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Impact of an innovative sandwich-microteaching framework on emergency skill training of resident physicians in a simulated ICU

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Highlights

- Innovative framework: This study evaluated a novel teaching model that integrates the sandwich methodology with microteaching for emergency skill training in a simulated ICU.
- Superior Learning Outcomes: Compared with the control group, the experimental group achieved significantly higher theoretical scores and markedly superior practical skill performance.
- Educational Implications: The proposed framework provides a promising strategy to optimize emergency skill acquisition and learner satisfaction, addressing critical gaps in acute care medical education.

Abstract

Objectives: To evaluate the effectiveness of an innovative teaching framework combining sandwich methodology and microteaching in improving emergency skill training outcomes among resident physicians. **Methods:** A randomized controlled trial was conducted involving 92 residents enrolled in standardized training programs. Participants were randomly allocated into two groups: the Experimental Group (EG, n=46), which received training via the sandwich-microteaching method in a simulated ICU, and the Control Group (CG, n=46), which received conventional teaching. Both groups underwent identical core curriculum content. Data collected included demographics (gender, age, resident year), theoretical knowledge scores, practical skill performance scores, self-assessed mastery levels, and course satisfaction. **Results:** Baseline characteristics showed no significant differences between groups (gender p=0.527, age p=0.394, resident year p=0.661). The EG demonstrated significantly higher theoretical scores (94.80±1.54 vs. 92.70±3.48, p<0.001) and practical skill scores (93.65±3.06 vs. 89.20±4.74, p<0.001) compared to the CG. Satisfaction rates were markedly elevated in the EG (95.65% vs. 78.26%, p=0.030). While overall self-assessed mastery distributions were similar (p=0.193), the EG reported a higher proportion of expert-level mastery (self-assessed level 10). **Conclusion:** This innovative teaching framework significantly improves emergency skill proficiency and learner satisfaction, while fostering clinically meaningful improvements in self-perceived expertise. The combined sandwich-microteaching approach represents a promising strategy for high-quality emergency skill training in residency programs.

Keywords: Basic anesthesiology, competency model, teaching methods

Introduction

Proficiency in emergency resuscitation and critical care procedures is essential for physicians, especially those training in acute care specialties such as emergency medicine, anesthesiology, and critical care medicine [1, 2]. The high-stakes, time-sensitive nature of intensive care

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Table 1. Emergency skill training curriculum

Course	Key Skills
I. Cardiac Arrest Resuscitation	Cardiopulmonary Resuscitation
II. Acute Respiratory Failure Management	Ventilator Management
III. Shock Recognition & Resuscitation	Central Venous Catheterization
IV. Multiple Trauma Management	Suture Ligation Hemostasis
V. Integrated Difficult Airway Management	Endotracheal Intubation

unit (ICU) emergencies requires not only solid theoretical knowledge but also exceptional psychomotor skills, rapid decision-making, and effective communication within teams [3, 4]. Traditional teaching methods, such as didactic lectures and sporadic clinical exposure, often fail to provide residents with sufficient, safe, and structured opportunities to acquire and refine these complex competencies [5-7]. Thus, identifying effective pedagogical strategies for training residents in high-stakes emergency skills in the ICU setting is of crucial importance [8].

The sandwich teaching method is a student-centered approach that alternates between problem presentation, independent or small-group learning, and facilitated discussion to synthesize and apply knowledge [9-11]. This structure fosters active learning, critical thinking, and knowledge integration. Microteaching, conversely, focuses on the deliberate practice of specific, well-defined skills. It typically involves a concise teaching session focused on one skill, followed by immediate feedback, which is often enhanced by video recording, reflection, and repeated practice cycles [12, 13]. This approach has proven highly effective for honing psychomotor and communication abilities.

Although both methods have demonstrated efficacy independently, their integration within a high-fidelity simulated ICU environment for emergency skill training remains underexplored, particularly in the context of standardized residency training programs in China [14-16]. Therefore, this study aimed to evaluate the efficacy of a combined sandwich-microteaching approach, delivered in a simulated ICU setting, compared to the conventional teaching method for emergency skill training among resident physicians.

Methods

Study design

This single-center randomized controlled trial was conducted from January to December 2023. Ninety-two resident physicians from the Affiliated Huai'an No.1 People's Hospital of Nanjing Medical University were recruited.

Inclusion criteria: active resident status, completion of basic life support training. Exclusion criteria: prior formal ICU training exceeding six months and a refusal to participate. Participants were randomly assigned to either the Experimental Group (EG, n=46) or the Control Group (CG, n=46) using computer-generated random numbers. Allocation concealment was ensured through sealed opaque envelopes, which were opened only after consent was obtained.

Ethics statement

This study focused on educational methodology and did not involve patient data or clinical interventions. As such, the Ethics Committee of the Affiliated Huai'an No.1 People's Hospital of Nanjing Medical University determined that a formal ethical review was not required. The research adhered to recognized ethical guidelines for educational research. All participants were fully informed about the study's purpose, and verbal consent was obtained. Voluntary participation and participant autonomy were emphasized throughout the study.

Intervention

The experimental group and the control group received the same standard emergency skill training curriculum, as outlined in **Table 1**: (1) Cardiopulmonary resuscitation for cardiac arrest; (2) Ventilator application in acute respiratory failure; (3) Central venous catheterization for shock resuscitation; (4) Suture ligation hemostasis for multiple trauma; (5) Endotracheal intubation for integrated difficult airway management. The total training time was equivalent between groups. The control group received traditional teaching methods, whereas the experimental group underwent training using the sandwich-microteaching approach within a high-fidelity simulated ICU, as shown in **Figure 1**.

Data collection

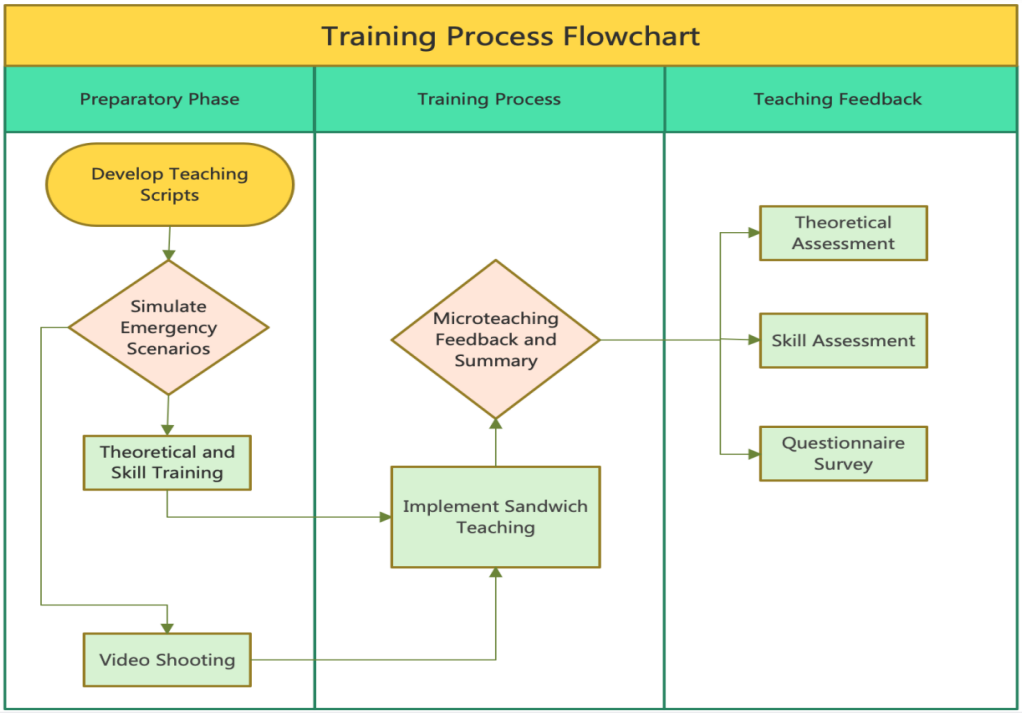

Figure 1. Flowchart of the innovative teaching framework for emergency skills training.

Data were collected immediately after completion of the training module for both groups, including:

Demographics: gender, age, and current year of residency training.

Theoretical Knowledge: assessed by a standardized multiple-choice examination covering core concepts related to ICU emergencies and procedures (score range: 0-100).

Practical Skill Performance: performance was assessed using objective structured clinical examination stations within the simulated ICU. Each station assessed key emergency skills using validated checklists. Scores were assigned by blinded assessors and standardized to a 0-100 scale.

Self-Rated Mastery: Participants rated their perceived level of mastery on a 10-point Likert scale, ranging from 1 (not mastered) to 10 (fully mastered).

Course Satisfaction: measured using a standardized 5-point Likert scale (1=very dissatisfied, 5=very ssatisfied). Satisfaction was defined as a rating of 5 (very satisfied) or 4 (satisfied).

Statistical analysis

Data were analyzed using GraphPad Prism 10.0 (GraphPad Software Inc., San Diego, CA, USA). Continuous variables were presented as Mean±Standard Deviation (SD). Between-group comparisons were performed using independent-samples t tests when normality was satisfied (assessed by Shapiro-Wilk test) and the Mann-Whitney U test for non-normally distributed data. Categorical variables were presented as frequencies (percentages) and compared using the Chi-square (χ^2) test or Fisher's exact test when expected cell counts were small. A two-tailed p-value<0.05 was considered statistically significant.

Results

Baseline participant characteristics

A total of 92 resident physicians (46 per group) completed the training and assessments. The control and experimental groups demonstrated comparable baseline characteristics (**Table 2**). There were no statistically significant differences between the two groups regarding gender distribution (p=0.527), age (p=0.398), or residency training year (p=0.661), indicating successful randomization.

Theoretical and practical performance

Results for learning outcomes are summarized in **Figure 2**. The EG achieved significantly higher theoretical knowledge scores (94.80±1.54 vs. 92.70±3.48; p<0.001) and practical skill scores (93.65±3.06 vs. 89.20±4.74; p<0.001) compared with the CG.

Table 2. Baseline characteristics

Characteristic	Control Group (n=46)	Experimental Group (n=46)	t/χ^2	*P* value
Gender, n (%)				
Male	28 (60.87%)	25 (54.35%)	0.40	0.53
Female	18 (39.13%)	21 (45.65%)		
Age (years), Mean±SD	26.98±3.09	27.54±3.28	0.85	0.40
Resident Year, n (%)				
1	13 (28.26%)	14 (30.43%)		
2	17 (36.96%)	13 (28.26%)	0.83	0.66
3	16 (34.78%)	19 (41.31%)		

Note: NS, not significant.

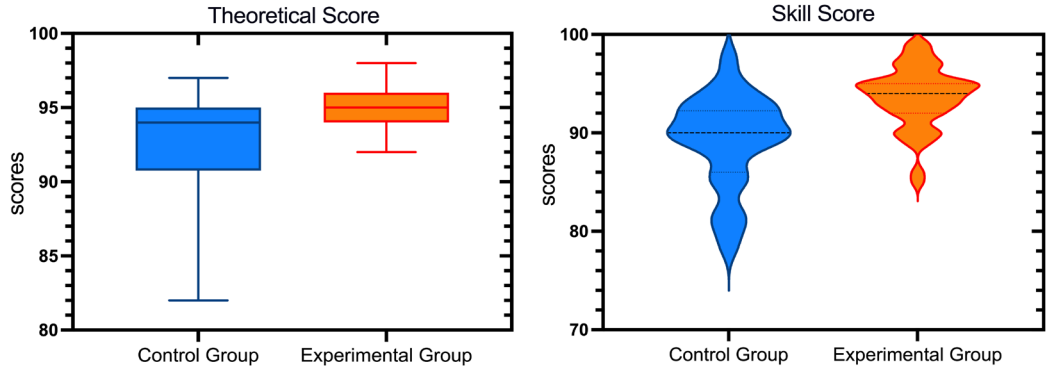

Figure 2. Comparison of theoretical knowledge (left) and practical skill proficiency (right) between control and experimental groups (n=46 per group). Box plot distribution of theoretical knowledge scores demonstrates significantly higher median performance in the experimental group compared to control (Mann-Whitney U=640, p<0.001). Violin plot distribution of practical skill proficiency shows enhanced performance density in the experimental group versus control (Mann-Whitney U=425, p<0.001).

Satisfaction outcomes

Compared with the CG, a significantly higher proportion of residents in the EG (44, 95.65% vs. 36, 78.26%; p=0.030) reported being satisfied or very satisfied with the course (**Table 3**).

Self-assessed mastery

While overall mastery distributions were similar between groups (p=0.193), the experimental group reported a higher rate of expert-level mastery (self-rated level 10) compared to the control group (**Figure 3**).

Discussion

This randomized controlled trial demonstrates that an innovative teaching framework integrating the sandwich methodology with microteaching in a high-fidelity simulated ICU environment significantly enhances emergency skill training outcomes among resident physicians compared to conventional methods. The experimental group consistently outperforms the control group, achieving higher theoretical knowledge scores, superior practical skill performance, markedly increased course satisfaction, and a greater proportion of self-assessed expert-level mastery (Level 10).

The enhanced theoretical knowledge acquisition observed in the experimental group (94.80±1.54 vs. 92.70±3.48, p<0.001) likely resulted from the structured cyclical nature of the sandwich methodology, which promotes deeper cognitive engagement, active knowledge construction, and repeated reinforcement, addressing a critical limitation of passive didactic learning [17]. These findings are consistent with findings from community nursing education, where sandwich teaching improved critical thinking and self-directed learning, though it did not significantly enhance final exam performance [18]. The even greater advantage in practical skill performance (93.65±3.06 vs. 89.20±4.74, p<0.001) may be attributed to the integration of microteaching, which emphasizes deliberate, focused practice of discrete skills, immediate feedback, and iterative refinement [19, 20]. This method enables repetitive psychomotor training essential for mastering time-sensitive ICU procedures.

Notably, previous studies using standalone microteaching strategies, such as a WeChat-based intervention at Changhai Hospital in Shanghai, also reported improved learning outcomes, but noted challenges such as reliance on stable internet access and increased demands on student self-discipline [21]. Our integrated framework mitigates these limita-

Table 3. Comparative analysis of satisfaction levels in control and experimental groups

Satisfaction	Control Group	Experimental Group	χ^2	*P* value
Very Satisfied	34	41		
Satisfied	2	3		
Neutral	5	1	6.52	0.16
Dissatisfied	3	1		
Very Dissatisfied	2	0		
Positive Response[#]	36 (78.26%)	44 (95.65%)	4.70	0.03[*]

Note: [#]Positive Response=Satisfied+Very Satisfied. [*]p<0.05

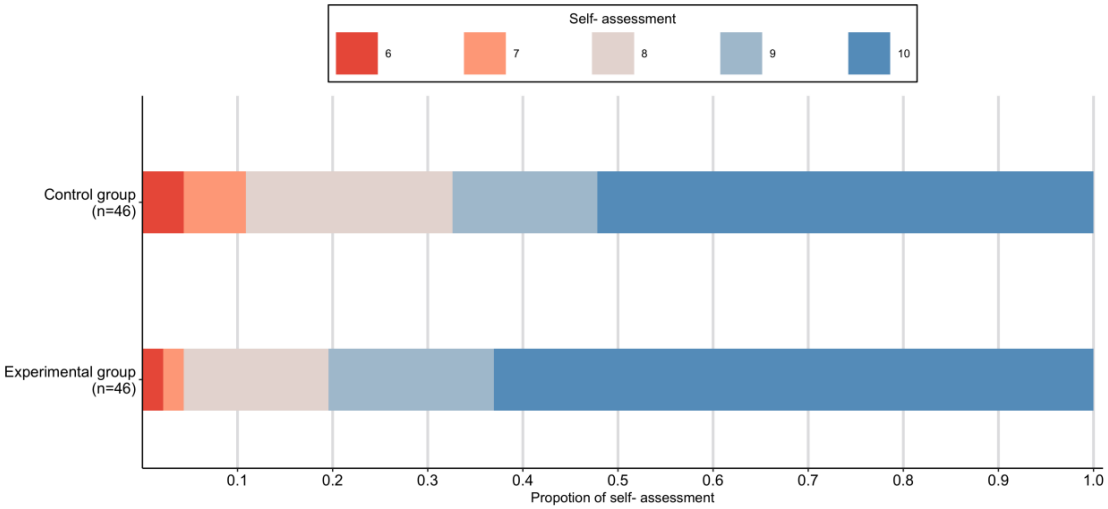

Figure 3. Horizontal stacked bars show the proportional distribution of self-assessment scores (6=minimal mastery, red; 10=expert mastery, blue) in the control (top, n=46) and experimental (bottom, n=46) groups. The length of each colored segment corresponds to the proportion of participants selecting that score. The overall distribution did not differ significantly between groups (p=0.193).

tions by incorporating structured face-to-face sessions within a simulated ICU, offering a safe yet realistic setting for skill practice and error correction [22, 23]. The significantly higher satisfaction rate in the experimental group (95.65% vs. 78.26%, p=0.030) underscores the value of this combined approach. Residents likely appreciated the opportunities for active participation, structured feedback, tangible skill improvement, and the psychological safety provided by simulation-based training [24]. Although self-assessed mastery distributions were generally similar between groups, more participants in the experimental group rated themselves at Level 10, suggesting that the integrated approach may also enhance self-efficacy, an important predictor of performance in high-stress clinical situations.

Several limitations warrant consideration. First, this was a single-center trial conducted in China, and thus findings may be influenced by local institutional culture, available resources, and characteristics of the Chinese medical education system. These factors may limit generalizability, highlighting the need for future multi-center studies across different regions and health systems to strengthen external validity. Second, the relatively small sample size may limit statistical power, and a larger cohort would enhance the robustness of our conclusions. Third, while assessors were blinded, participants were not, which may have introduced performance bias. Finally, this study assessed only immediate post-training outcomes. While these results are encouraging, the long-term retention and transfer of acquired skills remain uncertain. Future studies will incorporate longitudinal follow-up at 3, 6, and 12 months to determine the durability of the educational impact.

In conclusion, combining sandwich and microteaching methodologies within a high-fidelity simulated ICU environment proved highly effective for emergency skill training, yielding superior knowledge acquisition, practical skill performance, and learner satisfaction compared with conventional teaching. Incorporating this framework into standardized residency training programs may represent a promising strategy to strengthen emergency skill education.

Ethics approval and consent to participate: Ethical approval was waived for this educational methodology study that used no patient data or clinical interventions, and verbal informed consent was obtained from all participants fol-

lowing a explanation of the voluntary study.

Author contributions: All authors contributed to this manuscript. Xiangcheng Zhang provided guidance throughout the research process. Ying Huang conducted the majority of the experiments and drafted the manuscript. Tongkun Zuo and Shiguang Guo performed experiments and analyzed the data. Xusheng An contributed to data collection and testing.

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