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Design and usability of an immersive virtual reality simulation in orthopaedic nursing education: A pilot study

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ABSTRACT

Background: The increasing complexity of musculoskeletal surgical nursing education requires innovative pedagogical strategies that integrate immersive technologies with structured instructional design to enhance clinical reasoning and theory–practice integration.
Aim: To design and develop a nursing process–structured immersive virtual reality simulation for orthopaedic nursing education and to pilot test its usability and educational appraisal among undergraduate nursing students.
Design: Pilot mixed-methods study.
Method: The simulation, NurseTechGames, was designed as a three-dimensional orthopaedic inpatient scenario structured sequentially according to the nursing process and incorporating gamification elements to support clinical reasoning. The intervention was implemented using Meta Quest 3 head-mounted displays. Usability was assessed using the System Usability Scale, and educational appraisal was measured using the Serious Educational Game in Nursing Appraisal Scale. Open-ended responses were analysed through qualitative content analysis. Participants were monitored during and after the sessions for potential cybersickness symptoms.
Results: The simulation achieved a mean score of 83.15 on the System Usability Scale, indicating excellent usability. The total mean SEGINAS score was 95.58, reflecting a very high pedagogical evaluation across the dimensions of engagement, impact on learning, and content relevance. The qualitative analysis identified eight categories, with no reports of significant cybersickness symptoms: Perceived Learning Value, Clinical Transfer, Realism and Immersion, Engagement and Motivation, Technical Robustness, Development Potential, Minor Technical Issues, and Time Constraints.
Conclusion: The immersive simulation NurseTechGames demonstrated high usability and strong pedagogical acceptance in musculoskeletal surgical nursing education. Future controlled and longitudinal studies are required to evaluate objective and sustained impact on learning outcomes.

1. Introduction

The increasing complexity of contemporary clinical contexts requires nursing education to develop pedagogical strategies capable of promoting advanced clinical reasoning, evidence-based decision making, and safe technical performance (Cant and Cooper, 2017; Chen et al., 2020; Hsieh et al., 2025). Consistent evidence demonstrates that exclusively transmissive approaches present limitations in preparing students for dynamic and technologically demanding healthcare environments, particularly in areas of high technical complexity (Chen et al., 2020; Sim et al., 2022). The incorporation of innovative educational resources in nursing education has been supported by scientific evidence

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demonstrating significant improvements in learning outcomes, clinical performance, and student self-confidence (Almeida et al., 2024; Laguna et al., 2024; Fernandes et al., 2024; Cant and Cooper, 2017; Chen et al., 2020).

In this context, the development of innovative simulation-based interventions becomes particularly relevant to support clinical reasoning and safe decision making in orthopaedic nursing. NurseTechGames was developed as an immersive virtual reality (IVR) simulation prototype for orthopaedic nursing education. It consists of a three-dimensional virtual clinical environment structured according to the nursing process, in which students interact with a simulated patient scenario, make clinical decisions, and receive feedback throughout the experience.

The integration of digital technologies has been progressively recognised as a pedagogical response aligned with student-centred experiential learning models (Kolb, 1984; Saab et al., 2023; Sim et al., 2022). According to experiential learning theory, knowledge is constructed through cycles of concrete experience, reflection, conceptualization, and active experimentation (Kolb, 1984), a process that can be operationalised within simulated environments. Technological immersion associated with virtual reality has been linked to the development of clinical reasoning, enabling contextualised real-time decision making and reinforcing learning consolidation (Sim et al., 2022; Hsieh et al., 2025).

The design of NurseTechGames was grounded in experiential learning approaches, particularly Kolb's Experiential Learning Theory (1984), which conceptualizes learning as a continuous cyclical process involving four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation. In the context of orthopaedic nursing education, this framework supports the development of clinical reasoning through structured exposure to realistic clinical situations within immersive virtual reality simulation environments. The interactive nature of the simulation enables students to test decisions and explore consequences in a safe setting, thereby facilitating active experimentation. This approach is consistent with prior evidence demonstrating that the integration of simulation, reflection, and clinical reasoning within Kolb's experiential learning cycle enhances the linkage between theory and practice (Wijnen-Meijer et al., 2022), and aligns with recent evidence in nursing indicating the effectiveness of structured experiential learning-based interventions in improving critical thinking and learning outcomes (Cheng et al., 2025).

The evolution of simulation towards immersive digital formats represents a significant advancement within this pedagogical paradigm. Virtual reality-based interventions are associated with improvements in knowledge, practical skills, and student self-confidence when compared with traditional methods (Chen et al., 2020; Hsieh et al., 2025). Immersive virtual reality enables the creation of interactive three-dimensional environments that support experiential learning, deliberate practice, and safe exposure to complex clinical situations (Kiegaldie and Shaw, 2023; Park and Moon, 2025). This type of intervention has been associated with positive user experiences and with the development of clinical and socioemotional competencies in nursing education (Koivisto et al., 2025; Hsieh et al., 2025).

However, the effectiveness of immersive environments depends on the balance between realism, pedagogical structure, and cognitive load management. Cognitive Load Theory suggests that excessive stimuli or unstructured complexity may compromise information processing and learning retention (Sweller, 1988). Therefore, immersive virtual reality simulation interventions should be designed with clear instructional organisation, structured task progression, and explicit alignment with learning objectives to prevent cognitive overload (Sweller, 1988; Saab et al., 2023).

The pedagogical impact of these interventions therefore depends on the articulation between technological immersion and structured instructional design. Recent reviews emphasise the need for clearly defined learning objectives, integration of realistic clinical scenarios, and structured feedback mechanisms to ensure educational effectiveness (Chatzea et al., 2025; Mehraeen et al., 2025). The development of simulation interventions should align with theoretical models that integrate context, design, facilitation, and learning outcomes (Jeffries, 2016), ensuring coherence between instructional objectives and the immersive experience (Chatzea et al., 2025).

In musculoskeletal surgical nursing, educational demands are particularly complex. Care delivery in orthopaedic contexts involves specific technical procedures, rapid decision making, and rigorous application of patient safety principles (Cameron and Araújo, 2011; Zhao and Zhu, 2024). Studies indicate that students frequently experience difficulties in consolidating competencies in orthopaedic nursing, particularly in integrating theory with clinical practice (Cameron and Araújo, 2011). Structured scenario-based approaches and evidence informed teaching have been recommended to strengthen clinical preparation in this area (Zhao and Zhu, 2024; Cant and Cooper, 2017).

Considering this theoretical and empirical evidence, it is pertinent to develop an immersive virtual reality simulation specifically designed for musculoskeletal surgical nursing education, integrating structured scenarios, explicit curricular alignment, pedagogical grounding in experiential learning theory, and rigorous usability evaluation (Kolb, 1984; Chatzea et al., 2025; Hyzy et al., 2022). Accordingly, the present study aimed to design and develop a nursing process structured immersive virtual reality simulation for orthopaedic nursing education and to pilot test its usability and educational appraisal among undergraduate nursing students, contributing to methodological advancement in the integration of immersive technologies in nursing education (Hsieh et al., 2025; Kiegaldie and Shaw, 2023).

2. Methods

2.1. Design

This study was conducted as a mixed-methods pilot study aimed at the technological development and preliminary evaluation of an immersive virtual reality simulation, NurseTechGames, designed for third-year undergraduate students. The research comprised two sequential phases: (1) development of the immersive virtual simulation structured according to the nursing process, and (2) a classroom-based evaluation of its usability and educational appraisal. The evaluation integrated quantitative measures and qualitative data to provide a comprehensive assessment of the intervention.

2.2. Prototype development

NurseTechGames was designed as a structured three-dimensional immersive simulation aimed at promoting the development of clinical reasoning, evidence-based decision making, and integration of continuity of care in orthopaedic nursing. The virtual scenario was developed using the Delighted Edu platform, a digital environment used to design and deploy interactive virtual learning scenarios, within which the simulation environment and its interactive components were created and structured. The simulation was then delivered through Meta Quest 3 devices, standalone virtual reality headsets with integrated inside-out spatial tracking and haptic hand controllers, enabling students to interact immersively with the virtual clinical scenario. Meta Quest 3 is a standalone virtual reality headset that allows users to engage with three-dimensional environments without the need for external hardware.

The implementation of NurseTechGames took place in a face-to-face setting within the institution's clinical skills laboratory as a complementary learning activity integrated into the curricular unit, without contributing to formal course assessment. Participation was voluntary.

2.3. Setting and population

The eligible population comprised 68 third-year undergraduate nursing students enrolled in a surgical nursing curricular unit. The

activity was integrated as an additional component of the course, without being mandatory or influencing academic assessment. Participation was voluntary, and only students who expressed interest and provided informed consent were included. Of the 68 eligible students, 50 participated in the activity and completed the evaluation protocol in full.

The activity was organised in small groups, with a maximum of 8 to 10 students per session, to ensure appropriate supervision and sufficient time for individual exploration of the simulation. Each session lasted approximately 2 h and included an initial orientation to the use of the Meta Quest 3 devices, individual immersive experience, debriefing, and completion of the evaluation instruments. During the immersive experience, participants were actively monitored for potential adverse effects associated with virtual reality use, including symptoms of cybersickness such as dizziness, nausea, visual discomfort, or disorientation. At the end of each session, all participants were asked about the presence of any discomfort. No participant reported significant adverse symptoms requiring interruption of the experience.

2.4. Instruments

The data collection instrument included an initial section aimed at the sociodemographic and academic characterisation of the participants. The usability of NurseTechGames was assessed using the System Usability Scale (SUS) (2015). The SUS consists of 10 items rated on a five-point Likert scale (1 = strongly disagree; 5 = strongly agree). The final score ranges from 0 to 100, with values above 68 indicating above average usability (Brooke, 1996).

Educational perception was assessed using the Serious Educational Game in Nursing Appraisal Scale (SEGiNAS), comprising 20 items distributed across three dimensions: Engagement and Teaching Effectiveness, Learning Impact and Practical Application, and Relevance and Clarity of Content. Higher scores correspond to a more favourable evaluation of the experience (Fernandes et al., 2024).

Open-ended questions were also included to gather participants' perceptions regarding advantages, disadvantages, suggestions for improvement, identified inconsistencies, and difficulties experienced during the use of the simulation.

2.5. Data analyses

The data collected were analysed according to their quantitative and qualitative nature. The overall usability of NurseTechGames was evaluated using the System Usability Scale, calculated in accordance with standardised guidelines, yielding a total score ranging from 0 to 100. Quantitative data were analysed using descriptive statistics. Qualitative data obtained from the open-ended questions were analysed using content analysis, following Bardin's methodological framework (2011). The analysis was conducted by two researchers with expertise in qualitative research and followed three stages: pre-analysis, material exploration, and treatment of results. Initially, the data were read repeatedly to ensure familiarization. Subsequently, inductive open coding was performed, considering each autonomous textual segment as the unit of analysis. Codes were compared and discussed between the researchers, with disagreements resolved by consensus involving a third researcher. Thereafter, codes were grouped into categories and organized into overarching themes.

2.6. Ethical considerations

The study obtained approval from the relevant institutional and ethics committees and was conducted in accordance with the principles outlined in the Declaration of Helsinki. All participants received comprehensive verbal and written information about the study's purpose, objectives, procedures, and data protection measures. Written informed consent was obtained prior to participation, which was entirely voluntary.

3. Results

3.1. Participant characteristics

The eligible population comprised 68 students enrolled in the third year of the bachelor's degree in nursing, of whom 50 participated in the study, corresponding to a response rate of 73.5%. The sample was predominantly composed of female participants (n = 48; 96.0%), with male participants represented by only two students (4.0%). Age ranged between 20 and 55 years (mean = 22.92 years; SD = 7.08), indicating a predominantly young cohort with moderate age dispersion. Only four participants (8.0%) reported previous experience with virtual reality technologies.

3.2. NurseTechGames: prototype development

NurseTechGames was designed to promote the development of clinical reasoning, evidence-based decision making, and integration of continuity of care in musculoskeletal surgical nursing. The virtual scenario was developed using the Delighted Edu platform (Fig. 1). The experience was operationalised using Meta Quest 3 and hand controllers. This configuration enabled three-dimensional navigation with freedom of movement and direct interaction with virtual objects, fostering a sense of presence and experiential engagement.

The environment represented a three-dimensional hospital setting consisting of an orthopaedic inpatient room, involving an older adult patient hospitalised due to a femoral neck fracture (Fig. 1A).

The instructional design of NurseTechGames was structured around the nursing process, integrating stages of assessment, diagnosis, planning, and prioritisation of interventions (Fig. 1B).

Gamification elements were incorporated as a strategy for cognitive and motivational reinforcement. Throughout exploration of the environment, contextualised quiz-based challenges were presented, requiring responses related to clinical assessment, prioritisation of care, and decision making. These challenges functioned not only as a mechanism for knowledge validation but also as a stimulus for active engagement and self-regulation of learning (Fig. 1C). The scenario was intentionally developed to require students to identify clinical and environmental risks, analyse continuity of care following hospital discharge, recognise potential home-based barriers, and integrate the family into the therapeutic plan (Fig. 1D).

NurseTechGames was conceived not merely as a visualisation tool but as an active learning environment requiring cognitive processing, situational analysis, and practical application of theoretical knowledge within a simulated context.

3.3. Evaluation of usability and educational outcomes

3.3.1. Usability assessment (SUS)

The usability of NurseTechGames was evaluated using the System Usability Scale. The mean SUS score was 83.15 (SD ≈ 14.2), with a median of 87.5. Scores ranged from 50 to 100. According to international SUS benchmarks (Hyzy et al., 2022; Maramba et al., 2019), scores above 68 indicate above average usability, while values above 80.3 are classified as excellent. Therefore, the mean score obtained positions NurseTechGames within the excellent usability category.

The distribution of scores showed a predominant concentration between 77.5 and 100, indicating a high perceived ease of use and strong system acceptance. A small number of participants reported scores between 50 and 60, suggesting greater individual difficulty in navigating the immersive environment. No scores below 50 were recorded, indicating the absence of critical usability issues.

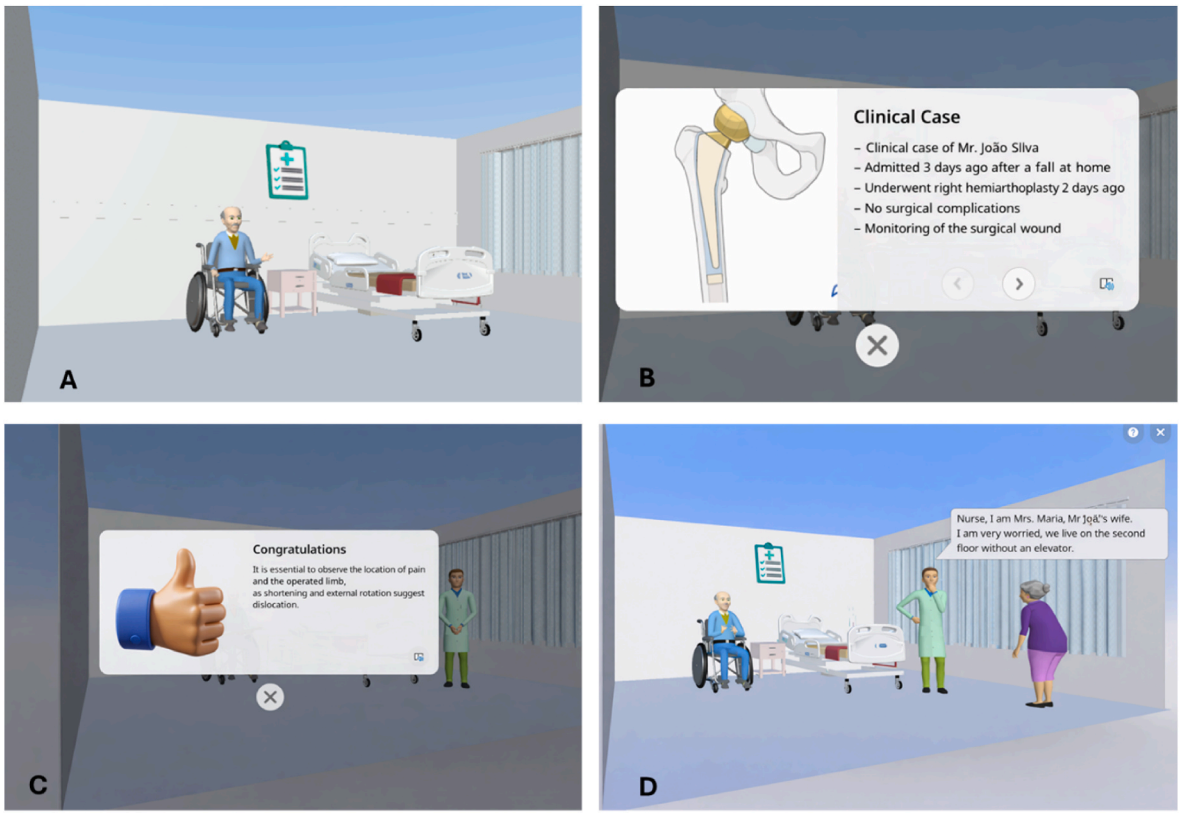

Fig. 1. Screenshots of the NurseTechGames immersive virtual reality simulation. (A) Three-dimensional hospital room environment representing an orthopaedic inpatient setting with an older adult following hip arthroplasty. (B) Clinical case presentation interface providing structured patient information to guide assessment and clinical reasoning. (C) Gamified feedback screen delivered after quiz-based decision-making, reinforcing correct clinical identification. (D) Interactive scenario integrating family involvement and continuity of care considerations, including identification of potential home barriers.

3.3.2. *Educational appraisal (SEGINAS)*

Pedagogical perception of the immersive virtual reality simulation was assessed using SEGINAS (20 items; theoretical range 20 to 100) (see Table 1). The mean total score was 95.58 (SD = 5.77), with observed values ranging from 76 to 100 (Table 2). Considering the theoretical midpoint of the scale (60), these findings indicate an exceptionally high appraisal of the pedagogical strategy. The mean score per item was 4.78 (SD = 0.29), reflecting strong agreement across statements. The overall internal consistency was excellent (α = 0.918), supporting the psychometric robustness of the instrument in this context. The three subscales exhibited consistently high mean scores, indicating strong perceived performance across all evaluated pedagogical domains.

- *Factor 1: Engagement and Teaching Effectiveness (8 items; range 8–40).* The mean total score was 39.18 (SD = 1.93), corresponding to a mean per item of 4.90. Internal consistency was excellent (α = 0.918). Scores approached the upper limit of the scale, indicating very high perceived engagement, motivation, and pedagogical effectiveness, with limited variability among participants.

Table 1
System usability scale results for NurseTechGames (n = 50).

Measure	Value
Mean SUS Score	83.15
Standard Deviation	14.02
Median	87.50
Minimum	50.0
Maximum	100.0
Overall Classification:	Excellent

Table 2
SEGiNAS score for NurseTechGames (n = 50).

Dimension	Mean (SD)	Observed Range	Cronbach's α
SEGiNAS Total Score (20–100)	95.58 (5.77)	76–100	0.918
Mean Item Score	4.78 (0.29)	3.80–5.00	—
Factor 1: Engagement and Teaching Effectiveness (8–40)	39.18 (1.93)	34–40	0.918
Factor 2: Learning Impact and Practical Application (6–30)	28.14 (2.38)	21–30	0.875
Factor 3: Content Relevance and Clarity (5–25)	23.42 (2.08)	18–25	0.717

- Factor 2: Learning Impact and Practical Application (6 items; range 6–30). The mean total score was 28.14 (SD = 2.38), with a mean per item of 4.69. Internal consistency was good to excellent (α = 0.875), suggesting strong perceived impact on learning and clinical applicability.
- Factor 3: Content Relevance and Clarity (5 items; range 5–25). The mean total score was 23.42 (SD = 2.08), corresponding to a mean per item of 4.68. Internal consistency was acceptable (α = 0.717), adequate for applied educational research, indicating high perceived clarity and relevance of the content.

3.3.3. *Qualitative findings*

From the qualitative analysis of the open-ended responses, eight thematic categories emerged: Perceived Learning Value, Clinical Transfer, Realism and Immersion, Engagement and Motivation, Technical Robustness, Development Potential, Minor Technical Issues, and Time Constraints (Table 3).

Perceived Learning Value emerged as the most prevalent category,

Table 3
Thematic categories identified through qualitative content analysis of open-ended responses (N = 50).

Category	N (%)	Example Recording Units
Perceived Learning Value	32 (64%)	"Makes learning more interactive and facilitates understanding of the content." (P2)
Clinical Transfer	24 (48%)	"Useful to apply in real clinical contexts." (P18)
Realism and Immersion	21 (42%)	"Realistic simulation." (P1) "The environment closely resembles reality." (P14)
Engagement and Motivation	19 (38%)	"Learning in an interactive way." (P4) "A different methodology that increases interest." (P27)
Technical Robustness	18 (36%)	"I did not identify any relevant errors." (P9)"
Development Potential	14 (28%)	"Use it more often with different situations." (P1)"
Minor Technical Issues	9 (18%)	"Some initial difficulty with the controllers." (P7) "The headset was slightly uncomfortable." (P31)
Time Constraints	8 (16%)	"The time was short to explore everything." (P19) "It would be important to have more time to practice." (P8)

identified by 32 participants. The category Clinical Transfer was mentioned by 24 participants, who highlighted the applicability of virtual reality experience to real clinical contexts. The dimensions of Realism and Immersion emerged in the responses of 21 participants. The category Engagement and Motivation was identified in the discourse of 19 participants. The methodology was described as dynamic, interactive, and differentiated when compared with traditional teaching strategies.

Within the technological domain, the category Technical Robustness was reflected in statements from 18 participants who reported not identifying any errors. The category Development Potential was emphasised by 14 participants, expressing the desire to expand the number of scenarios or increase the frequency of use. The category Minor Technical Issues was reported by 9 participants and primarily concerned initial difficulties in adapting to the equipment. These occurrences were described as non-structural. Finally, Time Constraints was identified by 8 participants, reflecting the perception that the time allocated could be extended to allow more in-depth exploration of the simulation.

4. Discussion

The present study aimed to design and to develop a nursing process structured immersive virtual reality simulation for musculoskeletal surgical nursing and to conduct a pilot evaluation of its usability and educational appraisal among undergraduate nursing students. Recent literature on immersive virtual reality in nursing education demonstrates benefits in knowledge acquisition and development of clinical competencies (Chen et al., 2020; Sim et al., 2022; Kiegaldie and Shaw, 2023; Hsieh et al., 2025; Mehraeen et al., 2025). However, systematic reviews report substantial heterogeneity in scenario design, with frequent focus on isolated tasks, specific technical skills, or narrowly defined learning objectives, without structured longitudinal integration of the different stages of the nursing process (Kiegaldie and Shaw, 2023; Saab et al., 2023; Mehraeen et al., 2025; Hsieh et al., 2025). This limitation has been identified as a challenge to the consolidation of coherent and theoretically grounded pedagogical models.

The findings of the present study demonstrated excellent usability and substantially elevated pedagogical evaluation. However, the contribution of this study extends beyond technological implementation and lies primarily in its sequential pedagogical structure, contextual specificity, and functional integration of gamification elements. NurseTechGames was structured sequentially according to the stages of the nursing process, integrating clinical assessment, risk identification, prioritisation of interventions, care planning, and discharge preparation. This organisation promotes structured clinical reasoning and articulation across care dimensions, aligning with contemporary simulation models that emphasise the importance of instructional design in educational effectiveness (Jeffries, 2016). The observed educational value therefore cannot be attributed solely to technological immersion but to the underlying pedagogical coherence.

The specificity of the musculoskeletal surgical context constitutes an additional differentiating element. The literature on immersive virtual reality in nursing predominantly focuses on emergency scenarios, intensive care, medication administration, or communication skills (Sim et al., 2022; Hsieh et al., 2025). Orthopaedic surgical nursing involves distinct challenges, and studies in orthopaedic education indicate difficulties in theory practice integration within this domain (Zhao and Zhu, 2024), reinforcing the relevance of targeted immersive interventions.

The integration of gamification elements was also designed with explicit pedagogical intentionality. Unlike approaches in which gamification serves a primarily motivational function, the quizzes embedded within the scenario operated as mechanisms of cognitive activation, requiring evidence-based decision making and providing immediate feedback. Recent evidence suggests that gamification, when aligned with clear educational objectives, may enhance engagement and conceptual retention (Mehraeen et al., 2025). In the present study, the convergence between high scores in the Engagement and Teaching Effectiveness dimension and qualitative categories related to engagement suggests that these mechanisms fulfilled a structured formative function.

The usability score (SUS = 83.15) places the system within the excellent category. This result is particularly relevant given that immersive environments may increase extraneous cognitive load when not adequately structured (Frederiksen et al., 2020; Makransky et al., 2021).

Immersive virtual reality offers several advantages compared with high-fidelity manikin-based simulation, including greater accessibility, repeatability (Makransky et al., 2021; Radianti et al., 2020), and the ability to expose learners to a broader range of clinical scenarios within a controlled and safe environment (Chen et al., 2020; Hsieh et al., 2025). However, high-fidelity simulation remains particularly relevant for the development of psychomotor skills and hands-on clinical competencies that are essential in nursing education (Cant and Cooper, 2017; INACSL Standards Committee, 2021). Therefore, immersive virtual reality should be considered a complementary approach.

The extremely high SEGINAS scores should nevertheless be interpreted with caution. Recent research in immersive environments indicates that high levels of engagement may partially reflect a novelty effect associated with exposure to immersive technology (Hamilton et al., 2021; Wu et al., 2023). However, the coherence between quantitative and qualitative findings, particularly within the Clinical Transfer and Realism and Immersion categories, suggests that the positive perception extended beyond technological enthusiasm and included recognition of the concrete clinical applicability of the orthopaedic scenario. From a curricular perspective, the sequential structure based on the nursing process facilitates formal integration within the surgical nursing curricular unit. This approach is aligned with the INACSL Standards of Best Practice: Sim et al. (2022), which emphasise clear objective definition, structured design, and systematic debriefing.

The present study demonstrated that NurseTechGames, designed as a three-dimensional orthopaedic inpatient scenario structured according to the nursing process and incorporating gamification elements, can be effectively implemented as an immersive learning strategy. NurseTechGames can be integrated into nursing curricula as a complementary simulation-based learning approach to support the development of clinical reasoning. Its use in clinical skills laboratories may enhance students' confidence and decision-making capacity. Furthermore, the

scalability of immersive virtual reality supports curricular innovation, enabling structured simulation to be adapted to diverse clinical scenarios and integrated across different nursing courses.

4.1. Study limitations

This study presents several limitations that should be considered when interpreting the findings. First, it was a pilot study conducted at a single higher education institution using a convenience sample. Voluntary participation may have introduced self-selection bias. Additionally, no comparison group was included and no pre-and-post-intervention assessment was performed.

Although all participants were monitored for potential cybersickness symptoms and none reported significant discomfort, no standardised instrument was used for formal assessment of adverse effects associated with virtual reality. Another limitation concerns the absence of longitudinal evaluation. The results reflect immediate perceptions following the immersive experience and may have been partially influenced by a novelty effect associated with exposure to immersive technology.

5. Conclusion

The present study demonstrated that NurseTechGames constitutes an immersive virtual reality simulation with high usability and strong pedagogical acceptance within the context of musculoskeletal surgical nursing. The structured integration of immersive virtual reality simulations into surgical nursing education represents a pedagogically coherent and scalable complementary strategy to enhance clinical reasoning and theory–practice integration. Future research should adopt controlled designs, include objective assessment of clinical competencies, and explore the feasibility of large-scale implementation to consolidate robust evidence regarding its effectiveness.

CRediT authorship contribution statement

Carla Sílvia Fernandes: Writing – original draft, Validation, Supervision, Software, Methodology, Investigation, Conceptualization. **Ana Galvão:** Writing – review & editing, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Cris Renata Grou Volpe:** Writing – review & editing, Methodology, Investigation, Data curation, Conceptualization. **Marta Campos Ferreira:** Writing – original draft, Software, Methodology, Investigation, Conceptualization.

Data availability statement

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

Ethical approval

The study was conducted in accordance with institutional and international ethical guidelines.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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