JOURNAL OF INTERNATIONAL CRISIS AND RISK COMMUNICATION RESEARCH
ISSN: 2576-0017
2024, VOL 7, NO S6

Clinical judgment of nursing students and the delivery of virtual health assessment laboratory courses

Naelah Mubarak Ahmed Alsamili[1], Raad Saud Mehmas Alharthi[2], Fatimah Makki Alsadiq[3], Rasmy Saud Alrashdi[4], Saleh Ahmed Khormi[5], Nourah Aaid Alblewi[6], Homoud Abdullah Algosheri[7], Turki Mohammed Hassan Asiri[8], Ahad Ebrahim Yahiya Asiri[9], Athba Ebrahim Yahiya Asiri[10], Ali Mohammed Ali Alghamdi[11], Ahmed Fahad Alsharari[12]

1. *Nursing and Midwifery , Al-Laith General Hospital*
2. *king Abdulaziz specialist hospital , Laboratory*
3. *Saud albabtain cardiac center , Nursing specialist*
4. *Laboratory technician, Hospital king Fahd in buraidah*
5. *Abu Arish General Hospital , Nursing specialist*
6. *Midwife , Mental health hospital*
7. *Laboratory technician , Khober health network*
8. *BIOMEDICAL DEVICES, MUHAYIL GENERAL HOSPITAL*
9. *NURSING, MUHAYIL GENERAL HOSPITAL*
10. *NURSING, MUHAYIL GENERAL HOSPITAL*
11. *Laboratory Specialist, Ministry of Health - Ministry Office - General Administration of Medical Supplies*
12. *Assistant nurse , Aljouf tabatjal*

Abstract

Background: The education of nursing students faces ongoing challenges in ensuring both high-quality learning and safe clinical practice. Traditional methods have been augmented by advanced simulation technologies, which enhance knowledge and skills in clinical settings. However, limitations such as high costs and space constraints persist. Clinical virtual simulation, an emerging approach, offers an interactive and immersive alternative that may address these challenges, but its impact on student satisfaction, self-efficacy, and knowledge retention remains unclear.

Methods: This randomized controlled trial involved second-year nursing students (N=42) enrolled in a course on physiological responses. Participants were randomly assigned to either an experimental group using clinical virtual simulation or a control group using low-fidelity simulation. Assessments were conducted at three time points: pretest (A0), immediately post-intervention (A1), and two months later (A2). Knowledge retention, satisfaction, and self-efficacy were measured using tailored instruments. Data analysis included t-tests, MANOVA, and Cohen's d for effect size.

Results: Significant differences were found between the groups in knowledge retention and learning satisfaction. The experimental group showed superior outcomes in both immediate and long-term knowledge retention ($P = .001$, $P = .02$) and higher satisfaction levels ($P < .001$). MANOVA indicated significant time-related changes influenced by group allocation. No significant differences were observed in self-efficacy between groups ($P = .9$), although group differences were noted across assessments ($P = .003$).

Conclusion: Clinical virtual simulation significantly enhances knowledge retention and student satisfaction in nursing education. While its impact on self-efficacy was less pronounced, the findings underscore the potential of virtual simulation to improve clinical competence and contribute to safer healthcare training.

Introduction

Nursing Education

The education of nursing students has consistently presented challenges to governments, healthcare educators, administrators, and the students themselves. Ensuring both the quality of education and the safety of clinical practice requires continuous innovation and attention.

Students of the 21st century have been immersed in the use of information and communication technologies (ICT) throughout their daily lives. This extensive use of ICT influences their learning approaches and the ways they organize information (1).

Educators and administrators must recognize that these students possess the ability to access information instantly, multitask effectively, and process parallel streams of information. Additionally, they favor visual aids over textual information, thrive in collaborative environments, and seek immediate feedback and frequent reinforcement (2).

Given these unique ICT capabilities, there is a demand for innovative pedagogical methods in healthcare education grounded in constructivist principles. Educators now act as facilitators of learning rather than traditional lecturers, engaging with students as active participants who assign personal significance to their experiences and gradually construct their own knowledge. A learning environment that emphasizes challenges and clear objectives fosters deeper understanding and encourages the practical application of knowledge rather than rote memorization (3, 4-8).

The emergence of advanced simulation technologies has transformed healthcare education. High-fidelity simulators, in particular, have been instrumental in shifting educational paradigms. These simulators enhance knowledge acquisition and skills while prioritizing safety and quality in clinical training (3, 9-15). However, significant hurdles persist, such as the rising costs of simulators, limited physical space, and a shortage of clinical scenarios.

Clinical Virtual Simulation

Advancements in digital and virtual technologies have made it possible to simulate real-world scenarios through virtual patients (16) displayed on computer interfaces, an approach known as clinical virtual simulation. This simulation replicates real-world settings on digital platforms and involves users interacting with simulated systems. It places individuals at the center of the experience, challenging their decision-making, motor coordination, and communication abilities (11).

Clinical virtual simulation employs interactive, screen-based environments featuring virtual patients in various dynamic settings, including prehospital and community scenarios (17). Supported by physiological algorithms, these simulations provide interactive and immersive experiences that enhance feedback, improve perceptions of self-efficacy, and boost satisfaction among users (18, 19). The integration of clinical virtual simulation into nursing education has shown improvements in performance and the development of competencies, including psychomotor skills (21), critical thinking (22), clinical abilities (23), and decision-making (17). Recent technological progress in this field has led to heightened realism and interactivity, offering thousands of clinical scenarios accessible via touchscreen or web-based platforms. However, there remains a lack of clarity regarding its impact on students' learning satisfaction, self-efficacy, knowledge retention, and clinical reasoning, particularly when utilizing the most advanced forms of clinical virtual simulation.

As educators in healthcare, we are deeply invested in understanding the factors that enhance students' satisfaction with learning and the effectiveness of educational outcomes (13). This study aims to evaluate the impact of clinical virtual simulation on fostering satisfaction, improving self-efficacy, enhancing knowledge retention, and strengthening clinical reasoning among nursing students.

Methods

This study employed a randomized controlled trial design combined with a prospective and analytical approach, conducted over a three-month period in 2017. It included a pretest and two posttests to evaluate outcomes.

Participants and Allocation

The participants were second-year nursing students enrolled in a course on physiological responses related to respiratory, cardiac, and urinary systems. All enrolled students (N=128) were invited via email to voluntarily participate in the study. Of the respondents, 56 students attended an initial meeting, consented to participate, and completed a questionnaire capturing sociodemographic information and academic performance metrics, such as current grade

averages, total credits achieved, and admission grade averages. This information was utilized for randomization. Anonymity was ensured by assigning each participant a self-selected six-digit identification number, preventing any potential identification by the researchers.

Sample size calculation was based on a one-tailed, unpaired *t* test with a type I error rate of 0.05, statistical power of 0.80, and an effect size of 0.80, requiring 42 participants (21 per group) as determined using G*Power3 software (24). Random allocation was performed using IBM SPSS Statistics version 24.

One week after randomization, the 56 participants were invited to a meeting held immediately before the intervention. During this session, they completed the first assessment (pretest, A0), which evaluated their baseline knowledge and clinical reasoning. Following this, participants were directed to separate classrooms based on their assigned group.

Intervention

Both the experimental and control groups participated in a 45-minute laboratory session designed to activate knowledge and develop clinical reasoning related to ineffective airway clearance and hypoxia.

The experimental group engaged with a case-based learning strategy using a clinical virtual simulation platform, facilitated by their course instructor. The simulation tool featured dynamic virtual patients powered by physiological algorithms. Participants interacted with the simulation by conducting assessments, monitoring parameters, prescribing tests or treatments, and making clinical decisions. The scenarios were resolved based on participants' actions, with an integrated debriefing session following the simulation. The debriefing included a performance report, timeline of actions, correct diagnoses, and relevant scientific references.

The control group underwent a similar laboratory session, utilizing a low-fidelity simulation and a realistic setting, guided by the same instructor. This approach followed traditional pedagogical methods previously employed in the curriculum. Both groups received identical session structures: briefing (5 minutes), simulation (20 minutes), and debriefing (20 minutes).

Outcome Measures

Immediately following the intervention, participants completed a second assessment (A1) to evaluate immediate outcomes. A third assessment (A2) was conducted two months later to measure retention.

Knowledge assessments across all three time points utilized the same true-or-false and multiple-choice tests, designed by course instructors and tailored to the clinical reasoning required in the simulation. Additionally, satisfaction levels and perceived self-efficacy were assessed after the intervention. Satisfaction was measured using the Learner Satisfaction with Simulation Tool (19), adapted for local use (25),on a 10-point Likert scale. Perceived self-efficacy was measured using an adapted version (26) of the General Self-Efficacy Scale (27), scored on a 5-point Likert scale. Reliability coefficients for these tools are presented in Table 1.

Data Analysis

The normality of the data distribution was assessed using the Kolmogorov-Smirnov test with Lilliefors correction. The results indicated normal distribution for the key variables in both groups.

To compare group performance, an unpaired *t* test was used for mean differences, with the Welch correction applied when variances were unequal. A multivariate analysis of variance (MANOVA) was conducted to assess differences across the three measurement points (A0, A1, and A2). Statistical significance was set at $P<.05$, with effect sizes interpreted according to Cohen's criteria (1988) (29): small ($d=0.2$; partial $\eta^2=0.02$), medium ($d=0.5$; partial $\eta^2=0.13$), and large ($d=0.8$; partial $\eta^2=0.26$).

Table 1. Cronbach alpha coefficients for the original, for the Portuguese versions, for this study's sample of the Learner Satisfaction with Simulation Tool, and for the General Self-efficacy Scale.

Scales	Original version, Cronbach alpha	Portuguese version		Study sample	
		Cronbach alpha	Correlation item-item total	Cronbach alpha	Correlation item-item total
Learner Satisfaction with Simulation Tool	.952	.969	.633-.823	.970	.660-.910
The General Self-Efficacy Scale (average for 25 language versions) [28]	.860	.760	.290-.530	.882	.527-.726

Results

A total of 42 second-year nursing students participated in this study, with 21 students in the experimental group and 21 in the control group. The mean age of the students was 19.9 years (SD 1.99), and the majority (95%, 40/42) were female. The results for the variables under study are presented in Table 2.

Knowledge Retention and Learning Satisfaction

The statistical analysis using t tests revealed significant differences in knowledge retention immediately after the intervention ($t40 = -3.656$; $P = .001$; $d = 1.13$), knowledge retention at a 2-month follow-up ($t40 = -2.439$; $P = .02$; $d = 0.75$), and learning satisfaction ($t40 = -4.309$; $P < .001$; $d = 1.33$). The experimental group demonstrated better outcomes in both knowledge retention and satisfaction compared to the control group. The Cohen's d values indicated a substantial effect from the intervention.

The MANOVA results were significant for the time factor (Pillai Trace; $F2,39 = 13.4$, $P < .001$, partial eta squared = 0.407) as well as the interaction between time and group ($F2,39 = 4.45$, $P = .02$, partial eta squared = 0.186), suggesting that the students' knowledge levels changed over time and that these changes were influenced by the group allocation. A Bonferroni post-hoc test showed significant differences between A0 and A1 ($P < .001$), and between A0 and A2 ($P = .02$), but no significant difference between A1 and A2 ($P > .99$). When comparing the groups, significant differences were found between A0 and A1 ($P < .001$) and between A0 and A2 ($P = .01$), but no significant difference between A1 and A2 ($P = .75$). No significant changes were observed within the control group (A0-A1: $P = .44$, A0-A2: $P = .99$, A1-A2: $P > .99$).

Self-Efficacy Perception

Regarding self-efficacy perception, no statistically significant differences were found between the groups: $t40 = -0.174$, $P = .9$, $d = 0.054$.

However, there was a significant effect of the group on scores across the three measurement points: $F1,40 = 10.2$, $P = .003$, partial eta squared = 0.204. This indicates that 20.4% of the variation in the students' scores across the three assessments was accounted for by the group to which they were assigned.

Table 2. Means of sample characteristics and study variables and SDs.

Study variables		Control group	Experimental group
Sex, n			
	Female	19	21
	Male	2	0
Age, mean (SD)		20.29 (2.19)	19.29 (0.46)
Mean entry grade to the degree course, mean (SD)		15.54 (1.46)	15.97 (0.85)
European Credit Transfer System credits on the degree course, mean (SD)		87.29 (6.90)	86.86 (5.41)
Degree course mean grade so far, mean (SD)		13.21 (0.67)	13.42 (0.99)
Self-efficacy perception, mean (SD)		30.14 (4.29)	30.38 (4.57)
Learning Satisfaction, mean (SD)		7.47 (1.58)	9.04 (0.55)
Knowledge assessment before intervention (A0), mean (SD)		9.87 (2.24)	10.15 (1.27)
Knowledge assessment after intervention (A1), mean (SD)		10.51 (1.89)	12.47 (1.57)
Knowledge assessment follow-up (2 months; A2), mean (SD)		10.55 (1.81)	11.93 (1.84)

Discussion

Key Findings

This study demonstrates that clinical virtual simulation enhances both knowledge retention and clinical reasoning skills over time (2 months) while also increasing student satisfaction with the learning process, although it does not impact perceptions of general efficacy. Specifically, clinical virtual simulation resulted in a 20.4% improvement in students' knowledge retention and clinical reasoning. The findings suggest that this approach, when combined with other teaching strategies like briefing, simulation, and debriefing, significantly improves both immediate and long-term knowledge retention. Furthermore, it enhances the overall learning experience for nursing students, aligning with the expectations and learning styles of the modern generation. The positive effects on knowledge retention, clinical reasoning, and satisfaction with the learning process corroborate previous studies that indicated high levels of usefulness, ease, and intent to use clinical virtual simulation among twenty-first-century nursing students [30].

The results are consistent with findings from other studies, which also reported improvements in knowledge levels [31-33] and satisfaction with the learning process [14] through the use of virtual simulations.

Clinical virtual simulation integrates strategies such as gaming and problem-based learning, utilizing interactive 3D technology to foster active, critical, and action-based learning.

Self-Efficacy Perception

No significant differences were observed in the students' self-efficacy perceptions when using clinical virtual simulation, which aligns with Bandura's [34] self-efficacy theory. According to this theory, self-efficacy is shaped by the interaction of multiple variables over time, and in this study, only one intervention with a single class was implemented.

Clinical Virtual Simulation in Nursing Education

Clinical virtual simulation serves as a supplementary pedagogical tool that enhances clinical reasoning skills by exposing students to numerous clinical scenarios. It should be used in conjunction with other teaching strategies in classrooms [35,36] and integrated with various

simulation resources—ranging from low- to high-tech simulators available in simulation labs—to optimize students' development in cognitive, affective, and psychomotor domains.
These findings are consistent with those of Berman and colleagues [17], who highlighted that clinical virtual simulation is an interactive and motivational learning strategy. It emphasizes applying foundational knowledge to clinical challenges, recreating realistic scenarios that students are likely to encounter in their future clinical work. This approach supports competency-based education and assessment, fostering deep learning and clinical expertise. Additionally, clinical virtual simulation can help reduce clinical errors and enhance patient safety and healthcare quality.
One of the key advantages of clinical virtual simulation is its ability to address space limitations in labs, enabling institutions to offer more clinical scenarios for student training. This approach also makes it feasible to conduct training in a classroom setting and provides broader access to scenarios in an online environment, thereby increasing the number of students who can receive individualized training and significantly reducing simulation costs per student.

Study Limitations

This study has several limitations, including its confinement to a single context with second-year nursing students and a single course focused on respiratory processes. Additionally, the follow-up period was relatively short, which may not fully capture the long-term impact on knowledge retention.

Future Research

Given these promising findings, we recommend replicating this study with a multicentric, prospective design that includes a variety of health science courses to better assess the broader applicability of clinical virtual simulation.

Conclusions

Clinical virtual simulation is an effective pedagogical tool that enhances knowledge retention in the short and long term, while also improving student satisfaction. This research highlights the significant impact of clinical virtual simulation in nursing education and emphasizes its potential utility in fostering clinical competence. By improving the quality of training for future healthcare providers, clinical virtual simulation plays a critical role in enhancing healthcare safety and quality.

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