

Article

Sustainable Disaster Nursing Education Through Functional Exercises and Simulation: Effects on Knowledge, Problem-Solving, and Learning Outcomes

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Abstract

The present study developed and evaluated an integrated disaster nursing education program combining functional training and simulator-based learning to address limitations of traditional, theory-driven approaches. Overall, 49 senior nursing students completed the program using a four-stage repeated-measures design. The findings indicated a substantial enhancement in disaster nursing knowledge over time. However, problem-solving ability, learning self-efficacy, and motivation exhibited improvement only in post hoc comparisons. This contradictory yet fundamental finding suggests that knowledge acquisition occurs more directly, whereas problem-solving and motivational competencies require cumulative practice, feedback, and contextual immersion. Educator reflections and student debriefings further underscored the significance of teamwork, communication, and scenario relevance in facilitating learning transfer. Despite its limitations, including a single-site, female-dominated sample, reliance on self-reported measures, and a brief follow-up period, this study makes a significant contribution to the field of disaster nursing education by presenting a sustainable and adaptable model. Incorporation of multi-institutional and longitudinal designs, as well as qualitative analyses of learning processes will be crucial in future studies. This will ensure the study's generalizability and long-term impact.

Keywords: disaster nursing education; functional exercise; simulation-based training; emergency preparedness; sustainable education



Academic Editor: Jaime Santos-Reyes

Received: 3 September 2025

Revised: 11 October 2025

Accepted: 15 October 2025

Published: 16 October 2025

Citation: Cho, M.; Kwon, M. Sustainable Disaster Nursing Education Through Functional Exercises and Simulation: Effects on Knowledge, Problem-Solving, and Learning Outcomes. *Sustainability* **2025**, *17*, 9165. <https://doi.org/10.3390/su17209165>

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1. Introduction

1.1. Global and National Context

The World Health Organization (WHO) emphasizes strengthening the preparedness and response capacity of health workers through Emergency and Disaster Risk Management for Health (EDRM). The United Nations' (UN)-adopted Sendai Framework Priority 4 also emphasizes building national and community preparedness and response systems, as well as developing human resource capacity, as core strategies [1,2]. Specifically, in the healthcare sector, education and training on disaster response and crisis management, establishing emergency medical systems, strengthening the capabilities of medical personnel, and stockpiling medicines and other supplies are necessary [3]. South Korea's disaster emergency medical response system was legally and institutionally established based on

the Framework Act on the Management of Disasters and Safety as well as Emergency Medical Service Act. The Ministry of Health and Welfare, along with the National Emergency Medical Center, oversees national-level governance [4]. In the aftermath of the 2022 Itaewon Crowd Crush incident in Seoul, the 2023 revised Disaster Emergency Medical Response Manual underwent significant revisions. These revisions included the incorporation of enhanced on-site procedures and dispatch criteria to reinforce integrated cooperation among the National Fire Agency, public health centers, Disaster Medical Assistance Team (DMAT), and designated hospitals [5]. The key procedures involve (1) situational awareness and the step-by-step issuance of alerts; (2) dispatching rapid response teams and DMAT; (3) systematic implementation of patient triage, treatment, and transportation after establishing on-site emergency medical stations; and (4) real-time monitoring of hospital beds and resources through the central situation room to coordinate distributed transportation [4].

Additionally, essential elements include stockpiling supplies, securing communication systems, conducting training and education, and performing after-action reviews (AAR). Flexible expansion of medical resources and cooperation between local and central authorities are emphasized [4]. This serves as a crucial foundation for enhancing the sustainability and resilience of emergency medical response during disasters, becoming the primary basis for the education and training of relevant personnel [5]. Furthermore, recent discourse emphasizes that sustainable disaster preparedness requires legal frameworks, continuous education and training, and AARs to ensure that health systems can adapt to emerging threats [6,7].

1.2. Literature Review

Beyond legal and institutional frameworks, recent studies emphasize the role of simulation-based training in equipping healthcare professionals with the capabilities necessary for disaster preparedness [8]. Particularly, international organizations, such as the WHO and International Council of Nurses, emphasize simulation and functional training as essential strategies for improving disaster preparedness education [9].

Simulation training can improve communication skills, self-efficacy, critical thinking tendencies, clinical performance, learning satisfaction, problem-solving abilities, and teamwork [10–12]. A recent systematic review confirmed that simulation-based training contributes to the continuous competency development and disaster preparedness of nursing students and healthcare professionals [9].

Compared with simple theory-based education or model utilization, the combination of team-based functional exercises and simulators can simultaneously cultivate teamwork, practical thinking, and problem-solving skills. This provides learners with a more realistic level of preparedness for real-world situations [13]. However, research integrating simulator with team-based functional training remains scarce.

According to a Korean study, students who completed a training program combining simulation scenarios and functional training actively performed their roles even in atypical disaster situations [14]. Functional exercises specifically enhanced practical actions, collaboration, and communication skills, while repetitive training using simulators boosted confidence and on-site responsiveness [15]. Therefore, simulation training includes functional exercises, which are effective methods for clarifying roles as team members in real situations and improving on-site response capabilities [16].

Despite these positive findings, previous studies rarely demonstrate the integrated application of simulation and functional training within sustainable nursing curricula, particularly in the context of disaster preparedness education. This highlights the gap between theoretical potential and practical curriculum implementation. Consequently, fur-

ther empirical research is necessary to establish a sustainable, role-based, and longitudinal disaster nursing education model that integrates these approaches [9].

1.3. Research Purpose and Study Objectives

This study systematically examined the educational effects of simulation-based disaster nursing training by proposing a sustainable educational model to strengthen the disaster response capacity among nursing students. Specifically, this study evaluated the impact of combining functional exercises and simulators on four core outcome variables: Disaster nursing knowledge, problem-solving ability, learning self-efficacy, and learning motivation. Disaster nursing knowledge served as the foundation for clinical judgment and nursing practice in disaster contexts [17], while problem-solving ability is a critical competency that enables individuals to analyze diverse situations and make optimal decisions in rapidly changing environments [18]. Learning self-efficacy reflects learners' confidence in their capacity to effectively manage disaster situations [19]. Learning motivation functions as a key driver of engagement and active participation, which are essential for the sustainability of educational outcomes [20].

Disaster nursing education faces several challenges, including a lack of field-based practical training opportunities and difficulties in sustaining learning outcomes. To address these issues, this study developed and evaluated an educational program integrating functional training, simulating disaster field emergency medical stations, with simulator-based disaster nursing education. This program enhanced nursing students' prehospital disaster response capabilities and presented a sustainable educational model for disaster nursing education.

2. Materials and Methods

2.1. Study Design

This study employed a single-group, repeated-measures design. Data collection occurred at four time points: Pre1 and Pre2 (two baseline measurements), Post1 (immediately after intervention), and Post2 (four weeks after intervention; Table 1).

Table 1. Study design: One-group time-series design (n = 49).

Time Point	Activity/Context	Assessment
T1	Before theoretical lectures on disaster nursing	Pre-test 1
T2	After theoretical lectures on disaster nursing	Pre-test 2
Intervention	Functional Exercise + Simulator-based training	—
T3	Immediately after intervention	Post-test 1
T4	Four weeks after intervention	Post-test 2

2.2. Setting and Participants

This study was conducted with fourth-year nursing students who had taken a disaster nursing theory course at a university in Korea. The inclusion criteria were students who fully understood the research purpose and procedures, provided written consent on the consent form, and had previously completed the disaster nursing theory course. Students who had received formal disaster-related education or participated in similar simulation training within the past year were excluded. Those who could not participate in the entire research process were also excluded. The sample size for this study was calculated using the G*Power 3.1.9.7 program. With a significance level of 0.05, an effect size of 0.2, and a power of 0.9, the required sample size for a single-group repeated measures analysis of variance (ANOVA) was calculated to be 46 participants. However, considering a 10% dropout rate, the target sample size was set at 51 participants. A preliminary survey was conducted on five participants, representing 10% of the total sample of 50. Thus, a total of

56 students participated in this study, including 5 in the preliminary survey and 51 in the primary survey. Of these, 2 participants either withdrew from the simulation course or took a leave of absence, resulting in 49 students who completed all stages and were included in the final analysis.

2.3. Development of the Educational Program

The simulation-based disaster nursing education program was developed and implemented in eight sequential steps (Figure 1). The conceptual framework of the program was guided by the WHO's EDRM and Sendai Framework Priority 4 (Strengthening Disaster Preparedness for Effective Response).

Step	Procedure	Key Contents
1	Needs Assessment	Survey of nursing students and frontline nurses; review of prior studies to identify disaster competency gaps and educational needs
2	Expert Panel Review	Advisory panel (Nurses, Disaster nursing faculty, >10 years disaster responders) validated scenario realism, safety, equipment list
3	Scenario & Learning Objective Development	Disaster type, triage categories (emergent, urgent, non-urgent, deceased), role assignments (leader, triage, transport, etc.)
4	Functional Exercise (FX) Design	Team-based decision-making, communication, resource allocation, transport prioritization tasks
5	Simulator Matching	Simulators for essential nursing skills (CPR) linked to patient cases
6	Operation Manual & Evaluation Tools	Role cards, checklists, video recording, debriefing guidelines standardized
7	Pilot Testing & Revision	Small-scale pilot, feedback from participants and observers used for refinement
8	Program Implementation	Full-scale execution of the education program

Figure 1. Development procedure for the simulation-based disaster nursing education program.

- Step 1: Needs Assessment

A needs assessment was conducted through surveys with nursing students and frontline nurses, as well as a review of previous studies, to identify gaps in disaster competency, self-efficacy, and priority learning areas. Additionally, the Disaster Emergency Medical Response Manual published by the Ministry of Health and Welfare [3] was reviewed to align the educational objectives with national disaster response standards [5].

- Step 2: Expert Panel Advisory

An expert advisory panel was established, comprising nurses, disaster nursing faculty, and practitioners with over 10 years of experience in disaster fieldwork [21]. The panel evaluated the realism, safety, and appropriateness of the scenario content and equipment list, and provided feedback for refinement.

- Step 3: Scenario and Learning Objective Development

Two nursing faculty members drafted a preliminary simulation scenario using a standardized template, which included pre-learning materials, performance instructions, evaluation tools, and a debriefing guide. Content validity was evaluated following Lynn's procedure [22]. Each item was rated on a four-point scale (1 = very inappropriate to

4 = very appropriate), with an item-level content validity index ≥ 0.80 considered acceptable and a scale-level content validity index ≥ 0.90 indicating overall validity. Items below the threshold were revised or removed based on expert feedback and re-evaluated using the same procedure. The final validation involved two community health nursing faculty and two field practitioners who had not participated in scenario development.

- Step 4: Functional Exercise Design

The functional exercise was designed to enable participants to experience both teamwork-based decision-making and nursing skill performance required in disaster response. Based on the developed scenario, the functional exercise simulated the operation of an on-site medical station in a public health center, including triage using the Simple Triage and Rapid Treatment system (emergent, urgent, non-urgent, and deceased), first aid, patient transport, monitoring of transport conditions, and reporting. To ensure practical nursing application, simulators were used to provide cardiopulmonary resuscitation (CPR) practice for “emergent” patients. Student roles and responsibilities were clearly defined; the environment and equipment were arranged accordingly [23].

- Step 5: Simulator Matching

Simulators were matched to critical patient cases within the scenario to facilitate the integration of clinical nursing skills with disaster response tasks [11].

- Step 6: Operation Manual and Evaluation Tools

The educational session was structured for feasibility and effectiveness, totaling 210 min. This included 60 min of theoretical instruction and orientation (objectives, role assignments, safety guidelines, and confidentiality), 90 min of group discussion and practice (scenario analysis, decision-making, and communication training), 20 min of simulation execution, and 40 min of debriefing using a “facts–feelings–analysis–application” framework [12,18]. Standardized checklists, role cards, and debriefing guides supported consistent delivery.

- Step 7: Pilot Testing and Revision

A pilot test involving five nursing students was conducted to confirm the feasibility, clarity, and appropriateness of evaluation tools [12]. Feedback from participants and observers was incorporated to refine the program.

- Step 8: Program Implementation

The final program was conducted from October to December 2023 (see Supplementary Materials for detailed tables and additional analyses). During the orientation phase, the importance of confidentiality was emphasized in an effort to minimize information diffusion.

2.4. Outcome Measures

The survey consisted of 80 items in total, comprising four items on demographic and academic variables, 10 items on disaster nursing knowledge, 30 items on problem-solving ability, 10 items on learning self-efficacy, and 26 items on learning motivation. The four items related to demographic and academic variables were only surveyed in the initial questionnaire.

2.4.1. Demographic and Academic Variables

The subjects’ gender, age, grade point average (GPA), and satisfaction with their major were measured. Academic performance was assessed using student GPAs on a 4.5-point scale, which is the standard grading system in Korean universities. Major satisfaction was measured using the instrument employed in Lee & Ha [14]. Major satisfaction was

assessed using a single-item measure (“How satisfied are you with your major?”) rated on a five-point Likert scale (1 = very dissatisfied to 5 = very satisfied). A higher score indicated a greater level of satisfaction with the major.

2.4.2. Disaster Nursing Knowledge

Disaster nursing knowledge was measured using a tool based on Huh [24], which was revised and supplemented by incorporating practical elements from the Disaster Emergency Medical Response Manual [3]. The final instrument consisted of 10 multiple-choice items designed to reflect both theoretical content and practical disaster response competencies. Two nursing faculty members, with experience in disaster nursing education, evaluated content validity by reviewing the items for clarity, relevance, and appropriateness for undergraduate nursing students. Each correct response was scored as 1 point, with a total possible score of 10. Higher scores indicated greater knowledge levels in disaster nursing.

2.4.3. Problem-Solving Ability

To measure nursing students’ problem-solving abilities in disaster situations, the Adult Problem-Solving Ability Assessment tool developed by Lee et al. [25] was used. This scale consists of 30 items on a Likert scale (5 points = strongly agree to 1 point = strongly disagree) across five domains: Problem clarification (six items), solution exploration (six items), decision-making (six items), solution implementation (six items), and evaluation and reflection (six items). The score range was 30–150 points, with higher scores indicating greater problem-solving ability. In Lee et al. [25], the tool’s reliability was indicated by a Cronbach’s α of 0.93. The reliability in this study was Cronbach’s $\alpha = 0.98$.

2.4.4. Learning Self-Efficacy

Learning self-efficacy refers to an individual’s belief in their ability to apply knowledge acquired through new learning [26]. It was measured using a tool developed by Ayres [27] and adapted by Park & Kweon [27]. The tool consists of a total of 10 items on a Likert scale (ranging from 7 points = strongly agree to 1 point = strongly disagree), with a score range of 7–70 points. Higher scores indicate greater learning self-efficacy. In Park & Kweon’s study, the tool’s reliability, as measured by Cronbach’s α , was 0.95 [27]. The reliability in this study was Cronbach’s $\alpha = 0.98$.

2.4.5. Learning Motivation

Learning Motivation refers to the tendency to develop interest in academic pursuits by valuing learning, thereby inducing positive effects in academic performance. In this study, the tool adapted by Hwang and Jang [28] from Keller’s Instructional Material Motivation Survey was employed. The modified tool was used [29]. This scale consists of 26 items, each measured on a five-point scale (ranging from 1 = “Not at all” to 5 = “Very much so”). Higher scores indicate a stronger learning motivation. At development, the scale’s reliability, as measured by Cronbach’s α , was 0.95; in studies using the revised scale, it was 0.85 [29]. The reliability in this study was Cronbach’s $\alpha = 0.93$.

2.5. Data Collection

Data were collected at four time points using structured questionnaires and practical assessment checklists. To establish a stable baseline and differentiate the effects of preliminary disaster nursing lectures from those of the simulation training, two pre-training assessments were conducted. The first pre-test (T1) was administered before the disaster nursing lecture, while the second pre-test (T2) was administered immediately after the lecture, but before the simulation training. Post-training assessments were conducted immediately after the simulation (T3) and 4 weeks later (T4) to evaluate both the imme-

mediate impact and retention of the educational effects. The research purpose and survey instructions were provided by uploading the research description and consent form to a student-only social networking service group chat. After understanding the research purpose, participants could sign the consent form to agree to participate and then take the online survey.

2.6. Data Analysis

Descriptive statistics (frequencies, percentages, means, and standard deviations [SD]) were used to summarize participant characteristics. Repeated-measures ANOVA with covariates was conducted to examine changes in disaster nursing knowledge, problem-solving ability, learning self-efficacy, and learning motivation across four time points (T1–T4) while controlling for general variables (age, sex, GPA, and major satisfaction). The assumption of sphericity was tested using Mauchly’s test; when it was violated, the Greenhouse–Geisser correction was applied to adjust the degrees of freedom for within-subject effects. When significant main effects were detected, Bonferroni-adjusted post hoc pairwise comparisons were performed to identify specific differences between time points. Effect sizes were reported using partial η^2 , interpreted as small (0.01), medium (0.06), or large (0.14). Statistical significance was set at $p < 0.05$.

2.7. Ethical Considerations

The study received approval from the Gangneung-Wonju National University Institutional Review Board (GWNUIRB-2023-28, 20 September 2023). Written informed consent was obtained from all participants; consent for publication of aggregated results was secured. The recruitment, preliminary testing, and data collection procedures were conducted in accordance with the approved Institutional Review Board protocol.

3. Results

3.1. Participant Characteristics

Table 2 presents the general characteristics of the participants. Of the 49 nursing students, 83.7% were female and 16.3% were male. The mean age of the participants was 25.96 years (SD = 5.11). Their mean GPA was 3.59 (SD = 0.39). Furthermore, the mean score for major satisfaction was 3.83 (SD = 0.85), indicating that participants generally reported moderate to high levels of satisfaction with their major.

Table 2. General characteristics of the participants (n = 49).

Variable	Category	N (%) or M ($\pm$ SD)
Gender	Men	8 (16.3)
	Women	41 (83.7)
Age (years)		25.96 $\pm$ 5.11
Academic grade (GPA)		3.59 $\pm$ 0.39
Major satisfaction		3.83 $\pm$ 0.85

3.2. Evaluation of the Effectiveness of Simulation-Based Disaster Nursing Education with Functional Exercises and Simulators

As demonstrated in Table 3, disaster nursing knowledge steadily increased across the four time points, with the most significant improvement observed between T1 and T4 ($p < 0.001$). A decline in problem-solving ability was observed from T1 to T2 ($p < 0.01$); however, this was followed by a substantial increase from T2 to T3 ($p < 0.01$) and T3 to T4 ($p < 0.001$), culminating in a pronounced overall enhancement from baseline to the final measurement ($p < 0.001$). While learning self-efficacy and learning motivation did not

demonstrate significant main effects across time, Bonferroni-adjusted paired comparisons indicated that both outcomes improved significantly during the later phases of the program, particularly between T3 and T4 (both $p < 0.001$).

Table 3. Changes in study variables reflecting the effectiveness of the disaster nursing education program across four time points (T1–T4).

Variable	T1	T2	T3	T4	Pairwise Comparisons †	F	p (Partial η²)
	M ± SD						
Disaster nursing knowledge	5.84 ± 1.70	6.84 ± 1.70	6.98 ± 1.42	8.63 ± 1.27	T1 < T4 **, T2 < T4 *, T3 < T4 **	8.22	0.001 (0.157)
Problem-solving ability	109.65 ± 12.20	95.35 ± 13.44	109.33 ± 12.23	132.57 ± 14.87	T1 > T2 *, T2 < T3 *, T3 < T4 **, T1 < T4 **	0.22	0.798 (0.005)
Learning self-efficacy	3.86 ± 11.23	53.96 ± 11.38	54.82 ± 11.37	64.04 ± 8.15	T1 ≈ T2; T2 < T3 **, T3 < T4 **, T1 < T4 **	0.68	0.417 (0.015)
Learning motivation	74.02 ± 15.08	74.12 ± 15.06	75.16 ± 15.12	92.49 ± 17.52	T1 ≈ T2; T2 < T3 **, T3 < T4 **, T1 < T4 **	0.57	0.454 (0.013)

† Pairwise comparisons based on Bonferroni-adjusted post hoc tests. * $p < 0.05$, ** $p < 0.01$. Greenhouse–Geisser corrections were applied when the assumption of sphericity was violated (Mauchly's test, all $p < 0.001$).

3.2.1. Improvement in Disaster Nursing Knowledge

Disaster nursing knowledge showed an increase over time ($F = 8.22$, $p = 0.001$, partial $\eta^2 = 0.157$). Pairwise comparisons revealed that knowledge improved from T1 to T4 ($p < 0.001$), T2 to T4 ($p < 0.01$), and T3 to T4 ($p < 0.001$).

3.2.2. Enhancement of Problem-Solving Ability

Although repeated-measures ANOVA did not show a significant main effect ($F = 0.22$, $p = 0.798$, partial $\eta^2 = 0.005$), Bonferroni-adjusted pairwise comparisons revealed significant differences between several time points. Scores decreased from T1 to T2 ($p < 0.01$), then increased from T2 to T3 ($p < 0.01$) and from T3 to T4 ($p < 0.001$). The overall increase from T1 to T4 was also significant ($p < 0.001$).

3.2.3. Increase in Learning Self-Efficacy

Learning self-efficacy did not show a significant main effect across time ($F = 0.68$, $p = 0.417$, partial $\eta^2 = 0.015$). However, Bonferroni-adjusted post hoc tests indicated increases between T2 and T3 ($p < 0.001$), T3 and T4 ($p < 0.001$), and T1 and T4 ($p < 0.001$).

3.2.4. Strengthening of Learning Motivation

Repeated-measures ANOVA revealed no significant main effect for learning motivation ($F = 0.57$, $p = 0.454$, partial $\eta^2 = 0.013$). Nonetheless, post hoc comparisons showed differences between T2 and T3 ($p < 0.001$), T3 and T4 ($p < 0.001$), and T1 and T4 ($p < 0.001$).

4. Discussion

Traditional disaster nursing education, which excludes theoretical lectures and skill training in favor of simulations, does not sufficiently develop practical competencies. It also has limitations in terms of maintaining long-term learning effects and enhancing

responsiveness to atypical disaster situations. To address these issues, we developed and evaluated an educational program integrating skill training and simulations based on community disaster scenarios from multiple perspectives.

First, disaster nursing knowledge consistently increased over time, with the largest improvement observed between T3 and T4. These results suggest a gradual and sustained enhancement of disaster nursing knowledge, particularly following the simulation-based learning phase. This aligns with prior findings indicating that simulation and repetitive learning are advantageous for knowledge and skill transfer [11,12]. Therefore, the scenario design, iterative execution, and structured feedback system of this program are considered key mechanisms for enhancing knowledge.

Second, although no significant main effect for problem-solving ability was detected, post hoc pairwise comparisons revealed significant differences across several time points. A temporary decrease was observed between T1 and T2, followed by significant increases from T2 to T3 and from T3 to T4. These findings suggest that, while the overall time effect was not significant, problem-solving ability tended to improve during the functional training and simulation phases. This indicates that the overall average difference across time points was small, perhaps because sharp improvements occurred in specific stages of training, particularly during transition from functional to simulator training. These results suggest that learning improvement was not linear, but rather occurred intensely during the later, practice-focused stages. Initial stress and cognitive burden have been reported in prior studies when introducing simulation-based learning, indicating that an adaptation period is required [30]. This suggests that learners may have experienced difficulties in performance during the early stages of education due to high cognitive load and situational uncertainty. Subsequent cumulative effects of repetitive functional training, simulator performance, and structured debriefing-based reflection appear to have restored and enhanced problem-solving abilities. This aligns with findings from other simulation education studies indicating that repeated practice and debriefing contribute to improvements in clinical reasoning and problem-solving processes [31]. The findings of this study suggest that when designing simulation-based education, strategies are needed to gradually adjust difficulty levels and strengthen initial emotional and cognitive support.

Both learning self-efficacy and learning motivation increased at T4 compared with that of earlier time points. These results suggest a marked upward trend during the simulation phase, implying that experiential learning may have positively influenced students' confidence and motivation. According to Bandura's self-efficacy theory, the accumulation of successful experiences, vicarious learning, and social persuasion are key to enhancing self-efficacy, and simulation training can provide these elements [32]. The findings of the current study suggest that through simulation and team collaboration activities, learners gradually regained confidence, recognized the meaning of the learning content, and experienced enhanced intrinsic motivation.

Finally, this study suggests that integrating functional training with simulation-based learning may promote complementary improvements across knowledge, skills, and metacognitive components, including learning self-efficacy and motivation. While training at various scales (tabletop, functional, and full-scale) each have their strengths and weaknesses, an integrated approach is advantageous for achieving learning objectives [30]. Tabletop functional training, and hybrid simulation should be complementarily integrated as the standard operational framework. Additionally, a modular design that clearly separates the initial adaptation phase (cognitive load reduction) from the mid-to-late reinforcement phase (repetition and feedback) is necessary when structuring the curriculum [33]. An initial phase, centered on tabletop and role-playing exercises in a safe environment, is recommended to build foundational decision-making skills. This

can be followed by a later phase that reinforces actual skills and team training through a stepwise approach [2]. Furthermore, we recommend that future disaster nursing curricula explicitly incorporate psychological preparedness modules, such as stress management and resilience building, alongside technical training [34]. Simulation-based effects require regular retraining and follow-up evaluations to ensure retention. Previous studies, which have observed retention after 1 month, similar to this study, have highlighted the necessity of retraining [31]. Scenario design, debriefing techniques, and simulator operation capabilities are key for training effectiveness, necessitating the internalization of competency through a “train-the-trainer” program [35].

Additionally, while learning outcomes in this study were primarily assessed through quantitative tools, such an approach did not fully reflect the learners’ immersive experiences or process-oriented aspects of education. Educators’ observations and student debriefings indicated that the building-collapse scenario used in this study closely mirrored real disaster events in Korea, which contributed to heightened immersion [36]. Students reported that performing casualty triage, allocating victims to medical facilities, and providing emergency care within a limited timeframe underscored the critical importance of teamwork and communication. In South Korea, recent large-scale disasters such as the Itaewon stampede and building collapses have heightened societal awareness of disaster response, potentially strengthening students’ training immersion and motivation. For instance, in this study, the CPR procedure using simulators strongly resonated with scenes repeatedly reported in the media, enhancing learner engagement and realism. Therefore, future disaster nursing curricula should be developed by combining quantitative evaluation with qualitative analysis of learning needs, antecedent effects, and the curriculum itself. This will provide a foundation for a multidimensional understanding of how competencies are formed and applied in practice [17]. Beyond methodological limitations, contextual factors and learner-related characteristics are worthy of consideration in future research [36].

This study had several limitations. First, the participants were restricted to fourth-year nursing students from a single university, and the majority were female, which may limit result generalizability. However, this also reflects the demographic characteristics of nursing students and structure of nursing curricula in Korea. Second, the relatively small sample size (final $n = 49$) and inclusion of a single academic year reduced the statistical power and limited the extent to which the findings can represent broader populations of nursing students or nurses. Third, although the educational effects were assessed at four time points, which allowed the examination of short- and medium-term effects, the 4-week follow-up period was too short to confirm the long-term sustainability of the outcomes. While the repeated-measures design reduced the likelihood that the results were due solely to increased familiarity with the concepts, residual practice or familiarity effects could not be fully eliminated. Fourth, reliance on self-reported questionnaires and checklist-based assessments may have introduced response bias, such as social desirability bias, potentially leading to the overestimation of competencies compared with actual performance. Finally, learning outcomes were assessed primarily through quantitative tools, which did not fully capture learners’ immersive experiences or the processual aspects of the educational intervention.

To address these limitations, future studies should (1) employ multi-institutional and multi-cohort designs to enhance external validity across diverse educational and cultural contexts; (2) conduct long-term follow-up studies to verify the sustainability and transferability of disaster nursing competencies to clinical practice; (3) include comparison groups to more clearly establish program effectiveness; and (4) complement quantitative outcome measures with qualitative analyses of learners’ experiences, reflections, and knowledge transfer through mixed-methods approaches. Such efforts would provide a

more multidimensional understanding of how disaster nursing competencies are developed and strengthened within sustainable curricula.

5. Conclusions

This study developed and evaluated an integrated disaster nursing education program combining functional training and simulator-based learning to overcome the limitations of traditional, theory-driven approaches. The findings showed a significant improvement in disaster nursing knowledge, as well as post hoc improvements in problem-solving ability, self-efficacy, and motivation. These results underscore the complementary value of functional and simulation training. Reflective insights from educators and student debriefings further emphasized the importance of teamwork, communication, and contextual immersion in facilitating learning transfer.

From an educational perspective, the study highlights the importance of a modular program design with adaptation and reinforcement phases; use of contextually relevant scenarios to enhance engagement; and consideration of financial, technological, cultural, and gender-related factors for broader implementation.

Furthermore, the sustainability of this program lies in its community-based pre-hospital rescue system, which is applicable to urban disaster situations, particularly large-scale incidents such as building collapses. By integrating actual disaster response manuals with immediately deployable field scenarios, this program bridges theory and practice, simultaneously enhancing urban disaster response capabilities and community resilience. This approach presents a scalable and sustainable educational framework enabling local health systems to effectively respond to large-scale urban disasters.

Despite its limitations, including a single-institution, female-dominated sample, a short follow-up period, and reliance on self-reported measures, this study provides an original, sustainable model integrating simulator-based training with team-based functional exercises. Future research should expand to multi-institutional and longitudinal designs and adopt mixed-methods approaches to deepen the understanding of learning processes and outcomes.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su17209165/s1>, Table S1: Overview of the Disaster Nursing Education Program.

Author Contributions: M.C. contributed to conceptualization, methodology, and formal analysis. M.K. contributed to data interpretation, manuscript review and editing, and project administration. The original draft was prepared jointly by M.C. and M.K. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: This study was approved by the Institutional Review Board of Gangneung-Wonju National University (approval number: GWNUIRB-2023-28; date of approval: 20 September 2023).

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: The data are not publicly available due to privacy or ethical restrictions.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

References

- Wright, N.; Fagan, L.; Lapitan, J.M.; Kayano, R.; Abrahams, J.; Huda, Q.; Murray, V. Health emergency and disaster risk management: Five years into implementation of the Sendai framework. *Int. J. Disaster Risk Sci.* **2020**, *11*, 206–217. [\[CrossRef\]](#)
- Ghale, A.; Jnawali, K.; Paneru, D.P. Knowledge on disaster risk reduction among secondary level students of public schools of Pokhara metropolitan city of Nepal. *BMC Public Health* **2025**, *25*, 2058. [\[CrossRef\]](#) [\[PubMed\]](#)
- White, P.; Di Benedetto, F.; Hansen, K.; Medcalf, S.; Lookadoo, R. Not ready: The need for a training standard in healthcare emergency preparedness. *Health Secur.* **2025**, *23*, 147–154. [\[CrossRef\]](#) [\[PubMed\]](#)
- Ministry of Health and Welfare. *Disaster Emergency Medical Response Manual*; Ministry of Health and Welfare: Sejong-si, Rpublc of Korea, 2023.
- Ministry of Health and Welfare. Revision of the Disaster Emergency Medical Response Manual. Available online: <https://www.innovation.go.kr/ucms/bbs/B0000037/view.do?nttId=15511&menuNo=300083&pageIndex=1> (accessed on 21 August 2025).
- Voicescu, G.T.; Lamine, H.; Loşonţi, A.E.; Lupan-Mureşan, E.M.; Luka, S.; Ulerio, J.G.; Ragazzoni, L.; Corte, F.D.; Caviglia, M. Monitoring and evaluation in disaster management courses: A scoping review. *BMC Med. Educ.* **2025**, *25*, 188. [\[CrossRef\]](#)
- McLennan, J.; Hayes, P.; Bearman, C.; Penney, G.; Butler, P.C.; Flin, R. Training to improve emergency management decision-making: What the research literature tells us. *Aust. J. Emerg. Manag.* **2024**, *39*, 33–45. [\[CrossRef\]](#)
- Doumi, R.; Alassaf, W.; Aljahany, M.; Aldobeaban, S.; Mirghani, H.A.; BinSaleh, Y.; Ibrahim, S.F. The effectiveness and benefits of disaster simulation training for undergraduate medical students in Saudi Arabia. *Adv. Med. Educ. Pract.* **2024**, 707–714. [\[CrossRef\]](#)
- Al Thobaity, A. Overcoming challenges in nursing disaster preparedness and response: An umbrella review. *BMC Nurs.* **2024**, *23*, 562. [\[CrossRef\]](#)
- Zhuge, R.; Ruzieva, A.; Chang, N.; Wang, X.; Qi, X.; Wang, Q.; Wang, Y.; Kang, Z.; Liu, J.; Wu, Q. Evaluation of emergency drills effectiveness by center of disease prevention and control staff in Heilongjiang Province, China: An empirical study using the logistic-ISM model. *Front. Public Health* **2024**, *12*, 1305426. [\[CrossRef\]](#) [\[PubMed\]](#)
- Kaplan, B.G.; Connor, A.; Ferranti, E.P.; Holmes, L.; Spencer, L. Use of an emergency preparedness disaster simulation with undergraduate nursing students. *Public Health Nurs.* **2012**, *29*, 44–51. [\[CrossRef\]](#)
- Xia, R.; Li, S.; Chen, B.; Jin, Q.; Zhang, Z. Evaluating the effectiveness of a disaster preparedness nursing education program in Chengdu, China. *Public Health Nurs.* **2020**, *37*, 287–294. [\[CrossRef\]](#)
- Lee, Y.J.; Kim, M.W.; Oh, E.G. The current use of human patient simulators in nursing schools in Korea. *Korean Med. Educ. Rev.* **2011**, *13*, 47–57. [\[CrossRef\]](#)
- Lee, H.Y.; Ha, Y.M. The effects of disaster nursing simulation on attitudes toward disaster management, disaster preparedness, learning self-efficacy, and nursing practice satisfaction in nursing college Students. *J. Korean Soc. Sch. Health* **2022**, *35*, 104–112. [\[CrossRef\]](#)
- Geng, C.; Luo, Y.; Pei, X.; Chen, X. Simulation in disaster nursing education: A scoping review. *Nurse Educ. Today* **2021**, *107*, 105119. [\[CrossRef\]](#) [\[PubMed\]](#)
- Kim, J.S.; Kong, J.H.; Nam, C.S.; Sangsook, K.; Jung, E.-Y. Development and effect of simulation-based disaster nursing education program for nursing college students. *J. Korean Soc. Simul. Nurs.* **2019**, *7*, 31–43. [\[CrossRef\]](#)
- Emaliyawati, E.; Ibrahim, K.; Trisyani, Y.; Songwathana, P. The effect of integrated simulation experiential learning disaster nursing for enhancing learning outcomes among undergraduate nursing students: A quasi-experimental study. *Adv. Med. Educ. Pract.* **2025**, 311–321. [\[CrossRef\]](#)
- Kim, M.S.; Sohn, S.K. Emotional intelligence, problem solving ability, self efficacy, and clinical performance among nursing students: A structural equation model. *Korean J. Adult Nurs.* **2019**, *31*, 380–388. [\[CrossRef\]](#)
- Hwang, W.J.; Lee, J. Effectiveness of the infectious disease (COVID-19) simulation module program on nursing students: Disaster nursing scenarios. *J. Korean Acad. Nurs.* **2021**, *51*, 648–660. [\[CrossRef\]](#)
- Momeni, M.; Asadi, M.; Shadin, H.; Noorian, S.; Senmar, M. Self-efficacy of clinical performance in nursing students and its relationship with the motivation of field choice and clinical education status. *BMC Med. Educ.* **2025**, *25*, 767. [\[CrossRef\]](#)
- Shinchi, K.; Matsunaga, H.; Fukuyama, Y. Proposal of a model of disaster medicaleEducation for practical risk management and disaster nursing: The SINCHI education model. *Prehosp. Disaster Med.* **2019**, *34*, 438–441. [\[CrossRef\]](#)
- Lynn, M.R. Determination and quantification of content validity. *Nurs. Res.* **1986**, *35*, 382–385. [\[CrossRef\]](#)
- Perry, R.W. Disaster exercise outcomes for professional emergency personnel and citizen volunteers. *J. Conting. Crisis Manag.* **2004**, *12*, 64–75. [\[CrossRef\]](#)
- Huh, S.S. The Effect of a Disaster Nursing Education Program on Disaster nursing Competency of Nursing Students: Case Based Small Group Learning. Ph.D. Thesis, Chosun University, Gwangju, Republic of Korea, 2017.
- Lee, W.S.; Park, S.H.; Choi, E.Y. Development of a Korean Problem Solving Process Inventory for Adults. *J. Korean Acad. Fundam. Nurs.* **2008**, *15*, 548–557.
- Ayres, H.W. *Factors Related to Motivation to Learn and Motivation to Transfer Learning in a Nursing Population*; North Carolina State University: Raleigh, NC, USA, 2005.

27. Park, S.Y.; Kweon, Y.R. The effect of using standardized patients in psychiatric nursing practical training for nursing college students. *J. Korean Acad. Psychiatr. Ment. Health Nurs.* **2012**, *21*, 79–88. [\[CrossRef\]](#)
28. Hwang, S.Y.; Jang, K.S. Development and implementation of problem-based learning packages on the respiratory and cardiac system. *Korean J. Adult Nurs.* **2004**, *16*, 636–647.
29. Hwang, Y.-Y.; Chu, M.-S.; Park, C.-S. The effects of problem based learning (PBL) in nursing students studying through PBL curriculum. *J. Korean Acad. Soc. Nurs. Educ.* **2007**, *13*, 155–161.
30. Mahdi, S.S.; Jafri, H.A.; Allana, R.; Battineni, G.; Khawaja, M.; Sakina, S.; Agha, D.; Rehman, K.; Amenta, F. Systematic review on the current state of disaster preparation Simulation Exercises (SimEx). *BMC Emerg. Med.* **2023**, *23*, 52. [\[CrossRef\]](#) [\[PubMed\]](#)
31. Cicero, M.X.; Auerbach, M.A.; Zigmont, J.; Riera, A.; Ching, K.; Baum, C.R. Simulation training with structured debriefing improves residents' pediatric disaster triage performance. *Prehosp. Disaster Med.* **2012**, *27*, 239–244. [\[CrossRef\]](#)
32. Cardós-Alonso, M.C.; Inzunza, M.; Gyllencreutz, L.; Espinosa, S.; Vázquez, T.; Fernandez, M.A.; Blanco, A.; Cintora-Sanz, A.M. Use of self-efficacy scale in mass casualty incidents during drill exercises. *BMC Health Serv. Res.* **2024**, *24*, 745. [\[CrossRef\]](#)
33. Daumiller, M.; Meyer, J. Advancing feedback research in educational psychology: Insights into feedback processes and determinants of effectiveness. *Contemp. Educ. Psychol.* **2025**, 102390. [\[CrossRef\]](#)
34. Hawthorne, B.S.; Vella-Brodrick, D.A.; Hattie, J. Well-being as a cognitive load reducing agent: A review of the literature. *Front. Educ.* **2019**, *4*, 121. [\[CrossRef\]](#)
35. Nagle, B.M.; McHale, J.M.; Alexander, G.A.; French, B.M. Incorporating scenario-based simulation into a hospital nursing education program. *J. Contin. Educ. Nurs.* **2009**, *40*, 18–25. [\[CrossRef\]](#) [\[PubMed\]](#)
36. Mitsuhashi, H.; Tanimura, C.; Nemoto, J.; Shishibori, M. Expressing Disaster Situations for Evacuation Training Using Markerless Augmented Reality. *Procedia Comp. Sci.* **2021**, *192*, 2105–2114. [\[CrossRef\]](#)

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