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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

Background. High-fidelity simulation is a key teaching method in nursing education, but its effect on creative clinical reasoning is still little studied, especially in Southeast Asian higher education.

Objective. This study evaluated the effectiveness of high-fidelity simulation on creative clinical reasoning, clinical judgment, and self-efficacy in nursing students.

Methods. We used a quasi-experimental pre-test/post-test control group design at a private university in Palembang, Indonesia. Ninety undergraduate nursing students took part. The simulation group (n = 46) attended four structured high-fidelity simulation sessions over eight weeks. The control group (n = 44) followed conventional case-based learning. Clinical reasoning (Health Sciences Reasoning Test), creative problem-solving (Creative Clinical Problem-Solving Scale), clinical judgment (Lasater Clinical Judgment Rubric), and self-efficacy (General Self-Efficacy Scale) were measured before and after the intervention. All scores were standardized to a 0–100 metric. Analyses used paired and independent t-tests, ANCOVA with pre-test scores as covariates, and Cohen's d.

Results. Pre–post gains were larger in the simulation group than in the control group for clinical reasoning (16.2 vs 4.5 points; within-group d = 2.02), creative problem-solving (15.5 vs 3.9; d = 2.10), self-efficacy (14.5 vs 3.8; d = 1.73), and clinical judgment (16.3 vs 4.4; d = 2.12); the simulation-group gains had p F(1, 87) = 41.35–52.18, p r = 0.72, p < 0.001).

Conclusion. Four high-fidelity simulation sessions were associated with larger gains in creative clinical reasoning and related competencies than conventional case-based learning. These findings support structured simulation in nursing curricula, pending randomized, multicenter confirmation.

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1. Introduction

Clinical reasoning is a core competency in nursing education. It underpins safe, effective patient care in every healthcare setting[1,2]. Nurses must gather information, interpret it, and synthesize it into sound judgments. This ability sits at the heart of professional practice[3]. Teaching it to students is still among the hardest tasks in health professions education, particularly as healthcare systems grow more complex and patients become more acutely ill[4]. Worldwide, tension runs through nursing education. What students learn in the classroom does not always match the practical reasoning that clinical environments demand[5,6]. The theory–practice gap widens when placements are scarce, when student numbers climb, when patient safety is at stake, or when a pandemic such as COVID-19 sharply cuts face-to-face clinical learning[7]. A 2025 systematic review concluded that clinical simulation helps bridge this gap[8]. In Southeast Asia, including Indonesia, uneven clinical facility resources, limited preceptor availability, and little standardization of clinical teaching add to the problem.

Simulation-based education has emerged as a promising answer. Its settings are controlled, reproducible, and safe, so students can practice clinical reasoning without any risk to patients[9,10]. In high-fidelity simulation, computerized patient manikins reproduce physiological responses, and students work through realistic scenarios that call for the same thinking as real patient care[11]. Systematic reviews and meta-analyses repeatedly show gains in critical thinking, clinical competence, and knowledge retention over traditional teaching[1,4,12]. A meta-analysis of randomized and quasi-experimental studies found that simulation-based learning also improves nursing students' clinical decision-making skills[13]. Virtual and flipped simulation formats report similar benefits[14–16]. So does manikin-based simulation aimed at clinical reasoning[17].

Even so, the creative side of clinical reasoning has received little attention. In nursing education, creative thinking has been examined mainly in dedicated innovation courses[18]. Clinical reasoning has mostly been studied as a convergent process. Its divergent counterpart, the ability to produce novel, flexible, and inventive solutions to complex or ambiguous clinical problems, remains underexplored. Why does this matter? Patients often arrive with multimorbidity and atypical symptoms. Practitioners then need to think beyond algorithmic decision-making, and creativity has been described as an important component of diagnostic reasoning[19].

Simulation is a natural setting for this creative side. Scenarios can be built around incomplete information, competing priorities, and atypical presentations, and none of these has a single scripted answer. Students must then generate and weigh several explanations before they act. Evidence on this possibility is still thin. Studies of simulation in nursing often report knowledge, skills, competence, or confidence[20,21], and clinical judgment can be rated with validated rubrics[22]. Few of the studies we reviewed asked whether simulation changes how flexibly students reason. Indonesian nursing programs add a practical reason to ask: clinical judgment tools such as the Lasater rubric are already available in Indonesian[23], so the outcome can be measured in local classrooms.

This study draws on Kolb's Experiential Learning Theory. In that view, learning moves through a cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation[24]. High-fidelity simulation can supply every stage. It does so within a structured educational setting. Tanner's Clinical Judgment Model adds a second lens: clinicians notice, interpret, respond, and reflect as they reason[25]. Together, the two perspectives suggest that simulation may be well placed to build conventional clinical reasoning and its creative dimensions alike.

Does high-fidelity simulation improve creative clinical reasoning? Does it also lift clinical judgment and self-efficacy? We put both questions to nursing students at a private university in Palembang, Indonesia. The aim was to evaluate the effect of simulation against conventional case-based learning in a controlled pre-test/post-test design. The novelty is threefold. The creative, divergent side of clinical reasoning is the primary outcome, not a by-product of simulation. Creative problem-solving, clinical judgment, and self-efficacy are measured in one study and placed on a single 0–100 metric, so the three can be compared directly. And the setting is an Indonesian nursing program, where, as far as the literature we reviewed shows, evidence on creative clinical reasoning, clinical judgment, and self-efficacy studied together is scarce.

2. Methods

2.1 Study Design and Setting

The study used a quasi-experimental pre-test/post-test control group design and is reported with reference to the TREND statement for nonrandomized designs[26]. It ran at a private university in Palembang, Indonesia, from August to November 2024. The university has a dedicated simulation center, equipped with high-fidelity patient manikins and standardized clinical simulation rooms. The intervention lasted eight weeks. It was embedded in the regular academic curriculum.

2.2 Participants and Sampling

The target population was undergraduate nursing students in the third to fifth semester. To be included, students had to be actively enrolled, have completed the foundational nursing courses, be willing to attend all sessions, and give informed consent. Sample size was calculated in G*Power 3.1 (effect size f = 0.35, α = 0.05, power = 0.80), which gave a minimum of 34 participants per group. Allowing for 15% anticipated attrition, 100 students were recruited by convenience sampling. In all, 90 completed the study (90%): 46 in the simulation group and 44 in the control group.

2.3 Intervention

The simulation group took part in four structured high-fidelity simulation sessions, held every two weeks. Each lasted about 90 minutes and followed the INACSL Healthcare Simulation Standards of Best Practice: pre-briefing (15 minutes)[27], active simulation (30 minutes)[28], and structured debriefing based on Gibbs' Reflective Cycle[29] (45 minutes)[30]. Debriefing drew on methods established in the nursing simulation literature[31–33]. The scenarios grew steadily more complex and required creative problem-solving. The control group had conventional case-based learning of the same duration and frequency.

2.4 Instruments

Four instruments were given at baseline and after the intervention. These were the Health Sciences Reasoning Test (HSRT; Cronbach's α = 0.82)[34], the Creative Clinical Problem-Solving Scale (CCPS; α = 0.79)[35], the Lasater Clinical Judgment Rubric (LCJR; α = 0.88)[25,36], and the General Self-Efficacy Scale (GSE; α = 0.86)[37]. All were translated into Bahasa Indonesia; an Indonesian version of the LCJR has been reported to be valid and reliable[23], and the rubric has also been validated for simulation-based education in other languages[22]. Validation combined expert panel review (content validity index 0.87–0.94) with pilot testing on 20 students who were not part of the main study. So that measures could be compared, every instrument score was linearly transformed to a standardized 0–100 metric.

2.5 Data Analysis

Data were analyzed in SPSS version 26.0. Normality was checked with the Shapiro–Wilk test (all $p > 0.05$), and Levene's test confirmed homogeneity of variances. Baseline equivalence was assessed with independent t-tests and chi-square tests. Paired t-tests examined changes within groups, while analysis of covariance (ANCOVA) with pre-test scores as covariates examined differences between groups (degrees of freedom 1 and 87). Effect sizes were Cohen's d, calculated from the paired pre–post differences within each group, and partial η^2. To test the relationship between total simulation hours and outcome gains, a Pearson correlation was used. Significance was set at α = 0.05 (two-tailed).

2.6 Ethical Considerations

The study protocol was approved by Ethical Committee of Social Research, Enigma Institute, Indonesia (Approval number 2024/0158). All procedures nonetheless followed the ethical principles of the Declaration of Helsinki. Every participant gave written informed consent. Participation was entirely voluntary and had no bearing on academic grades. All data were anonymized and stored securely, with access limited to the research team.

3. Results

3.1 Participant Characteristics

In all, 90 nursing students completed the study (90% of the 100 recruited). Baseline demographic and academic characteristics are summarized 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 groups were comparable on every baseline variable, 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. No difference was statistically significant (all $p > 0.05$), which suggests comparable groups 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 were derived from independent t-tests (continuous variables) and chi-square tests (categorical variables).

3.2 Primary Outcomes

Pre-test and post-test scores for all outcome variables are presented in Table 2. Both groups improved, but the simulation group improved more on all four outcomes. Clinical reasoning rose by 16.2 points (95% CI 13.8–18.6, $p < 0.001$, $d = 2.02$) 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 rose 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 rose 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 rose 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, $p = 0.001$, $d = 0.52$). The between-group differences in gain were therefore 11.7, 11.6, 10.7, and 11.9 points, respectively (derived from Table 2). These pre–post changes 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 change (95% CI)	Within-group Cohen's d (95% CI)	p-value
Clinical reasoning	Simulation	62.4 (8.7)	78.6 (7.3)	16.2 (13.8–18.6)	2.02 (1.52–2.52)	<0.001
	Control	61.8 (9.2)	66.3 (8.8)	4.5 (2.1–6.9)	0.50 (0.22–0.78)	0.001
Creative problem-solving	Simulation	58.7 (7.9)	74.2 (6.8)	15.5 (13.0–18.0)	2.10 (1.56–2.64)	<0.001
	Control	59.2 (8.4)	63.1 (8.0)	3.9 (1.6–6.2)	0.47 (0.18–0.76)	0.003
Self-efficacy	Simulation	65.3 (9.1)	79.8 (7.5)	14.5 (11.9–17.1)	1.73 (1.27–2.19)	<0.001
	Control	64.7 (9.5)	68.5 (9.0)	3.8 (1.3–6.3)	0.41 (0.13–0.69)	0.005
Clinical judgment	Simulation	60.1 (8.3)	76.4 (7.0)	16.3 (13.8–18.8)	2.12 (1.58–2.66)	<0.001
	Control	59.8 (8.6)	64.2 (8.3)	4.4 (2.0–6.8)	0.52 (0.22–0.82)	0.001

Note. CI = confidence interval; SD = standard deviation. Mean change is post-test minus pre-test within each group, and p-values are from paired t-tests. Cohen's d is calculated from the paired pre–post differences within each group; it is a within-group standardized change and not a between-group effect size. The CIs of d were recomputed for paired data: the pre–post correlation was derived from each reported CI of the mean change, and the variance of d was taken as $2(1 - r)/n + d^2/(2n)$; the submitted intervals (for example, −0.02 to 0.83 for control self-efficacy) used an independent-groups formula. d for clinical reasoning in the simulation group was recalculated from the printed means and SDs (2.02; submitted value 1.98).

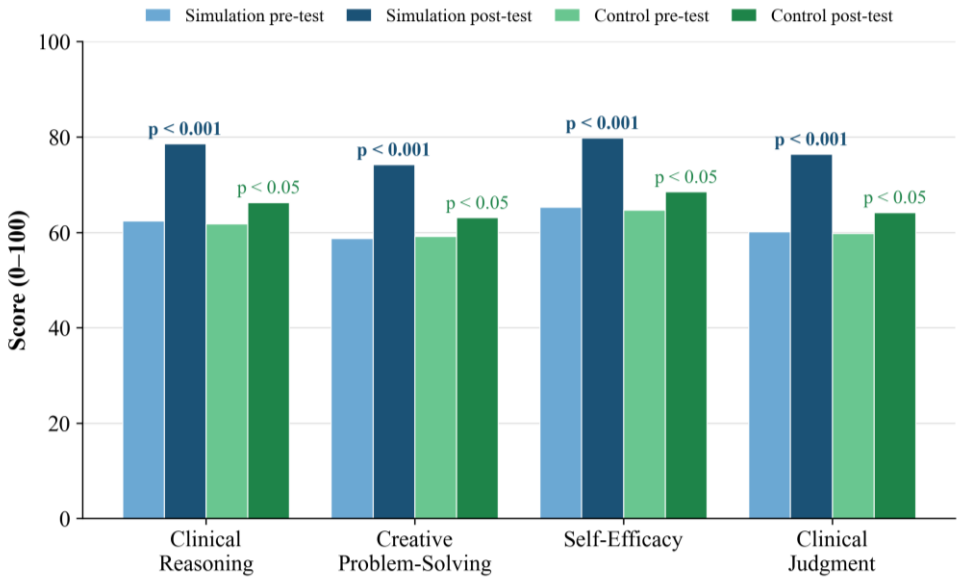

Figure 1. Comparison of pre-test and post-test scores between the simulation and control groups across the four outcome variables (values from Table 2). Labels give the significance of the within-group paired t-tests.

3.3 ANCOVA Results

ANCOVA with pre-test scores as covariates showed significant group effects for all outcomes (Table 3). The largest effect was for creative problem-solving ($F(1, 87) = 52.18$, $p < 0.001$, 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. Expressed as standardized between-group differences, these effects correspond to about 1.52 (creative problem-solving), 1.50 (clinical judgment), 1.47 (clinical reasoning), and 1.36 (self-efficacy), derived from the F values as $\sqrt{F} \times \sqrt{(1/46 + 1/44)}$.

Table 3. Analysis of Covariance (ANCOVA) Results for Post-Test Scores with Pre-Test as Covariate.

Dependent variable	Source	$F(1, 87)$	p-value	Partial η^2	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). All tests have 1 and 87 degrees of freedom.

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 between Sessions 1 and 3. A Pearson correlation revealed a significant positive association between total simulation hours and clinical reasoning score gain ($r = 0.72$, 95% CI 0.54–0.84, $p < 0.001$, $n = 46$; Figure 3), which is compatible with a dose–response relationship. The n equals the 46 points plotted in Figure 3, that is, the simulation group; the interval is derived with the Fisher transformation.

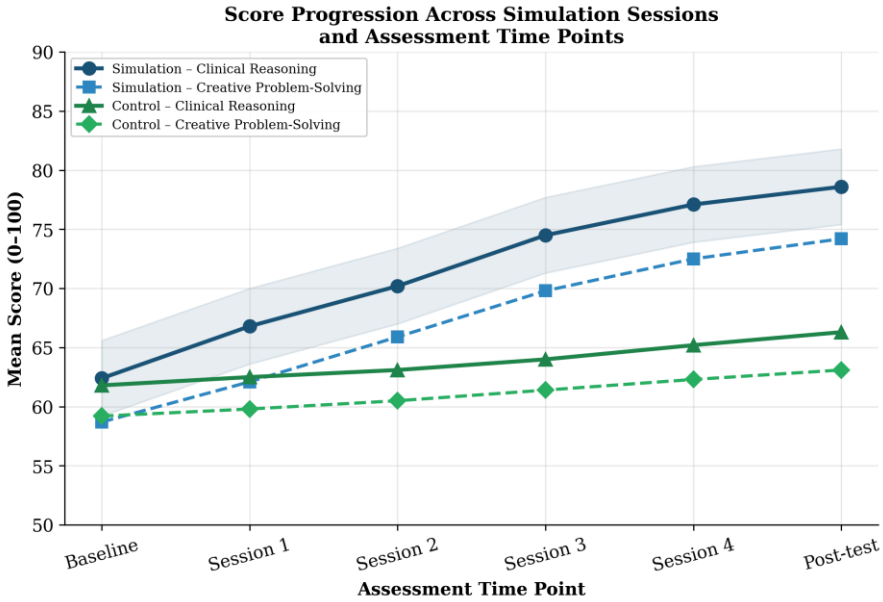

Figure 2. Score progression across simulation sessions and assessment time points. The shaded area represents the 95% confidence interval for the simulation group.

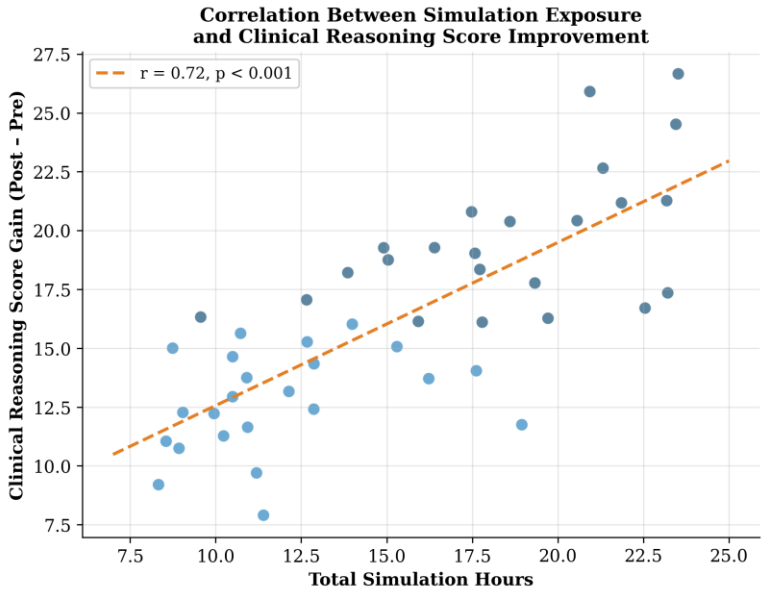

Figure 3. Correlation between total simulation hours and clinical reasoning score improvement in the simulation group (r = 0.72, p < 0.001, n = 46).

4. Discussion

This study examined how effective high-fidelity simulation is for creative clinical reasoning, clinical judgment, and self-efficacy among nursing students at a private university in Palembang. The simulation group improved more than the control group on all four outcome measures, with within-group effect sizes of d = 1.73–2.12. These gains are educationally meaningful in size.

The gain in clinical reasoning (d = 2.02) fits recent evidence. Bogossian et al.[3], in a multicenter study, found that high-fidelity simulation of acutely deteriorating patients improved students' recognition of and response to clinical deterioration. A systematic review by Alshehri et al.[38] likewise concluded that high-fidelity simulation strengthens clinical reasoning-related skills. Our larger effect sizes may owe something to the progressive complexity of the scenarios, which follows Kolb's experiential learning cycle[24]. Kim et al.[4] reported the same pattern for fidelity: higher-fidelity simulation led to better learning outcomes. Nair et al.[20] also found, in a quasi-experimental study, that high-fidelity simulation raised the clinical competence of nursing students, and a meta-analysis found that simulation-based learning improves clinical decision-making[13].

Creative problem-solving showed the largest ANCOVA group effect (partial η^2 = 0.375), although clinical judgment had the largest within-group d (2.12) and creative problem-solving followed closely (d = 2.10). That deserves note, since the literature has given this dimension little attention; in nursing, creative thinking has mostly been examined in dedicated innovation courses[18]. Gonzalez and Kardong-Edgren[11] promoted deliberate practice-based simulation for mastery learning but did not address creative reasoning. Our findings suggest something here. Scenarios built on purpose around ambiguous, complex, many-sided problems may enhance students' capacity to generate novel clinical responses.[34,35]

Self-efficacy rose by d = 1.73, in step with Guerrero et al.[39], who found greater self-confidence after high-fidelity simulation, and with Ozata and Dinc[21] and Cengiz et al.[40], who reported higher self-efficacy (and, in the latter, better problem-solving skills) after high-fidelity simulation. Mastery experiences may be the source: students repeatedly handled demanding scenarios in a psychologically safe setting[41], a condition that has also been linked to reflective thinking during debriefing[42]. The improvement in clinical judgment (d = 2.12) can be read through Tanner's Clinical Judgment Model[25]. The structured simulation phases train, in turn, noticing, interpreting, responding, and reflecting.

Clinical judgment deserves a separate comment. The rubric we used follows Tanner's model. It was designed to rate observable behavior in simulated encounters and has been validated for simulation-based education in several languages[22,23]. The gain of 16.3 points in the simulation group, against 4.4 in controls, should be read with that design in mind, although the manuscript does not say who rated the encounters. Self-efficacy and clinical judgment moved by similar amounts, and the two are probably related, but they measure different things: how capable students feel and how well they notice, interpret, respond, and reflect.

The positive correlation between total simulation hours and gain (r = 0.72) is compatible with the idea that longer exposure to simulation brings progressively larger learning gains, in line with the deliberate practice framework[11,31]. This may matter for curriculum design. One session is probably not enough. Repeated, structured experiences may be necessary if reasoning is to improve in a meaningful way.

The size of the effects calls for care. The within-group values (d = 1.73–2.12) describe change from pre-test to post-test, and they include practice effects and the natural progress of a semester. The standardized differences between groups, derived here from the ANCOVA statistics, are smaller (1.36–1.52). They are the better guide to what simulation added beyond case-based learning. They are also still large, yet they come from one site, from non-randomized groups, and from measures that were translated and rescaled. A reader should treat them as promising and not as a forecast for other programs.

Four practical implications follow. First, the large effect sizes may support making high-fidelity simulation a core teaching strategy. Second, the progressive complexity design offers nursing curricula a framework that others can replicate. Third, the focus on creative reasoning asks educators to move past protocol-execution scenarios and toward real clinical ambiguity. Fourth, where clinical placements are limited, simulation gives a standardized educational alternative[6,7], and a recent systematic review reached the same conclusion about the theory–practice gap[8].

For nursing programs in Indonesia and similar settings, the findings fit a practical argument. Clinical placements are limited and uneven, and the theory–practice gap is a recognized concern[5,6,8]. High-fidelity simulation does not replace placements, but it can give every student the same carefully designed encounters, with structured debriefing, at a time and place the program controls. Our eight-week schedule of four sessions is modest. Programs with fewer resources could start with a small

number of well-designed scenarios and add sessions as faculty skills and equipment allow.

Two features of the design shape how these results should be read. First, the control group had case-based learning of the same duration and frequency, which reduces the worry that the simulation group simply received more teaching time. It does not remove other differences. Simulation is hands-on and emotionally engaging, whereas case discussion is not, so the comparison estimates the effect of the whole simulation package against case-based teaching and not the effect of fidelity alone. Second, half of each simulation session (45 of 90 minutes) was debriefing, the phase in which reflective observation and abstract conceptualization in Kolb's cycle are expected to occur[24,42]. Debriefing was not varied between conditions, so the data cannot separate its contribution from that of the scenario itself. Comparing simulation with and without structured debriefing[31–33] would answer that question.

Measurement choices also call for caution. The four outcomes were converted to a common 0–100 metric. That helps comparison across instruments, but it removes the natural meaning of each score: a 16-point gain cannot be mapped back to the original scales without the transformation formula, and no minimal important difference is available for any of them. Readers should therefore focus on the direction and relative size of the effects and on the group comparison, not on absolute points. The sample-size calculation was set for $f = 0.35$. The observed partial η^2 values of 0.322–0.375 correspond to f of about 0.69–0.77, roughly twice the planned effect, so estimates from a sample of this size may prove smaller when the study is repeated.

The study has several strengths. Its quasi-experimental design with a well-matched control group allowed meaningful comparison between groups. Four instruments covered several competency domains. The 90% completion rate and comparable baseline characteristics supported internal validity. There are also limitations. Without randomization, selection bias is possible, although the groups were comparable at baseline. The sample came from a single institution, which limits generalizability to other educational settings. Participants were recruited by convenience sampling, the instruments were translated and rescaled to a common metric, and the manuscript does not report whether outcome assessors were blind to group. An immediate post-test cannot say anything about long-term retention, so future studies should add follow-up assessments at three and six months, as a recent review of simulation-based learning also examined knowledge retention among its outcomes[43].

Future studies can build on this work in several ways. A randomized or cluster-randomized design would remove the selection concern. Follow-up testing at three and six months would show whether gains last. A creativity measure with documented validity for clinical reasoning would strengthen the central outcome, because the scale used here has no published source. Recording each student's attendance and total contact hours would make the dose–response question testable. Finally, a completed TREND checklist and a participant flow diagram would let readers judge the study design and the analysis sample at a glance[26].

5. Conclusion

High-fidelity simulation was associated with larger gains than conventional case-based learning. The gains covered creative clinical reasoning, clinical judgment, and self-efficacy in nursing students. Within-group effects were large on every outcome (Cohen's d = 1.73–2.12). Improvement was significantly greater in the simulation group, and total simulation hours correlated positively with reasoning gains. These findings support building structured, progressively complex high-fidelity simulation into nursing curricula as a core teaching strategy; programs may consider investing in simulation infrastructure and faculty development. Later research needs randomized designs. It also needs several sites and longitudinal follow-up, so that the generalizability and durability of these effects can be confirmed across educational and cultural contexts.

Declaration

Artificial Intelligence Use Statement

No generative artificial intelligence tool was used to write or revise the text, analyze the data, create images, or generate any other scholarly content of this manuscript.

Author Contribution Statement

Conceptualization, D.H.M. and K.C.; methodology, D.H.M. and K.C.; investigation, D.H.M.; data curation, D.H.M.; formal analysis, K.C.; validation, M.R.; visualization, M.R.; writing – original draft, D.H.M.; writing – review and editing, K.C. and M.R.; supervision, K.C.; project administration, K.C. All authors have reviewed and approved the final version of the manuscript.

Funding Statement

This research received no external funding.

Conflict of Interest / Competing Interests

The authors declare that they have no competing financial or non-financial interests related to this work.

Ethics Approval and Consent to Participate

This study was an educational evaluation embedded in routine curricular activities and did not require formal research ethics committee approval; all procedures followed the Declaration of Helsinki, and all participants gave written informed consent. The study protocol was approved by Ethical Committee of Social Research, Enigma Institute, Indonesia (Approval number 2024/0158).

Consent for Publication

Not applicable. All data are anonymized and reported in aggregate.

Data Availability Statement

The datasets generated and analyzed during this study can be obtained from the corresponding author on reasonable request.

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