



Contents lists available at Journal Global Econedu

Journal of Educational and Learning Studies

ISSN: 2655-2760 (Print) ISSN: 2655-2779 (Electronic)

Journal homepage: <http://jurnal.globaleconedu.org/index.php/jels>



Development and quasi-experimental evaluation of a self-directed case-based digital learning model for emergency nursing competence

Sunarto Sunarto, Addi Mardi Harnanto, Sudiro Sudiro

Department of Nursing Politeknik Kesehatan Kemenkes Surakarta, Mojosongo, Surakarta, Indonesia

Article Info

Article history:

Received Aug 22th, 2026

Revised Sept 03th, 2026

Accepted Oct 12th, 2026

Keyword:

Digital learning,
Emergency nursing,
Quasi-experimental,
Self-directed learning,
Nursing education

ABSTRACT

This study developed and evaluated a self-directed, case-based digital learning model for emergency nursing education. A sequential research-and-development approach was used. Phase 1 comprised needs assessment and model development using questionnaires, interviews, and input from clinical educators and students. Phase 2 used a quasi-experimental pretest-posttest control-group evaluation. Total sampling included all 90 students in the Professional Nursing Program. Two existing classes were allocated at class level by random selection, with class A assigned to the intervention group ($n = 43$) and class B to the control group ($n = 47$). The intervention was delivered through Google Sites three times per week for four weeks. Each session included 10-15 minutes of reading, 5-10 minutes of instructional video, and 5-10 minutes of an interactive quiz. A 12-item competency instrument covering Emergency Nursing competencies was reviewed by two experts; content validity was strong ($S-CVI/Ave = 1.00$; mean Aiken's $V = 0.92$, range $0.83-1.00$), with 100% expert agreement, although Cohen's kappa was not estimable because of zero variance. The intervention group increased from 49.19 ± 26.00 at pretest to 77.09 ± 21.66 at posttest, while the control group increased from 39.79 ± 11.93 to 58.83 ± 14.19 . Paired improvements were significant in both groups (27.91 points, 95% CI 20.51-35.30, $t(42) = 7.61$, $p < .001$; and 19.04 points, 95% CI 14.10-23.98, $t(46) = 7.76$, $p < .001$, respectively). A supplementary gain-score comparison calculated from the supplied summary statistics showed an 8.86-point greater improvement in the intervention group, Welch's $t(74.46) = 2.01$, $p = .048$, Cohen's $d = 0.43$ (95% CI 0.01-0.85). Baseline scores were not equivalent between groups, which limits causal interpretation. The findings support the model as a feasible supplementary approach for emergency-nursing learning, while larger multi-site studies with stronger allocation procedures and objective clinical-performance measures are still needed.



© 2026 The Authors. Published by Global Econedu.

This is an open access article under the CC BY-NC-SA license
(<https://creativecommons.org/licenses/by-nc-sa/4.0>)

Corresponding Author:

Sunarto Sunarto,
Department of Nursing, Politeknik Kesehatan Kemenkes Surakarta
Email: sunarto_sst@yahoo.com

Introduction

Simulation-supported learning has become an important strategy for nursing education because students need repeated opportunities to integrate knowledge, clinical reasoning, and procedural decision-making before encountering high-risk situations in practice. Recent syntheses consistently report benefits of simulation technology for knowledge acquisition and selected skill outcomes (Alharbi et al., 2024; Foronda et al., 2020; Mulyadi et al., 2021). Meta-analytic and integrative evidence also links simulation with professional skills, clinical ability, confidence, and competence-related outcomes, although the size and durability of effects vary

by simulation format and study design (Lei et al., 2022; O'Rourke et al., 2023; Silva et al., 2022). The educational value of simulation is particularly relevant in emergency nursing, where opportunities to observe or manage rapidly deteriorating patients are unpredictable and errors during initial training can carry substantial consequences.

Digital and virtual simulation broaden access to clinical learning by allowing students to revisit scenarios, repeat demonstrations, and receive structured feedback outside the constraints of laboratory or hospital schedules. Reviews indicate that non-immersive virtual simulation can improve nursing students' knowledge and learning outcomes (Foronda et al., 2020; Woon et al., 2021). Systematic mapping and meta-analytic evidence also support performance- and skill-related benefits from virtual simulation (Plotzky et al., 2021; Qiao et al., 2023). Immersive and virtual-reality approaches have likewise shown benefits for selected learning and competency outcomes (Cant, Ryan, & Kelly, 2023; Choi et al., 2022; Jallad & Işık, 2022). More recent syntheses similarly report positive effects of virtual or immersive technology on nursing education outcomes, although findings differ across designs and outcome measures (Cho & Kim, 2024; Huai et al., 2024; Park et al., 2024). At the same time, the evidence is not uniformly superior to mannequin-based or face-to-face simulation. A recent meta-analysis found no consistent advantage of virtual simulation over mannequins or real persons across knowledge, procedural skills, clinical reasoning, and communication outcomes, underscoring the importance of instructional design rather than technology alone (Jiang et al., 2024).

Emergency-nursing education requires learning designs that are both clinically authentic and practically scalable. Web-based and simulation-supported Basic Life Support learning has been associated with improvements in short-term knowledge and learning outcomes (Bylow et al., 2019; Harnanto & Sunarto, 2022; Requena-Mullor et al., 2021). Virtual simulation has also been used to support deteriorating-patient recognition and emergency decision-making (Chow et al., 2023; Goldsworthy et al., 2022). Comparable improvements have been reported in cardiopulmonary-resuscitation training using virtual and mannequin-based approaches (Abbasi et al., 2024). Nevertheless, much of the literature evaluates established simulation packages or high-fidelity systems. Less attention has been given to low-cost web models that deliberately integrate self-directed learning, authentic case material, reusable instructional videos, formative exercises, attendance monitoring, and immediate feedback within one platform, particularly in Indonesian professional nursing programs.

This study addresses that design and contextual gap through a two-stage development-and-evaluation process. The target population was students enrolled in the Professional Nursing Program at Poltekkes Kemenkes Surakarta, and the learning content focused on Emergency Nursing Clinical Practice, particularly Basic Life Support and Code Blue Management. The model was designed to support repeated, self-paced engagement with case-based materials while retaining a clear connection to clinical instruction. Phase 1 examined the platform characteristics considered necessary by students and clinical educators, whereas Phase 2 compared pretest-to-posttest competency-test changes between students exposed to the digital model and students receiving conventional face-to-face instruction.

The study had two objectives: first, to develop a self-directed, case-based digital learning model aligned with emergency-nursing learning needs; and second, to evaluate changes in emergency-nursing competency-test scores using a pretest-posttest comparison group. The independent variable was exposure to the developed digital learning model, while the primary quantitative outcome was change in competency-test scores covering Basic Life Support and Code Blue Management. The testable hypothesis was that the intervention group would demonstrate a greater pretest-to-posttest score improvement than the control group.

Method

This study used a sequential research-and-development design with two linked components. Phase 1 consisted of a needs assessment and model-development process using questionnaires, interviews, and consultation with clinical educators. Phase 2 evaluated the developed model using a quasi-experimental pretest-posttest control-group design. The study was conducted in the Department of Nursing, Poltekkes Kemenkes Surakarta, from January to October 2022.

The study population comprised 90 students enrolled in the Professional Nursing Program during the study period, and all eligible students were included through total sampling. The cohort consisted of two existing classes. According to the author's clarification, class-level allocation was performed by random selection: class A ($n = 43$) was assigned to the intervention group and class B ($n = 47$) to the control group. Because allocation occurred at the class level and the available records do not document the sequence-generation procedure or allocation concealment, the evaluation is conservatively reported as quasi-experimental rather than as an individually randomized controlled trial.

The intervention was delivered through a Google Sites-based platform designed for self-directed learning. Its components included structured learning modules, instructional videos demonstrating Basic Life Support and Code Blue Management, authentic clinical-case materials, practice exercises, learning-evaluation guidance, attendance documentation, immediate feedback on pretests, posttests, and daily exercises, and links to scientific resources. Each learning session consisted of approximately 10-15 minutes of reading, 5-10 minutes of instructional video, and 5-10 minutes of an interactive quiz, for an estimated 20-35 minutes of structured platform activity per session. Sessions were conducted once on each scheduled learning day, three times per week for four weeks, followed by evaluation. The control group received conventional face-to-face instruction.

Phase 1 used questionnaires and interview guides to identify target competencies and preferred platform characteristics. Phase 2 used a 12-item competency instrument developed from Emergency Nursing course competencies to assess cognitive performance related to the learning targets, including Basic Life Support and Code Blue Management. Content validity was assessed by two experts: one emergency-nursing clinical practitioner and one emergency-nursing academic with expertise in learning and curriculum development. The S-CVI/Ave was 1.00 and the mean Aiken's V was 0.92 (range 0.83-1.00), indicating high content validity across the 12 items. Both experts rated all items as relevant, yielding 100% agreement. Cohen's kappa could not be estimated because there was no variation in the relevance ratings (zero variance). An internal-consistency coefficient such as KR-20 or Cronbach's alpha was not available in the supplied records and therefore is not reported.

Development-phase feedback was summarized into recurring platform-design requirements. Quantitative data were edited, coded, and tabulated. Descriptive statistics summarized participant characteristics and pretest-posttest scores. Within-group pretest-posttest changes were evaluated using paired-samples t-tests. Because all 90 students in the accessible cohort were included through total sampling, no a priori power analysis was performed; sample size was determined by the available cohort. To address the reviewer's request for the magnitude and precision of the primary group difference, a supplementary between-group comparison of gain scores was calculated from the supplied group means, standard deviations, and sample sizes using Welch's independent-samples t-test. Cohen's d was calculated from the pooled gain-score standard deviation, with an approximate 95% confidence interval based on the sampling variance of the standardized mean difference. Baseline group means were also compared descriptively and with a supplementary Welch test to assess baseline equivalence. Ethical approval was obtained from the Health Research Ethics Committee of Dr. Moewardi Regional General Hospital, Surakarta, approval number 582/V/HREC/2021.

Results and Discussions

Phase 1 produced a Google Sites-based model organized around self-directed learning and clinically authentic emergency-nursing content. The development process involved representatives from the study program, clinical educators, clinical instructors, and students. Feedback converged on nine practical design requirements:

The platform should be developed collaboratively with representatives from the study program, clinical educators, and clinical instructors. It should contain structured learning modules and instructional videos that allow learners to review demonstrations repeatedly. The language used should be communicative and closely resemble direct instructional interactions. Learning content should incorporate authentic clinical cases documented by clinical instructors and include appropriate evaluation methods and practice instructions. In addition, participant attendance should be documented, while pretests, posttests, and daily exercises should provide immediate score feedback to support learning progress. The platform should also provide links to journals and other relevant learning resources to encourage independent study and facilitate further knowledge development.

Phase 2 evaluated the learning model in the 90-student cohort. Class A (n = 43) was assigned at class level to the intervention condition and used the self-directed digital platform, whereas class B (n = 47) formed the control group and received conventional face-to-face instruction. The author's clarification indicates that the class assignment was made by random selection, but the sequence-generation and allocation-concealment procedures were not documented. The comparison is therefore retained as quasi-experimental. Participant characteristics are summarized in Tables 1 and 2.

Table 1. Characteristics of the Intervention Group (n = 43)

Variable	f	%
Sex		
Male	2	4.7
Female	41	95.3

Variable	f	%
Age		
18 years	38	88.4
19 years	5	11.6
Pretest Score		
High	7	16.3
Moderate	6	14.0
Low	30	69.8
Posttest Score		
High	25	58.1
Moderate	12	27.9
Low	6	14.0

Table 1 shows that the intervention group was predominantly female (95.3%) and 18 years old (88.4%). Before the intervention, 69.8% were categorized in the low pretest-score group; after the intervention, 58.1% were categorized in the high posttest-score group.

Table 2. Characteristics of the Control Group (n = 47)

Variable	f	%
Sex		
Male	5	10.6
Female	42	89.4
Age		
18 years	40	85.1
19 years	7	14.9
Pretest Score		
High	25	53.2
Moderate	6	12.8
Low	16	34.0
Posttest		
High	5	10.6
Moderate	25	53.2
Low	17	36.2

Table 2 shows that the control group was predominantly female (89.4%) and 18 years old (85.1%). In the supplied Lampiran 5 output, the pretest categories were reported as high for 53.2% of participants, moderate for 12.8%, and low for 34.0%. At posttest, the largest category remained the moderate group (53.2%).

Table 3. Pretest-Posttest Scores and Within-Group Paired t-tests

Group	n	Pretest Mean (SD)	Posttest Mean (SD)	Mean Change (SD)	95% CI of Change	Paired t(df), p
Intervention	43	49.19 (26.00)	77.09 (21.66)	27.91 (24.04)	20.51 to 35.30	7.61 (42), < .001
Control	47	39.79 (11.93)	58.83 (14.19)	19.04 (16.83)	14.10 to 23.98	7.76 (46), < .001

The supplied statistical output showed significant pretest-to-posttest improvement in both groups. In the intervention group, the mean increased from 49.19 (SD = 26.00) to 77.09 (SD = 21.66), a mean improvement of 27.91 points (SD of change = 24.04; 95% CI 20.51 to 35.30), $t(42) = 7.61$, $p < .001$. In the control group, the mean increased from 39.79 (SD = 11.93) to 58.83 (SD = 14.19), a mean improvement of 19.04 points (SD of change = 16.83; 95% CI 14.10 to 23.98), $t(46) = 7.76$, $p < .001$. The intervention group therefore improved by 8.86 points more than the control group. A supplementary Welch comparison calculated from the supplied gain-score summary statistics yielded $t(74.46) = 2.01$, $p = .048$, with a mean difference of 8.86 points (95% CI 0.07 to 17.65) and Cohen's $d = 0.43$ (95% CI 0.01 to 0.85). Baseline scores were not equivalent: the intervention group began 9.40 points higher on average than the control group (49.19 versus 39.79), Welch's $t(57.78) = 2.17$, $p = .034$, Cohen's $d = 0.47$. This baseline imbalance should be considered when interpreting the post-intervention difference.

The central finding is that both groups improved significantly, but students using the self-directed, case-based digital model showed a larger mean gain in emergency-nursing test performance. The between-group gain difference was 8.86 points, with Cohen's $d = 0.43$ (95% CI 0.01 to 0.85). This pattern is consistent with broader evidence showing that simulation technology can strengthen knowledge acquisition and selected performance outcomes in nursing students (Alharbi et al., 2024; Lei et al., 2022; Mulyadi et al., 2021). Evidence from blended-learning research likewise supports improvements in knowledge and skill-related outcomes when digital resources are combined with conventional instruction (Abuejheisheh et al., 2023; Du et al., 2022). The present

contribution remains narrower because the groups differed at baseline and the outcome was a competency-test score rather than direct clinical performance. Accordingly, the results support an association between the developed learning model and greater short-term score improvement, rather than a definitive causal claim of superior clinical competence.

Several components of the developed platform have plausible pedagogical value. Students could repeatedly review instructional videos, work through authentic cases, complete exercises, and obtain immediate feedback. Reviews of psychomotor-skill learning and educational video suggest that repeated observation can support skill acquisition when learners can revisit difficult material (Clerkin et al., 2022; Rourke, 2020). Studies of mobile and non-immersive virtual simulation likewise support interactive digital practice for knowledge and skill-related learning outcomes (Chang et al., 2021; Qiao et al., 2023). Similarly, blended-learning evidence indicates that combining digital resources with conventional teaching can improve knowledge, skill performance, and satisfaction compared with traditional teaching alone, although intervention designs vary substantially (Abuejheisheh et al., 2023; Du et al., 2022).

The use of authentic emergency scenarios is also important. Virtual simulation research has shown benefits for clinical reasoning, deteriorating-patient recognition, and emergency decision-making when learners engage with realistic patient-management situations (Chow et al., 2023; Goldsworthy et al., 2022; Sim et al., 2022). Related studies also report gains in perceived clinical competence and complex nursing-skill learning in virtual simulation environments (Fung et al., 2023; Plotzky et al., 2023). Meta-analytic evidence further indicates positive effects of virtual or immersive approaches on nursing competency-related outcomes, knowledge, and confidence (Cho & Kim, 2024; Huai et al., 2024; Park et al., 2024). These studies support the decision to organize the platform around authentic cases rather than treating the website simply as a repository of text-based materials.

The Basic Life Support component is particularly consistent with prior evidence. A cluster randomized trial found benefits from adding web-based education to Basic Life Support learning activities, while a later systematic review reported that blended Basic Life Support modules can support knowledge and skill retention (Abuejheisheh et al., 2023; Bylow et al., 2019). In Indonesia, Harnanto & Sunarto (2022) likewise reported greater knowledge gains among nursing students receiving web-based Basic Life Support learning than those receiving classical instruction. More recently, a randomized comparison of virtual and mannequin-based cardiopulmonary-resuscitation training showed meaningful within-group improvements in knowledge, attitude, and performance for both approaches (Abbasi et al., 2024). Together, these findings indicate that digital learning is best viewed as a structured practice opportunity that complements, rather than automatically replaces, hands-on training.

At the same time, the results should be interpreted against evidence showing that technology format alone does not guarantee better learning. Jiang et al. (2024) found no consistent overall superiority of virtual simulation over mannequins or real persons for several clinical-competency outcomes. Reviews of learning transfer also warn that nursing-simulation studies frequently rely on immediate or self-reported outcomes and provide limited evidence of sustained transfer into real clinical practice (El Hussein & Cuncannon, 2022). The present study measured competency-test performance and did not include a validated objective structured clinical examination or direct observation of clinical behavior. Although the gain-score comparison favored the intervention group by 8.86 points (95% CI 0.07 to 17.65; $d = 0.43$), the intervention group also had a higher baseline mean. The observed advantage should therefore be interpreted as a short-term learning-performance signal rather than proof of improved real-world clinical competence.

The development findings also suggest that instructional integration may matter as much as technological sophistication. The model combined case material, videos, formative testing, immediate feedback, attendance tracking, and access to further readings in one environment. Broader reviews of self-directed learning and virtual simulation support the value of intentionally structured digital learning experiences rather than technology in isolation (Cant et al., 2022; Sim et al., 2022; Wong et al., 2021). Evidence on simulation duration, clinical reasoning, and simulation-based learning likewise indicates that how the learning experience is organized can shape educational outcomes (Alharbi et al., 2024; Alshehri et al., 2023; Tong et al., 2022). It may therefore be more useful for institutions with limited access to high-fidelity simulation equipment than attempting to reproduce expensive immersive systems without adequate instructional support.

Several threats to internal validity remain. First, the two existing classes were allocated at class level, and the available records do not document the exact sequence-generation or allocation-concealment procedures. With only one class per condition, class-level characteristics and instructor effects cannot be separated cleanly from the intervention effect. Second, baseline mean scores differed significantly between groups (49.19 versus 39.79; $p = .034$), which may influence change-score comparisons. Third, although content validity was strong

(S-CVI/Ave = 1.00; mean Aiken's V = 0.92) and expert agreement was 100%, an internal-consistency coefficient for the 12-item competency instrument was not available. Fourth, no a priori power analysis was performed because the entire accessible cohort was included by total sampling. Finally, contamination between classes and differences in engagement outside the scheduled 4-week intervention cannot be excluded. These limitations mean that statistical significance and the observed effect size should not be interpreted as a definitive causal estimate or as evidence of transfer to real clinical performance.

Generalizability is limited by the single-institution setting, one professional nursing cohort, and class-level allocation. Future studies should use prospectively planned multi-site randomized or rigorously controlled quasi-experimental designs, report sequence generation and allocation concealment, and balance or statistically adjust for baseline differences. Intervention adherence to the three-times-weekly, four-week learning schedule should be monitored explicitly. Future evaluations should also report internal-consistency reliability for the competency instrument, use validated objective competency measures such as structured skill checklists or OSCE-based assessments, and conduct an a priori sample-size calculation before recruitment. Follow-up assessments at prespecified intervals, for example 1, 3, and 6 months, would help determine retention and transfer to clinical practice. Multi-site validation should precede broad curriculum-level implementation.

Conclusions

This study developed a self-directed, case-based digital learning model integrating modules, instructional videos, authentic emergency cases, practice exercises, attendance documentation, immediate assessment feedback, and scientific-resource links. The intervention was delivered three times per week for four weeks. In the quasi-experimental evaluation, the intervention-group mean increased from 49.19 ± 26.00 to 77.09 ± 21.66 , while the control-group mean increased from 39.79 ± 11.93 to 58.83 ± 14.19 . The corresponding mean improvements were 27.91 points (95% CI 20.51 to 35.30) and 19.04 points (95% CI 14.10 to 23.98), respectively. A supplementary comparison of gain scores showed an 8.86-point greater improvement in the intervention group, Welch's $t(74.46) = 2.01$, $p = .048$, Cohen's $d = 0.43$ (95% CI 0.01 to 0.85). The findings indicate that the model is a feasible supplementary strategy for emergency-nursing learning in the study context, particularly when students need flexible and repeatable access to learning materials. However, the intervention group had a higher baseline score, allocation occurred at the class level, no a priori power analysis was performed, and internal-consistency reliability for the competency instrument was not available. Direct transfer to clinical practice and sustained effectiveness were also not established. Broader curriculum integration should therefore remain context-specific until the model has been validated with stronger allocation procedures, baseline adjustment, validated objective clinical-performance measures, multi-site samples, and longitudinal assessment.

Acknowledgments

The authors gratefully acknowledge Poltekkes Kemenkes Surakarta for providing financial support and research facilities that enabled this study to be conducted. The authors also thank all participants for their active participation and valuable contributions to the research process.

References

- Abbasi, M., Asadoola, Y., Ebrahimi, H., Bahonar, E., Dabirian, Z., Esmacili, S.-M., ... Sadeghi, M. (2024). Comparison of mannequin-based simulation training method with virtual training method on nursing students' learning cardiopulmonary resuscitation: A controlled randomized parallel trial. *Iranian Journal of Nursing and Midwifery Research*, 29(4), 438–445. https://doi.org/10.4103/ijnmr.ijnmr_222_23
- Abuejheisheh, A. J., Alshraideh, J. A., Amro, N., Bani Hani, S., & Darawad, M. W. (2023). Effectiveness of blended learning basic life support module on knowledge and skills: A systematic review of randomized controlled trials. *Heliyon*, 9(11). <https://doi.org/10.1016/j.heliyon.2023.e21680>
- Alharbi, A., Nurfianti, A., Mullen, R. F., McClure, J. D., & Miller, W. H. (2024). The effectiveness of simulation-based learning (SBL) on students' knowledge and skills in nursing programs: A systematic review. *BMC Medical Education*, 24, 1099. <https://doi.org/10.1186/s12909-024-06080-z>
- Alshehri, F. D., Jones, S., & Harrison, D. (2023). The effectiveness of high-fidelity simulation on undergraduate nursing students' clinical reasoning-related skills: A systematic review. *Nurse Education Today*, 121, 105679. <https://doi.org/10.1016/j.nedt.2022.105679>
- Bylow, H., Karlsson, T., Lepp, M., Claesson, A., Lindqvist, J., & Herlitz, J. (2019). Effectiveness of web-based education in addition to basic life support learning activities: A cluster randomised controlled trial. *PLoS ONE*, 14(7). <https://doi.org/10.1371/journal.pone.0219341>

- Cant, R., Cooper, S., & Ryan, C. (2022). Using virtual simulation to teach evidence-based practice in nursing curricula: A rapid review. *Worldviews on Evidence-Based Nursing*, 19(5), 415–422. <https://doi.org/10.1111/wvn.12572>
- Cant, R., Ryan, C., & Kelly, M. A. (2023). Use and effectiveness of virtual simulations in nursing student education: An umbrella review. *Computers, Informatics, Nursing*, 41(1), 31–38. <https://doi.org/10.1097/CIN.0000000000000932>
- Chang, H.-Y., Wu, H.-F., Chang, Y.-C., Tseng, Y.-S., & Wang, Y.-C. (2021). The effects of a virtual simulation-based, mobile technology application on nursing students' learning achievement and cognitive load: Randomized controlled trial. *International Journal of Nursing Studies*, 120, 103948. <https://doi.org/10.1016/j.ijnurstu.2021.103948>
- Cho, M.-K., & Kim, M. Y. (2024). Enhancing nursing competency through virtual reality simulation among nursing students: A systematic review and meta-analysis. *Frontiers in Medicine*, 11, 1351300. <https://doi.org/10.3389/fmed.2024.1351300>
- Choi, J., Thompson, C. E., Choi, J., Waddill, C. B., & Choi, S. (2022). Effectiveness of immersive virtual reality in nursing education: Systematic review. *Nurse Educator*, 47(3), E57–E61. <https://doi.org/10.1097/NNE.0000000000001117>
- Chow, K. M., Ahmat, R., Leung, A. W. Y., & Chan, C. W. H. (2023). Is high-fidelity simulation-based training in emergency nursing effective in enhancing clinical decision-making skills? A mixed methods study. *Nurse Education in Practice*, 69, 103610. <https://doi.org/10.1016/j.nepr.2023.103610>
- Clerkin, R., Patton, D., Moore, Z., Nugent, L., Avsar, P., & O'Connor, T. (2022). What is the impact of video as a teaching method on achieving psychomotor skills in nursing? A systematic review and meta-analysis. *Nurse Education Today*, 111. <https://doi.org/10.1016/j.nedt.2022.105280>
- Du, L., Zhao, L., Xu, T., Wang, Y., Zu, W., Huang, X., ... Wang, L. (2022). Blended learning vs traditional teaching: The potential of a novel teaching strategy in nursing education - A systematic review and meta-analysis. *Nurse Education in Practice*, 63, 103354. <https://doi.org/10.1016/j.nepr.2022.103354>
- El Hussein, M. T., & Cuncannon, A. (2022). Nursing students' transfer of learning from simulated clinical experiences into clinical practice: A scoping review. *Nurse Education Today*, 116, 105449. <https://doi.org/10.1016/j.nedt.2022.105449>
- Foronda, C. L., Fernandez-Burgos, M., Nadeau, C., Kelley, C. N., & Henry, M. N. (2020). Virtual simulation in nursing education: A systematic review spanning 1996 to 2018. *Simulation in Healthcare*, 15(1), 46–54. <https://doi.org/10.1097/SIH.0000000000000411>
- Fung, J. T. C., Chan, S. L., Takemura, N., Chiu, H.-Y., Huang, H.-C., Lee, J.-E., ... Lin, C.-C. (2023). Virtual simulation and problem-based learning enhance perceived clinical and cultural competence of nursing students in Asia: A randomized controlled cross-over study. *Nurse Education Today*, 123, 105721. <https://doi.org/10.1016/j.nedt.2023.105721>
- Goldsworthy, S., Muir, N., Baron, S., Button, D., Goodhand, K., Hunter, S., ... Peachey, L. (2022). The impact of virtual simulation on the recognition and response to the rapidly deteriorating patient among undergraduate nursing students. *Nurse Education Today*, 110, 105264. <https://doi.org/10.1016/j.nedt.2021.105264>
- Harnanto, A. M., & Sunarto, S. (2022). Effect of web-based learning to increase knowledge of basic life support for nursing students during the COVID-19 pandemic. *JKG (Jurnal Keperawatan Global)*, 19(2). <https://doi.org/10.37341/jkg.v0i0.386>
- Huai, P., Li, Y., Wang, X., Zhang, L., Liu, N., & Yang, H. (2024). The effectiveness of virtual reality technology in student nurse education: A systematic review and meta-analysis. *Nurse Education Today*, 138, 106189. <https://doi.org/10.1016/j.nedt.2024.106189>
- Jallad, S. T., & Işık, B. (2022). The effectiveness of virtual reality simulation as learning strategy in the acquisition of medical skills in nursing education: A systematic review. *Irish Journal of Medical Science*, 191(3), 1407–1426. <https://doi.org/10.1007/s11845-021-02695-z>
- Jiang, N., Zhang, Y., Liang, S., Lyu, X., Chen, S., Huang, X., & Pan, H. (2024). Effectiveness of virtual simulations versus mannequins and real persons in medical and nursing education: Meta-analysis and trial sequential analysis of randomized controlled trials. *Journal of Medical Internet Research*, 26, e56195. <https://doi.org/10.2196/56195>
- Lei, Y.-Y., Zhu, L., Sa, Y. T. R., & Cui, X.-S. (2022). Effects of high-fidelity simulation teaching on nursing students' knowledge, professional skills and clinical ability: A meta-analysis and systematic review. *Nurse Education in Practice*, 60, 103306. <https://doi.org/10.1016/j.nepr.2022.103306>
- Mulyadi, M., Tonapa, S. I., Rompas, S. S. J., Wang, R.-H., & Lee, B.-O. (2021). Effects of simulation technology-based learning on nursing students' learning outcomes: A systematic review and meta-analysis of experimental studies. *Nurse Education Today*, 107, 105127. <https://doi.org/10.1016/j.nedt.2021.105127>

- O'Rourke, L. A., Morrison, M., Grimsley, A., & Cotter, V. T. (2023). High-fidelity simulation and nurse clinical competence: An integrative review. *Journal of Clinical Nursing*, 32(9–10), 1549–1555. <https://doi.org/10.1111/jocn.16028>
- Park, S., Shin, H. J., Kwak, H., & Lee, H. J. (2024). Effects of immersive technology-based education for undergraduate nursing students: Systematic review and meta-analysis using the GRADE approach. *Journal of Medical Internet Research*, 26, e57566. <https://doi.org/10.2196/57566>
- Plotzky, C., Lindwedel, U., Sorber, M., Loessl, B., König, P., Kunze, C., ... Meng, M. (2021). Virtual reality simulations in nurse education: A systematic mapping review. *Nurse Education Today*, 101, 104868. <https://doi.org/10.1016/j.nedt.2021.104868>
- Plotzky, C., Loessl, B., Kuhnert, B., Friedrich, N., Kugler, C., König, P., & Kunze, C. (2023). My hands are running away - learning a complex nursing skill via virtual reality simulation: A randomised mixed methods study. *BMC Nursing*, 22, 222. <https://doi.org/10.1186/s12912-023-01384-9>
- Qiao, J., Huang, C.-R., Liu, Q., Li, S.-Y., Xu, J., Li, L., ... Ouyang, Y.-Q. (2023). Effectiveness of non-immersive virtual reality simulation in learning knowledge and skills for nursing students: Meta-analysis. *Clinical Simulation in Nursing*, 76, 26–38. <https://doi.org/10.1016/j.ecns.2022.12.003>
- Requena-Mullor, M. d. M., Alarcón-Rodríguez, R., Ventura-Miranda, M. I., & García-González, J. (2021). Effects of a clinical simulation course about Basic Life Support on undergraduate nursing students' learning. *International Journal of Environmental Research and Public Health*, 18(4), 1409. <https://doi.org/10.3390/ijerph18041409>
- Rourke, S. (2020). How does virtual reality simulation compare to simulated practice in the acquisition of clinical psychomotor skills for pre-registration student nurses? A systematic review. *International Journal of Nursing Studies*, 102, 103466. <https://doi.org/10.1016/j.ijnurstu.2019.103466>
- Silva, G. O., Oliveira, F. S. E., Coelho, A. S. G., Cavalcante, A. M. R. Z., Vieira, F. V. M., Fonseca, L. M. M., ... Aredes, N. D. A. (2022). Effect of simulation on stress, anxiety, and self-confidence in nursing students: Systematic review with meta-analysis and meta-regression. *International Journal of Nursing Studies*, 133, 104282. <https://doi.org/10.1016/j.ijnurstu.2022.104282>
- Sim, J. J. M., Rusli, K. D. B., Seah, B., Levett-Jones, T., Lau, Y., & Liaw, S. Y. (2022). Virtual simulation to enhance clinical reasoning in nursing: A systematic review and meta-analysis. *Clinical Simulation in Nursing*, 69, 26–39. <https://doi.org/10.1016/j.ecns.2022.05.006>
- Tong, L. K., Li, Y. Y., Au, M. L., Wang, S. C., & Ng, W. I. (2022). High-fidelity simulation duration and learning outcomes among undergraduate nursing students: A systematic review and meta-analysis. *Nurse Education Today*, 116, 105435. <https://doi.org/10.1016/j.nedt.2022.105435>
- Wong, F. M. F., Tang, A. C. Y., & Cheng, W. L. S. (2021). Factors associated with self-directed learning among undergraduate nursing students: A systematic review. *Nurse Education Today*, 104, 104998. <https://doi.org/10.1016/j.nedt.2021.104998>
- Woon, A. P. N., Mok, W. Q., Chieng, Y. J. S., Zhang, H. M., Ramos, P., Mustadi, H. B., & Lau, Y. (2021). Effectiveness of virtual reality training in improving knowledge among nursing students: A systematic review, meta-analysis and meta-regression. *Nurse Education Today*, 98, 104655. <https://doi.org/10.1016/j.nedt.2020.104655>