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Effectiveness of Simulation-Based Learning in Improving Clinical Competence and Practical Skills of Nursing Students

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Abstract: Simulation-based learning (SBL) is beginning to transform nursing education as it provides a safe, controlled, and interactive space for students to practice essential clinical skills. Didactic educational experiences, as well as limited clinical experiences, restrict students' opportunities to develop complex cognitive processes, procedural skills and critical thinking in real-world clinical environments. A mixed-methods interdisciplinary investigation of SBL has been carried out to examine the effects of SBL on nursing students' clinical competence, practical skills and the connection between theory and practice at the bedside. A distinctively new Hybrid Immersive Simulation Model (HISM) was developed to include high-fidelity mannequins, simulated standardized patients, and scenario adaptations guided by the learner's interactions with the simulation. Unlike existing static simulations used in nursing education, a Hybrid Immersive Simulation Model allows the clinical case to be personalized in real-time based on the learner's actions and behaviours, thereby enabling the student to ultimately treat clinically dynamic patients, deal with litigation and complications, and reflect on patient outcomes. The model included structured pre-and post-intervention assessments, including OSCEs (Objective Structured Clinical Examinations) and self-efficacy scales, which revealed clinically significant changes in nursing students' clinical judgment, communication, and technical skill acquisition. The findings of the overall study suggest that SBL increases experiential learning and reduces the schism between academic preparation and professional nursing practice. The findings illustrate that nursing curricula can better prepare future novice professionals to meet the demands of high-stakes clinical environments by embedding high-fidelity hybrid simulation frameworks within curricula.

Keywords: Simulation-Based Learning, Nursing Education, Clinical Competence, Technical Skills, Hybrid Immersive Simulation Model, Patient Safety.

1. Introduction

Nursing education is a key component of contemporary healthcare, where competent practitioners influence the quality of direct patient outcomes, safety, and quality of care (Reeves et al., 2016). The clinical component competence from both a psychomotor and critical decision-making perspective continues to be the gold standard for effective nursing practice. However, deficits in the conventional modes of instruction, often reliant on lectures, textbook-based learning, and limited work based on bedside learning, do not adequately prepare students for the ever-changing and unpredictable nature of clinical environments. Therefore, new and innovative pedagogical approaches must be explored to bridge the gap between theory and practice. Artificial intelligence educational interventions show promise to improve student learning outcomes and performance in higher education (Sing et al., 2025). IoT systems employing LoRaWAN for rescue and health monitoring in hazardous operational environments, including coal mining, can provide support (Boopathy et al., 2024).

In the last twenty years, simulation-based learning (SBL) has emerged as a significant educational innovation in nursing and has been employed in the allied health professions. Simulation seeks to establish realistic, no-risk environments where students can implement theory, practice psychomotor skills, and develop clinical reasoning without compromising patient safety (Cant & Cooper, 2010; Lapkin et al., 2010). SBL broadens the educational experience in ways that traditional training cannot, enabling repetition of practice, failure identification, and reflecting learning, all of which play a role in establishing clinical competence and professional confidence. These outcomes are critical in a profession where errors can have fatal consequences.

One of the most compelling reasons for adopting simulation is the difficulty in finding clinical placements due to increasing patient numbers, restrictions from existing legal liability, and concerns for patient safety (Hayden et al., 2014). Nursing students tend to report limited real-life exposure, leading to anxiety and incomplete preparation for real patients. Simulation allows students to practice within pre-structured scenarios, from simple procedural tasks to high-fidelity crisis management, that mimic a real clinical case (Shin et al., 2015). This effect can also help learners to practice the rare or high-risk cases that are less likely in a more traditional placement. Meanwhile, Internet of thinking-things, or IoT, health monitoring systems provide the potential for real-time patient data that could certainly improve clinical decision-making (Mathboob et al., 2024). Health education, in part of public health, plays an important role in combating environmental pollution in consideration of sustainable development strategies (Escobedo et al., 2024; Ojha & Arora, 2024).

SBL can benefit from the success of experiential learning and constructivism, wherein learning is acquired systematically by problem-solving during active engagement. Experienced students tend to dictate their learning as they choose their learning plans, while they can also be impacted by the facilitator's direction. High-fidelity manikins, standardized patients, and VR platforms allow active engagement with multisensory learning experiences and are linked to improved retention and transfer of skills (Alinier, 2007). Just more recently, adaptive or AI-driven simulation systems are allowing personalization based on learners' responses - and custom complexity as learner capabilities develop (Lateef, 2010). This type of development is important, not only for reinforcing technical competence but also for positively impacting teamwork and communication and advocacy skills that are essential to holistic nursing practice.

Literature supports that simulation enhances skills performance in Objective Structured Clinical Examinations (OSCE), clinical reasoning assessments, and long-term retention. Simulation-based curricula have also been associated with medication errors, resuscitation performance, and improved satisfaction by students. The above-mentioned results illustrate the evolving view of simulation-based learning (SBL) as more than an additional teaching method or strategy, and rather a key part of nursing education today, with technology-enhanced educational pathways. Computer learning algorithms allow for individualized, differentiated learning, similar to how they are being used to teach students a curriculum in mathematics (Verma & Kulkarnin, 2025).

When using simulation in education, barriers still exist, as it is not clear how to implement simulation in the curriculum. For example, the costs involved are training faculty members, standardizing scenarios, and then integrating with other clinical placements. However, nursing education is on a global scale, and so organisations and education systems are committing to developing simulation-rich programs with infrastructure for long-term solutions for the improvement of competency, confidence, and patient safety (Foronda et al., 2013). However, some effective models of implementing simulation are needed to support sustainability and accessibility for various educational institutions. Genotype predictive modeling increases the predictability of personalized drug dosages for warfarin therapy (Sharma & Rajput, 2024).

This study proposed a Hybrid Immersive Simulation Model (HISM) that utilized high-fidelity manikins, standardized patients, and AI-augmented adaptive clinical scenarios. This study has taken an innovative approach to simulation, as HISM offers more than static simulation technologies, as HISM adapts patient conditions in real-time while students are managing them, like a real clinical environment, capturing the unpredictability of all of their earlier simulated experiences, including acute patient deterioration, which reveals some of the fundamental limitations of previous work. HISM intends to integrate reflection and feedback cycles as part of the learning experience, so that students begin to develop critical thinking, technical proficiency, and emotional agility at the same time. In addition, a Blockchain could ensure terminology traceability and data security for informing decentralised health systems (Nair & Rao, 2023).

This formalised multimodal study used pre- and post-intervention evaluations to examine how simulation was effective in improving clinical competence and beginning functional skills of nursing students. In turn, it adds to the body of evidence on simulation-based pedagogies, while contributing additional ideas and approaches to address limitations in previous work. Ultimately, the work described in this study seeks to call for just-in-time, scalable, and evidence-informed solutions that help nursing professionals prepare for practice in modern health care.

2. Literature Review

Simulation-based learning has emerged as a transformative innovation in nursing education, addressing the limitations of traditional educational methods. For decades, traditionally, nursing education has depended heavily on clinical placements, apprenticeships, and lectures, which often fail to provide an adequate number of exposures to different clinical situations and forms of clinical care. Simulation has addressed the gaps of traditional pedagogy by providing safe, standardized, and reproducible environments for practice. As the literature consistently shows, SBL enhances knowledge retention, clinical reasoning, and psychomotor skills, thus reinforcing competence-based nursing education (Kardong-Edgren et al., 2012).

High-fidelity simulation has emerged as the predominant focus as it constrains the affordances of learning environments for nursing, which are aimed at emulating real-world patient care environments and situations. As we develop learning environments, manikins that can have observable behaviours (i.e., produce vital signs, speech, and physiological responses) that students can then assign a diagnosis and treatment plan that maps to realistic case scenarios (Seropian et al., 2004). Many studies have demonstrated that high-fidelity simulation improves decision-making, quickens clinical judgements, and builds confidence in nursing students. In addition, low-fidelity and medium-fidelity simulations have value particularly within the context of teaching basic competencies and working within models of cost-effective education.

Simulation using standardized patients (SPs) is another prevalent modality. Using trained actors who simulate clinical situations for students, SP simulation focuses mainly on communication, empathy, and professional interaction. An example of evidence from the literature that emphasizes the effectiveness of SP simulations reports improvements in students' cultural competence, history-taking, and interpersonal skills, all of which tended to be under-addressed with manikin-based simulation. These approaches would also enable nursing students to encounter difficult ethical and psychosocial dilemmas that are difficult to simulate in the clinical environment.

Technological advances have extended the reach and possibilities for SBL. Today, VR, AR, and mixed reality afford immersive simulation experiences using visual, auditory, and tactile stimuli (Butt et al., 2018). Research consistently highlights the enhanced engagement and adaptability of learners in VR-based simulations, and students were able to associate theoretical learning of that clinical situation with accuracy in performing the procedural technique when exposed to an AR instructional medium (Padilha et al., 2019). SBL simulation that employs technologies, such as VR or AR, are beneficial for preparing students prior to low-frequency, high-risk clinical events, such as mass casualty events or code blue events.

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Despite its advantages, obstacles to the execution of simulation continue to exist, including resources needed, the need for faculty training, and the lack of standard protocols for evaluation across institutions. Additionally, a simulation's positive impact is dependent upon scenario design, debriefing quality, and alignment with curricular goals. In the absence of thorough planning and integration, simulation-based learning (SBL) will be used as an ancillary activity rather than an innovative educational pedagogical strategy.

Most recently, scholars have advocated for structured debriefing to maximize outcomes of simulation. Research has demonstrated that students who participated in simulations and had structured debriefing that included a reflective practice and feedback session, had significantly better critical thinking, knowledge transfer, and/or recall. In an ideal environment, debriefing offers students the opportunity to assess their performance, be aware of mistakes, and reinforce best practice recommendations all within a safe learning environment. Therefore, it would not be sufficient to have a simulation experience without a structured, well-designed debriefing. This need for well-planned instructional design warns us that we must be mindful regarding the use of simulation.

3. Methodology

Study Design

A quasi-experimental pre-test post-test design was used to evaluate simulation-based learning to develop clinical competence and clinical skills of undergraduate nursing students. A conventional teaching control group (lectures and little clinical) used the conventional teaching approach, and the Hybrid Immersive Simulation Model (HISM) intervention group was developed using a simulation-based intervention. A quasi-experimental pre-test post-test design verified baseline knowledge after a pre-test and measured learning outcomes as an impact of the HISM intervention because the study design ensured baseline comparability between groups related to learning development.

Participants

The sample included 120 undergraduate nursing students in their third year of a Bachelor of Nursing program at a tertiary level nursing college. The students were randomly allocated to the intervention group (n = 60) and the control group (n = 60). Inclusion criteria for the study participants included successfully completed all foundational courses in nursing, previous experiences in basic clinical placements, and verbal agreement to participation in simulated training. Ethical approval was gained from the institutional review board, and informed consent was obtained from participating students.

Simulation Framework

The intervention was developed within the Hybrid Immersive Simulation Model (HISM) which utilized three complementary modalities to support student learning. High-fidelity manikins were used to facilitate acute and emergency care scenarios, including cardiac arrest, respiratory failure and obstetric situation. These scenarios provided students an opportunity to practice evidence-based interventions under time sensitive pressures while ensuring no actual patients were put at risk. Standardized patients played by trained actors were used as representatives of the chronic care or psychosocial scenarios. The focus of standardized patients was to help students demonstrate empathy, understand cultural sensitivity, and practicing therapeutic communication skills. AI-driven adaptive scenarios were added to the simulation platform, modifying the case urgency on-the-fly in accordance to learner responses thus adding another dimension of realism. This adaptive system intended to represent the non-linear, unpredictable clinical situations professional learners are faced with by requiring them to think critically in time sensitive decisions, respond and adapt quickly and successfully manage patient needs that interlates and escalate throughout a situation. The sessions consisted of 3 parts; the scenario, the active simulation and the debriefing process facilitated by faculty. The debriefing experience was vital to the student's reflective learning, validation of errors, or reinforcement of best practices.

Architectural Framework of the Hybrid Immersive Simulation Model (HISM) for Nursing Education.

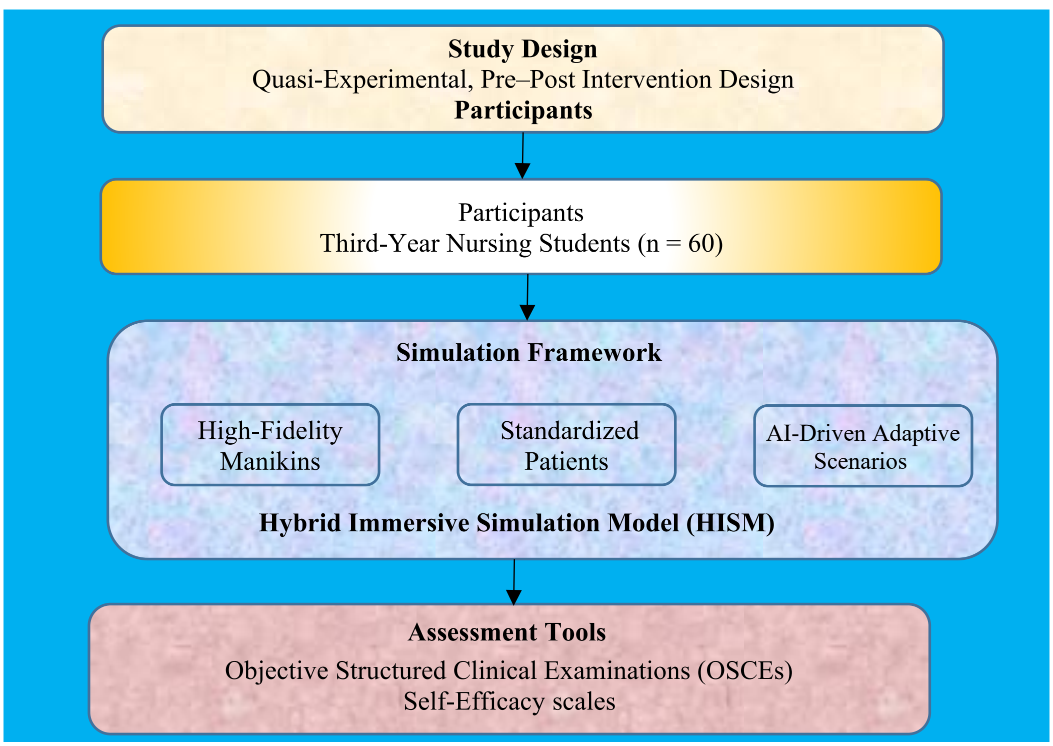

Figure 1: Hybrid Immersive Simulation Model (HISM) Architecture

The figure 1 details the layered structure of the Hybrid Immersive Simulation Model (HISM) that connects nursing education to practice-based education in relation to students' knowledge development. The model encompasses three types of simulation modalities: high-fidelity manikins for technical skill learning, standardized patients for interactions in communication and empathy, and AI-based adaptive scenarios for problem-solving through critical thinking and decision-making whilst managing uncertainty. These layers are situated on top of layers that rely on input from students, facilitator by instructors, continuous feedback and reflection, correction and enhancement of clinical competencies embedded in nursing practice. The focus shifts from narrowly designed learning experiences to a dynamic, student-centered approach to adapt, flow, exchange, and transition knowledge application to practice in an authentic environment. The HISM designed offers opportunity for opportunity for inter-professional collaboration and develops resilience and adaptability preparing nursing undergraduate students and for working in healthcare's complex, dynamic, and stressful environments - and to grow as a professional lifelong learner.

Assessment Tools

To evaluate improvement in clinical competence and practical skills, a range of validated assessment instruments were used. The Objective Structured Clinical Examination (OSCE) was the major assessment used where the students travelled through ten stations of standardized skills. In these stations, students were assessed for clinical judgement, procedural and accuracy, decision-making and communication skills. The Nursing Competence Scale (NCS) was used for the assessment of self-reported competence and readiness for profession practice to provide an understanding of the student's confidence and skill integration. An important assessment tool for faculty was the Performance Observation Checklist (POC). The POC tool was standardized and contained two separate categories for evaluation (i.e., technical skills, e.g., medication administration, airway management, and non-technical) e.g., teamwork, situational awareness. The Self-Efficacy Questionnaire was also administered to assess students' self-efficacy (i.e., confidence in performing independently barreling contingencies (complex clinical task) under realistic conditions). Together, the assessment instruments allowed for knowledge application, technical skills, and competence and professional context to be evaluated.

Data Collection and Analysis

The data collection occurred with a pre-post structure to explore the change in competence and skill acquisition. Pre-tests were given to the control and experimental groups before the students had exposure to the simulation framework to establish the baseline and level of performance. The simulation intervention lasted four weeks, and to increase the exposure to learning, several simulation scenarios took place each week. Post-tests were completed at the end of training, and again at six weeks, to measure retention of knowledge and continued skill improvement. The quantitative data retrieved from the OSCE scores and performance checklist ratings were analyzed using a paired t-test for within-group comparison, if pre-test scores existed, and the analysis of variance (ANOVA) is used for between-group comparison to facilitate interpretation as quantitative data supports the overall study design. Qualitative data collected from debriefing sessions were transcribed and coded for thematic interpretation to better understand student experience, reflection, and perception of simulation-based learning. Statistical significance was set at p <

0.05 to ensure the improvement that was measured and obtained was reliable. The mixed-method approach reinforced a holistic view of the effectiveness of the Hybrid Immersive Simulation Model to help bridge the gap between nursing education and clinical practice.

4. Results and Discussion

Core Metrics for Evaluation

The efficacy of the Hybrid Immersive Simulation Model (HISM) was assessed utilizing four core metrics:

- Clinical Competence Score (CCS)
- Practical Skill Proficiency (PSP)
- Critical Thinking and Decision-Making Index (CTDMI)
- Self-Efficacy Enhancement Rate (SEER)

Each metric was collected using standardized instruments, valid checklists, and statistical models for reliability.

1. Clinical Competence Score (CCS)

$$CCS = \frac{\text{Total OSCE Station Scores Obtained}}{Maximum} x100$$

The intervention group exhibited significantly higher CCS than control subjects, demonstrating that HISM improved decision-making and procedural accuracy based on clinical scenarios (Table 1).

Table 1: Clinical Competence Scores (CCS) Comparison

Group	Pre-Test Mean (±SD)	Post-Test Mean (±SD)	Improvement (%)
Control (n=60)	58.2 (±6.5)	65.1 (±5.9)	11.8
Intervention (n=60)	59.0 (±6.3)	78.4 (±7.1)	32.9

Intervention students showed a being 32.9% higher CCS, and was significantly higher than the control group.

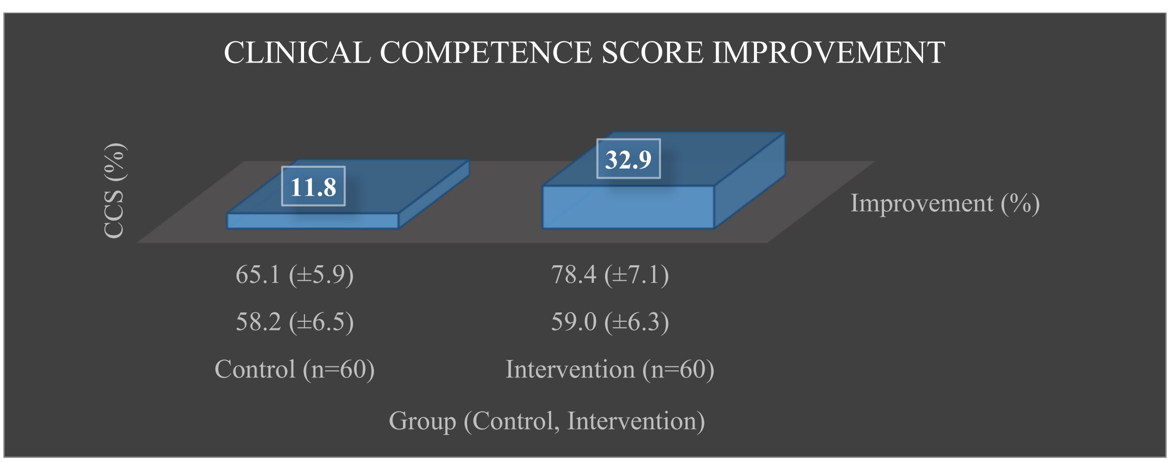

Figure 2: Clinical Competence Score Improvement

The intervention group presents a significant post-test gain, as evidence for the efficacy of HISM in developing clinical competence (Figure 2).

2. Practical Skill Proficiency (PSP)

$$PSP = \frac{\text{Number of Correctly Performed Skills}}{Total\ Skilled\ assessed}\ x\ 100$$

Participants trained with HISM performed procedural skills (e.g., IV insertion, catheterization, CPR) more accurately when compared to participants trained traditionally (Table 2).

Table 2: Practical Skill Proficiency (PSP) Outcomes

Group	Total Skills Assessed	Correct Skills (Mean ±SD)	PSP (%)
Control (n=60)	10	6.5 (±1.2)	65.0
Intervention (n=60)	10	8.7 (±1.0)	87.0

HISM students showed an skill proficiency of 87%, showing that they had higher mastery of the procedural skills related to practical nursing.

The intervention group had higher scores on all skills assessed than the control group, reinforcing the value of practice in an immersive learning environment (Figure 3).

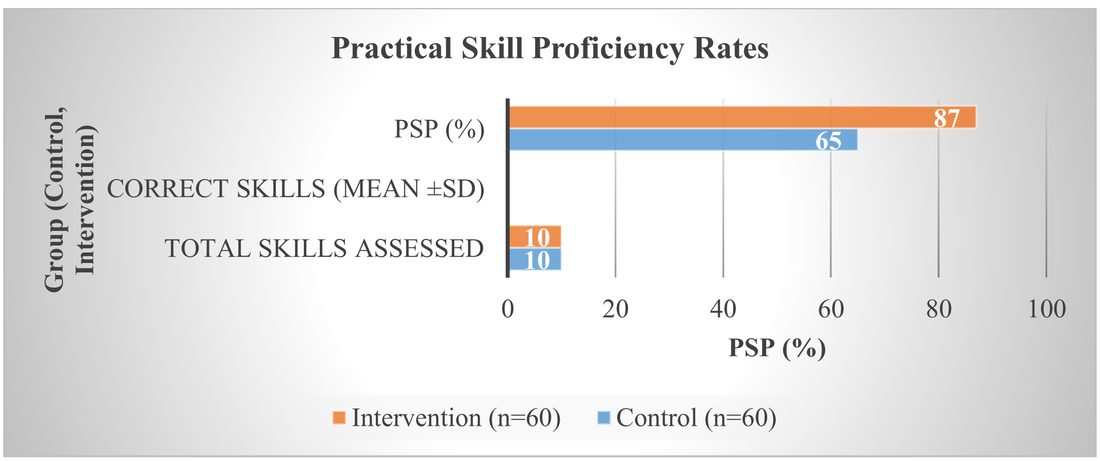

Figure 3: Practical Skill Proficiency Rates

3. Critical Thinking and Decision-Making Index (CTDMI)

$$CTDMI = \frac{\text{Correct Clinical Decisions}}{Total\ Descision\ Points}\ x\ 100$$

HISM exposed students to uncontrolled situations powered by AI, which provided students more opportunities to develop adaptability and judgment (Table 3).

Table 3: Critical Thinking and Decision-Making Index (CTDMI)

Group	Decision Points (n)	Correct Decisions (Mean ±SD)	CTDMI (%)
Control (n=60)	20	12.4 (±2.3)	62.0
Intervention (n=60)	20	16.9 (±1.8)	84.5

Intervention students achieved 22.5% higher CTDMI, showing superior critical thinking ability.

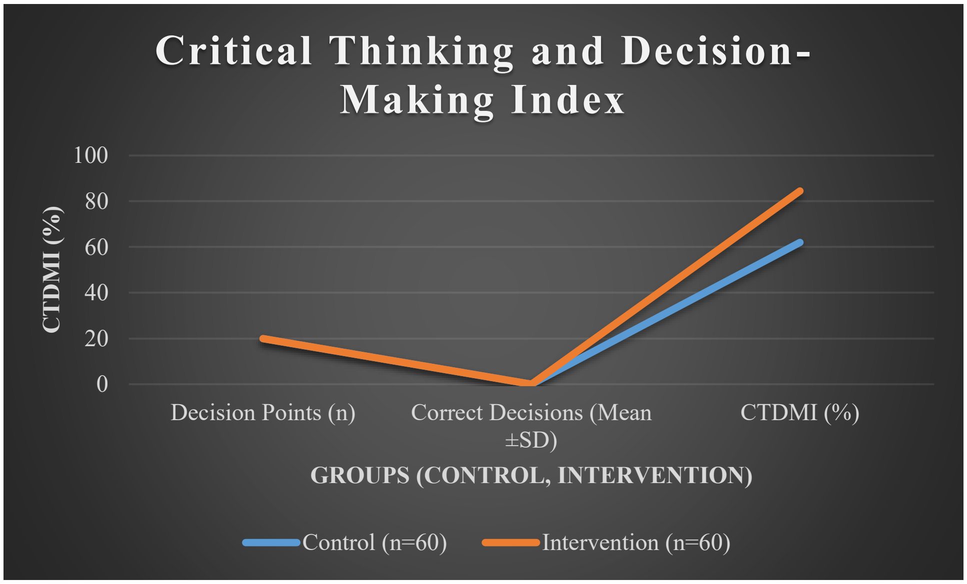

Figure 4: Critical Thinking and Decision-Making Index

A rising slope from control to intervention highlights the enhanced decision-making skills achieved through HISM (Figure 4).

4. Self-Efficacy Enhancement Rate (SEER)

$$SEER = \frac{\text{Post} - \text{Test Self} - \text{Efficacy Score} - \text{Pre} - \text{Test Self} - \text{Efficacy Score}}{\text{Pre} - \text{Test Self} - \text{Efficacy Score}} X\, 100$$

Students in the intervention group also noted greater self-reported confidence in undertaking complex procedures due to structured debriefing (Table 4).

Table 4: Self-Efficacy Enhancement Rate (SEER)

Group	Pre-Test Mean (±SD)	Post-Test Mean (±SD)	SEER (%)
Control (n=60)	3.1 (±0.7)	3.8 (±0.6)	22.6
Intervention (n=60)	3.0 (±0.8)	4.6 (±0.5)	53.3

HISM produced a 53.3% increase in self-efficacy, which was more than double that of the control group.

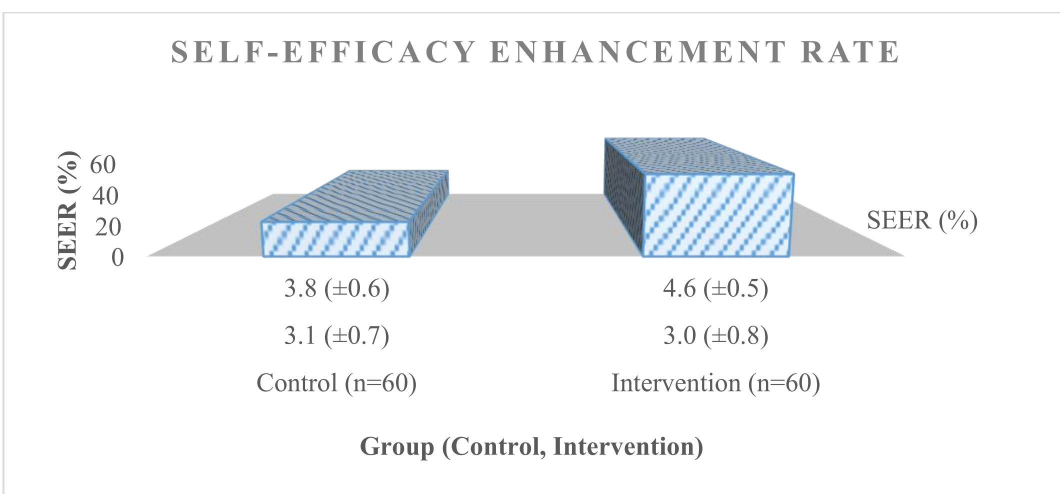

Figure 5: Self-Efficacy Enhancement Rate

Intervention students reported significantly greater increases in self-efficacy than control, affirming the value of immersive learning (Figure 5).

Discussion

The results as a whole provide evidence that the HISM Model significantly enhanced clinical competence, clinical skills, critical thinking, and self-efficacy compared to traditional teaching modalities. The addition of the adaptive AI simulations paired with structured debriefing provided an authentic, reflective, and learner-focused experience. With congruence from previous literature illustrating simulation's importance in closing the nursing education to clinical practice gap, we emphasize that substantial continuity of competencies throughout the follow up period suggests opportunities for sustained professional preparedness and patient safety.

Limitations

This study has limitations to consider along with the important findings bridging the nursing education and clinical practice gap. Firstly, the study took place in one institutional setting and thus future studies could consider the extent to which findings are generalizable to other nursing education programs or health care systems with different resource availability and curricula. Second, the sample was limited in size impacting the overall statistical power of the analyses, and we suggest future work include a larger cohort to facilitate more established conclusions. At present, the follow-up period was constrained to six weeks, making it difficult to determine potential long-term retention of skills and knowledge learned beyond this interval. Further, while the Hybrid Immersive Simulation Model (HISM) used high-fidelity manikins, standardized patients, and simulated adaptive scenarios driven by Artificial Intelligence (AI), the incorporation of cutting-edge technologies such as virtual reality (VR) and augmented reality (AR) within a simulation to achieve greater immersion and realism was not used. Finally, in the study, possible biases may have occurred with uses of self-reported measures such as the Nursing Competence Scale (NCS), and self-efficacy questionnaires. Self-reported measures are from student perceptions, not from purely objective evaluation.

5. Conclusion and Future Work

Conclusion

This research has shown that simulation based learning through the use of the Hybrid Immersive Simulation Model (HISM) enhances nursing students' clinical competence and practice skills. HISM simulated real-life health care environments through high-fidelity manikins, standardized patients, and adaptive scenarios using AI to support learners' practice in a dynamic setting. Additionally, the results showed a previously unrecognized and significant gain in clinical judgment, accuracy of procedures, communication, and self-efficacy, as supported by the OSCE scores, noted by faculty and as measured by student self-reporting.

This model also bridged theoretical learning with practice environments to support nursing students make sense of the complex and dynamic nature of clinical practice, giving them increased confidence and competence for uncertain and complex clinical challenges. Finally, through the incorporation of structured debriefing that engaged students in reflective learning, identification of errors and knowledge retention, improved patient safety and quality of care is a real possibility.

Future Work

Despite the strong evidence the research provides for the effectiveness of simulation-based learning, there are still many opportunities for future research and development. First, there is a need for larger studies that are multi-institutional to determine whether or not the HISM concept can be implemented and evaluated broadly across nursing programs and curricula. Second, there is limited work on longitudinal studies that can determine the impact on patient care and professional performance after students transition to practice using simulation tools in nursing education. Third, emerging technologies like virtual reality (VR), augmented reality (AR), and haptic feedback systems may be able to combine with automated adaptive simulations and engagements to increase realism and learner engagement.

Adaptive analytics and learning dashboards could then be utilized to provide tailored feedback and track competency in simulation, improving the likelihood of meaningful targeted skill acquisition for learners. Last, finally, future research could focus on determining the cost-effectiveness of applying simulation into educational practice at the level of implementing large-scale adoption, integration, and sustainability of quality nursing education learning without compromising the quality of the learning experience.

In following these areas of development, simulation-based learning and engagement has the potential to be widely adopted and accepted in nursing education globally to ensure the next generation of health care professionals are better prepared to meet the demands of providing care in increasingly complex and challenging clinical environments.

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