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Effectiveness of High-Fidelity Simulation on Creative Clinical Reasoning Among Nursing Students: A Quasi-Experimental Study

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ABSTRACT

High-fidelity simulation has become a key pedagogical strategy in nursing education, yet its specific effect on creative clinical reasoning remains underexplored, particularly in Southeast Asian higher-education contexts. The aim of this study was to evaluate the effectiveness of high-fidelity simulation on creative clinical reasoning, clinical judgment, and self-efficacy among nursing students. This quasi-experimental pre-test/post-test control group study, conducted at a private university in Palembang, Indonesia, evaluated its effectiveness among ninety final-year nursing students allocated to a simulation group (n=46) receiving four structured high-fidelity simulation sessions over eight weeks or a control group (n=44) receiving conventional case-based learning. Outcomes were measured using the Health Sciences Reasoning Test, a Creative Clinical Problem-Solving Scale, the Lasater Clinical Judgment Rubric, and the General Self-Efficacy Scale, with all scores standardized to a 0–100 metric, and analyzed using paired t-tests, independent t-tests, and ANCOVA with pre-test covariates. The simulation group demonstrated significantly greater improvements than controls in clinical reasoning (mean difference 16.2, 95% CI 13.8–18.6, $p<0.001$, Cohen's $d=1.98$), creative problem-solving (15.5, $p<0.001$, $d=2.10$), self-efficacy (14.5, $p<0.001$, $d=1.73$), and clinical judgment (16.3, $p<0.001$, $d=2.12$); ANCOVA confirmed significant group effects (partial $\eta^2=0.322$–0.375), and a positive dose-response correlation was observed ($r=0.72$, $p<0.001$). High-fidelity simulation was highly effective in enhancing creative clinical reasoning and related competencies, with large effect sizes supporting its systematic integration into nursing education curricula.

1. Introduction

Clinical reasoning constitutes a fundamental competency in nursing education, underpinning safe and effective patient care delivery across diverse healthcare settings[1,2]. The ability to systematically gather, interpret, and synthesize clinical information to make sound judgments represents the cornerstone of professional nursing practice[3]. However, developing clinical reasoning among nursing students remains one of the most persistent challenges in health professions education, particularly as healthcare systems become increasingly complex and patient acuity rises[4]. Globally, nursing education faces a critical tension between the theoretical preparation students receive in classroom settings and the practical reasoning skills demanded in clinical environments[5,6]. This theory–practice gap is further exacerbated by limited clinical placement opportunities, increasing student numbers, patient-safety concerns, and disruptions caused by the COVID-19 pandemic that significantly reduced face-to-face clinical learning experiences[7]. In Southeast Asian countries, including Indonesia, these challenges are compounded by variations in clinical facility resources, preceptor availability, and standardization of clinical teaching approaches.

Simulation-based education has emerged as a promising pedagogical strategy to address these challenges by providing controlled, reproducible, and safe learning environments in which students can practice clinical reasoning without risk to patients[8,9]. High-fidelity simulation employing computerized patient mannequins that replicate physiological responses enables students to engage in realistic clinical scenarios that demand the same cognitive processes as authentic patient care[10]. Systematic reviews and meta-analyses have consistently demonstrated that simulation-based teaching methods improve critical thinking, clinical competence, and knowledge retention compared with traditional approaches[1,4,11], with comparable benefits reported for virtual and flipped simulation modalities[12-14] and for manikin-based simulation targeting clinical reasoning[15].

Despite the growing evidence base, a significant gap exists regarding the creative dimension of clinical reasoning. While clinical reasoning has been extensively studied as a convergent cognitive process, the divergent aspect—specifically the ability to generate novel, flexible, and innovative solutions to complex or ambiguous clinical problems—remains underexplored[16]. Creative clinical reasoning is particularly relevant in contemporary healthcare, where patients frequently present with multimorbidity and atypical symptoms that require practitioners to think beyond algorithmic decision-making.

The theoretical framework for this study draws on Kolb's Experiential Learning Theory, which posits that effective learning occurs through a cyclical process of concrete experience, reflective observation, abstract conceptualization, and active experimentation[17]. High-fidelity simulation provides this complete experiential cycle within a structured educational context. Additionally, Tanner's Clinical Judgment Model describes the cognitive processes of noticing, interpreting, responding, and reflecting that are essential for clinical reasoning development[18]. The integration of these perspectives suggests that simulation environments may be uniquely positioned to foster not only conventional clinical reasoning but also its creative dimensions. The aim of this study was to evaluate the effectiveness of high-fidelity simulation on creative clinical reasoning, clinical judgment, and self-efficacy among nursing students at a private university in Palembang, Indonesia.

2. Methods

2.1 Study design and setting

This study employed a quasi-experimental pre-test/post-test control group design conducted at a private university in Palembang, Indonesia, between August and November 2024. The university operates a dedicated simulation center equipped with high-fidelity patient mannequins and standardized clinical simulation rooms. The study was conducted over an eight-week intervention period embedded within the regular academic curriculum.

2.2 Participants and sampling

The target population comprised undergraduate nursing students enrolled in the third to fifth semester. Inclusion criteria were active enrollment status, completion of foundational nursing courses, willingness to participate in all sessions, and provision of informed consent. Sample size was determined using G*Power 3.1 (effect size $f=0.35$, $\alpha=0.05$, $power=0.80$), yielding a minimum of 34 participants per group. After accounting for an anticipated 15% attrition, 100 students were recruited via convenience sampling, of whom 90 completed the study: 46 in the simulation group and 44 in the control group.

2.3 Intervention

The simulation group participated in four structured high-fidelity simulation sessions conducted biweekly. Each session lasted approximately 90 minutes and followed the INACSL Standards of Best Practice, comprising pre-briefing (15 minutes), active simulation (30 minutes), and structured debriefing using Gibbs' Reflective Cycle (45 minutes)[19]. Debriefing followed established methods documented in the nursing simulation literature[20,21]. Scenarios presented progressively complex clinical situations requiring creative problem-solving. The control group received conventional case-based learning of equivalent duration and frequency.

2.4 Instruments

Four validated instruments were administered at baseline and post-intervention: the Health Sciences Reasoning Test (HSRT; Cronbach's α=0.82)[22], the Creative Clinical Problem-Solving Scale (CCPS; α=0.79)[16], the Lasater Clinical Judgment Rubric (LCJR; α=0.88)[18], and the General Self-Efficacy Scale (GSE; α=0.86)[23]. All instruments were translated into Bahasa Indonesia and validated through expert panel review (content validity index 0.87–0.94) and pilot testing with 20 students not included in the main study. To facilitate comparison across measures, all instrument scores were linearly transformed to a standardized 0–100 metric.

2.5 Data analysis

Data were analyzed using SPSS version 26.0. Normality was assessed using the Shapiro–Wilk test (all $p>0.05$), and homogeneity of variances was confirmed using Levene's test. Baseline equivalence was assessed using independent t-tests and chi-square tests. Within-group changes were analyzed using paired t-tests, and between-group differences were examined using analysis of covariance (ANCOVA) with pre-test scores as covariates. Effect sizes were calculated using Cohen's d and partial η^2. Pearson correlation was used to assess the dose-response relationship between simulation exposure and outcome gains. Statistical significance was set at α=0.05 (two-tailed).

2.6 Ethical considerations

This study was conducted as an educational evaluation embedded within routine curricular activities and therefore did not require formal research ethics committee approval. Nonetheless, all procedures adhered to the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants, participation was entirely voluntary with no impact on academic grades, and all data were anonymized and stored securely with access restricted to the research team.

3. Results

3.1 Participant characteristics

A total of 90 nursing students completed the study, yielding a 100% completion rate. Baseline demographic and academic characteristics are summarized in Table 1. As detailed in Table 1, the mean age was 20.4 years (SD=1.3) in the simulation group and 20.7 years (SD=1.5) in the control group. The two groups were comparable across all baseline variables, including sex distribution (female: 82.6% vs. 81.8%), grade point average (3.24 vs. 3.19), prior clinical hours (120.3 vs. 118.6), and pre-test clinical reasoning (62.4 vs. 61.8) and creative problem-solving (58.7 vs. 59.2) scores, with no statistically significant differences (all $p>0.05$), confirming group equivalence at baseline.

Table 1. Demographic and baseline characteristics of participants (N=90).

Characteristic	Simulation Group (n=46)	Control Group (n=44)	p-value
Age (years), mean (SD)	20.4 (1.3)	20.7 (1.5)	0.312
Female, n (%)	38 (82.6)	36 (81.8)	0.921
GPA, mean (SD)	3.24 (0.38)	3.19 (0.41)	0.546
Prior clinical hours, mean (SD)	120.3 (24.7)	118.6 (26.1)	0.748
Semester (3rd/4th/5th), n	12/18/16	10/19/15	0.874
Pre-test clinical reasoning, mean (SD)	62.4 (8.7)	61.8 (9.2)	0.752
Pre-test creative problem-solving, mean (SD)	58.7 (7.9)	59.2 (8.4)	0.774

Note: SD = standard deviation. p-values derived from independent t-tests and chi-square tests.

3.2 Primary outcomes

Pre-test and post-test scores for all outcome variables are presented in Table 2. As detailed in Table 2, the simulation group demonstrated significantly greater improvements across all four outcomes compared with the control group. Clinical reasoning improved by 16.2 points (95% CI 13.8–18.6, $p<0.001$, d=1.98) in the simulation group versus 4.5 points (95% CI 2.1–6.9, $p=0.001$, d=0.50) in controls.

Creative problem-solving improved by 15.5 points (95% CI 13.0–18.0, $p<0.001$, d=2.10) versus 3.9 points (95% CI 1.6–6.2, $p=0.003$, d=0.47). Self-efficacy increased by 14.5 points (95% CI 11.9–17.1, $p<0.001$, d=1.73) versus 3.8 points (95% CI 1.3–6.3, $p=0.005$, d=0.41). Clinical judgment improved by 16.3 points (95% CI 13.8–18.8, $p<0.001$, d=2.12) versus 4.4 points (95% CI 2.0–6.8, $p=0.001$, d=0.52). These between-group comparisons are illustrated in Figure 1.

Table 2. Comparison of pre-test and post-test scores between simulation and control groups.

Outcome Variable	Group	Pre-Test Mean (SD)	Post-Test Mean (SD)	Mean Diff. (95% CI)	Cohen's d (95% CI)	p-value
Clinical Reasoning	Simulation	62.4 (8.7)	78.6 (7.3)	16.2 (13.8–18.6)	1.98 (1.48–2.48)	<0.001
	Control	61.8 (9.2)	66.3 (8.8)	4.5 (2.1–6.9)	0.50 (0.07–0.93)	0.001
Creative Problem-Solving	Simulation	58.7 (7.9)	74.2 (6.8)	15.5 (13.0–18.0)	2.10 (1.58–2.62)	<0.001
	Control	59.2 (8.4)	63.1 (8.0)	3.9 (1.6–6.2)	0.47 (0.05–0.90)	0.003
Self-Efficacy	Simulation	65.3 (9.1)	79.8 (7.5)	14.5 (11.9–17.1)	1.73 (1.25–2.21)	<0.001
	Control	64.7 (9.5)	68.5 (9.0)	3.8 (1.3–6.3)	0.41 (−0.02–0.83)	0.005
Clinical Judgment	Simulation	60.1 (8.3)	76.4 (7.0)	16.3 (13.8–18.8)	2.12 (1.60–2.64)	<0.001
	Control	59.8 (8.6)	64.2 (8.3)	4.4 (2.0–6.8)	0.52 (0.09–0.95)	0.001

Note: CI = confidence interval. Cohen's d calculated from paired pre–post differences within each group.

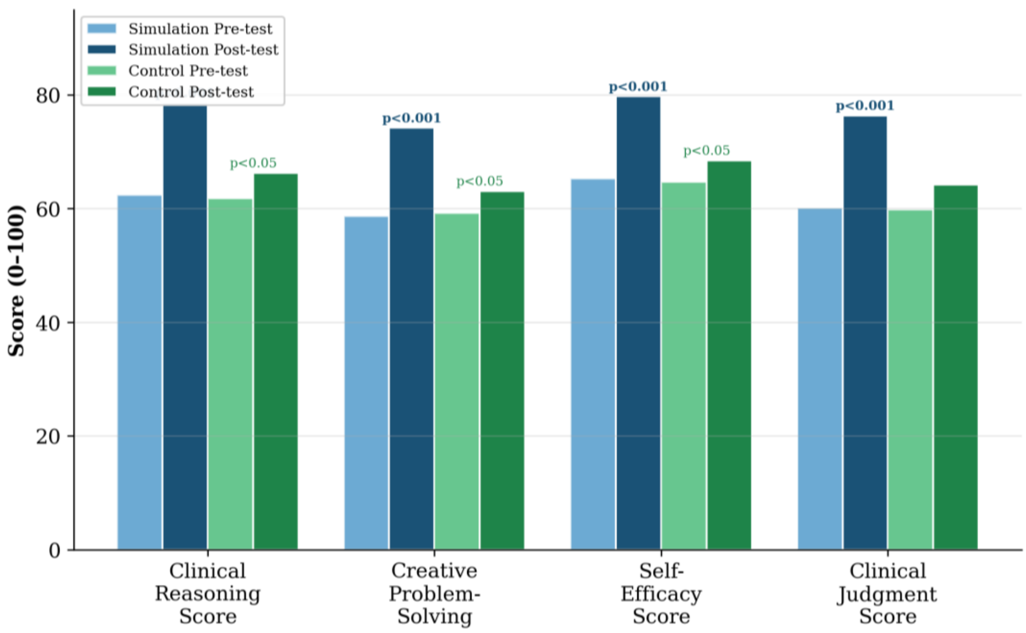

Figure 1. Comparison of pre-test and post-test scores between the simulation and control groups across the four outcome variables.

3.3 ANCOVA results

ANCOVA with pre-test scores as covariates confirmed significant group effects for all outcomes, as detailed in Table 3. The largest effect was observed for creative problem-solving ($F=52.18$, $p<0.001$, partial $\eta^2=0.375$), followed by clinical judgment ($F=50.91$, $p<0.001$, partial $\eta^2=0.369$), clinical reasoning ($F=48.72$, $p<0.001$, partial $\eta^2=0.359$), and self-efficacy ($F=41.35$, $p<0.001$, partial $\eta^2=0.322$). All group effect sizes exceeded the conventional threshold for a large effect.

Table 3. Analysis of covariance (ANCOVA) results for post-test scores with pre-test as covariate.

Dependent variable	Source	F	P-value	Partial η²	Effect size
Post-test Clinical Reasoning	Group	48.72	<0.001	0.359	Large
	Pre-test (covariate)	35.41	<0.001	0.289	Large
Post-test Creative Problem-Solving	Group	52.18	<0.001	0.375	Large
	Pre-test (covariate)	28.63	<0.001	0.248	Large
Post-test Self-Efficacy	Group	41.35	<0.001	0.322	Large
Post-test Clinical Judgment	Group	50.91	<0.001	0.369	Large

Note: Partial η^2 interpretation: small (0.01), medium (0.06), large (0.14).

3.4 Score progression and correlation analysis

The progression of scores across the four simulation sessions and assessment time points is illustrated in Figure 2. The simulation group showed consistent upward trajectories, with the steepest gains occurring between Sessions 1 and 3. A Pearson correlation analysis revealed a significant positive association between total simulation exposure (hours) and clinical reasoning score gain ($r=0.72$, $p<0.001$), as displayed in Figure 3, indicating a clear dose-response relationship.

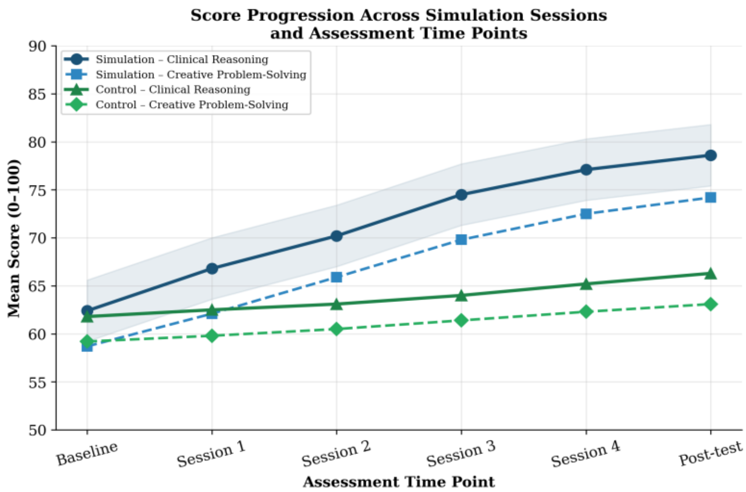

Figure 2. Score progression across simulation sessions and assessment time points. The shaded area represents the 95% confidence interval for the simulation group.

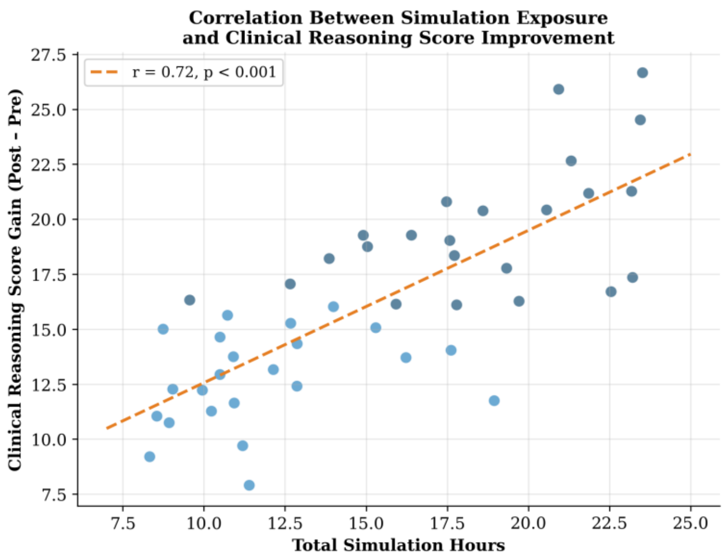

Figure 3. Correlation between simulation exposure and clinical reasoning score improvement ($r=0.72$, $p<0.001$).

4. Discussion

The present study investigated the effectiveness of high-fidelity simulation on creative clinical reasoning, clinical judgment, and self-efficacy among nursing students at a private university in Palembang. The principal findings demonstrated significantly greater improvements in the simulation group across all four outcome measures (Cohen's d=1.73–2.12), indicating practically meaningful educational gains.

The substantial improvement in clinical reasoning (d=1.98) is consistent with recent evidence. In a multi-centre study, Bogossian et al.[3] found that high-fidelity simulation of acute deteriorating patients improved nursing students' recognition of and response to clinical deterioration. A systematic review by Alshehri et al.[24] similarly concluded that high-fidelity simulation enhances clinical reasoning-related skills. The larger effect sizes observed in the present study may be attributable to the progressive complexity design of the simulation scenarios, consistent with Kolb's experiential learning cycle[17]. Kim et al.[4] likewise reported that higher-fidelity simulations produced greater learning outcomes.

The finding that creative problem-solving showed the largest effect (d=2.10) is particularly noteworthy, as this dimension has received limited attention in the literature. Gonzalez and Kardong-Edgren[10] advocated deliberate practice-based simulation for mastery learning without specifically addressing creative reasoning. The present study contributes by demonstrating that simulation scenarios intentionally designed around ambiguous, multifaceted problems enhance students' capacity for generating novel clinical responses.[16,22]

The improvement in self-efficacy (d=1.73) parallels findings from Guerrero et al.[25], who reported enhanced self-confidence following high-fidelity simulation. This likely reflects mastery experiences from repeated successful engagement with challenging scenarios in psychologically safe environments[9]. The clinical judgment improvement (d=2.12) can be interpreted through Tanner's Clinical Judgment Model[18], in which the structured simulation phases systematically develop the processes of noticing, interpreting, responding, and reflecting.

The positive dose-response correlation (r=0.72) supports the premise that sustained simulation exposure yields progressively larger learning gains, consistent with the deliberate practice framework[10,19]. This finding has important curriculum-design implications: isolated simulation sessions may be insufficient, and repeated, structured experiences appear necessary to achieve substantial improvements in reasoning.

These findings carry several practical implications. First, the large effect sizes support integrating high-fidelity simulation as a core pedagogical strategy. Second, the progressive complexity design provides a replicable framework for nursing curricula. Third, the emphasis on creative reasoning challenges educators to move beyond protocol-execution scenarios toward authentic clinical ambiguity. Fourth, in contexts where clinical placement opportunities are limited, simulation offers a standardized educational alternative[6,7].

This study possesses several strengths. The quasi-experimental design with a well-matched control group enabled meaningful between-group comparisons. Four validated instruments provided comprehensive assessment across multiple competency domains, and the 100% completion rate together with baseline group equivalence strengthened internal validity. Several limitations must be acknowledged. First, the quasi-experimental design without randomization introduces potential selection bias, although baseline equivalence was demonstrated. Second, the single-institution sample limits the generalizability of the findings to other educational settings. Third, the immediate post-test design precludes conclusions about long-term retention; future studies should incorporate follow-up assessments at three and six months[2,8].

5. Conclusion

High-fidelity simulation was highly effective in enhancing creative clinical reasoning, clinical judgment, and self-efficacy among nursing students, with large effect sizes across all outcome measures (Cohen's d=1.73–2.12). The simulation group demonstrated significantly greater improvements than those achieved through conventional case-based learning, and a dose-response relationship was observed between simulation exposure and reasoning gains. These findings support the integration of structured, progressively complex high-fidelity simulation into nursing education curricula as a primary pedagogical strategy. Nursing programs are encouraged to invest in simulation infrastructure and faculty development. Future research should employ randomized controlled designs with multi-site sampling and longitudinal follow-up to confirm the generalizability and durability of these effects across diverse educational and cultural contexts.

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