Chapter 89

Virtual reality serious game for medication administration training for nursing students: quasi-experimental study

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ABSTRACT
The use of clinical simulation combined with digital games has shown to be a promising teaching strategy, with virtual reality being the most modern application. This study's objective was to test a virtual simulation game on medication preparation and administration using a quasi-experimental design with nursing students. The results revealed that the game's use increased the students' grades in knowledge the tests, contributing to learning about the theme besides being a relevant tool for simulating the practice environment that added an innovative teaching approach of virtual immersion.

Keywords: Education, Nursing, Educational Technology, Patient Safety, Virtual Reality, Simulation Training.

1 INTRODUCTION

Errors related to the preparation and administration of drugs are a severe problem in health services and one of the leading causes of preventable adverse events. According to WHO[1], the cost associated with medication errors has been estimated at $ 42 billion annually, almost 1% of total health expenditure worldwide.

Due to the growing concern with the theme and recognizing the impact of the harm resulting from medications errors, in 2017, the WHO launched the 3rd global challenge for patient safety with the theme "Medication Without Harm", whose goal was to reduce severe avoidable medication-related harm by 50%, globally in the next 5 years, based on the development of safer practices in health systems at all stages of the medication process (prescription, dispensing, administration, monitoring, and use)[2].

In hospitals, the preparation and administration of drugs are part of the most important activities performed by the nursing team and fit in various contexts of disease treatment[3]. It is up to nurses to handle a high amount and diversity of therapeutic and diagnostic indications, the safe administration of

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medications, and the recognition of adverse reactions. For this, nurses must be updated in their knowledge to monitor the patients adequately and adopt measures to prevent medication-related errors[4].

Studies developed in recent years have reported that medication-related errors attributed to the nursing staff occur at an approximate frequency of one error every six doses administered, which reveals that the promotion of safe practices must be a constant concern of the nursing team, due to their great responsibility in handling medicines[5,6].

Given the above, it is believed that patient safety education must be more evident in training courses for student nurses who must incorporate this theme into their academic practices in health institutions. For this, the use of new educational methodologies can increase public access to various digital information sources.

In nursing, initiatives that have analyzed the development and implementation of strategies involving information and communication technologies (ICTs) and educational technologies in nursing teaching have grown. Their results have shown to be promising[7]. In this context, clinical simulation stands out as a teaching strategy that allows students to experience simple or complex situations in safe environments, making mistakes possible, and learning from them[8].

The use of simulation, combined with patient safety principles, also provides student preparation through training of skills and competencies that instigate decision making, clinical judgment, and critical thinking[9]. The simulation strategy can also contribute as a vigorous exercise in students' training because, by enabling them to practice their skills in safe environments, feelings such as anxiety and stress can be worked on[10].

As technological instruments for the practice of simulations, serious games stand out for allowing the integration of the subject to the game in an educational perspective and involving players in the search to discover the virtual world while promoting the link between playing and learning[11]. It is believed that learning mediated by serious games has a high potential to arouse interest among students, as it motivates them to become involved in didactic tasks while playing and performing activities that are often difficult to develop through traditional approaches.

Among the possibilities offered by serious games, the most modern application is software developed in virtual reality (VR), which constitutes virtual environments developed digitally to provide the user with a new reality. Authors describe that the active participation provided by VR to the student can improve the teaching-learning relationship, especially for people who prefer visual to verbal learning or who have difficulty in the abstraction of problems[12].

In this way, the present study aimed to test a virtual simulation game on medication preparation and administration validating it from the students' learning results.

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2 METHOD

A quasi-experimental before-and-after study was carried out. The game entitled NurseVR was built by a research team with the participation of a company specialized in virtual reality games. For the creation and programming of the virtual game, the selected approach was the administration of intravenous drugs, as it is believed that it has a high degree of complexity and it make possible associating the content with the practice of peripheral venipuncture. Authors describe that the risk potential for medication errors by the intravenous route is greater, because, according to them, it requires the addition of electrolytes and drip calculations during critical phases of care[6].

As an integral part of the production phase, the game was validated by students and teachers of the nursing course at the at the university in which the study was undertaken. After obtaining positive results in both validations, the game advanced to the testing phase with students of the "Semiology, Semiotechnics, and Care Process" course at the university, held in August and September 2019. The course is currently offered in the 4th semester of the nursing program at the university and covers theoretical and practical nursing foundations related to the preparation and administration of medicines.

The nursing program at this university consists of theoretical and practical courses and, at the end of the semester, a period of hospital internships. The game's testing phase started shortly after completing the theoretical part of the course related to the preparation and administration of medicines to ensure that all research participants had basic knowledge about the content to be addressed by the virtual game before using it.

The last stage of the experiment was carried out before the beginning of the practical clinical training in hospitals, aiming to assess the learning associated with the use of NurseVR without interference from clinical rotation experiences.

The course mentioned above involves classes taught in laboratories dedicated to the nursing program. In these laboratories, students can simulate the practices related to semiology and semiotics in nursing with the help of mannequins and clinical cases prepared by teachers, including the preparation and administration of medications. The virtual game took place in a classroom at the university, at a different date and time than other academic activities to not interfere with the students' usual schedule.

Initially, 24 students participated, and after completing the theoretical content block related to the preparation and administration of medicines, the class was randomly divided into two groups (A and B). All responded to the initial test (T_1).

Group A performed the virtual simulation practice with NurseVR first, participated in all course's laboratory classes, and after, answered the second test (T_2). Group B responded T_2 after participating only in the laboratory classes already established by the course. We opted to perform the second test (T_2) at different times for both groups in order to identify differences in learning between the group that played

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NurseVR and participated in the laboratory classes (A) and the group that participated only in the laboratory classes (B).

Two students from each group missed the T_2 application days, being excluded from the sample. Thus, each group followed the methodological path with 10 students. After applying T_2, Group B was also invited to play NurseVR so that all students could have the opportunity to learn laboratory practices and virtual reality simulation.

Before starting the period of hospital rotations, Groups A and B were invited to answer a third test (T_3) whose objective was to evaluate the students' learning after one month of using the game associated with the laboratory approach, before starting the clinical rotations. The methodological path of the experimental phase of the study can be seen in Figure 1.

Figure 1 - Methodological path for data collection.
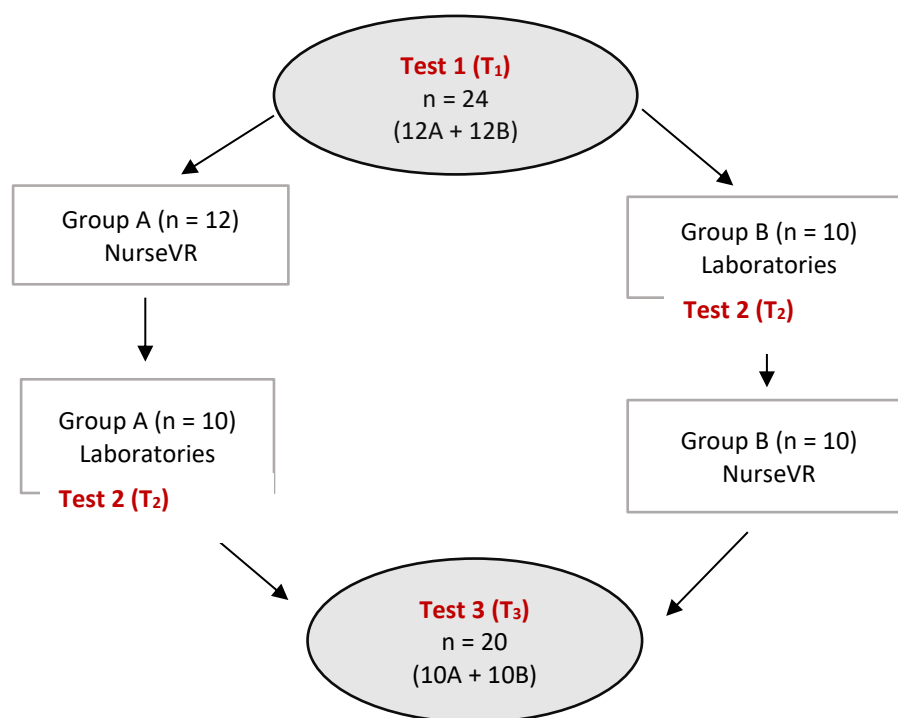
It is worth mentioning that all tests were applied without telling the students about it to prevent them from studying the content before the data collection. The three tests (T_1, T_2, and T_3) had questions with the same level of difficulty taken from a bank previously validated by teachers.

To allow the virtual game experience to the whole class, students excluded from the sample due to absences could play NurseVR together with the others if they were interested, however, without answering the tests.

The data were entered and processed in the IBM SPSS Statistics® software version 20.0 (license number 10101131007). The test results' quantitative data were analyzed according to descriptive statistics (frequency, mean, median, mode, and standard deviation).

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The variables for analysis were the number of correct answers in the tests and the students' grades. A t-test for paired samples was applied for comparing the test results before and after the game associated with the laboratory approach. Furthermore, a t-test was also used to compare the averages of correct answers and grades in groups A and B. A significance level of 0.05 was adopted in all analyzes.

The study obtained a favorable opinion from the Ethics Committee at the University in which the study was undertaken under opinion number 3,178,802. All ethical and legal precepts of Resolution No. 466 of December 12, 2012, of the National Health Council, related to the execution of research involving human beings[3] were respected.

3 RESULTS

The profile of the students who participated in the study was homogeneous, especially regarding age, access to computers, and use of virtual games.

Table 1 - Distribution of participants according to the professional, academic, and technology access profile.

Variables	Group A (n = 10)		Group B (n = 10)	
	n	%	n	%
Gender				
Female	7	70	9	90
Male	3	30	1	10
Age				
≤ 20 years	5	50	4	40
21 - 25 years	5	50	4	40
> 25 years	0	0	2	20
Degrees				
Nursing technician	0	00	2	20
Technician (from another area)	1	10	2	20
Non-nursing higher degree	0	0	1	10
No previous higher education	9	90	5	50
Academic profile				
Studying only	10	100	7	70
Working while Studying	0	0	3	30
Computer access				
Personal computer	8	80	8	80
Family computer	1	10	0	00
Uses a friend's computer	1	10	1	10
Uses a university's computer	0	0	1	10

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Internet access				
Access from home	10	100	10	100
Internet usage				
Read and send emails	10	100	9	90
Social networks	8	80	10	100
College research and work	10	100	10	100
Various researches	9	90	8	80
Virtual games	8	80	7	70
Use of games				
Plays games on the computer	8	80	7	70
Plays video games only	4	40	4	40
Plays virtual reality games	0	0	2	20
Has never played a digital game	1	10	3	30

The groups' description above reveals that all participants were connected to the internet during their daily study and leisure activities. Besides, it was found that university students are involved with digital games, however, without yet having direct contact with virtual reality. This fact reveals that NurseVR technology was adequate to the target audience's profile and needs, as it proposes teaching from games and adds innovation through simulation in a virtual environment.

Initially, the test scores for the group of 20 students were analyzed to identify the differences in the number of correct answers and grades of the class during the study stages. Table 2 shows the progresses in the number of correct answers and grades. All tests consisted of 14 questions and a maximum grade of 10.

Table 2 - Description of correct answers and grades.

	T_1		T_2		T_3	
	Number of right answers	Note	Number of right answers	Note	Number of right answers	Grade
Average	9.65	6.85	11.05	7.70	10.65	7.31
Median	10.00	6.87	11.00	7.62	10.50	7.37
Mode	9.00*	6.50*	10.00	7.00*	12.00	8.25
Deviation error	1.59	1.15	1.19	0.89	1.56	1.22
Minimum	7.00	4.75	9.00	6.25	8.00	5.00
Maximum	12.00	8.50	13.00	9.25	13.00	9.00

* There are several modes. The lowest value is shown.

It is worth noting that the tables present the number of correct answers and grades, as the questions had different scoring values according to their level of difficulty and, thus, a specific number of right answers does not necessarily generate the same grade.

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It was possible to observe that, regardless of the group to which the students belong, they obtained improvement in the T^2 grades, revealing that the laboratory activities with or without the simulation proposed by the virtual game are fundamental to the teaching-learning process (table 3).

Table 3 - Before and after comparisons.

Description of paired analysis	Average	Mean difference	P	SD
T_1 x T_2 right answers		-1.40	0.008	2.11
T_1	9.65			
T_2	11.05			
T_1 x T_2 grades		-0.85	0.021	1.51
T_1	6.85			
T_2	7.70			
T_1 x T_3 right answers		-1.00	0.091	2.51
T_1	9.65			
T_3	10.65			
T_1 x T_3 grades		-0.46	0.301	1.94
T_1	6.85			
T_3	7.31			

The comparisons between T_1 and T_2 correct answers and grades were statistically significant, revealing that the practical laboratory activities, associated or not with the use of the NurseVR virtual game, contributed to the increase of the students' knowledge.

The scores and grades of T_3 applied one month later were slightly lower than those of T_2. However, still high compared to T_1, with a statistically significant difference. Another outstanding value for the class analysis refers to the increase in the mode of the grades from 6.5 (T_1) to 8.25 (T_3), and more students in the class achieved better grades in the last test.

To identify the impact of NurseVR on the correct answers and grades for each group, the students who played and participated in the laboratory classes (Group A) were compared with those who only participated in the laboratory classes (Group B). The results can be seen in table 4.

Table 4 - Description of correct answers and grades for groups A and B in T_1, T_2, and T_3.

Tests	Average of correct answers	P	Average grades	P
T_1 (before)		0.894		0.926
Group A	9.60		6.87	
Group B	9.70		6.82	
T_2 (intermediate phase)		0.010		0.003
Group A: Game + Laboratory	11.70		8.25	
Group B: Laboratory	10.40		7.15	
T_3 (after)		0.680		0.760
Group A: Game + Laboratory	10.50		7.22	
Group B: Laboratory + Game	10.80		7.40	

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It can be seen with 95% confidence that the game contributed to increasing students' knowledge on the theme. On average, Group A students presented grades and correct answers in T_2 higher than Group B, with $p < 0.05$ for both groups.

Such results reveal that even with the increase in hits and grades identified for the whole class, on average, group A obtained a greater number of right answers and higher grades than group B, with a statistically significant difference.

Thus, it is possible to affirm that the game contributed positively to the learning about the preparation and administration of medications when associated with the laboratory activities already existing in the nursing program.

The results indicate that the game fulfilled its proposal of contributing to the discipline practices while offering an innovative learning approach for the students. It is believed that the use of virtual simulation does not overlap the laboratory practical classes in which the student acquires technical and manual skills for performing procedures but proposes the assimilation of care processes through immersion in an environment close to reality.

To guarantee the same learning opportunities for all participants, students in group B played NurseVR after answering T_2. When comparing the differences in values of groups A and B to T_3 (applied approximately one month later), there was no statistical significance. Thus, it is believed that by ensuring that both groups participate in laboratory classes and play, students obtained similar learning, regardless of which group they joined.

It is considered that the game is an important tool for simulating the practice environment that added an innovative teaching approach of virtual immersion that until then was not provided only by the laboratory approaches. Besides, virtual reality games have generated collective interest among students, bringing the proposed teaching methodologies closer to the modern learning profile of students.

4 DISCUSSION

The current literature addresses several examples of technologies developed at universities and research results have been showing a positive response to learning mediated by them. With the global dissemination of the internet, the studies addressed the inclusion of games and virtual learning environments to complement face-to-face classes.

In a Brazilian survey, researchers developed software as a tool for permanent education programs, using gamification to train nursing professionals in intensive care units to use high-surveillance drugs to reduce failures in their work process and improve the care provided to patients[14].

The use of safe practices for the preparation and administration of medications was also the main objective of the NurseVR game. Moreover, the virtual training offered the possibility of practicing in a controlled environment to exercise patient safety protocols associated with the medication process.

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As in NurseVR, authors used the methodological framework of serious games to develop a game that aimed to assist in decision making in first aid actions. The results pointed to the importance of using technology in the learning process. When applied in the pedagogical process, its advantages can provide the development of individual skills and abilities[15].

Another study addressed the development of a game in the Role Playing Game (RPG) modality, which represents a cooperative activity in which there is the incorporation of a character and an illusory reality for teaching basic life support practices. It is believed that the combination of action and invention offered by the game can be associated with the improvement of knowledge and clinical skills of the players, being valid for professional training[16].

Another type of technology widely used is simulation games. This type of technology makes it possible to improve the procedures and problems of clinical practice, highlighting each student's learning pace, and providing better patient care in the clinical routine[17].

For health education, simulation and virtual environments containing digital games can provide experiences more economically. Students can be exposed to different case scenarios that allow them to create and evaluate positive and negative results from clinical procedures, as well as providing a safe environment for them to acquire skills and self-confidence[18].

Virtual simulation through games can offer experimental learning opportunities that allow students to acquire and apply new knowledge while practicing skills in a safe and realistic environment and promote engagement among participants[19].

In the present study, it was observed that the use of virtual simulation added innovation to learning from practical activities. The students were able, through NurseVR, to live contextualized experiences in a reality-like environment.

In the field of emergency training and intensive care, a simulation-based course was created by Chinese teachers. The course was well received by nursing students and resulted in reduced response time in a resuscitation simulation[20].

Training students to perform tasks repeatedly with immediate feedback through simulation allows for improved professional practices and students' reflection on their performance. It also gives students time to refine and improve their motor skills to perform tasks intuitively, helping them transition the didactic content learned in the laboratory simulation to practical applications in the healthcare environment[21].

It is considered that the provision of safe and realistic virtual simulations can be an effective way to facilitate the transition from the classroom to clinical practice, presenting itself to students as an engaging, realistic learning tool and similar to a clinical experience[22].

With another simulation approach, a study described a virtual patient-simulator for teaching nursing students about the diagnostic process. The game was designed based on skills analysis, technical and scientific knowledge, logical reasoning, and critical thinking. It was found that the use of this technology

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can be one of the alternatives to support the teaching process and improve the quality of higher education in health[23].

After the end of the NurseVR testing period, it was possible to verify the students' feeling of involvement similar to the studies described above. The simulation in virtual reality provided the players' exposure in a new practice scenario, promoting learning from the challenges and motivation to achieve the objectives of the game. Thus, it is believed that the virtual game provided a dynamic practice. The player was an active subject and the protagonist of his actions and decisions within the simulated virtual environment.

As for the use of virtual reality, studies have also addressed a trend in modern games for allowing immersion in a programmed environment, pointing it as the most promising approach for professional training today.

Qualitative data from a study with a virtual reality game revealed the best results in the learning of medication administration and respiratory interventions. They demonstrated learning of assessment, prioritization, and management of emergencies. The findings provide data to guide nursing educators to integrate virtual simulation exercises[24] more strategically.

Another study with a virtual reality educational game about surgical instrumentation points out that the "digital student", in addition to playing, needs engagement, encouragement, reality and entertainment, and that the educational game was treated as an innovative teaching strategy in nursing that encourages the use of educational games to support theoretical or practical teaching in the classroom[25].

Still in the context of nursing education, researchers developed and evaluated the usability of a VR gaming system to sterile catheterization training. Participants reported pleasure, involvement, the probability of practicing repeatedly, and comfort when playing. The authors pointed to the promise that gaming in virtual reality provide for developing nursing skills[26].

Thus, it is believed that the initial proposal of the NurseVR game for the execution of simulated practices in a virtual environment meets the modern approach of the literature in the area, as it provided immersion for students' practice and interest, positively influencing learning.

5 CONCLUSIONS

From the results found, it is considered that the objective of testing a virtual simulation technology in the learning of nursing students was achieved, revealing that the game contributed positively to the learning about the preparation and administration of drugs associated with laboratory activities existing in the program.

It was noticed that, during the theoretical classes, students learn through content assimilation. Laboratory practices allowed students to develop manual and technical skills. However, with virtual

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simulation, they could insert themselves in contexts based on reality and developed procedural actions inherent to the professional practice.

Thus, it is understood that technology brings several benefits to the teaching-learning process, but that no didactic approach can be superimposed on others and should be used according to the teacher's objectives during the planning of courses.

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