Curatio : Journal of Advanced and Specialized Nursing, and Care Planning
E- ISSN : 3064-4089
Volume. 2 Issue 4 October 2025
Page No: 231-242

Unpacking the Influence of Fidelity, Learner Type, and Study Design on Simulation Outcomes in Nursing

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Received : August 29, 2025
Accepted : October 14, 2025
Published : October 31, 2025

Citation: Zaenal., (2025). Unpacking the Influence of Fidelity, Learner Type, and Study Design on Simulation Outcomes in Nursing. Curatio : Journal of Advanced and Specialized Nursing, and Care Planning, 2(4), 231-241.

https://doi.org/10.61978/curatio.v2i4.1408

ABSTRACT: Simulation-based learning (SBL) is a widely used instructional method in nursing education, valued for enhancing clinical competence, decision-making, and engagement, though outcomes vary considerably. This study synthesized findings from four meta-analyses to examine how simulation fidelity, participant type, and study design influence SBL effectiveness. Pooled effect sizes, confidence intervals, and heterogeneity metrics were analyzed, comparing moderator variables—simulation type (high/low fidelity, standardized patients, virtual), participant profile (students vs. clinical staff), and study design (quasi-experimental vs. RCT)—using stratified tables and standardized mean differences (SMD). Results showed consistently positive SBL outcomes across all simulation types (SMD: 0.52–1.20). High-fidelity simulations produced the strongest effects, while well-designed low-fidelity and virtual simulations also showed moderate effectiveness; standardized patients particularly benefited communication skill development. Clinical staff and advanced nurses achieved slightly better outcomes than undergraduate students, and RCTs yielded stronger, more reliable findings than quasi-experimental designs. Structured debriefing, contextual realism, and reflective practice were identified as key instructional elements supporting engagement and skill retention. These findings highlight the need for a moderator-aware approach when implementing SBL in nursing curricula. Thoughtful integration using evidence-based instructional design can maximize educational impact, and future research should prioritize isolating moderator effects and assessing long-term skill retention.

Keywords: Simulation-Based Learning, Nursing Education, Clinical Skills, Moderator Analysis, Instructional Design, Meta-Analysis.

INTRODUCTION

Simulation-based learning (SBL) has become a cornerstone of nursing education, adapting to the evolving requirements of healthcare and emphasizing experiential learning strategies. In contemporary nursing education, simulation represents not merely a supplemental instructional method but an integrated pedagogical approach aimed at bridging the gap between theoretical knowledge and practical application. This chapter synthesizes recent literature and meta-analytic findings to explore the current trends, impact, and theoretical foundations of SBL while highlighting the research problem addressed in the present study.

The increasing use of SBL is driven by its capacity to provide safe, repeatable, and student-centered learning experiences. High-fidelity simulations, standardized patients, and virtual simulations have emerged as dominant modalities in academic and clinical training programs (Gaspar & Banayat, 2024; Rajaguru & Park, 2021). These tools allow learners to engage in complex clinical scenarios, enhancing both technical and non-technical skills. The expansion of hybrid educational models, combining traditional clinical training with immersive simulation environments, signals a growing shift in nursing pedagogy toward more flexible and responsive instructional methods (Carman & Lim, 2024; Oh & Park, 2023).

SBL's adoption in nursing curricula is not limited to general clinical training; it also supports specialized areas such as geriatric care and critical care. The versatility of simulation modalities facilitates the accommodation of varied learner needs and aligns with competency-based education frameworks (Davitadze et al., 2022; Lee & Baek, 2024). Furthermore, advances in educational technology such as virtual reality have broadened access to high-quality simulations, enabling immersive experiences that contribute to deeper learning outcomes (Walker & Stevenson, 2016).

A substantial body of research affirms that SBL positively influences clinical competence, critical thinking, and decision-making. Meta-analytic evidence confirms that nursing students who engage in simulation-based instruction report greater self-confidence, improved skill proficiency, and enhanced readiness for clinical practice (Kao et al., 2021; Ruth, 2023). These outcomes are attributable to simulation's iterative nature and the opportunity for real-time feedback and reflective learning (Fegran et al., 2022). SBL environments promote teamwork and self-regulated learning, vital components of nursing performance (Murray, 2018).

Despite its strengths, SBL is not without challenges. Variability in simulation outcomes is evident across multiple studies, often attributed to inconsistent fidelity levels, facilitator experience, and debriefing quality (Rosa et al., 2022). Poorly executed simulations, particularly those lacking structured debriefing, may fail to produce the expected learning gains (Turrise et al., 2018). Moreover, some students report heightened anxiety during simulation activities, which can hinder performance and learning retention (Ford, 2023). Concerns about reduced exposure to real patient care, if SBL overcompensates traditional practice, further complicate implementation strategies (Chang & Do, 2024).

The effectiveness of SBL is informed by educational theory. Kolb's Experiential Learning Theory, which emphasizes learning through concrete experiences followed by reflection and conceptualization, is frequently cited in simulation research (Walker & Stevenson, 2016). Constructivist learning models also inform SBL design, advocating for learner-centered environments that promote active knowledge construction (Monteiro & Sibbald, 2020). These frameworks underscore the importance of immersive and interactive educational settings in cultivating professional competence.

A growing number of meta-analyses have evaluated the effectiveness of SBL, typically affirming its positive impact on nursing education (Rajaguru & Park, 2021). However, the degree of effectiveness often varies by simulation type, outcome measure, and study design. For instance, while high-fidelity simulation is widely regarded as beneficial, some meta-analyses suggest that low-fidelity and hybrid models may yield comparable results under certain conditions (Johnson, 2020). These findings point to the need for a more nuanced understanding of which factors most significantly influence SBL outcomes.

Against this backdrop, this study addresses the following research gap: What are the moderating factors that influence the effectiveness of simulation-based learning in nursing education? Specifically, it examines how simulation fidelity, participant type (e.g., students vs. staff), and study design (e.g., quasi-experimental vs. RCT) shape clinical skill outcomes. The novelty of this work lies in its synthesis of moderator effects drawn from existing meta-analyses. By analyzing these variables, the study aims to guide more targeted instructional design and inform evidence-based policy in simulation-based nursing education.

This chapter has introduced the scope and significance of SBL in nursing, reviewed relevant literature, and articulated the research problem. In doing so, it underscores the importance of identifying contextual and methodological factors that enhance or limit the impact of simulation on clinical training outcomes.

METHOD

Research Design

This study employs a secondary analysis approach, synthesizing existing meta-analytic data to identify moderating factors influencing the effectiveness of simulation-based learning (SBL) in nursing education. This methodology enables the reinterpretation of pooled effect sizes from published sources, providing a comprehensive understanding of the impact of simulation fidelity, participant type, and study design on clinical skill development.

Data Sources and Selection

Four major meta-analyses were selected for their rigorous methodological design, relevance, and breadth of included studies: Tonapa et al. (2021). These studies were chosen based on their focus on simulation-based interventions in nursing education and the availability of detailed statistical outcomes, including standardized mean differences (SMD), confidence intervals (CI), p-values, and heterogeneity metrics (I^2).

Methodological Standards for Secondary Analysis

To ensure methodological integrity, this secondary analysis followed best practices in meta-analytic research.

- Clear Objectives: The research questions and objectives were defined a priori to guide data extraction and analysis.
- Justification of Use: The selected meta-analyses offered pre-analyzed datasets, enabling unique interpretations focusing on moderator variables.
- Standardized Integration: Uniform data coding and extraction protocols were applied to ensure consistency. Data management was facilitated through spreadsheets and statistical software.
- Appropriate Statistical Models: Depending on the heterogeneity of the original studies, random-effects models were favored to generalize findings across varied contexts.
- Practical Significance: Clinical and educational relevance of findings was emphasized alongside statistical significance.
- Transparency and Reproducibility**:** Full documentation of extracted data, coding categories, and analytic steps supports replicability.

Moderator Analysis Protocol

Moderators were identified from the included meta-analyses and categorized as follows:

- Simulation Type: High-fidelity simulation (HFS), low-fidelity simulation (LF), standardized patients (SP), and virtual simulation (VS).
- Participant Type: Undergraduate nursing students vs. clinical staff.
- Study Design: Quasi-experimental vs. randomized controlled trials (RCTs).

The analysis included stratified tables and comparisons by moderator category. Effect sizes were recalculated or extracted for each subgroup, with attention to CI width and significance levels.

- Descriptive Contextualization: Baseline characteristics of the included studies were summarized before comparative analysis.
- Forest Plot Structuring: Where possible, forest plots or tabular summaries were used to present moderator outcomes.
- Interaction Testing: Subgroup analyses included basic statistical tests to assess the moderating impact of each variable (Johansen et al., 2024; Raman et al., 2024).

Effect Size Extraction and Heterogeneity Management

Effect size analysis was based on standardized procedures:

- Effect Size Metrics: SMD was primarily used for continuous outcomes, aligning with conventional practices in nursing education research.

- Reporting Standards: All effect sizes were reported with corresponding confidence intervals and p-values. Sample sizes and standard deviations were included where available.
- Heterogeneity Assessment: I^2 statistics were used to quantify variability among studies. Studies showing high heterogeneity prompted subgroup analyses and sensitivity checks.
- Robustness Checks: Sensitivity analyses assessed how variations in study quality or design influenced the pooled results.
- Integrated Reporting: Moderator effects, effect sizes, and heterogeneity metrics were compiled into tables to support synthesis and interpretation.

Ethical Considerations

As this study is a secondary analysis of published data, ethical approval was not required. However, all sources were cited appropriately, and data usage adhered to the principles of academic transparency and respect for intellectual property.

RESULT AND DISCUSSION

This chapter presents the results of the secondary analysis based on findings from meta-analyses related to simulation-based learning (SBL) in nursing education. The outcomes are organized by four key subthemes: overall meta-analytic effectiveness, simulation type, participant type, and study design. Where appropriate, findings are displayed in tabular format to ensure clarity.

Meta-Analytic Effectiveness

Table 1. Pooled Effect Sizes, Confidence Intervals, and Heterogeneity in SBL Meta-Analyses

Effect Size (SMD)	95% CI	p-value	I^2	Tool Used
0.64	0.38–0.90	<0.05	57%	OSCE
0.78	0.51–1.05	<0.001	68%	OSCE, RAPIDS
0.61	0.44–0.78	<0.01	70%	RAPIDS
0.52	0.22–0.82	0.03	62%	OSCE

The pooled effect sizes across the reviewed meta-analyses range between 0.52 and 0.78, indicating a moderate to strong effect of SBL interventions on clinical skills. The p-values are statistically significant across all studies, though moderate to high heterogeneity ($I^2 > 50\%$) suggests differences in implementation context and participant demographics. OSCE and RAPIDS are consistent tools in clinical performance evaluation.

Simulation Type as Moderator

Table 2. Effectiveness of Different Simulation Modalities

Simulation Type	Effect Size (g/SMD)	95% CI
High-Fidelity Simulation	1.20	0.90–1.50
Low-Fidelity Simulation	0.58	0.32–0.84
Standardized Patients	0.71	0.45–0.97
Virtual Simulation	0.65	0.38–0.92

High-fidelity simulation consistently yields the highest effect size, supporting its value in skill-intensive training. However, low-fidelity and virtual simulations also demonstrate moderate effectiveness, suggesting that well-designed instructional strategies can make less complex simulations effective. Standardized patients particularly benefit communication skill development.

Participant Type

Table 3. Effectiveness by Participant Group

Participant Type	Outcome Focus	Effect Size (SMD)	95% CI
Undergraduate Students	Skill development	0.89	0.55–1.23
Clinical Staff	Teamwork, response	1.03	0.68–1.38
Advanced Practice Nurses	Critical decision-making	1.10	0.74–1.46

Effect sizes for clinical staff and advanced practice nurses are marginally higher than for undergraduate students, likely due to prior experience and the nature of advanced simulations. These results suggest that tailoring simulation content to participant expertise enhances training outcomes.

Study Design

Table 4. Comparative Effectiveness by Study Design

Study Design	Effect Size (SMD)	95% CI	Bias Risk
Quasi-Experimental	0.76	0.49–1.03	Moderate
Randomized Controlled Trial (RCT)	1.14	0.88–1.40	Low

RCTs show stronger effect sizes and lower risk of bias compared to quasi-experimental designs. These findings underline the value of rigorous methodology in evaluating educational interventions. While quasi-experimental designs are more common in educational contexts, the trade-off is reduced control over confounding variables.

In summary, meta-analytic synthesis confirms the overall effectiveness of simulation-based learning in nursing. The effectiveness varies depending on simulation type, participant characteristics, and study design. High-fidelity simulations and RCT designs generally yield stronger outcomes, but all modalities demonstrate value when supported by robust instructional design and assessment practices.

Simulation-based learning (SBL) in nursing education has demonstrated consistent effectiveness across a range of educational contexts. However, the degree of its impact is heavily influenced by specific design and contextual factors, instructional approaches, and the way simulations are integrated into the curriculum. This discussion elaborates on the key moderating variables and strategic practices that shape the learning outcomes of SBL.

Design and Contextual Factors Moderating Simulation Outcomes

Simulation fidelity is a primary factor that affects outcomes. High-fidelity simulations (HFS), involving advanced technology and realistic clinical environments, have been shown to significantly enhance knowledge retention, clinical reasoning, and learner confidence when compared to lower-fidelity alternatives. The immersive nature of HFS supports the replication of complex scenarios that closely mimic real clinical challenges (Haghbin et al., 2024; Shiferaw et al., 2020). Yet, the educational value of low-fidelity simulation should not be discounted, particularly when paired with structured learning objectives and appropriate debriefing.

The quality of debriefing is universally acknowledged as essential to the success of simulation-based interventions. Structured debriefing models facilitate reflective practice, reinforce learning objectives, and promote self-awareness. Debriefing enables students to critically analyze their performance, enhancing the retention of skills and their application in future scenarios (Araghi et al., 2024; Wiksten et al., 2016). Additionally, instructors play a critical role; those with extensive training and experience in simulation facilitation can provide timely, constructive feedback and optimize learner engagement (Diener et al., 2016; Ghazanfari et al., 2022).

Environmental factors, such as psychological safety, physical comfort, and peer dynamics, also contribute to the effectiveness of simulations. Students are more likely to engage fully and learn meaningfully in a space that supports open communication and collaborative learning (Ghaedi & Hosseini, 2023).

Influence of Instructional Design on Engagement and Skill Retention

The instructional design of simulation activities directly affects learner motivation and knowledge retention. Key elements include alignment of simulations with learning outcomes, incorporation of active learning strategies, and the contextualization of scenarios. When simulations reflect real-world clinical practice and address actual challenges faced by nurses, learners are more engaged and able to transfer their learning to professional settings (Buecker et al., 2020; Mohammadi et al., 2020).

Innovative instructional techniques, such as the integration of virtual reality or real-time feedback apps, increase interactivity and promote deeper engagement (Abesi & Golikani, 2023). Repetitive practice and immediate feedback during simulations further support the consolidation of technical and decision-making skills (Aziz et al., 2021). These strategies help bridge the gap between cognitive understanding and psychomotor proficiency.

Best Practices for Debriefing in Simulation-Based Education

Effective debriefing is structured, reflective, and psychologically safe. Models such as Debriefing for Meaningful Learning (DML) ensure that learners explore not only what occurred during a simulation but also why it happened and how it relates to clinical practice. Such models promote critical thinking and professional identity formation (Viani et al., 2020).

Equally important is fostering an atmosphere of trust and psychological safety during debriefing. Learners must feel comfortable discussing errors and uncertainties without fear of embarrassment or reprimand. Evidence-based debriefing tools, including structured prompts, video-assisted reviews, and thematic reflection guides, further enhance learner insight and development (Debbaneh et al., 2019).

Integrating Moderator-Aware Simulation Strategies into Nursing Curricula

To maximize the impact of SBL, simulation strategies must be intentionally aligned with curriculum goals. Curriculum mapping ensures that simulation scenarios are strategically placed to reinforce key competencies at appropriate stages of learning (Miola et al., 2022). Additionally, flexible designs allow simulations to be adapted to different learner levels, thereby addressing prior experience and individual readiness (Brevik et al., 2021).

Continuous evaluation and integration of student and faculty feedback are essential for refining simulations and ensuring relevance. Simulation scenarios must also be kept current with clinical best practices and evolving educational standards (Gao et al., 2020; Lee et al., 2024). Ultimately, successful integration of simulation into nursing education depends on its ability to evolve responsively, maintain relevance, and support diverse learner needs through evidence-based practice.

In conclusion, design fidelity, instructional strategies, debriefing quality, and thoughtful curriculum integration are crucial to maximizing the benefits of simulation-based learning in nursing education. A moderator-aware approach enables more personalized, impactful learning experiences that contribute to the development of competent, confident, and reflective nursing professionals.

CONCLUSION

Simulation-based learning (SBL) continues to demonstrate its value as a transformative instructional strategy in nursing education. The findings presented in this study underscore the importance of understanding and leveraging key moderating factors simulation fidelity, participant characteristics, and research design to optimize learning outcomes. Meta-analytic evidence consistently affirms the effectiveness of SBL in improving clinical skills, critical thinking, and decision-making, while also highlighting significant variability driven by contextual and methodological differences.

High-fidelity simulations (HFS) tend to yield stronger outcomes in terms of learner engagement and skill development, especially when supported by structured debriefing and experienced facilitators. However, low-fidelity simulations, standardized patients, and virtual environments also demonstrate substantial benefits when integrated into a robust instructional framework. These findings suggest that the success of SBL is not solely dependent on fidelity level, but rather on the quality of instructional design and alignment with learner needs.

The role of participant type is another vital consideration. Clinical staff and advanced practice nurses often experience higher gains from simulation due to their ability to integrate prior knowledge with complex scenarios. Meanwhile, undergraduate students benefit most from structured, foundational simulations that build core competencies and self-confidence. Tailoring simulations to participant experience levels enhances learning effectiveness across the board.

Study design significantly influences the interpretation of SBL outcomes. Randomized controlled trials (RCTs) offer higher internal validity and demonstrate stronger effect sizes than quasi-experimental designs. This reinforces the call for more rigorous research methodologies and comprehensive reporting standards to strengthen the evidence base.

This study contributes to the growing literature on simulation-based education by synthesizing data through a moderator-aware lens. It emphasizes the necessity of intentional design, context sensitivity, and strategic curricular integration. Educators and curriculum developers are encouraged to adopt evidence-informed approaches that account for the diverse factors impacting simulation outcomes.

Future research should focus on isolating specific moderator effects through experimental designs, exploring long-term retention outcomes, and expanding simulation practices to underrepresented contexts. As healthcare systems continue to evolve, simulation remains a dynamic and essential tool for preparing nursing professionals to deliver safe, effective, and compassionate care.

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