Global Scientific and Academic Research Journal of Education and literature.
ISSN: 2583-7966 (Online)
Frequency: Monthly
Published By GSAR Publishers
Journal Homepage Link- https://gsarpublishers.com/gsarjel-home-page/

Impact of Immersive Clinical Simulation on Knowledge Acquisition

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Article History

Received: 01/12/2023
Accepted: 04/12/2023
Published: 05/12/2023

Vol – 1 Issue – 7

PP: - 11-18

Abstract

***Background**: The goal of this research report is to validate the impact of immersive clinical simulations on knowledge acquisition.*

***Methodology**: This prospective, multicenter study is based on a quasi-experimental type of evaluative research. The participants in the experimental group were taught using a series of four progressive Immersive Clinical Simulations (ICS)-assisted lessons, while those in the control group were taught using traditional methods. All participants also wrote two exams about their cardiology knowledge: version A pretest conditions and version B post-test conditions.*

***Results**: A total of 177 participants (N=177) were involved in this research project, including 93 (n=93) in the experimental group and 84 (n=84) in the control group. Under pretest conditions, the results obtained by the two groups of version A of the questionnaire are statistically equivalent (p=.63). Under post-test conditions, participants in the experimental group scored significantly higher (p=.002).*

***Conclusion**: The results of this research further confirm the impact of simulations on knowledge acquisition.*

***Keywords**: clinical simulation, high-fidelity clinical simulation, knowledge acquisition process, clinical knowledge, clinical reasoning, cardiology, Rasch model.*

INTRODUCTION:

For several decades, Immersive Clinical Simulation (ICS) has been one of the various teaching strategies used in nursing education. Specifically, ICS allows students to provide nursing care in environments that are comparable to clinical settings, but without exposing any potential patient to risks. Studies demonstrate that ICS-assisted teaching requires active student participation (Akhu-Zaheya et al., 2013; Decker et al., 2013; Jeffries, 2012; Zulkosky, 2010). This active learning thus contributes to the development of beginning nurses' communication abilities, as well as their critical thinking, reasoning, and clinical judgment (Dreifuerst et al., 2014; Green & Bull, 2014; Hart et al., 2014; Willhaus, 2014). According to DeVita (2009), ICS is an essential teaching method in health education because "it is measurable, focused, reproducible, and, above all, easily remembered" (p. 46). Finally, the results of a study conducted by the National Council of State Boards of Nursing (Hayden et al., 2014), indicate that the lessons taught through ICS by a qualified instructor favour the development of nursing abilities that are equivalent to those abilities taught in mobilized clinical settings.

Learning is the process of acquiring and integrating new knowledge in order to reuse it later. According to the cognitive conception of learning, prior knowledge determines not only what students can learn, but also what they will actually learn later on (Charlin et al., 2000). The understanding of a fact or concept depends on students' prior knowledge (Leahey & Jackson Harris, 2000). Therefore, in order to acquire new knowledge, students will refer to information previously encoded in their memory (Anderson, 2010; Rumelhart, 1980). When trying to provide quality care that is in line with good clinical practice, it is important for students to possess as much prior knowledge as possible (Melnyk et al., 2014). According to the literature, it is possible to increase students' knowledge through the use of ICS (Letcher et al., 2017). However, current research results are limited, in that the actual impact of ICS on knowledge enhancements still needs to be determined (Boling & Hardin-Pierce, 2016; Cant & Cooper, 2017). The meta-analyses by Yuan William, Fang & Ye (Yuan et al., 2012), and Boling & Hardin-Pierce (Boling & Hardin-Pierce, 2016) emphasize that the majority of studies on the link between ICS and the increase in students' knowledge contain methodological weaknesses. According to these two meta-analyses, the impact of ICS on student knowledge cannot be fully ascertained at the moment. This lack of consensus is due to previous studies' methodologies. Among these methodological limitations, some research has sought to demonstrate the impact of ICS based on students' self-reporting, identical pretest, and post-test examinations, use of a single post-test, or absence of a control group. All of these situations affect the methodological quality of the studies, thereby leading to questions concerning their conclusions (Boling & Hardin-Pierce, 2016). So far, no studies have examined the impact of ICS on knowledge acquisition of two equivalent – but not identical – knowledge measurement instruments, which neutralizes the potential testing bias that arises when the same instrument is used for both the pretest and post-test. This study fills in this gap while also using a control group.

RESEARCH QUESTION:

The research question for this study is: "What is the impact of a series of progressive ICS-assisted lessons?" More specifically, it seeks to assess the impact of ICS on the acquisition of cardiology knowledge by students in the nursing program. Its ultimate goal is to use a more robust methodology to determine the impact of ICS on students' knowledge acquisition.

METHODS:

Framework

This study is based on two complementary models: the Brown, Collins & Newman (1989), cognitive learner model and the Jeffries (2014) conceptual model of clinical simulation. The cognitive learner model is based on the situated cognition approach. According to this model, the learning activity prepares students to acquire expertise, develop problem-solving abilities, and improve their learning abilities. ICS was therefore developed according to the four dimensions of this model: 1) content, 2) teaching strategies, 3) teaching sequences, and 4) the social environment. Meanwhile, Jeffries' conceptual model of clinical simulation proposes a way to plan, structure, and evaluate a simulation activity. According to Jeffries and the National League for Nursing, this method maximizes the effective acquisition of the abilities required by the training program (Groom et al., 2014).

Experimental Design

This prospective, multicenter study is based on a quasi-experimental type of evaluative research using a "pretest/post-test with non-equivalent control group." This type of research allows for validation of the real impact of ICS on knowledge acquisition. Participants in the experimental group were taught with ICS-assisted lessons whereas those in the control group continued with traditional training without use of ICS. The convenience sample consisted of students enrolled in their fifth session of a nursing program.

Participants

All participants (N=177) needed to have previously completed their physiopathology and nursing courses on cardiovascular conditions. In addition, none of the students had previously received ICS-assisted lessons in the content area. The participants were divided into two groups: an experimental group (n=93) and a control group (n=84). All participants subsequently wrote two exams to measure their cardiology knowledge: version A in pretest conditions and version B in post-test conditions. The participants in the experimental group were comprised of students enrolled in two separate schools, while those in the control group were enrolled in six different schools.

Measurement Instruments

Both versions of the cardiology knowledge measurement instruments were created prior to the experimental phase. Each measurement instrument consists of 35 items, including seven common items found in both versions of the exams. These measurement instruments were developed in compliance with recommendations from (Case & Swanson, 2001). Although the instruments contain different items, each one evaluates the exact same construct of cardiology knowledge. These measurement instruments were submitted to an external committee for content validation. Subsequently, each one was subjected to a validation process using the unidimensional Rasch model for dichotomous data and they were successfully equated, which means that measures obtained on both instruments are directly comparable. A complete description of the validation of these measurement instruments and more information on equating can be found in Kolen & Brennan (2014).

Ethical Consideration

In compliance with Canada's research ethics policy, this research project obtained the approval of the Ethics Committee for Research Involving Humans at Sherbrooke and Sainte-Foy CEGEPs. All those who participated in the research project signed a consent form. In addition, those who participated in the four progressive ICS-assisted lessons did so knowing that their performance during the lessons and the tests would not be used to inform their mark in their regular classes.

Experimental Design

A series of four progressive cardiology-based lessons using ICS were developed in order to meet the methodological demands of this research. In this type of series of lessons or "unfolding cases," students are immersed in a clinical case that develops over time (2016). This format allows students to monitor a patient from initial assessment to discharge. For Glendon & Ulrich (Ulrich & Glendon, 2005), these types of progressive lessons enable students to actively develop and apply their knowledge, abilities, and attitudes toward patients. The four progressive lessons used in this research were created and scripted based on the knowledge, skills, and abilities that needed to be developed in the training program. Use of the fundamentals of the NLN-JSF conceptual framework led to the development course plans for each of the four lessons. The guide contains a series of informational sections, including: 1) The goals of the simulations; 2) The identification of the knowledge, skills, and abilities to be developed; 3) The prerequisites for the simulation; 4) The team members; 5) The simulation and progress of the clinical case; 6) The structure of the debriefing; and 7) The planning and implementation of the simulation. The guide sections adhere to the didactic principles of developing a clinical simulation activity as suggested by Aschenbrenner, Milgrom & Settles (Aschenbrenner et al., 2012). The four-lesson sequence of this research focuses on the evolving health status of a patient with cardiovascular disease. The construct and content of the lessons are based on the concepts described in the reference book *Nursing Medicine Surgery* (Lewis et al., 2011).

RESULTS:

The measurement of cardiology knowledge acquisition was performed using the Rasch model, which assumes that the probability of a person obtaining a correct response to an item is a function of both the individual's ability level and the difficulty level of the item. These levels are expressed in logit, as shown by the following equation:

where θn represents the ability of student n, βi the difficulty of the item i, ln the natural logarithm, and P the probability of obtaining the correct answer (one). Ability level measures, in logit, are continuous and serve as a dependent variable for subsequent analyses. To ensure the quality of the data, the verification of the conditions of the application of the Rasch model was carried out for the two exams. These conditions are unidimensionality, local independence (the probability of obtaining a correct answer to an item depends only on the ability level), and monotonicity (the higher the student's ability level, the higher the probability of obtaining a correct answer). All tests' results and statistical indices used showed no important violations of those conditions. Finally, the seven common items on the pretest and post-test exams make it possible to obtain directly comparable measurements on the same scale, since the data obtained were equated successfully. A *t-test* was used to compare the averages of the two groups in the pretest, and an analysis of covariance (ANCOVA) was used to compare the post-test averages, checking for any differences in the pretest. The conditions of use of the *t-test* and the ANCOVA were verified, and no violation was detected. The effect sizes and their 95% confidence interval are represented by Cohen's *d*.

Table 1 depicts the descriptive statistics of the logit scores of pre-test knowledge for the two groups. The mean logit score obtained by the participants in the pretest control group is 0.93 ± 0.71 logit, whereas it is 0.97 ± 0.54 logit for participants in the experimental group. A *t-test* shows that these means are not significantly different (p=.63, d=0.07, C.I. 95% d=-0.23, 0.37). Quartile values are also very close for both groups.

Table 1: Descriptive statistics of logit scores on cardiology knowledge at the pre-test (N = 177)

	Pre-test ECC								
Group	***M***	***S***	**min**	**Q1**	***Md***	**Q3**	**max**	**kurtosis**	**asymmetry**
Control (*n* = 84)	0.93	0.71	-0.41	0.53	0.90	1.28	2.78	-0.13	0.42
Experimental (*n* = 93)	0.97	0.54	-0.41	0.73	0.90	1.23	2.78	0.54	0.12

Annotations: *M* = mean, *S* = standard deviation, min = minimum score, Q1 = first quartile, *Md* = median, Q3 = third quartile, max = maximum score

Figure 1 illustrates the density of the logit score distribution for both groups. Both groups received almost identical scores on the pretest.

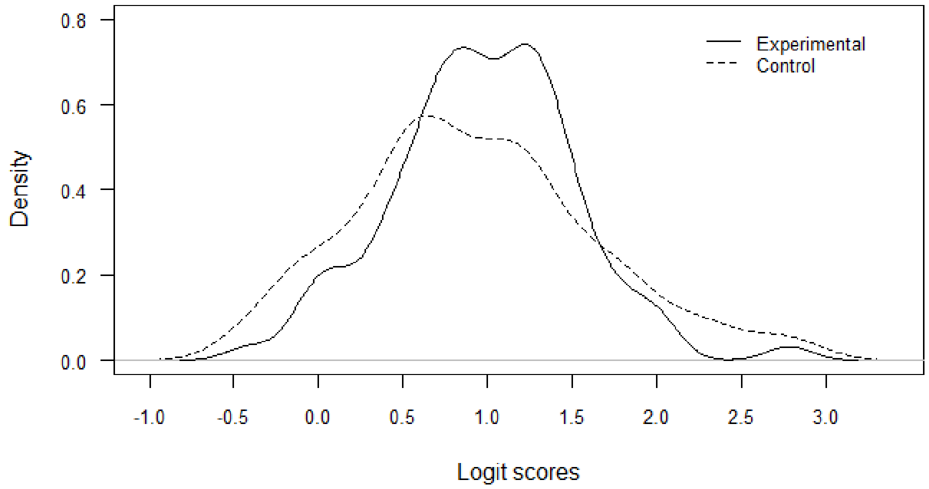

Figure 1: Density of score distribution in logit at the pre-test

Table 2 depicts the descriptive statistics of the logit scores obtained in the post-test by the two groups. On the whole, the distribution of the experimental group has higher values than that of the control group. The mean of the control group is 1.06 ± 0.62 logit, whereas it is 1.37 ± 0.65 logit for the experimental group.

Table 2: Descriptive statistics of logit scores on cardiology knowledge at the post-test (N = 177)

	Post-test ECC								
Group	*M*	*S*	min	Q1	*Md*	Q3	max	kurtosis	asymmetry
Control (*n* = 84)	1.06	0.62	-0.44	0.61	0.98	1.43	2.67	-0.23	0.11
Experimental (*n* = 93)	1.37	0.65	-0.27	0.98	1.37	1.82	3.06	-0.18	0.02

Annotations: *M* = mean, *S* = standard deviation, min = minimum score, Q1 = first quartile, *Md* = median, Q3 = third quartile, max = maximum score

Figure 2 illustrates the density of logit score distribution on the post-test. The ANCOVA results show a significant difference in post-test means between the two groups (group difference=0.28, t=3.5, p=.0004, d=0.53, C.I. 95% d=0.22, 0.83). The medium-sized effect represents a difference of half a standard deviation between the two groups. Both groups have a higher post-test mean than their pretest mean, but the increase is bigger for the experimental group. The experimental group increased by 0.39 logit and the control group by 0.13 logit.

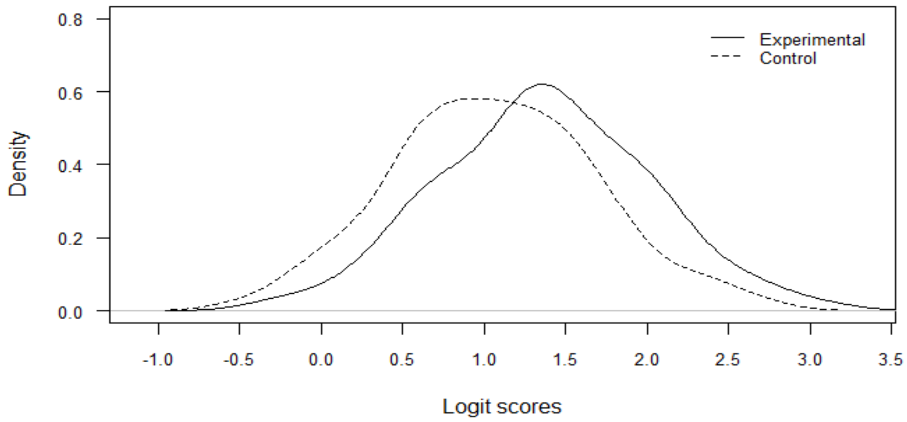

Figure 2: Density of score distribution in logit at the post-test

Table 3 shows the descriptive statistics of the gain scores and the differences between the post-test and pretest scores for the two groups.

Table 3: Descriptive statistics of logit gain scores on cardiology knowledge (N = 177)

	Gain scores on ECC								
Group	*M*	*S*	min	Q1	*Md*	Q3	max	kurtosis	asymmetry
Control (*n* = 84)	0.13	0.64	-1.69	-0.19	0.21	0.57	1.61	0.36	-0.40
Experimental (*n* = 93)	0.39	0.59	-1.17	0.06	0.41	0.69	2.10	0.53	0.23

Annotations: *M* = mean, *S* = standard deviation, min = minimum score, Q1 = first quartile, *Md* = median, Q3 = third quartile, max = maximum score

Figure 3 illustrates the density distribution of these scores. For the sake of robustness, the data were also analyzed using repeated measures ANOVA, and the results are similar to the ANCOVA results. As such, they are not reported.

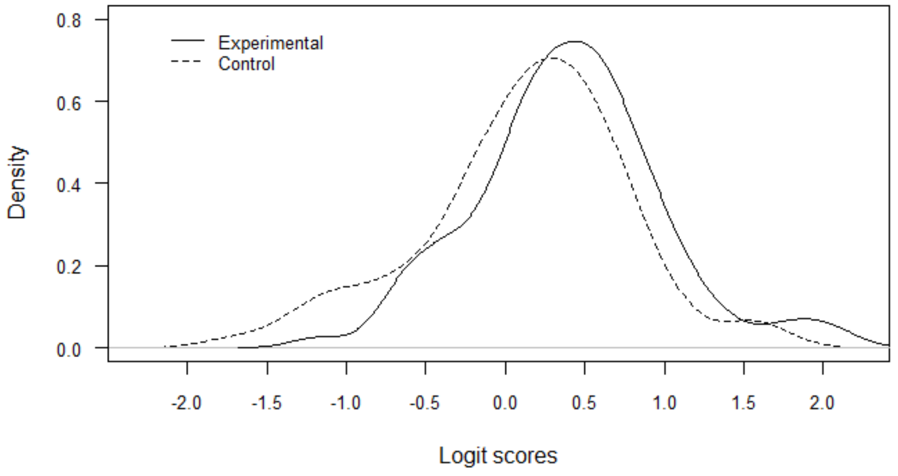

Figure 3: Density of gain score distribution in logit

DISCUSSION:

Providing safe, high-quality care to patients with cardiovascular problems represents one of the most important challenges for novice nurses worldwide. In fact, acquiring complex knowledge and applying this knowledge in a real-life context is a major challenge for all educational institutions. This study showed that using ICS as a teaching method improves the retention of cardiology knowledge among nursing students. By extension, ICS is a method that improves the retention of complex information acquired in nursing programs. When students have different clinical exposure during their training, the importance of ICS in the program curriculum becomes evident. The plurality of the internship environments combined with the variety of patients seen expose students to various different learning activities. This diversity also leads to a non-equivalent clinical exposure between the students of the same program. In the long term, some students will face situations that mobilize their knowledge of cardiology while others will not have dealt with the same cases. The use of ICS makes it possible to avoid this inconsistency. Several researchers report that better nursing education, including use of ICS, helps to improve the management of all patients (Fisher & King, 2013; Kenner et al., 2009). Furthermore, the implementation of simulation activities in the initial training curriculum allows for more efficient preparation for the nursing profession (Ricketts, 2011). Nevertheless, one of the difficulties novice nurses face concerns their ability to assimilate all the knowledge transmitted during their training (Boling & Hardin-Pierce, 2016). Theoretical knowledge that is never applied in clinical settings is thus more difficult to mobilize. Although ICS enhances critical thinking and the ability to recognize the deterioration of a patient, its actual impact on knowledge acquisition and retention remains ambiguous to this day (Lapkin et al., 2010).

Therefore, despite an abundance of literature on the impact of ICS on training, the impact of ICS on knowledge acquisition remains ambiguous. The literature review by Yuan et al. (Yuan et al., 2012) mentions that the weak methodological rigour of randomized controlled studies partly explains this lack of consensus. Some studies have demonstrated a significant increase in this area; however, all had a small number of participants (Boling & Hardin-Pierce, 2016). In the study by Jansson et al. (Jansson et al., 2014), the authors sought to objectify the impact of ICS through use of a simulated patient with 15 nursing students. Despite the small number of participants and the use of identical pre-test and follow-up exams, the results demonstrate a significant increase in knowledge retention in the experimental group compared to the control group. These results corroborate those found in our study. These results also suggest that the impact of ICS on knowledge acquisition is not dependent on the type of simulation used (simulated patient vs. high-fidelity manikin). Another randomized controlled study of ICS' impact on knowledge acquisition shows a positive impact of ICS on physicians (Schroedl et al., 2012). These results confirm ours and further specify that ICS' contributions to knowledge acquisition are not limited to nursing alone.

In return, our results run counter to those found in some studies (Cavaleiro et al., 2009; Cherry et al., 2007; Kim et al., 2002). In these studies, there was no significant difference between control groups and experimental groups. This lack of significant difference can be explained, among other things, by the type of knowledge participants needed to mobilize. Indeed, those studies focused on the impact of ICS on the retention of procedural knowledge: in this case, the participants' knowledge of neonatal resuscitation procedures, advanced trauma care, and advanced cardiac care. The lack of significant results can also be attributed to the fact that ICS promotes more complex knowledge mobilization and clinical judgment than learning a decision-making algorithm does. It is therefore normal and expected that an algorithmic-based cognitive process produces more mixed results with respect to ICS' knowledge retention.

CONCLUSION:

A great deal of recent research surrounding ICS shows a connection between this pedagogical approach and an increase in student knowledge (Cant & Cooper, 2017; Sapyta & Eiger, 2017). However, no recent study has demonstrated the links between ICS and knowledge gain using such methodology as described above. The benefits of this study further confirm the impact of ICS in increasing knowledge retention. These findings help to enhance the body of knowledge about the impact of ICS on health education and ultimately end the debate surrounding the contribution of ICS to knowledge acquisition. As a result, in addition to the many other benefits attributed to ICS, these findings validate the relevance of incorporating ICS into the nursing program curriculum. The positive impact of ICS on students' knowledge acquisition therefore suggests that simulation pedagogy could positively impact the rate of students' success on the entrance exam for the nursing profession.

ACKNOWLEDGEMENTS:

This research project was made possible with financial support from the Teaching and Learning Research Assistance Program (*PAREA*). The research team would like to thank the Ministry of Education and Higher Education for its financial support. The team also wishes to thank the Sherbrooke and Sainte-Foy CEGEPs for their continued trust in this project. Finally, the team hopes to acknowledge the students, whose participation helped make this research project a success.

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