

Exploring the Acceptability, Feasibility, and Perceived Effects of Immersive Virtual Reality in Comparison to Standardized Patient Simulations in Nursing Education: A Mixed-Methods Pilot Study

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Background

The quest for optimal pedagogical methodologies continues to evolve in the realm of nursing education. With a focus on enhancing student preparation and competencies acquisition, there is a growing interest in innovative approaches such as immersive virtual reality (IVR) simulation (Verkuyl et al., 2024). IVR allows participants to see a virtual world with their own eyes, providing the sensory illusion of being present in an environment replicating a real or virtual space. Participants can interact with their environment using controllers that represent their hands. These controllers can offer haptic feedback by vibrating during specific actions (Chiniara, 2019). A virtual reality headset and a computer are generally used to project a scenario found on a web platform (Jeong & Lee, 2019).

The integration of IVR into health care education has gained attention due to its potential to provide immersive and realistic clinical simulations, enhance student engagement and active learning, and facilitate repetitive practice in a safe and controlled environment (Gasteiger et al., 2022; Lavoie et al., 2024). Several authors reported possible effects of IVR on the development of knowledge and competencies in nursing students, such as clinical patient assessment, communication, technical skills, critical thinking, decision-making, and stress management in critical situations (Chiniara, 2019; Ferrandini Price et al., 2018; Gasteiger et al., 2022; Jensen & Konradsen, 2018; Lemée et al., 2024; Plotzky et al., 2021; Tan et al., 2017). However, some cybersickness symptoms (e.g., nausea, dizziness) caused by a mismatch between visual stimuli and the vestibular system can occur. Finally, the efficacy of IVR to decrease cognitive load and increase engagement, situational motivation, and satisfaction is inconsistent in the literature (Lavoie et al., 2024; Padilha et al., 2019).

When preparing implementation, it is essential to assess the acceptability and feasibility to tailor new interventions to clients' needs (Sidani & Braden, 2021). Acceptability reflects the perceptions and preferences of the participants. It influences the interventions' use, implementation, adherence, and overall effects (Sidani & Braden, 2021). Feasibility refers to the practical and logistical aspects of the interventions. It determines whether the interventions can be successfully applied to reality (Sidani & Braden, 2021). Several studies explored the acceptability and feasibility of IVR and concluded that despite some technological limitations, students perceived IVR as a positive addition to health care programs (Adhikari et al., 2021; Chang et al., 2024; Chiniara, 2019; Ferrandini Price et al., 2018; Gasteiger et al., 2022; Jensen & Konradsen, 2018).

Although research on the use of IVR has been growing, currently very few studies exist that compare IVR with more traditional simulation methods, such as standardized patient simulation (SPS). SPS is similar to a real environment, in which students are invited to intervene in a care situation of a simulated patient (an actor) who reacts to the student according to a predefined scenario (Charrette et al., 2015). Despite the potential benefits of IVR technology, a research gap exists in systematically comparing its acceptability, feasibility, and educational effectiveness with a similar SPS (Sim et al., 2022). This study aimed to bridge this gap.

Objectives

This study aimed to explore the comparison between IVR with SPS activities among undergraduate nursing students regarding acceptability, feasibility, and perceived effects. The objective was to describe the acceptability and feasibility of IVR compared to SPS activities among undergraduate nursing students.

This work aimed to prepare for a larger, multicentre study to compare the effects of IVR and SPS. Therefore, an underlying goal was to pre-test the protocol, including design, recruitment procedures, and measurements, with a small sample of participants.

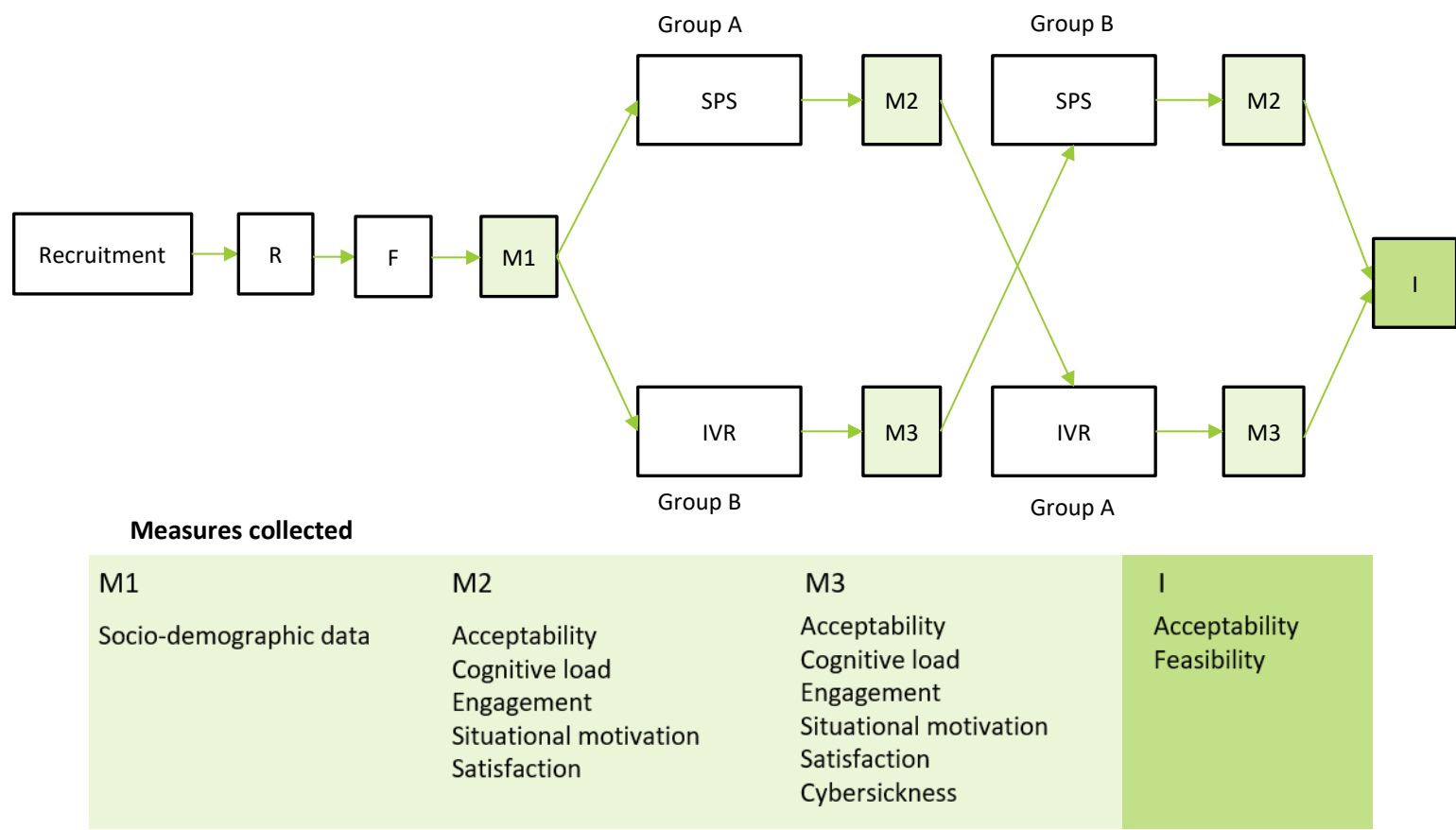
As quantitative data collection was completed, a secondary specific objective was to explore the perceived effects of IVR compared to SPS activities among undergraduate nursing students regarding cognitive load, engagement, situational motivation, and satisfaction.

Methods

Design

The pilot study used a mixed-methods randomized crossover trial design with questionnaires and semi-structured interviews to reach the objectives (see Figure 1). It ensured comparable groups participated in both simulation types and prevented cumulative and habituation effects of a participant taking part in the same scenario twice (Fortin & Gagnon, 2022). This study was inspired by previous work (Lavoie et al., 2024).

Figure 1
Study Design



Note. R = randomization; F = familiarization; M = measures; SPS = standardized patient simulation; IVR = immersive virtual reality; I = interview.

Sample

A total of 14 nursing undergraduate students from two separate campuses of a Quebec university were recruited through convenience sampling. The inclusion criterion was completion of all of the program's first-year courses. Exclusion criteria included students with epilepsy, balance-affecting conditions, or drug consumption in the last 24 hours. These criteria were chosen to avoid contraindications and complications with IVR (epilepsy). Since sample size calculation is not necessary for a pilot study as long as the sample is representative of the target population (Thabane et al., 2010), we estimated that 10 to 20 participants would be sufficient to meet the research objectives and feasibility issues.

Data Collection

Acceptability and Feasibility

The operationalization of acceptability and feasibility was done according to Sidani and Braden's (2021) work. We assessed acceptability both quantitatively and qualitatively to ensure a deeper understanding of the construct. Feasibility was assessed only qualitatively and is further described below, due to lack of availability of a quantitative instrument. The Treatment Acceptability and Preference Questionnaire was completed by participants following each simulation (Sidani et al., 2009). The questionnaire, which is divided into four questions, was answered by participants on a five-point Likert scale, allowing the evaluation of appropriateness, convenience, effectiveness, and adherence (ranging from 1 to 5, where 1 indicates the lowest level of acceptability and 5 indicates the highest). Mean acceptability scores can be calculated across the four questions and provide an average measure of participants' perceptions regarding the intervention's acceptability. The instrument's internal consistency is good, with a Cronbach's alpha ranging from 0.80 to 0.87. Factorial validity has been described with a single factor explaining 63% of the variance (Sidani et al., 2009).

To further assess risks, participants were invited to indicate if they experienced any discomfort during the IVR activity to assess the presence of cybersickness. The Cybersickness Questionnaire consists of 16 statements referring to possible symptoms experienced by the respondent. For each item, the evaluation is made on a scale ranging from 1 = not at all to 4 = severely (Kennedy et al., 1993). A global score is calculated by summing the responses to all 16 items, providing an overall measure of cybersickness severity (ranging from 16 to 64). This questionnaire has been translated into French and validated by a Quebec team (Bouchard et al., 2007).

At the end of the data collection, participants were invited to participate in an in-person semi-structured individual or dyad interview based on a validated interview guide. As some simulation timeslots were vacant, only one participant went through both simulations according to his randomized group and was interviewed as an individual. If two participants went through both simulations according to the randomization order, they participated in the interview together. The interviews were audio-recorded and lasted approximately 30 minutes. The objective of the interviews was to explore the participants' opinions on the acceptability and feasibility of IVR compared to SPS activities, as well as the factors that influenced their perceptions. The same indicators adopted in the quantitative questionnaire were addressed with open-ended questions, with the addition of perceived risks.

Finally, we adopted the main indicators of the feasibility, according to Sidani and Braden's (2021) framework, such as the quality of trainers, the preparation of participants, material resources, and the context and the fidelity of the scenario, which is the realism and the standardized aspect of the simulated case (International Nursing Association of Clinical Simulation and Learning Standards Committee, 2016).

Perceived Effects

We explored perceived effects of IVR compared to SPS activities among undergraduate nursing students regarding cognitive load, engagement, situational motivation, and satisfaction. We chose these variables based on previous empirical data suggesting possible effects and measured to pre-test data collection for a future multicentre study.

Cognitive load is defined by the extent to which the learner's working memory is engaged during the educational activity (Leppink et al., 2013). We measured cognitive load after each simulation using the French version of the Cognitive Load Index (Fontaine et al., 2019; Leppink et al., 2013). This instrument includes 10 items divided into three subscales: 1) intrinsic load (three items), 2) extraneous load (three items), and 3) essential load (four items). Participants indicated their level of agreement from 0 = not at all agree to 5 = strongly agree, with a higher score representing a greater cognitive load. A satisfactory Omega coefficient of 0.70 demonstrates the internal consistency of this subscale (Fontaine et al., 2019). In the same study, the intrinsic and essential load subscales obtained satisfactory Omega coefficients of 0.83 and 0.96, respectively.

We measured engagement, which refers to the degree of investment in an activity, after each simulation using the French version of the User Engagement Scale – Short Scale (Fontaine et al., 2019; O'Brien et al., 2018). This scale includes 12 items equally divided into four subscales: 1) focused attention, 2) perceived usability, 3) aesthetic appeal, and 4) reward. Participants expressed their level of agreement from 1 = strongly disagree to 10 = strongly agree, with a higher score representing better engagement. Each dimension of engagement is assessed by calculating the mean score of items within each subscale. Satisfactory Omega coefficients between 0.77 and 0.89 are reported for each of the four subscales of the French version, demonstrating their internal consistency (Fontaine et al., 2019).

Situational motivation refers to the motivation one experiences when engaging in a specific activity (Guay et al., 2000). We measured the situational motivation after each simulation using the French version of the Situational Motivation Scale (Guay et al., 2000), which includes 16 items divided into four subscales: 1) intrinsic motivation, 2) extrinsic motivation by identified regulation, 3) extrinsic motivation by external regulation, and 4) motivation. Participants rated their level of agreement from 1 = strongly disagree to 7 = strongly agree, with a higher score mean representing greater motivation. The subscales produced Cronbach's alphas ranging from 0.77 to 0.95, demonstrating their internal consistency (Guay et al., 2000).

We measured satisfaction, defined by the appreciation of the educational activity, after each simulation using a subscale of the French version of the Student Satisfaction and Self-Confidence in Learning Scale (Jeffries, 2012; Simoneau et al., 2011). This questionnaire includes five items with which participants expressed their level of agreement, from 1 = strongly disagree to 5 = strongly agree, with a higher mean score representing greater satisfaction. A satisfactory Cronbach's alpha of 0.94 demonstrates the internal consistency of the original version (Jeffries, 2012), which has also been reported with the French version of the instrument ($\alpha = 0.83$) (Simoneau et al., 2011).

Procedure and Interventions

A research assistant presented the research project in a mandatory class of the 3-year program. A recruitment email was also sent out to all admissible students, including information about the project and the consent form. Students interested were asked to contact the research assistant. Once officially recruited, participants were randomly assigned to either SPS (Group A) or IVR (Group B). They received

further instructions on how to access and complete the familiarization station, which was done asynchronously, and a time slot for the simulation activities.

On the simulation day, participants first signed the consent form and completed a demographic questionnaire. Then, they consecutively completed two simulation activities, followed by self-reported questionnaires about their experience with each activity type. Both activities used the same scenario addressing the management of post-operative pain and respiratory depression due to opioid overdose (see Appendix A). These formative activities occurred outside the regular nursing program. Each simulation activity followed the same flow, including a briefing, the simulation, and a debriefing based on the Promoting Excellence and Reflective Learning in Simulation (PEARLS) model (Eppich & Cheng, 2015), with the addition of a familiarization station for IVR. Table 1 reports the similarities and differences between both simulation types. No data were collected during debriefing. Finally, participants took part in individual or dyad interviews with a research assistant.

Table 1

Differences Between IVR and SPS Simulations

Components	IVR	SPS
Student preparation	Familiarization station (60 minutes): Asynchronous preparation at home and trial with tutorial in person	No specific preparation.
Simulator	The virtual reality software and scenario from UbiSim (Switzerland) were translated in French and adapted to local context. The headset was the Oculus Quest.	A trained standardized patient with similar physical characteristics than the one available in the IVR scenario.

Note. IVR = immersive virtual reality; SPS = standardized patient simulation. Adapted from the key elements to report for simulation-based research: “Reporting Guidelines for Health Care Simulation Research: Extensions to the CONSORT and STROBE Statements,” by A. Cheng, D. Kessler, R. Mackinnon, T. P. Chang, V. M. Nadkarni, E. A. Hunt, J. Duval-Arnould, Y. Lin, D. A. Cook, M. Pusic, J. Hui, D. Moher, M. Egger, and M. Auerbach, 2016, *Simulation in Healthcare*, 11(4), 238–248 (<https://doi.org/10.1097/SIH.0000000000000150>).

Ethical Considerations

We obtained approval from the local university ethics board for the study before data collection. If willing to participate in the study, participants signed a consent form that stated that their choice to participate would have no impact on their success in the course. The participants were instructed that they could withdraw at any time.

Data Analysis

Quantitative

SPSS version 29.0 was used to conduct statistical analyses. First, we examined descriptive statistics. With fewer than 30 participants and without data normality, we then conducted non-parametric tests. We performed Wilcoxon tests to describe the quantitative acceptability and perceived effects of IVR compared to SPS activities between paired observations. The statistical significance level was set at $p \leq 0.05$.

Qualitative

The interviews were transcribed verbatim. Three team members conducted the content analysis using Elo and Kyngäs's (2008) method. An open co-coding of the transcripts was carried out for all the transcripts with Dedoose version 9.2.014. Next, we used inductive coding to explore emerging ideas, followed by deductive coding to categorize initial codes within the predefined indicators of acceptability and feasibility from Sidani and Braden's (2021) framework. We produced summary tables to synthesize data. We conducted the qualitative work in French and free-translated quotations for the purpose of this article.

Data Integration

We compared and integrated the results from the qualitative and quantitative data analyses according to the steps suggested by Creswell and Clark (2017) to describe the acceptability of the two simulation types. We first collected and analyzed quantitative and qualitative data separately. Subsequently, we presented the comparisons as summary tables to highlight the similarities and differences.

Measures to Ensure the Validity and Reliability of the Study

All quantitative measurement tools are reliable and were used with an undergraduate nursing population, indicating relevant validity. Three members of our research team (EG, JP, and MHL) carried out open co-coding of the verbatim transcripts to ensure uniform coding and the reliability of the results. The entire team had the opportunity to contribute to the analysis and interpretation phase through frequent meetings and an iterative process. We triangulated acceptability data with a comparison between quantitative and qualitative results. A detailed description of the research context, participants, and processes is provided to enable transferability. We maintained a logbook of all research decisions and activities throughout the study (Corbière & Larivière, 2020; Miles et al., 2019).

Results

A total of 14 undergraduate nursing students participated in the study. The participants had an average age of 23 ($SD = 2.4$) and were mostly female ($n = 12$; 85.7%). More than half of them were affiliated with the urban campus ($n = 8$; 57.1%), and they all had past simulation experience in general ($n = 14$; 100%). Before the study, their average comfort level using the visual analogue scale was 56.6% for IVR and 76.8% for SPS. All participants completed the entire study. Six individual interviews and four dyadic interviews were conducted.

Acceptability and Feasibility

Table 2 summarizes the quantitative and emerging qualitative results related to each indicator of acceptability according to Sidani and Braden's definition. Scores were high on all acceptability indicators for both simulation activities. IVR and SPS activities had no statistically significant difference on all acceptability indicators.

Table 2

Summary Table of Acceptability Results (n = 14)

	IVR	SPS	
Indicators	Median (IQR)	Median (IQR)	Emerging content about IVR
Appropriateness	3.5 (1)	4 (1)	Benefits of experiential approaches Psychological safety Innovative aspect
Convenience	3 (1)	4 (1)	Individual characteristics and preferences Technology features
Effectiveness	4 (1)	4 (1)	Knowledge and skills development Student experience and satisfaction
Adherence	4 (1)	3 (1)	For almost everyone, thoughts of alternatives
Risks	N/A	N/A	Types and level of risks

Note. IVR = immersive virtual reality; SPS = standardized patient simulation; IQR = interquartile range; no difference was statistically significant.

In the interviews, participants discussed several positive and negative aspects of the acceptability of IVR when compared to SPS. For appropriateness, they mentioned that IVR had pedagogical and clinical benefits similar to those of other experiential approaches. For example, they underlined the possibility of experimenting with rare or hard-to-replicate clinical situations, combining and putting into action several knowledges and skills, and being able to repeat the same situation many times. Participants sensed a level of psychological safety higher in IVR than in SPS. IVR felt like a safe space in which they could make mistakes and take their time to think before reacting.

Something positive about virtual reality, in comparison with a real patient, is that I have less stress about communication than I did virtually. I have less stress about getting the wrong question or doing anything wrong, so it gives me a little more freedom to do my stuff better. (Urban participant 8)

Participants felt that IVR prepared them for stressful situations and that they would experience a reduced stress level when similar situations occurred in an evaluation or clinical context. Finally, the innovative aspect of IVR appealed to participants; they found that it could positively affect the university's reputation.

Regarding convenience, opinions varied and were influenced by individual characteristics, preferences, and technology features, bringing out both positive and negative aspects of IVR. Different learning styles, levels of openness, or previous exposure to technology influenced the effort required to deploy and become familiar with IVR. Moreover, most participants mentioned the immersive and realistic aspect of IVR. They felt that they could easily interact with the environment, find the tools they needed, and get immediate feedback after an intervention while fully immersed, alone in the patient's room. However, technical problems, the lack of nuances, and some actions, such as technical skills, were areas for improvement.

[With] virtual reality, I really felt like I was in the patient's room, then I didn't feel that it wasn't real.... It's, like, really well simulated, let's say. I found it fun because we could do almost

everything with it. We could talk to the patient, and he could answer us. ... But I find that at a technical level, taking vital signs, taking the pulse—I find it better on a person, a real person. (Suburban participant 3)

Participants discussed effectiveness, including possible knowledge and skills development, as well as positive, engaging experiences and high satisfaction. The main learning points were patient assessment structure and fluidity, priority establishment, clinical reasoning, and autonomy. Depending on the participant, patient approach and technical skills were perceived as sometimes better with IVR and sometimes better with SPS.

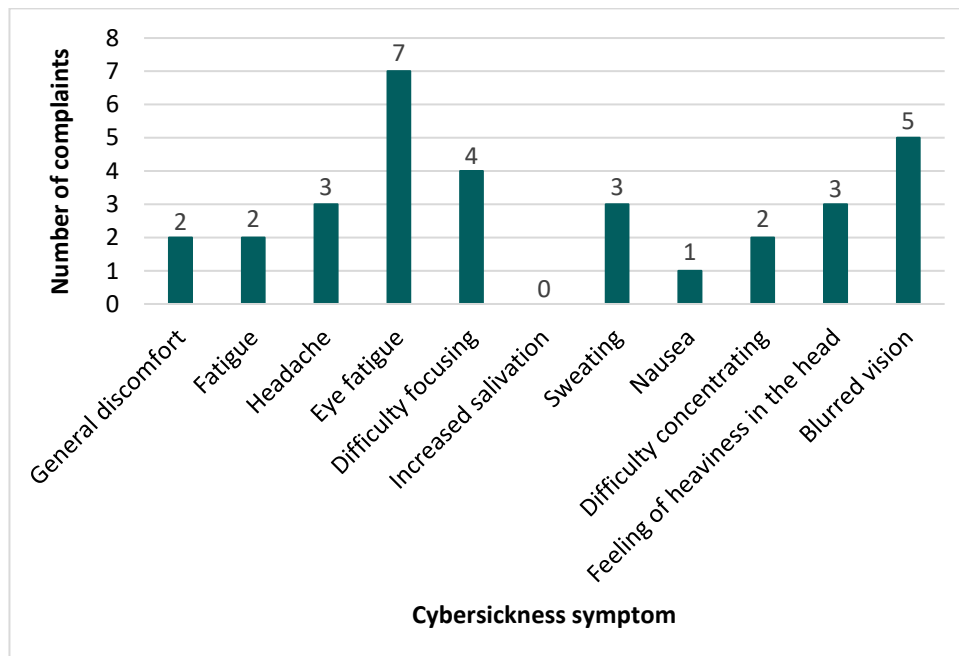
Well, I would say that I think that what could really be good is situations of stress, like respiratory distress, like cardiovascular arrest, things like that.... What I learned a lot is, what is the priority? I see that he is breathing less. What should I do? Should I call the doctor? Do I take his vital signs? That side of prioritizing, knowing what the steps are—that, I think, is especially where it seems like I could learn more with virtual reality. (Suburban participant 12)

Regarding adherence, most participants said they would like to introduce and use IVR in the nursing curriculum. They pointed out that some of their colleagues might struggle with IVR due to limited technology literacy, contraindications, and resistance to change. They suggested planning alternatives to IVR to avoid inequity in learning opportunities.

Participants named several possible risks associated with IVR but specified that they had not experienced them yet, suggesting a low level of perceived risks. Figure 2 shows the frequency of symptoms of cybersickness in this project. Eye fatigue was the most common side effect of IVR in this project.

Figure 2

Frequency of Cybersickness Symptoms (n = 14)



Feasibility was described qualitatively with data from the semi-structured interviews, in which participants gave their opinions on the future implementation of IVR activities in the undergraduate nursing program. Table 3 presents a summary of the main emerging ideas about feasibility.

Table 3

Summary Table of Feasibility Results

Indicators	Emerging content about IVR
Quality of trainers	Adequate pedagogical support
Preparation of participants	Appropriate and imperative Familiarization station essential Minor improvement suggestions
Material resources	Quality and quantity
Context	Society's knowledge of technology Moment and format suggested to implement throughout the program
Fidelity of the scenario	High potential for reproducibility of a scenario

Note. IVR = immersive virtual reality.

For the quality of trainers, students appreciated having a sense of support and no judgement. The preparation of participants, including watching tutorial videos and practising some actions in the IVR environment before the actual scenario, was appropriate and imperative.

Then we weren't going into the unknown, and the fact that we had the opportunity to get familiar with it made doing the simulation easier. For example, if there hadn't been the familiarization station, I would have been like, "Why isn't this working?" I would have wasted time, so being able to get familiar with it, read the instructions, and watch the videos really helped, in my opinion. (Urban participant 8)

The material resources were deemed mainly adequate, though participants mentioned the heaviness of the headset and the controllers' ergonomics: "The headset wasn't very comfortable.... The controllers aren't great, not really, but they were okay. I'd just say they were okay" (Urban participant 10).

The COVID-19 pandemic and rapid technological advances presented a favourable context for the implementation of IVR activities. Students specified some preferred moments to access IVR, such as frequent exposure over the course of their study, starting at the beginning of the program; before complex simulations, an exam, an internship, or externship (high importance activities); and in continuing education. As for the format, students suggested free access or home access, activities in teams, and a hybrid between IVR and standardized patients.

The fidelity of the scenario was a critical and interesting aspect of IVR compared to SPS, according to participants. They thought it was possible and essential to replicate the same scenario many times, which suggests the potential of IVR activities for evaluation.

Clearly, virtual reality beats standardized patients because the comment we often receive from students who have done the objective structured clinical exam (OSCE) and all is that, "Ah, the patient didn't react like that. Now, you can't say that to everyone. It's the same situation, you

see, so I think that, in terms of evaluation, it would really be fairer for everyone.” (Urban participant 8)

Perceived Effects of the Simulations

Cognitive load, engagement, situational motivation, and satisfaction were compared between IVR and SPS activities. Table 4 presents the main results for each subscale. No statistically significant difference was found between the two simulation types.

Table 4

Summary of Perceived Effects (n = 14)

	IVR	SPS
Concepts	Median (IQR)	Median (IQR)
Cognitive load		
Intrinsic load	3 (3)	4 (3)
Extrinsic load	0 (2.75)	1 (2)
Essential load	8 (2)	8 (2.25)
Engagement		
Focus attention	9 (2)	8 (2.75)
Perceived usability	9 (2)	N/A
Aesthetic appeal	9 (1)	N/A
Reward	10 (1.75)	9.5 (1.75)
Situational motivation		
Intrinsic motivation	6 (1.25)	6 (1)
Extrinsic motivation by identified regulation	6 (1.75)	6 (1.375)
Extrinsic motivation by external regulation	1 (0.875)	1 (0.5)
Amotivation	1 (0.875)	1.25 (0.875)
Satisfaction		
Helpful and effective	4.5 (1)	4.5 (1)
Inclusion of various educational activities to enhance learning	5 (1)	5 (0)
Professor leading the simulation	5 (0)	5 (1)
Motivating	5 (1)	4.5 (1)
Learning style	5 (0)	5 (1)

Note. IVR = immersive virtual reality; SPS = standardized patient simulation; IQR = interquartile range; no difference was statistically significant.

Discussion

This study aimed to compare IVR with SPS activities among undergraduate nursing students, specifically regarding acceptability and feasibility, as well as perceived effects such as cognitive load, engagement, situational motivation, and satisfaction. Overall, IVR was deemed acceptable and feasible to the same extent as SPS activities. The study found no statistically significant differences between IVR and SPS activities across the variables, keeping in mind the pilot and underpowered nature of data. The qualitative data revealed mixed results about both simulation types.

As in other studies, participants pointed out many positive aspects of IVR. IVR offers various possibilities of realistic scenarios, patients' demographic characteristics, and environments (Adhikari et al., 2021; Chang et al., 2024; Lee et al., 2020). Furthermore, as in other studies, participants in our study appreciated practising in a psychologically and physically safe environment (Adhikari et al., 2021; Lee et al., 2020). Moreover, nearly all participants mentioned experiencing high satisfaction through an innovative, fun, engaging, and immersive experience. The impact of a positive experience with IVR for students has also been reported (Adhikari et al., 2021; Bracq et al., 2019; Gasteiger et al., 2022; Harmon et al., 2021; Lee et al., 2020). Participants in our study judged that IVR had the potential to support the development of some specific knowledge and competencies, such as patient assessment structure and fluidity, priority establishment, clinical reasoning, and autonomy. These results were also reported in other studies (Adhikari et al., 2021; Chang et al., 2024; Chiniara, 2019; Ferrandini Price et al., 2018; Gasteiger et al., 2022; Jensen & Konradsen, 2018); Lemée et al., 2024).

Some negative aspects that emerged in our study were also documented in the literature. For example, limitations related to IVR technology use, such as technical problems and unrealistic interactions with patients, could hinder student learning (Chang et al., 2024; Lavoie et al., 2024; Lee et al., 2020). Moreover, the comfort of the physical equipment could improve to allow for longer and/or more IVR repetitions, as noted in another study (Bracq et al., 2019). As technology improves, IVR has the potential to overcome these barriers. Nevertheless, even with adequate preparation, participants reported a need for constant concentration during the activities, which suggests a certain cognitive load that could create additional fatigue for the students. Thus, familiarization with IVR appears essential to focus on skills development, not only the technical aspects of IVR that are often associated with an increased cognitive load (Bracq et al., 2019). This approach involves extra steps in implementing IVR activities, requiring more human and material resources. Finally, a low level of perceived risk was found with IVR, and participants experienced little cybersickness symptoms. Nevertheless, risks must be considered when implementing IVR activities.

Regarding the exploratory perceived effects of IVR (compared to SPS) on cognitive load, engagement, situational motivation, and satisfaction, no significant difference was found, probably related to a lack of statistical power. Nonetheless, these results suggest no differences in outcomes, highlighting the potential of both approaches in nursing education. Inconsistent results have been found in the literature when assessing the effects of IVR on similar outcomes (Lavoie et al., 2024; Padilha et al., 2019), which could be due to the heterogeneity of IVR intervention types and study designs (Liu et al., 2023; Plotzky et al., 2021; Shorey & Ng, 2021). According to several systematic reviews about IVR in nursing education, future research should focus on standardizing IVR interventions and conducting multicentre studies with larger sample sizes to produce robust evidence on student outcomes (Liu et al., 2023; Plotzky et al., 2021; Shorey & Ng, 2021).

One original contribution in this pilot work is the crossover comparison between IVR and SPS. Participants saw the potential of IVR to replicate the same scenario more accurately, which they perceived more positively than in an SPS activity. As a result, participants suggested the use of IVR for evaluation purposes. To date, most researchers have investigated IVR as an educational tool to develop skills and competencies in preparation for a high-stakes situation, such as an evaluation or clinical reality (Mistry et al., 2023; Plotzky et al., 2021; Shah et al., 2023). Nonetheless, a hybrid simulation including a mannequin and IVR for cardiopulmonary resuscitation training and evaluation showed potential to replace an objective structured clinical exam (OSCE), showing a first step in that direction (Rodríguez-Matesanz et al., 2022). As learners and educators become more familiar with IVR activities, and these activities are

added to the constant evolution of technology, IVR's place in the evaluation process should be further explored.

Strengths and Limitations

Conducting this pilot study allowed for the comparison of IVR's acceptability and feasibility with SPS, a novel contribution to the literature. All quantitative instruments have good psychometric properties and were previously validated in similar populations. Additionally, the scientific rigour used for the qualitative component added richness and depth to the study's conclusions.

However, some limitations should be considered. The small sample came from a single university setting (though at two campus locations), which limits the generalization of the results. This pilot work does not reach a sufficient statistical power to confirm or infirm differences between IVR and SPS. Therefore, quantitative results should be interpreted with caution. Additionally, using self-reported and repeated measures is vulnerable to various types of bias (e.g., recall, social desirability, circularity). Furthermore, the highly technological aspect of IVR could have introduced bias and influenced participants' reactions if they were enthusiastic or fearful about it. Finally, since participation in the study was voluntary, the students who agreed to participate may have differed from those who refused to participate, introducing a possible selection bias.

Conclusion

IVR simulation implementation appeared acceptable and feasible to undergraduate nursing students, with particular attention to certain factors, such as technological limitations and possible cybersickness, to ensure optimal outcomes. Furthermore, students qualitatively perceived scenario fidelity to be superior in IVR compared to in SPS. No quantitative differences between IVR and SPS were found across targeted variables, reflecting the possibility of similar outcomes in both simulation types, which should be further explored in larger studies. Overall, the findings suggest that IVR could offer significant development potential for schools of nursing. The two types of simulations should not be systematically opposed but rather be combined to address different ways of learning. This approach would leverage the strengths of each type of simulation. Future research should focus on using IVR for evaluation purposes in nursing curricula.

References

- Adhikari, R., Kydonaki, C., Lawrie, J., O'Reilly, M., Ballantyne, B., Whitehorn, J., & Paterson, R. (2021). A mixed-methods feasibility study to assess the acceptability and applicability of immersive virtual reality sepsis game as an adjunct to nursing education. *Nurse Education Today*, 103, 104944. <https://doi.org/10.1016/j.nedt.2021.104944>
- Bouchard, S., Robillard, G., & Renaud, P. (2007). Revising the factor structure of the simulator sickness questionnaire. *Annual Review of CyberTherapy and Telemedicine*, 5, 128–137.
- Bracq, M.-S., Michinov, E., Arnaldi, B., Caillaud, B., Gibaud, B., Gouranton, V., & Jannin, P. (2019). Learning procedural skills with a virtual reality simulator: An acceptability study. *Nurse Education Today*, 79, 153–160. <https://doi.org/10.1016/j.nedt.2019.05.026>
- Chang, Y.-Y., Chao, L.-F., Chang, W., Lin, C.-M., Lee, Y.-H., Latimer, A., & Chung, M. L. (2024). Impact of an immersive virtual reality simulator education program on nursing students' intravenous injection administration: A mixed methods study. *Nurse Education Today*, 132, 106002. <https://doi.org/10.1016/j.nedt.2023.106002>
- Charrette, S., Ledoux, I., & Jetté, S. (2015). *Typologie de la simulation en sciences infirmières : un outil indispensable* [Paper presentation]. 6^e Congrès mondial des infirmières et infirmiers francophones, Montréal, QC, Canada.
- Cheng, A., Kessler, D., Mackinnon, R., Chang, T. P., Nadkarni, V. M., Hunt, E. A., Duval-Arnould, J., Lin, Y., Cook, D. A., Pusic, M., Hui, J., Moher, D., Egger, M., & Auerbach, M. (2016). Reporting guidelines for health care simulation research: Extensions to the CONSORT and STROBE statements. *Simulation in Healthcare*, 11(4), 238–248. <https://doi.org/10.1097/SIH.0000000000000150>
- Chiniara, G. (2019). *Clinical simulation: Education, operations and engineering* (2nd ed.). Academic Press.
- Corbière, M., & Larivière, N. (2020). *Méthodes qualitatives, quantitatives et mixtes : dans la recherche en sciences humaines, sociales et de la santé* (2nd ed.). Presses de l'Université du Québec.
- Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.
- Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, 62(1), 107–115. <https://doi.org/10.1111/j.1365-2648.2007.04569.x>
- Eppich, W., & Cheng, A. (2015). Promoting excellence and reflective learning in simulation (PEARLS): Development and rationale for a blended approach to health care simulation debriefing. *Simulation in Healthcare*, 10(2), 106–115. <https://doi.org/10.1097/SIH.0000000000000072>
- Ferrandini Price, M., Escribano Tortosa, D., Nieto Fernandez-Pacheco, A., Perez Alonso, N., Cerón Madrigal, J. J., Melendreras-Ruiz, R., García-Collado, Á. J., Pardo Rios, M., & Juguera Rodriguez, L. (2018). Comparative study of a simulated incident with multiple victims and immersive virtual reality. *Nurse Education Today*, 71, 48–53. <https://doi.org/10.1016/j.nedt.2018.09.006>
- Fontaine, G., Cossette, S., Maheu-Cadotte, M.-A., Mailhot, T., Lavoie, P., Gagnon, M.-P., Dubé, V., & Côté, J. (2019). Traduction, adaptation et évaluation psychométrique préliminaire d'une mesure d'engagement et d'une mesure de charge cognitive en contexte d'apprentissage numérique. *Pédagogie Médicale*, 20(2), 79–90. <https://doi.org/10.1051/pmed/2020009>

- Fortin, M.-F., & Gagnon, J. (2022). *Fondements et étapes du processus de recherche : méthodes quantitatives et qualitatives* (4th ed.). Chenelière Éducation.
- Gasteiger, N., van der Veer, S. N., Wilson, P., & Dowding, D. (2022). How, for whom, and in which contexts or conditions augmented and virtual reality training works in Upskilling health care workers: Realist synthesis. *JMIR Serious Games*, 10(1), e31644. <https://doi.org/10.2196/31644>
- Guay, F., Vallerand, R. J., & Blanchard, C. (2000). On the assessment of situational intrinsic and extrinsic motivation: The Situational Motivation Scale (SIMS). *Motivation and Emotion*, 24(3), 175–213. <https://doi.org/10.1023/A:1005614228250>
- Harmon, J., Pitt, V., Summons, P., & Inder, K. J. (2021). Use of artificial intelligence and virtual reality within clinical simulation for nursing pain education: A scoping review. *Nurse Education Today*, 97, 104700. <https://doi.org/10.1016/j.nedt.2020.104700>
- International Nursing Association of Clinical Simulation and Learning Standards Committee. (2016). INACSL Standards of Best Practice: Simulation simulation glossary. *Clinical Simulation in Nursing*, 12, S39–S47. <https://doi.org/10.1016/j.ecns.2016.09.012>
- Jeffries, P. R. (2012). *Simulation in nursing education: From conceptualization to evaluation* (2nd ed.). National League for Nursing.
- Jensen, L., & Konradsen, F. (2018). A review of the use of virtual reality head-mounted displays in education and training. *Education and Information Technologies*, 23(4), 1515–1529. <https://doi.org/10.1007/s10639-017-9676-0>
- Jeong, S. Y.-S., & Lee, K.-O. (2019). The emergence of virtual reality simulation and its implications for nursing profession. *Korean Journal of Women Health Nursing*, 25(2), 125–128. <https://doi.org/10.4069/kjwhn.2019.25.2.125>
- Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *The International Journal of Aviation Psychology*, 3(3), 203–220. https://doi.org/10.1207/s15327108ijap0303_3
- Lavoie, P., Lapierre, A., Maheu-Cadotte, M.-A., Brien, L.-A., Ledoux, I., & Gosselin, É. (2024). Nursing students' engagement in virtual reality and hybrid simulations: A quasi-experimental study. *Clinical Simulation in Nursing*, 87, 101496. <https://doi.org/10.1016/j.ecns.2023.101496>
- Lee, A. L., DeBest, M., Koeniger-Donohue, R., Strowman, S. R., & Mitchell, S. E. (2020). The feasibility and acceptability of using virtual world technology for interprofessional education in palliative care: A mixed methods study. *Journal of Interprofessional Care*, 34(4), 461–471. <https://doi.org/10.1080/13561820.2019.1643832>
- Lemée, M.-H., Lavoie, S., Provost, J., & Ledoux, I. (2024). Exploring the acceptability and feasibility of an immersive virtual reality intervention for newly graduated nurses working in a rural area. *Clinical Simulation in Nursing*, 91, 101542. <https://doi.org/10.1016/j.ecns.2024.101542>
- Leppink, J., Paas, F., Van der Vleuten, C. P. M., Van Gog, T., & Van Merriënboer, J. J. G. (2013). Development of an instrument for measuring different types of cognitive load. *Behavior Research Methods*, 45(4), 1058–1072. <https://doi.org/10.3758/s13428-013-0334-1>
- Liu, K., Zhang, W., Li, W., Wang, T., & Zheng, Y. (2023). Effectiveness of virtual reality in nursing education: A systematic review and meta-analysis. *BMC Medical Education*, 23, Article 710. <https://doi.org/10.1186/s12909-023-04662-x>

- Miles, M. B., Huberman, A. M., & Saldaña, J. (2019). *Qualitative data analysis: A methods sourcebook* (4th ed.). SAGE Publications.
- Mistry, D., Brock, C. A., & Lindsey, T. (2023). The present and future of virtual reality in medical education: A narrative review. *Cureus*, 15(12), e51124. <https://doi.org/10.7759/cureus.51124>
- O'Brien, H. L., Cairns, P., & Hall, M. (2018). A practical approach to measuring user engagement with the refined user engagement scale (UES) and new UES short form. *International Journal of Human-Computer Studies*, 112, 28–39. <https://doi.org/10.1016/j.ijhcs.2018.01.004>
- Padilha, J. M., Machado, P. P., Ribeiro, A., Ramos, J., & Costa, P. (2019). Clinical virtual simulation in nursing education: Randomized controlled trial. *Journal of Medical Internet Research*, 21(3), e11529. <https://doi.org/10.2196/11529>
- Plotzky, C., Lindwedel, U., Sorber, M., Loessl, B., König, P., Kunze, C., Kugler, C., & Meng, M. (2021). Virtual reality simulations in nurse education: A systematic mapping review. *Nurse Education Today*, 101, 104868. <https://doi.org/10.1016/j.nedt.2021.104868>
- Rodríguez-Matesanz, M., Guzmán-García, C., Oropesa, I., Rubio-Bolivar, J., Quintana-Díaz, M., & Sánchez-González, P. (2022). A new immersive virtual reality station for cardiopulmonary resuscitation objective structured clinical exam evaluation. *Sensors*, 22(13), 4913. <https://doi.org/10.3390/s22134913>
- Shah, A. S., Sobolewski, B., Chon, S., Cruse, B., Glisson, M. D., Zackoff, M. W., Davis, D., Zhang, Y., Schumacher, D. J., & Geis, G. L. (2023). Just-in-time, just-in-place virtual training in the pediatric emergency department: A novel approach to impact the perfusion exam. *Advances in Medical Education and Practice*, 14, 901–911. <https://doi.org/10.2147/amep.S414022>
- Shorey, S., & Ng, E. D. (2021). The use of virtual reality simulation among nursing students and registered nurses: A systematic review. *Nurse Education Today*, 98, 104662. <https://doi.org/10.1016/j.nedt.2020.104662>
- Sidani, S., & Braden, C. J. (2021). *Nursing and health interventions: Design, evaluation, and implementation* (2nd ed.). John Wiley & Sons, Inc. <https://doi.org/10.1002/9781119610113>
- Sidani, S., Epstein, D. R., Bootzin, R. R., Moritz, P., & Miranda, J. (2009). Assessment of preferences for treatment: Validation of a measure. *Research in Nursing & Health*, 32(4), 419–431. <https://doi.org/10.1002/nur.20329>
- Sim, J. J. M., Rusli, K. D. B., Seah, B., Levett-Jones, T., Lau, Y., & Liaw, S. Y. (2022). Virtual simulation to enhance clinical reasoning in nursing: A systematic review and meta-analysis. *Clinical Simulation in Nursing*, 69, 26–39. <https://doi.org/10.1016/j.ecns.2022.05.006>
- Simoneau, I. L., Van Gele, P., Ledoux, I., Lavoie, S., & Paquette, C. (2011). Reliability of the French translation of instruments designed to assess the affective learning outcomes of human patient simulation in nursing education. *Clinical Simulation in Nursing*, 7(6), E263–E264. <https://doi.org/10.1016/j.ecns.2011.09.069>
- Tan, A. J. Q., Lee, C. C. S., Lin, P. Y., Cooper, S., Lau, L. S. T., Chua, W. L., & Liaw, S. Y. (2017). Designing and evaluating the effectiveness of a serious game for safe administration of blood transfusion: A randomized controlled trial. *Nurse Education Today*, 55, 38–44. <https://doi.org/10.1016/j.nedt.2017.04.027>

- Thabane, L., Ma, J., Chu, R., Cheng, J., Ismaila, A., Rios, L. P., Rboson, R., Thabane, M., Giangregorio, L., & Goldsmith, C. H. (2010). A tutorial on pilot studies: The what, why and how. *BMC Medical Research Methodology*, 10, Article 1. <https://doi.org/10.1186/1471-2288-10-1>
- Verkuyl, M., Violato, E., Harder, N., Southam, T., Lavoie-Tremblay, M., Goldsworthy, S., Ellis, W., Campbell, S. H., & Atack, L. (2024). Virtual simulation in healthcare education: A multi-professional, pan-Canadian evaluation. *Advances in Simulation*, 9, Article 3. <https://doi.org/10.1186/s41077-023-00276-x>

Appendix A: Similarities and Differences Between IVR and SPS Simulations

Table 1

Similar Components in the IVR and SPS Simulations

Components	Description
Briefing (5–10 minutes)	• Introduction of the objectives and intended flow of the simulation. • Reminder of the previously agreed-upon fiction contract. • Assignment of student pairs to each of the three scenario phases.
Environment	• In a university classroom simulating a patient's bed in a hospital room, on a surgical ward. • Available equipment: oxygen equipment, intravenous material, glucometer, thermometer, flashlight, medication, gloves, hand disinfectant, patient's identification bracelet, medical cart, patient's files.
Scenario	Situation Mr. Richard Lavoie is on his second post-operative day following a total left-hip arthroplasty due to joint deterioration caused by a work-related injury 5 years ago. His surgery was completed without any complications. Mr. Lavoie frequently complains of pain in his left hip and lower back despite receiving 0.5 milligrams of subcutaneous hydromorphone every 3 hours. The night nurse increased his subcutaneous Dilaudid dose to 1 milligram, as prescribed, because his pain level was at a 10 out of 10. He received this increased dose 30 minutes ago. History Mr. Lavoie is a retired firefighter. He has a history of chronic lower-back pain and left-hip pain for the past 5 years, following a fall from a 15-foot ladder. His chronic pain is managed by his family doctor. At home, he takes 5 mg of Statex as needed, every 4 hours by prescription. He also has a history of hypertension, hyperlipidemia, and type 2 diabetes. He takes 20 mg of Lisinopril once daily, 40 mg of Simvastatin once daily, and 500 mg of Metformin twice daily.
Progression	• Patient on postoperative day 2 following surgery on the left hip. Persistent significant pain at the surgical site. He is unhappy and irritable. The patient believes that the care received is inadequate and takes his home pain medication to relieve himself. • After 6 minutes, the patient becomes drowsy, grunts/snorts, and breathes slowly due to an overdose of pain medication. He no longer responds to questions. • The patient wakes up after the administration of Narcan. He does not remember what happened. He was scared and thanks the nurse for her intervention. He still has pain.
Learning objectives	• Assess the physical and mental condition of a symptomatic patient. • Ensure clinical monitoring and intervene based on the evaluation results according to the patient's condition. • Communicate the clinical status to the physician.

Facilitators	• Nurses with expertise in surgical nursing and previous experience in teaching with simulation • Received a simulation guide detailing the simulation's storyboard • Provided with a briefing and debriefing guide
Duration	15–20 minutes
Timing	Participants took part in this study as an extracurricular activity, during the fall semester of their second year of a nursing program.
Debriefing (30 minutes)	• Facilitated using a debriefing guide prepared by the course educators • Three 20-minute debriefing sessions scheduled between the scenario states • Reaction, description, analysis, and application (Sawyer et al., 2016)

Note. IVR = immersive virtual reality; SPS = standardized patient simulation. Adapted from the key elements to report for simulation-based research: "Reporting Guidelines for Health Care Simulation Research: Extensions to the CONSORT and STROBE Statements," by A. Cheng, D. Kessler, R. Mackinnon, T. P. Chang, V. M. Nadkarni, E. A. Hunt, J. Duval-Arnould, Y. Lin, D. A. Cook, M. Pusic, J. Hui, D. Moher, M. Egger, and M. Auerbach, 2016, *Simulation in Healthcare*, 11(4), 238–248 (<https://doi.org/10.1097/SIH.0000000000000150>).