Clinical Simulation in Nursing 109 (2025) 101856

Contents lists available at ScienceDirect

Clinical Simulation in Nursing

journal homepage: www.elsevier.com/locate/ecns

Research Article

# Holographic versus video-based simulation in nursing education: A comparison of effectiveness and social presence

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ARTICLE INFO

*Keywords:*
Clinical simulation
Holography
Immersive learning
Nursing education
Simulation
Social presence

ABSTRACT

*Background:* Holographic simulation offers an immersive alternative to traditional video-based methods in nursing education.
*Methods:* A quasi-experimental study assigned 127 nursing students to Hologram ($n = 64$) or Flat Screen Video ($n = 63$) groups. Participants completed a pediatric clinical scenario and debriefing. Effectiveness and social presence were measured using the SET-M and Social Presence Scale.
*Results:* No significant differences were found in most SET-M domains. However, the Hologram group scored higher in two debriefing items ($p = .045$ and $p < .001$) and in presence items related to realism and engagement ($p < .01$).
*Conclusions:* Holographic simulation showed equal or greater effectiveness, supporting its use in nursing curricula.


## Introduction

Simulation-based education has become a cornerstone in nursing curricula, offering safe, structured environments for students to develop clinical competence while protecting patient safety (Gaba, 2004; INACSL Standards Committee, 2021). Traditional modalities, such as standardized patients and manikin-based scenarios, have evolved through technological advancements into more interactive and immersive learning experiences (Jeffries, 2020; Motola et al., 2013).

Augmented reality (AR) and holography have garnered attention for their capacity to be immersive, augment realism, increase learner engagement, and improve emotional involvement in clinical simulations (Padilha et al., 2019). Holographic simulation, in particular, employs volumetric video capture to project three-dimensional representations of patient actors through freestanding or tabletop display units. These systems generate lifelike visual and auditory cues that support greater co-presence and psychological fidelity. While still emerging in nursing education, holographic display platforms have demonstrated feasibility and potential benefits for immersive team training and learner interaction in healthcare settings (Bajwa et al., 2024).

In contrast, video-based simulation, pre-recorded clinical scenarios, or virtual simulation platforms are a cost-effective and scal-

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https://doi.org/10.1016/j.ecns.2025.101856
1876-1399/

able approach widely used in nursing education, allowing learners to observe, reflect, and analyze patient care asynchronously or synchronously. Although these modalities promote consistent exposure and repeated access, they often lack real-time interactivity and embodied co-presence, which may limit emotional engagement and the realism necessary for effective clinical decision-making (Stenseth et al., 2025).

Social presence, defined as the degree to which learners feel connected, engaged, and immersed in a learning environment, is an essential component of simulation-based education (Bailenson et al., 2001; Oh et al., 2018). Bailenson and colleagues (2001) link higher levels of social presence to improved communication, satisfaction, and affective learning outcomes. The Simulation Effectiveness Tool – Modified (SET-M) and the Social Presence Scale (Bailenson et al., 2001) are frequently used to evaluate learner perceptions of these environments (Leighton et al., 2015).

Despite growing interest in holographic simulation, few studies have compared its effectiveness with more accessible video-based modalities using standardized assessment tools. This gap is particularly relevant as nursing educators must balance educational impact with financial and infrastructural feasibility (Foronda et al., 2020). This study aimed to compare holographic and video-based simulation among undergraduate nursing students by evaluating learner perceptions of simulation effectiveness and social presence. We hypothesized that students participating in holographic simulation would report greater emotional engagement and reflective learning outcomes compared to those in video-based formats.

## Method

This quasi-experimental study used a parallel-group design to compare the perceived effectiveness and social presence of two simulation modalities: holographic and video-based. The research was conducted at a large public university in the southeastern United States and approved by the Institutional Review Board (IRB). Data collection occurred from January to March 2025.

### *Participants*

A total of 127 undergraduate nursing students enrolled in a pediatric clinical course were invited to participate in the study. All students were part of a traditional Bachelor of Science in Nursing (BSN) program. Participation in the simulation activity was required as part of the course, but participation in the research study was voluntary.

Random assignment was completed by the roll of the die method to determine group assignment:

- *Hologram Group ($n = 64$):* Participated in simulations using holographic patient representations delivered via a holographic tabletop system.
- *Flat Screen Group ($n = 63$):* Engaged in pre-recorded video simulations of the same clinical scenario, displayed on a large monitor/screen.

### *Simulation scenario*

The clinical case centered on a 14-year-old adolescent named 'Nicole' and focused on history-taking and communication skills. Learning objectives included screening for safety risks, substance use, sexual health, and nonverbal behavior. An objective for the course was to provide the learner with the ability to tailor care for pediatric patients. For this study, the case was converted into holographic and video formats.

Faculty members with Certified Healthcare Simulation Educator (CHSE) credentials developed the scenario. Although it had not undergone formal psychometric validation, the case was aligned with Healthcare Simulation Standards of Best Practice® (HSSOBP). Simulation objectives (INACSL Standards Committee, Miller et al., 2021) were formed based off course objectives, meeting criterion 1, ensuring curricular alignment. A pilot-test was conducted for clarity and instructional relevance to reinforce best practices in simulation design, meeting criterion 3-11. (INACSL Committee, Watts et al., 2021). Each simulation session lasted 10 minutes, followed by a 5-minute peer debrief and a 20-minute structured debriefing facilitated by trained simulation educators using the PEARLS (Eppich & Cheng, 2015) framework. All facilitators followed the same script to ensure consistency between groups.

### *Instruments*

- *Demographic Survey:* Collected participant data on age, gender, race, ethnicity, and previous exposure to holographic simulation.
- *Simulation Effectiveness Tool – Modified (SET-M)* (Leighton et al., 2015)**:** Assessed students' perceptions of simulation quality across four domains: prebriefing (2 items), scenario execution (12 items), and debriefing (5 items), totaling 19 items rated on a 3-point Likert scale (1 = Disagree, 2 = Neutral, 3 = Agree). Higher scores indicated greater perceived effectiveness. The instrument has demonstrated strong internal consistency (Cronbach's $\alpha = 0.936$) and cross-cultural reliability (Leighton et al., 2015).
- *Social Presence Scale* (Bailenson et al., 2001)**:** Measured students' sense of immersion and interaction using five items rated on a 7-point Likert scale (1 = Strongly Disagree to 7 = Strongly Agree). Items addressed perceived involvement, engagement, emotional connection, and awareness of others. The instrument has shown high reliability in prior studies of virtual environments.

### *Data analysis*

All data were analyzed using IBM SPSS Statistics, Version 29. Descriptive statistics were used to summarize demographic characteristics and survey responses. Independent samples t-tests were applied to compare continuous variables between the two groups, and chi-square tests were used for categorical variables. A $p$-value of $<.05$ was considered statistically significant. The same facilitator, CHSE-A certified, debriefed the overall simulation minimizing the need for inter-rater reliability and mitigating variations in the debrief.

## Results

### *Demographics*

A total of 127 students completed the study, with 64 assigned to the Hologram group and 63 to the Flat Screen group. No statistically significant differences were found between the groups regarding age, gender, race, ethnicity, or prior experience with holographic simulation, indicating demographic comparability between groups.

### *Simulation effectiveness (SET-M)*

Both groups rated the simulation experience positively across all SET-M (Leighton et al., 2015) domains. Independent samples t-tests revealed no significant differences in the Prebriefing or Scenario subscale items. However, the Hologram group scored significantly higher on two Debriefing items:

- **Item 1** ("The simulation helped me recognize what I did well"): Hologram ($M = 2.83$, SD = 0.38) vs. Flat Screen ($M = 2.67$, SD = 0.51), $t = 2.03$, $p = .045$, $d = 0.36$.
- **Item 2** ("The simulation helped me recognize what I need to improve"): Hologram ($M = 2.78$, SD = 0.42) vs. Flat Screen ($M = 2.41$, SD = 0.64), $t = 3.85$, $p < .001$, $d = 0.68$.

Effect sizes (Cohen's $d$) were calculated for significant comparisons, indicating small to large effects across debriefing items.

The remaining SET-M (Leighton et al., 2015) items showed no significant differences between groups.

### *Social presence*

Analysis of the Social Presence Scale (Bailenson et al., 2001) indicated significantly higher ratings in the Hologram group for three of the five items:

- **Presence 1** ("I felt like I was part of the action"): Hologram ($M = 4.80$, SD = 1.50) vs. Flat Screen ($M = 3.98$, SD = 1.81), $p = .007$, $d = 0.49$.
- **Presence 3** ("I felt like I was in the same space as the scenario"): Hologram ($M = 4.44$, SD = 1.53) vs. Flat Screen ($M = 3.70$, SD = 1.53), $p = .007$, $d = 0.48$.
- **Presence 5** ("I was aware of others' presence and reactions"): Hologram ($M = 4.77$, SD = 1.42) vs. Flat Screen ($M = 3.70$, SD = 1.53), $p < .001$, $d = 0.64$.

Effect sizes (Cohen's d) were calculated for all significant comparisons, indicating moderate to large effects across social presence items. Items 2 and 4 also trended toward higher means in the Hologram group, but differences were not statistically significant.

### *Summary*

Overall, both simulation modalities were perceived as effective. However, the hologram group reported greater benefits in reflective learning and social presence, particularly during debriefing. Aspects of realism and emotional engagement were also higher. These findings suggest that holographic simulation may foster deeper learner immersion and interpersonal connection.

## Discussion

This study compared the perceived effectiveness and social presence of holographic versus video-based simulation in undergraduate nursing education. While overall SET-M (Leighton et al., 2015) scores did not differ significantly between groups, students in the hologram group reported significantly higher ratings on two debriefing items, indicating enhanced reflective learning. These results align with the hypothesis that holographic simulation may support deeper engagement during post-simulation processing.

Debriefing is a critical component of simulation-based education, fostering learner reflection, insight, and integration of knowledge. The PEARLS framework (Eppich & Cheng, 2015) was applied consistently across both groups, with trained facilitators and standardized prompts. Therefore, the observed differences in debriefing perception are likely attributable to the simulation modality itself. Holographic technology may enhance cognitive and emotional engagement by providing lifelike representations of patients, thus intensifying the learner's psychological fidelity and affective investment in the scenario (Fey & Jenkins, 2015; Son, Kang, & De Gagne, 2023). Increased use of technology with proper integeration and fidelity has shown to increase knowledge retention and higher order thinking (Akintayo, Eden, et al., 2024).

The Hologram group also reported higher levels of social presence in three out of five items. These included statements reflecting realism ("I felt like I was part of the action"), spatial immersion ("I felt like I was in the same space as the scenario"), and interpersonal awareness ("I was aware of others' presence and reactions"). These findings are consistent with prior studies suggesting that immersive technologies enhance students' sense of co-presence and emotional involvement (Hill et al., 2025; Padilha et al., 2019). In contrast, while video-based simulation provides consistent, scalable instruction, it may lack the embodied interaction necessary to evoke the same level of presence.

Despite these advantages, perceptions of simulation effectiveness were largely comparable across both modalities. Students in both groups agreed that the experience supported their learning, decision-making, and communication skills. This suggests that instructional design, including prebriefing, scenario fidelity, and structured debriefing, plays a central role in learner outcomes, regardless of technological format. These results support findings from Foronda et al. (2020), who emphasized that pedagogical structure often outweighs modality in influencing simulation impact. Caution must be made when implementing new technology to ensure that proper facilitator training, implementation strategies, and teaching pedagogies are followed (Akintayo et al., 2024) allowing for greater higher order thinking and reasoning.

Importantly, the heightened immersion provided by holography did not universally translate into higher effectiveness scores. This underscores that novelty and visual engagement alone may not improve perceived learning unless paired with thoughtful instructional integration. Simulationists and faculty should avoid equating technological sophistication with educational quality and instead evaluate how immersive features align with learning objectives.

### *Cost considerations and practical implications*

While the study demonstrates that holographic simulation may enhance emotional engagement and presence, its implementation requires significant investment in equipment, infrastructure, and faculty development. Hologram systems, such as table-top volumetric devices, entail costs that may exceed the budgets of many nursing programs. In contrast, video-based simulation remains a highly accessible, scalable, and pedagogically sound option.

From a practical standpoint, educational leaders should weigh these trade-offs carefully. For institutions with limited resources, video simulation can continue to support meaningful learning when paired with effective debriefing strategies. However, where feasible, the integration of holographic technologies may offer added value for developing communication, empathy, and reflection—particularly in sensitive or high-stakes scenarios.

### *Limitations and future directions*

There are several limitations noted. This study was a single-site study with a relatively homogenous student sample, limiting generalizability. The outcome measures were based on student self-reports, which may be subject to bias or social desirability effects. Additionally, the study evaluated perceptions immediately after the simulation experience, without assessing long-term learning outcomes or clinical performance.

Future research should incorporate longitudinal designs to examine skill retention and application. Future studies might explore how different learner characteristics (e.g., anxiety, learning styles, prior tech exposure) interact with simulation modality preferences. Finally, comparative cost-effectiveness analyses would help inform institutional decision-making regarding technology adoption Tables 1–3.

**Table 1**
Demographic Characteristics of Participants By Group.

| Demographic Variable | Hologram ($n = 64$) | Flat Screen ($n = 63$) |
|---|---|---|
| Age (Mean ± SD) | 20.70 ± 3.01 | 21.02 ± 2.71 |
| Gender (Female/Male) | 56 / 8 | 54 / 9 |
| Ethnicity (White/Asian/Black/Others) | 42 / 10 / 10 / 2 | 40 / 12 / 9 / 2 |
| Hispanic or Latino | 21 | 17 |
| Prior Hologram Experience (Yes) | 3 | 0 |

**Table 2**
Comparison of SET-M Item Scores Between Groups By Domain.

| Item | Mean Hologram (SD) | Mean Flat Screen (SD) | t-statistic | *p*-value |
|---|---|---|---|---|
| Prebriefing 1 | 2.74 ± 0.44 | 2.60 ± 0.55 | 1.53 | .128 |
| Prebriefing 2 | 2.78 ± 0.46 | 2.67 ± 0.52 | 1.29 | .199 |
| Scenario 1 | 2.81 ± 0.41 | 2.67 ± 0.50 | 1.77 | .079 |
| Scenario 2 | 2.75 ± 0.48 | 2.60 ± 0.57 | 1.63 | .106 |
| Scenario 3 | 2.72 ± 0.51 | 2.63 ± 0.56 | 0.95 | .345 |
| Scenario 4 | 2.77 ± 0.45 | 2.62 ± 0.54 | 1.66 | .100 |
| Scenario 5 | 2.66 ± 0.52 | 2.57 ± 0.58 | 0.91 | .365 |
| Scenario 6 | 2.73 ± 0.47 | 2.56 ± 0.59 | 1.76 | .081 |
| Scenario 7 | 2.72 ± 0.48 | 2.63 ± 0.53 | 1.01 | .316 |
| Scenario 8 | 2.75 ± 0.44 | 2.67 ± 0.54 | 0.94 | .351 |
| Scenario 9 | 2.80 ± 0.42 | 2.65 ± 0.56 | 1.74 | .084 |
| Scenario 10 | 2.72 ± 0.49 | 2.60 ± 0.58 | 1.23 | .220 |
| Scenario 11 | 2.75 ± 0.47 | 2.62 ± 0.55 | 1.40 | .163 |
| Scenario 12 | 2.70 ± 0.49 | 2.60 ± 0.57 | 1.10 | .273 |
| Debriefing 1 | 2.83 ± 0.38 | 2.67 ± 0.51 | 2.03 | .045* |
| Debriefing 2 | 2.78 ± 0.42 | 2.41 ± 0.64 | 3.85 | <.001* |
| Debriefing 3 | 2.69 ± 0.50 | 2.52 ± 0.62 | 1.64 | .104 |
| Debriefing 4 | 2.75 ± 0.44 | 2.63 ± 0.60 | 1.23 | .222 |
| Debriefing 5 | 2.73 ± 0.45 | 2.76 ± 0.50 | −0.33 | .743 |

(*$p < .05$).

**Table 3**
Comparison of Social Presence Scale Scores Between Groups.

| Item | Mean Hologram (SD) | Mean Flat Screen (SD) | t-statistic | *p*-value |
|---|---|---|---|---|
| Presence 1 | 4.80 ± 1.50 | 3.98 ± 1.81 | 2.75 | .007* |
| Presence 2 | 4.52 ± 1.38 | 3.97 ± 1.72 | 1.97 | .051 |
| Presence 3 | 4.44 ± 1.53 | 3.70 ± 1.53 | 2.72 | .007* |
| Presence 4 | 5.11 ± 1.46 | 4.60 ± 1.56 | 1.89 | .062 |
| Presence 5 | 4.77 ± 1.42 | 3.70 ± 1.53 | 4.07 | <.001* |

(*$p < .05$).

## Conclusion

Both holographic and video-based simulation modalities were perceived as effective by undergraduate nursing students, supporting their development of communication and clinical reasoning skills. While video-based simulation remains a scalable and accessible tool, holographic simulation demonstrated greater emotional engagement and a stronger sense of social presence, particularly during debriefing. These findings suggest that immersive technologies may add value in fostering reflection and realism when integrated thoughtfully into the curriculum. However, given cost and resource considerations, institutions should align simulation modality choices with their pedagogical goals, technological capacity, and student needs. Ultimately, holographic simulation should be viewed not as a replacement for traditional approaches but as a complementary strategy to enhance learner engagement and deepen affective learning outcomes in nursing education.

## 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.

## CRediT authorship contribution statement

**Monica Motta Lino:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Danny J. Hernandez:** Writing – review & editing, Writing – original draft, Validation, Methodology, Data curation. **Peggy P. Hill:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Methodology, Investigation, Formal analysis. **Mindi Anderson:** Writing – review & editing, Writing – original draft, Visualization, Validation, Investigation. **Frank Guido-Sanz:** Writing – review & editing, Writing – original draft, Visualization, Validation, Investigation. **Jacqueline LaManna:** Writing – review & editing, Writing – original draft, Visualization, Validation, Investigation, Conceptualization. **Christopher W. Blackwell:** Writing – review & editing, Writing – original draft, Validation, Data curation. **Desiree A. Díaz:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

## Financial Disclosure Statement

The authors received no specific grant or financial support for the conduct of this study.

## Funding

The authors received no specific grant or financial support for the conduct of this study.

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