographic and digital fluency data, which encompassed information such as age, gender, current semester of study, prior experience in the health field, as well as proficiency in installing programs and tasks like text editing, creating spreadsheets, and designing slides.

It was used a knowledge assessment instrument based on the literature and protocol of a specified institution, consisting of 10 multiple-choice questions with four answer options each (Zarili & Nemes, 2021). The validation of the instrument was carried out using the Delphi Technique, in two rounds, to obtain a consensus of expert opinions. This technique, applied in health sciences, is valuable for identifying and formulating standards or guidelines for theoretical and methodological issues, as well as for reaching consensus on practical recommendations (Niederberger & Spranger, 2020). A committee of experts was formed, made up of nine professionals in the field of Oncology, selected based on the curriculum

available on the Lattes Platform of CNPq (National Council for Scientific and Technological Development). Nine professionals were selected and received the invitation letter, all of whom responded with assured consent.

The classification of professionals was carried out using the criteria proposed by Fehring, which are based on qualifications, specialization, scientific production, knowledge and time working on the topic under discussion, establishing a minimum score of five points (Fehring, 1987). The evaluation form was sent to the experts, using the Google Forms® platform accompanied by a five-point Likert scale, ranging from "5" (Totally disagree) to "1" (Totally agree). For cases of disagreement or neutrality, a space was maintained for comments and suggestions.

Data analysis

The basis for recruitment was anchored in regression analysis. For the calculation, a minimum of 20 cases was estimated, plus an extra contingent, considering the risk of losses (Riley et al., 2019; van Smeden et al., 2019). To analyze the agreement index in the evaluation of questions to test knowledge, the Content Validation Coefficient (CVC), proposed by Hernandez-Nieto25, was calculated. From the suggested formula, the CVC of each question and the total of the expert assessments. An agreement ≥ 80% and a CVC > 0.80 were considered adequate in the total result. Descriptive analyses, that is, frequencies, percentages, means, standard deviations (SD), and ranges, were used to describe the characteristics of the participants. The Chi-square test and Fisher's exact test were used to compare sociodemographic and digital fluency variables between groups. The associations between qualitative variables were evaluated using the non-parametric Mann-Whitney test, used to compare scores at each assessment moment, as well as the performance of the CG and EG. In all hypothesis tests, the significance level was set at 5%. Thus, results whose p-values were less than 0.05 were considered statistically significant. The free software "R" version 3.5 and the IBM SPSS version 25 software were used for data analysis.

RESULTS

Step 1: Construction and validation of the instrument for learning assessment

An instrument consisting of 10 objective questions, each with four answer options, was created. Validation was conducted using the Delphi Technique, involving a committee of experts. The committee comprised nine nurses in the first round and six in the second. They were classified based on the criteria proposed by Fehring, with an average score of five points. The expert committee's coefficient of variation (CVC) for the assessment instrument was 0.59 in the first round and increased to 0.84 in the second round.

Step 2: Experimental study

The sample consisted of 55 participants with diverse sociodemographic and educational backgrounds. The study evaluated these characteristics among nursing undergraduates in two groups, CG and EG. Both groups were predominantly female, with no significant difference in gender distribution (p = 0.65). Age distribution was also similar, with most students falling in the 21 to 23-year-old range, and no significant differences between the groups (p = 0.97). In terms of semester representation, most students were in their 6th and 7th semesters, with no significant difference

observed between the groups (p = 0.79). Concerning healthcare experience, 62.1% of CG students reported having prior experience, compared to 42.3% in the EG group, though this difference was not statistically significant (p = 0.23). Overall, the groups were comparable across these sociodemographic and educational characteristics.

To assess digital fluency, students were asked about their ability to perform tasks related to digital literacy, including installing/uninstalling programs, using text editors, calculation spreadsheets, and creating slideshows. A statistically significant difference was found in installing/uninstalling programs (p = 0.02), with more CG students (38.8%) finding it easy compared to EG students (22.2%). No significant differences were observed in the use of text editors (p = 0.39), calculation spreadsheets (p = 0.30), or slideshow creation (p = 0.13). Both groups showed similar abilities in using text editors and spreadsheets, and creating slideshows, with slight variations in the level of proficiency reported. Overall, the findings suggest that, except for installing/uninstalling programs, digital fluency levels were comparable between the two groups.

Table 1 contains the measures of central tendency and dispersion acquired from the assessment instrument during both the pre-and post-intervention phases.

Table 1

Measures of central tendency and dispersion were obtained with the assessment instrument in the pre-and post-intervention phase for the CG and EG by question

Theme of the questions	Pre-intervention			Post-intervention		
	Average		p	Average		*p* value
	GC (N=29)	EG (N=29)		GC (N=29)	EG (N=29)	
TQ1- Catheter indication	0.89	0.88	1.00	0.93	0.96	1.00
TQ2 - Advantages in use	0.51	0.53	1.00	0.89	0.76	0.29
TQ3 - Permeability and maintenance	0.27	0.34	0.78	0.93	0.53	**0.002**
TQ4 - Care in the event of an adverse event	0.48	0.46	1.00	0.44	0.76	**0.003**
TQ5 - Managed Solutions	0.58	0.61	1.00	0.75	0.73	1.00
TQ6 - Needle change period	0.58	0.65	0.81	0.96	1.00	1.00
TQ7 - Type of puncture device	0.86	0.65	0.13	0.86	0.69	0.23
TQ8 - Type of antiseptic for the puncture	0.68	0.65	1.00	1.00	1.00	1.00
TQ9 - Antisepsis technique during puncture	0.34	0.30	0.99	0.93	0.92	1.00
TQ10 - Puncture technique	0.48	0.30	0.29	0.96	0.96	1.00
Total	5.72	5.42	0.60	8.68	8.34	0.26

Note. TQ = question topic.
Statistically significant difference for p ≤ 0,05.

An improvement in learning was observed after the intervention in both groups, without statistical significance. However, the experimental group showed a significant improvement (p=0.003) in caring for the totally implanted catheter in the face of an adverse event.

Table 2 displays a comparison between learning outcomes and sociodemographic characteristics as well as computer usage.

Table 2

Comparison between CG and EG learning results with demographic and training characteristics

Variable	Pre-intervention				Post-intervention			
	Median (DP)			*p* value	Median (DP)			*p* value
	GC (N=29)	*p* value	EG (N=29)		GC (N=29)	p	EG (N=29)	
Gender		0.17		0.88		0.44		0.39
Female	6.00(1.70)		6.00(1.56)		9.00(0.90)		8.00(1.08)	
Male	4.00(1.41)		5.00(3.51)		8.00(1.41)		7.00(2.08)	
Age		**0.02**		0.53		0.37		0.46
18 to 20 years old	3,50(0.97)		6.00(1.52)		8.00(0.81)		10.00(1.15)	
21 to 23 years old	6.00(1.66)		6.00(1.50)		9.00(0.83)		8.00(1.10)	
23 to 26 years old	6.00(1.03)		4.00(2.67)		8.50(0.81)		9.00(1.38)	
Over 26 years old	5.00(1.72)		5.00(0.83)		9.50(1.26)		8.00(1.22)	
Current semester		0.42		0.06		0.68		0.73
5º	4.00(2.64)		5.00(0.75)		9.00(1.15)		7.50(1.77)	
6º	5.00(1.69)		6.00(1.80)		9.00(1.00)		8.00(1.09)	
7º	5.50(1.50)		6.00(1.39)		9.00(1.03)		9.00(1.11)	
8º	7.00(1.52)		8.00(2.08)		9.00(0.00)		8.00(1.52)	
9º	7.50(2.12)		2.50(0.70)		9.00(0.00)		7.50(2.12)	

Note. DP = standard deviation.
Statistically significant difference for p ≤ 0,05.

Table 3 displays a comparison between the learning outcomes and the digital fluency of nursing students.

Table 3

Comparison between GC and EG results of learning with digital fluency

Variable	Pre-intervention				Post-intervention			
	Median (DP)			*p* value	Median (DP)			
	CG (N=29)	*p* value	EG (N=29)		CG (N=29)	p	EG (N=29)	*p* value
Install and uninstall programs		0.31		0.26		0.62		0.79
Easy	6.00(0.00)		6.00(1.96)		8.00(0.00)		8.00(1.22)	
Difficulty	6.00(1.73)		5.50(1.66)		9.00(0.96)		8.00(1.21)	
I don't know how to do it	4.00(1.41)		N/A		8.50(0.70)		N/A	
Text editor		0.94		0.19		0.49		0.32
Simple formatting	6.00(1.15)		4.50(1.72)		8.00(0.57)		8.50(0.81)	
Simple formatting and basic features	6.00(1.71)		6.00(1.70)		9.00(0.89)		8.00(1.22)	
I use all the program's resources	5.00(2.13)		6.00(1.51)		9.00(1.13)		8.00(1.30)	
Does not edit text	N/A		2.00(0.00)		NA		6.00(0.00)	
Calculation spreadsheet		0.67		0.52		0.86		0.57

Simple calculation	5.00(1.06)		5.00(2.13)		9.00(0.90)		8.00(1.06)	
Simple calculation and basic features	6.00(2.06)		5.(2.82)		9.00(1.01)		8.00(1.41)	
Complex calculations and all program features	5.50(1.36)		6.00(1.41)		9.00(0.93)		9.00(1;30)	
Do not use	N/A		5.00(1.60)		N/A		8.00(1.25)	
Slideshow		0.10		0.67		0.53		0.50
Create simple presentation	8.00(2.29)		6.00(1.43)		9.00(1.03)		9.00(1.31)	
I create presentations with some elaboration using basic resources	5.50(1.20)		5.00(1.71)		8.50(0.92)		8.00(0.83)	
I create well-designed presentations using all resources	4.00(1.41)		6.00(2.53)		9.50(0.70)		7.50(1.47)	
Do not use	4.00(0.00)		4.00(0.00)		9.00(0.00)		8.00(0.00)	

Note. N/A = Not applicable.
Statistically significant difference for p ≤ 0,05.

DISCUSSION

Active methodologies, a trend in recent years, play an important role in promoting proactivity and interaction between students and teachers, linking learning to reality and developing capabilities for an intervention itself, and, in this way, aim to expand the participants' commitment to transforming reality (Lima, 2017).

In undergraduate nursing courses, several articles have been published, reinforcing the proposal to adopt teaching methods that place the student at the center of the teaching-learning process and that encourage the active search for knowledge (Gallegos et al., 2017; Carley, 2015; Johnsen et al., 2018; Jafarizadeh et al., 2017; Foronda et al., 2017). The use of cell phones, tablets, and other technological elements, in addition to stimulating curiosity and critical thinking, contribute to the retention and understanding of the content and provide instant feedback, generating satisfaction for the student and favoring their learning (Gallegos et al., 2017; Johnsen et al., 2018). In the present study, the sample consisted of interns who were in the final year of their Nursing degree. We can affirm that all of them had digital fluency, enabling the incorporation of new educational technologies in undergraduate courses.

These reflections are in line with the proposal of the present study, seeking to comparatively evaluate the learning results between conventional teaching and the use of a mobile simulator with virtual reality. In a comparative study by Gallego and collaborators, which involved traditional methodology (expository classes) and the use of technologies (hybrid course, classes mediated by technology), the results showed higher scores for the group subjected to active learning methodologies strategies. Results similar to those of the present study, when virtual reality was proposed as a technology-mediated strategy, showed it to be as effective as a face-to-face course combined with content available in a virtual learning environment, yielding better results in knowledge about adverse events for the intervention group.

In other study, students criticized the lack of interpersonal interaction in the technology-mediated methodologies (Jafarizadeh et al., 2017). On the other hand, Virtual Reality (VR) has the potential to meet this need, as it provides interaction from a real or

simulated environment, which offers several simultaneous stimuli, allowing the user to feel immersed in this environment. A systematic review of the literature aimed at evaluating its use for health education selected seven articles that showed that VR facilitates user interaction with computational applications, real-time interaction, and turning itself into a realistic three-dimensional medium. They concluded that RV presents itself as an important resource for the training and training of health professionals (Aguiar et al., 2021).

Immersive technology has been adopted in the development of simulators as an excellent technological resource, which allows you to visualize an environment or scenario realistically. This can be even more shocking if it happens through a pair of VR glasses, which will reinforce the feeling of full immersion in this three-dimensional virtual environment (Netto & Silva, 2022). For Valério Netto (2021), they are different realities created artificially but perceived by sensory systems in the same way as the physical world around us. This resource can generate emotion, teach, entertain, and respond to actions, without the need for a real scenario. The technology allows access to synthetic, immersive, and high-definition environments that can transfer to alternative realities, allowing students to make decisions in seconds, at low cost, and without an instructor (Netto, 2021).

In our study, the platform employed a process of building andragogic content of the topic catheter fully implanted in oncology, to assist in verifying whether the future professional is prepared to act correctly and make assertive decisions in case of problems. Associated with virtual simulation it is essential to employ content based on active methodologies, such as Problem-Based Learning (PBL) whose aim is to improve actions related to doing, learning, evaluating, or understanding situations, which allows the student to be an active character in their learning process (Costa et al., 2015; Rocha & Farias, 2020).

According to the perception of nurse educators about simulated training using virtual reality, developed for undergraduate nursing students, the main benefits reported were immersion in a scenario close to the real one, with effective participation, the opportunity to reflect on daily practice, correlating theory with practice, raising awareness about the damage that could cause the patient when not prepared, stimulating clinical reasoning for decision making in real-time (Serpa & Netto, 2024).

For this training, content has been developed from real scenarios, elaborating three modules with scripts for each of the defined themes: care with the catheter, catheter complications, and puncturing of the long-stay catheter fully implanted. Each module was created with three different clinical situations called outcomes, including problematic issues throughout the script, produced using 3D modeling. Similarly, Barros presents a simulator of complex clinical cases in the learning process in health, which presents itself as an important opportunity to establish a new form of relationship between educator and learner, by integrating computerized tools such as simulators of complex medical cases into the learning process. SimDeCS becomes a great assistant in the pedagogical learning process of students following the guidelines of problem-based learning (Barros et al., 2021).

In the same way as our study, carried out with undergraduate nursing students, the majority of whom were between 18 and 23 years old, Foronda et. all´s[33] study aimed to present new technologies aimed at

improving nursing teaching, such as augmented reality and virtual. The authors reinforce that these technologies are flourishing, they facilitate understanding, through high-quality three-dimensional images, enabling students to generate deeper knowledge. Furthermore, they believe that these technologies can present opportunities to improve teaching efforts, better engage students, and transform nursing education.

The results of the present study indicate that a training program for nursing graduates in oncology, focusing on puncture techniques and care for fully implanted catheters using virtual reality simulators, is as effective as a traditional face-to-face course supplemented with virtual learning environment content. This finding is supported by a study conducted by Gasperin et al. (2018), which aimed to assess the performance of resident doctors in a general surgery service. They used laparoscopic video simulation for cholecystectomy in a virtual reality center to determine if virtual reality training alone can provide the skills necessary for surgical practice. They concluded that the learning of the R1 and R2 groups can be considered equal, regardless of whether the previous practice was mostly in vivo (R2) or in virtual reality (R1). Thus, it was possible to consider that the surgical skills acquired from the virtual training form capable of equating the proficiency of the residents of the first and second year, being crucial for increasing the safety of patients and homogenizing the learning of basic surgery procedures.

According to Rudarakanchana et al. (2015) simulation training that allows deliberate practice without danger to patients may be the key to bridging the gap between new endovascular technology and improved patient outcomes. A point to highlight in our study is that the performance of nursing students was significantly higher in the EG, in one question evaluated, about care after adverse events (p= 0.003). This can be explained by the practical nature of the approach, which may have consequences for the patient's health condition.

It is important to emphasize that simulation with VR presents itself as a strategy for the development of skills and attitude, from exposure to challenges in real situations that require decision-making, enabling the repetition without bringing consequences to patients. It has been increasingly recognized as a valid mechanism with growing importance for the development of surgical skills safely and effectively and bringing better results than traditional teaching methods (McGaghie et al., 2011).

This study has several limitations that should be taken into account when interpreting the results and drawing conclusions. Firstly, the sample size was restricted and limited to a single internship program at a private institution, which may limit the generalizability of the results. Additionally, the sample was composed of nursing students from various private institutions, enrolled in different semesters. Another important consideration is that the students in the experimental group were exposed to the same strategies as the control group, with the addition of virtual reality, which may have influenced the assessment of the effectiveness of this teaching methodology.

However, this study demonstrates that the use of a virtual reality simulator for training in puncture and care of fully implanted catheters is as effective as in-person training combined with content available in a virtual learning environment. This suggests that virtual reality could be a viable and effective tool for teaching in specialized areas of nursing. Another highlight is the potential of virtual reality to provide more effective

training in specific and critical aspects of care. The use of virtual reality simulators can offer an accessible and flexible alternative for nursing education, allowing students to practice skills in a controlled and simulated environment, without the need for physical and logistical resources associated with in-person training.

CONCLUSION

The results showed that a training program for undergraduate oncology nursing students focused on puncture and care of the fully implanted catheter, using a virtual reality simulator, was as effective or better than a face-to-face course combined with content available in a virtual learning environment. Student performance was significantly higher in the EG for the question regarding care in case of an adverse event.

Further studies are needed with larger samples to confirm the effective contribution of virtual reality simulation in the learning process, in care contexts such as central venous catheter management.

CONFLICT OF INTEREST

REFERENCES

Aguiar, B., Gomes, M., Lins, A., & Muniz, M.T. (2021). Utilização da realidade virtual para o ensino em saúde. *Revista Educação Inclusiva*, 5(1), 106-117. https://revista.uepb.edu.br/REIN/article/view/325/292

Barros, P. R., Cazela, S. C., Bez, M. R., Flores, C. D., Dahmer, A., Mossmann, J. B., Fonseca, J. M., & Maroni, V. (2012). Um simulador de casos clínicos complexos no processo de aprendizagem em saúde. RENOTE. *Revista Novas Tecnologias na Educação*. 10(1), 1-11. https://doi.org/10.22456/1679-1916.30867

Bezerra, I.M.P. (2020). State of the art of nursing education and the challenges to use remote technologies in the time of corona virus pandemic. *J Hum Growth Dev.* 30(1), 141–147. https://doi.org/10.7322/jhgd.v30.10087

Carley, A. (2015). Using technology to enhance nurse practitioner student engagement. *Nurs Pract*. 40(7), 47-54. https://doi.org/10.1097/01.NPR.0000465119.04536.0e

Cavalcante, C.B.T.L., Pereira, C.R.C., Souza, S.R., Brito, R.A.S., Nunciaroni, A.T., & Corrêa, V.A.F. (2022). Ensino da prática de cuidado em oncologia na graduação em enfermagem: estudo qualitativo. *Research, Society and Development.* 11(3), e52811326693. https://doi.org/10.33448/rsd-v11i3.26693

Costa, R.R.O., Medeiros, S.M., Martins, J.C.A., Menezes, R.M.P., & Araújo, M.S. (2015). O uso da simulação no contexto da educação e formação em saúde e enfermagem: uma reflexão acadêmica. *Revista Espaço para a Saúde*. 16 (1), 59-65. https://doi.org/10.22421/15177130-2015v16n1p59

Damacena, D.E.L., Pereira, D.A., Vidal, A.S., & Farias, M.D.S.B. (2020). O cuidado de enfermagem e o port-a-cath ou cateter totalmente implantado em pacientes oncológicos: uma revisão da literatura. *Brazilian Journal of Surgery and Clinical Research,* 30 (2), 83–85. http://www.mastereditora.com.br/bjscr

Darmann-Finck, I., Wolf, K.D., Schepers, C., & Küster, J. (2016). Digital unterstütztes Lernen in der Pflegeausbildung. MedienPädagogik: Zeitschrift für Theorie und Praxis der Medienbildung. *Medien Pädagogik,* 16, 317–345. https://doi.org/10.21240/mpaed/jb16/2021.04.30.X

Dörner, R., Broll, W., Grimm, P., & Jung, B. (2022). *Virtual und Augmented Reality (VR/AR).* Springer. https://link.springer.com/book/10.1007/978-3-030-79062-2

Elfagi, S.A., Nouh, F.G., & Elmansory, M.A. (2022). The Perception of graduates on the curriculum for nutrition education a case study at the faculty of public health at the University of Benghazi. *Journals Misuratau.* 155-166. https://doi.org/10.36602/jebs.2022.I03.0

Fehring, R.J. (1987). Methods to validate nursing diagnoses. *Heart Lung.* 16, 625–9. https://core.ac.uk/download/pdf/213076462.pdf

Fischer, U.H.P., Müller, M., & Neumüller, M., (2021). Digitalisierung in der Pflegebranche fördern. *Pflegezeitschrift*. 74, 57–61. https://doi.org/10.1007/s41906-021-1148-x

Foronda, C.L., Alfes, C., Dev, P., Kleinheksel, A.J., Nelson, D., O'Donnell, J., & Samosky, J. (2017). Virtually

nursing. Emerging Technologies in Nursing Education. *Nurse Educator*. 42(1), 14-17. https://doi.org/10.1097/NNE.0000000000000295

Gallego,s C., Tesar, A.J., Connor, K., & Martz, K. (2017). The use of a game-based learning platform to engage nursing students: a descriptive, qualitative study. *Nurs Educ Pract*. 27, 101-106. https://doi.org/10.1016/j.nepr.2017.08.019

Gasperin, B.D.M., Zanirati, T., & Cavazzola, L.T. (2018). A Realidade Virtual pode ser tão boa como o treinamento em Sala Cirúrgica? Experiências de um Programa de Residência em Cirurgia Geral. *ABCD Arq Bras Cir Dig*. 31(4), e1397. https://doi.org/10.1590/0102-672020180001e1397

Gewandter, J.S., Eisenach, J.C., Gross, R.A., Jensen, M.P., Keefe, F.J., Lee, D.A., & Turk, D.C. (2019). Checklist for the preparation and review of pain clinical trial publications: a pain-specific supplement to CONSORT. *PAIN Reports* 4(3), e621. https://doi.org/10.1097/PR9.0000000000000621

Gottems, L.B.D., Alvarez, A.M., & Almeida, L.M.W.S. (2014). Nursing education: quality, innovation and accountability. *Rev Bras Enferm*. 67 (4), 499–501. https://doi.org/10.1590/0034-7167.2014670401

Hernández-Nieto, R. A. (2002). *Contributions to statistical analysis.* Universidad de Los Andes

Hong, C., & Wang, L. (2023). Virtual Reality Technology in Nursing Professional Skills Training: Bibliometric Analysis. *JMIR Serious Games*. 11 e44766. https://doi.org/ 10.2196/44766

Jafarizadeh, H., Rahmani, A., Habibzadeh, H., Amiri, S., Moghaddam, A.S., & Moradi, Y. (2017). The effect of blended training (Programmed and Lecture-Based Training) on learning health status assessment course among nursing students. *Bali Med J.* 6(3), 606-610. https://doi.org/10.15562/bmj.v6i3.688

Johnsen, H.M., Fossum, M., Vivekananda-Schmidt, P., Fruhling, A., & Slettebø, Å. (2018). Developing a Serious Game for Nurse Education. *J Gerontol Nurs*. 44(1), 15-19. https://doi.org/10.3928/00989134-20171213-05

Lessmann, J.C., Lanzoni, G.M.M., Gubert, E., Mendes, P.X.G., Prado, M.L., & Backes, V.M. (2012). Educação profissional em enfermagem: necessidades, desafios e rumos. *Rev Min Enferm*. 16(1), 106–10. http://www.revenf.bvs.br/pdf/reme/v16n1/15.pdf

Lima, V.V. (2017). Constructivist spiral: an active learning methodology. *Interface*. 21(31), 421-34. https://doi.org/10.1590/1807-57622016.0316

Matsubara, M.G.S., & Domenico, E.B.L. (2016). Building a Virtual Learning Environment for Distance Education in Nursing Oncology. *Int Arch Nurs Health Care* 2(2), 1-5. https://doi.org/10.23937/2469-5823/1510049

Matsubara, M.G.S., & Domenico, E.L.B. (2016). Virtual Learning Environment in Continuing Education for Nursing in Oncology: an Experimental Study. *J Cancer Educ*. 31(4), 804-810. https://doi.org/10.1007/s13187-015-0889-x

McGaghie, W.C., Issenberg, S.B., Cohen, E.R., Barsuk, J.H., & Wayne, D.B. (2011). Does simulation-based medical education with deliberate practice yield better results than traditional clinical education? A meta-analytic comparative review of the evidence. *Acad Med*. 86(6), 706-711. https://doi.org/10.1097/ACM.0b013e318217e119

Netto, A.V. (2021). Desenvolvimento de uma plataforma educacional baseada em realidade virtual para treinamento profissional. *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología.* 30, 66-73. https://doi.org/10.24215/18509959.30.e7

Netto, A.V., & Silva, C.I. (2022). Desenvolvimento de uma plataforma andragógica baseada em simulação virtual para qualificação e avaliação de alunos da área de saúde. Revista de Saúde Digital e Tecnologias Educacionais. 7(1), 65-80. http://periodicos.ufc.br/resdite/index

Niederberger, M., & Spranger, J. (2020). Delphi Technique in health sciences: a map. *Front Public Health.* 8, 457. https://doi.org/10.3389/fpubh.2020.00457

Padilha, J.M., Machado, P.P., Ribeiro, A., Ramos, J., & Costa, P. (2019). Clinical Virtual Simulation in Nursing Education: Randomized Controlled Trial. *J Med. Internet Res.* 21(3), e11529. https://doi.org/10.2196/11529

Pfeifer, L., Fries, S., Stirner, A., Nagel, L., Cohnen, C., Aschentrup, L., Schönbeck, M., Nauerth, A., Raschper, P., Herzig, T., & Wrona, K.J. (2024). Positive Aspects and Potential Drawbacks of Implementing Digital Teaching/Learning Scenarios in Health Professions Using Nursing Education as an Example: A Research Report from Germany. *Nurs Rep*. 14 (1), 468-481. https://doi.org/10.3390/nursrep14010036

Riley, R.D., Snell, K.I.E, Ensor, J., Burke, D.L., Harrell Jr, Karel, GM Moons K.G.M, & Collins, G.S. (2019).Minimum sample size for developing a multivariable prediction model: PART II - binary and time-to-event outcomes. Statistics in Medicine. 38,

1276–1296. https://doi.org/full/10.1002/sim.7992

Rocha, C.J.T., Farias, S.A., 2020. Metodologias Ativas De Aprendizagem Possíveis Ao Ensino De Ciências E Matemática. REAMEC - Rede AmazEduc em Ciências e Matemática. 8 (2), 69-87. https://doi.org/10.26571/reamec.v8i2.9422

Rudarakanchana, N., Van Herzeele, I., Desender, L., Cheshire, N. J., 2015. Virtual reality simulation for the optimization of endovascular procedures: Current perspectives. *Vasc Health Risk Manag.*, 11, 195-202. https://doi.org/10.2147/VHRM.S46194

Serpa, L.F., Netto, A.V., 2024. Percepção de enfermeiras educadoras sobre treinamento simulado utilizando realidade virtual aplicado aos alunos do curso de enfermagem. Revista Saúde em Redes. 10 (1), 4267. https://doi.org/10.18310/2446-4813.2024v10n1.4267

Sung, H., Ferlay, J., Siegel, R.L., Laversanne, M., I., Soerjomataram, I., Jemal, A., & Bray, F. (2021). Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. *CA Cancer J Clin*. 71(3), 209-249. https://doi.org/10.3322/caac.21660

van Smeden, M., Moons, K.G.M., Joris, A.H. de Groot, J.A.H., Gary S Collins, G.S., Altman D.G., Eijkemans, M.Jc., & Reitsma, J.B. (2019). Sample size for binary logistic prediction models: Beyond events per variable criteria. *Statistical Methods in Medical Research*. 28 (8) 2455–2474. https://doi.org/10.1177/0962280218784726

Ximenes, F.R.G., Neto, D.L., Ribeiro, M.A., Freire, N.P., Kalinowski, C.E., Oliveira, E.N., & Albuquerque, I.M.A.N. (2020). Reflections on Brazilian nursing education from the regulation of the unified health system. *Cienc e Saude Coletiva*. 25(1), 37–46. https://doi.org/10.1590/1413-1232020251.27702019

Zarili, T.F., & Nemes, M.I. (2021). Técnica Delphi no processo de validação do Questionário de Avaliação da Atenção Básica (QualiAB) para aplicação nacional. *Saude Soc*. 30(2), e190505. https://doi.org/10.1590/S0104-12902021190505