Study on the application effect of CDIO-based training mode in ECMO training for ICU nurses

Studija o efektu primene režima obuke zasnovanog na CDIO u ECMO obuci medicinskih sestara na odeljenju intenzivne nege

[1]Rui Zhu, [1]Yufang Geng, Jingjing Li, Min Shao

Anhui Medical University, First Affiliated Hospital, Hefei, Anhui, China

[1]These authors contributed equally to this study

Abstract

Background/Aim. Nurses in the intensive care unit (ICU) must have strong professional skills due to excessive workloads, high nursing risk events, and frequent nurse-patient disagreements. The aim of the study was to examine the use of Conceive, Design, Implement, and Operate (CDIO)-based teaching modalities in ICU nurses' extracorporeal membrane oxygenation (ECMO) training and find ways to increase training quality and professional capabilities. **Methods.** This study included 60 nurses and 100 ICU patients, selected from January 2020 to December 2021. They were split into an observation group (OG) and a control group (CG) (30 nurses and 50 patients each) based on ECMO nurse training methods. OG used CDIO-based training, whereas CG used ordinary training. Nurses' theoretical knowledge, fundamental nursing skills, professional nursing skills, Competency Inventory for Registered Nurses (CIRN) score, Critical Thinking Disposition Inventory-Chinese Version (CTDI-CV) score, and self-efficacy (General Self-Efficacy Scale – GSES) score were assessed. **Results.** Nurses' theoretical knowledge, basic skills, and professional skills were significantly greater ($p < 0.05$) in OG (95.34 ± 1.97, 56.84 ± 1.97, 36.19 ± 2.04) than in CG (87.11 ± 2.82, 51.17 ± 2.42, 31.52 ± 2.38). After training, nurses in OG had higher combined scores in CIRN, CTDI-CV, and GSES (75.84 ± 9.59) compared to CG (67.35 ± 8.43, $p < 0.05$). **Conclusion.** ICU nurses' ECMO training benefits from CDIO-based modalities. It may considerably increase nurses' evaluation outcomes, core competency, critical thinking, self-efficacy, and self-learning. Training quality is far greater than traditional training, making it worthy of promotion and utilization.

Key words:
extracorporeal membrane oxygenation; intensive care units; education; nurse clinicians; professional competence.

Apstrakt

Uvod/Cilj. Medicinske sestre na odeljenju intenzivne nege (*intensive care unit* – ICU) moraju imati napredne profesionalne veštine zbog prevelikog opterećenja, događaja visokog rizika kojima su izložene i čestih neslaganja između sestara i bolesnika. Cilj rada bio je da se ispita upotreba nastavnih modaliteta zasnovanih na konceptu, dizajnu, primeni i rukovanju (*Conceive, Design, Implement, and Operate* – CDIO) u obuci medicinskih sestara za ekstrakorporalnu membransku oksigenaciju (*extracorporeal membrane oxygenation* – ECMO) na ICU i da se nađe način za povećanje kvaliteta obuke i profesionalnih sposobnosti. **Metode.** Studijom je obuhvaćeno 60 medicinskih sestara i 100 bolesnika na ICU, izabranih u periodu od januara 2020. do decembra 2021. godine. Bili su podeljeni na posmatranu grupu (PG) i kontrolnu grupu (KG) (u svakoj po 30 sestara i 50 bolesnika) na osnovu metoda obuke medicinskih sestara za ECMO. Grupa PG je koristila obuku zasnovanu na CDIO, dok je KG koristila uobičajenu obuku. Procenjivani su teorijsko znanje medicinskih sestara, osnovne veštine, zahtevnije veštine, skor *Competency Inventory for Registered Nurses* (CIRN), skor *Critical Thinking Disposition Inventory-Chinese Version* (CTDI-CV) i skor *General Self-Efficacy Scale* (GSES). **Rezultati.** Teorijsko znanje, osnovne veštine i profesionalne veštine medicinskih sestara bile su značajno veće ($p < 0,05$) u PG (95,34 ± 1,97, 56,84 ± 1,97, 36,19 ± 2,04) nego u KG (87,11 ± 2,82, 51,17 ± 2,42, 31,52 ± 2,38). Posle obuke, medicinske sestre u grupi PG imale su više rezultate kombinacije skorova CIRN, CTDI-CV i GSES (75,84 ± 9,59) u poređenju sa KG (67,35 ± 8,43, $p < 0,05$). **Zaključak.** Primena modaliteta zasnovanih na CDIO je korisna za obuku medicinskih sestara na ICU za ECMO. To može značajno povećati ishod procene, osnovnu

Correspondence to: Min Shao, Anhui Medical University, First Affiliated Hospital of Hefei, Anhui, China, 230 001.
E-mail: minshao130@gmail.com, shaomin@ahmu.edu.cn

kompetenciju, kritičko razmišljanje, samoefikasnost i samoučenje medicinskih sestara. Kvalitet obuke je daleko veći od tradicionalne obuke, što je čini vrednom promocije i primene.

Introduction

The intensive care unit (ICU) has the characteristics of heavy workloads, a high incidence of nursing risk events, and easy-to-cause nurse-patient disputes, so it requires very high professional skills from nurses [1]. However, due to the influence of educational level, training, and other factors, ICU nurses' professional skills are uneven, and some ICU nurses' clinical thinking ability is not high, resulting in their poor emergency response ability, low work efficiency, and frequent nursing errors [2]. For that reason, it is necessary to train ICU nurses systematically in order to improve their professional skills. Extracorporeal membrane oxygenation (ECMO) is a new technology for rescuing the lives of critically ill patients [3]. The establishment, maintenance, and removal of the tubing need to be completed by skilled nurses. Therefore, it is necessary to enhance ECMO training for ICU nurses. Conceive, Design, Implement, and Operate (CDIO) is a new training mode. This training mode attaches importance to "learning and doing", requiring students to practice constantly by learning and mastering skills in practice in order to cultivate their comprehensive ability [4].

With the progress of science and technology, innovation has been raised to the height of national strategy in countries all over the world [5]. Nursing is the key force in medical development, but its professional and academic level lags behind clinical medical treatment. The fundamental reason is the lack of nursing innovation [6]. Some studies have shown that the innovative behavior of clinical frontline nursing staff is at a medium level [7]. Therefore, it is necessary to take the initiative to adjust the talent training mode to meet the demand for innovative nursing talents for the current development of health care [8]. Curriculum education is the core of innovation education. However, the development of the nursing innovation curriculum in China is still in its nascent stage. Hence, the most important task is to develop nursing education to create an innovative nursing curriculum and to seek a reasonable teaching design [9]. CDIO is a classic mode of engineering education at Massachusetts Institute of Technology that emphasizes that engineering education should focus on practice and place the education process in the specific context of the product or system life cycle. It is also an educational mode based on cultivating students' abilities with the aim of cultivating innovative talents. The CDIO concept has been widely applied in the field of applied talent cultivation because of its obvious effect on improving teaching quality and promoting talent cultivation [10].

Applying CDIO to ECMO training for ICU nurses can improve their training effect and professional skills to a certain extent [11]. The aim of the study was to analyze the application effect of CDIO-based training mode in ICU nurses' ECMO training regarding their assessment results, core competence, critical thinking ability, self-efficacy, and self-learning ability.

Methods

The study included a total of 60 nurses and 100 patients who were chosen as the subjects from the ICU of the First Affiliated Hospital of Anhui Medical University, China between January 2020 and December 2021. The participants were categorized into a control group (CG) and an observation group (OG), with 30 nurses and 50 patients each. The division was based on the various types of ECMO training for nurses.

The nurses in CG were all female, aged 20 to 42 years, with an average age of 28.87 ± 3.36 years. The length of service was 1–8 years, with a mean length of 4.43 ± 1.60 years. Among the professional titles were 2 head nurses, 5 staff nurses, and 23 junior nurses. Among them, there were 12 junior college students, 8 undergraduate students, and the other 10 nurses. The patient sample size consisted of 28 males and 22 females, with a mean age of 35.47 ± 7.25 years.

In OG, all the nurses were female, aged 20 to 43 years, with an average age of 28.91 ± 3.34 years. The length of service was 1–8 years, with a mean length of 4.45 ± 1.58 years. Among the professional titles, there were 2 head nurses, 5 staff nurses, and 23 junior nurses. Among them, there were 13 junior college students, 7 undergraduate students, and the other 10 nurses. There were 50 patients in total, 27 males and 23 females. The median age was 35.50 ± 7.23 years.

This study was approved by the Ethics Committee of the First Affiliated Hospital of Anhui Medical University, China (Reg. No. 45546/CDIO/2020) and was executed according to the ethical standards outlined in the Declaration of Helsinki. Written informed consent was obtained from each participant.

Study requirement criteria

Inclusion criteria for nurses were as follows: ICU nurses who were in service in 2020 and 2021; nurses with certain ICU nursing knowledge and operation skills; those who completed the ECMO training and passed the examination; those who were able to accept a questionnaire survey and understand the purpose of the questionnaire survey; those who know about the research and participate voluntarily. Exclusion criteria were as follows: those who failed to complete the training or pass the assessment; those who were unable to express personal wishes accurately; nurses unwilling to cooperate with the investigation.

Patient inclusion criteria were as follows: those with complete medical records; patients who stayed in the ICU for treatment; those who understood the purpose of the questionnaire and participated voluntarily. Exclusion criteria were the following: mental illness; death due to ineffective treatment; patients unable to express personal wishes accurately; patients unwilling to cooperate with the investigation.

Both groups of nurses completed the training under the guidance of the teachers, and the teachers' qualifications were the same. Prior to the training, the teachers prepare lessons and access relevant materials *via* the Internet to master the relevant knowledge of the training mode.

For the CG routine, ordinary training mode was used. According to the training plan formulated by the department, nurses should be organized to carry out unified training, focusing on theoretical teaching. The teachers use multimedia equipment and courseware to explain relevant knowledge to nurses according to the content of the syllabus. Nurses listen, take notes, and recap on their own after class. At the same time, teaching was conducted in stages according to the different teaching contents. The teacher led the nurses to make ward rounds, asked them questions, and gave explanations according to the characteristics of cases, clinical diagnoses, and treatment problems. During the training, a demonstration of an operation is performed using the traditional method, and then the operation is performed by a nurse.

In contrast, the CDIO-based training mode was applied for the OG routine. The CDIO-based training includes contents described in the following paragraphs.

Conception – used to evaluate nurses before training using the scales of core competence, critical thinking ability, emergency response ability, post-competence, self-efficacy, and self-learning ability. This is done in order to understand their professional level, professional ability, and cognition and formulate training plans according to the requirements of ICU nurses. At the same time, conception summarizes the problems and causes in the ECMO regarding the work of nurses with the ICU patients, including the pre-flushing of the membrane lung and tubing, ECMO puncture and catheterization, membrane lung replacement, etc. It defines the methods and objectives to improve the quality of ECMO care and devises the CDIO-based training framework.

Design – based on evidence-based medicine, consulting relevant data, analyzing and summarizing CDIO training mode and ECMO nursing guidance and literature, combining department nursing requirements, improving the nurse training system, and designing an ICU nurse training scheme based on CDIO training mode.

Implementation – the main contents include pre-training, joint exchange of retraining, and simulation exercise. First, in the pre-training, the following steps are taken: establish a WeChat group, require all nurses to join, and pay attention to group messages. Before each training, the instructor uploads the training-related materials (including graphic materials and videos) to the WeChat group, requiring nurses to download the materials in advance, learn by themselves, mark the contents they do not understand, and consult the materials to supplement and expand the relevant knowledge points. Second, in the joint exchange of retraining, the teacher will systematically explain ECMO knowledge, including indications and contraindications of ECMO, preparations before operation, key points of operation and precautions, treatment, and remedial measures for complications, and provide reference materials and literature. Reserve some time in class, let the nurses exchange and discuss the learned knowledge in the form of group discussion, and guide the teachers to design problems, such as: should ECMO be used for severe hypoxia, how to select an ECMO mode, what are the common complications of ECMO, how to select an ECMO puncture tube, etc. A representative chosen by the group answers the questions. The teacher will supplement and improve the answers and summarize the main knowledge points. Finally, in the simulation exercise, the following should be done: provide training and guidance for nurses on ECMO nursing operation technology; use simulators to conduct on-site simulation exercises; nurses can also play different roles in conducting situational simulation exercises to feel the clinical atmosphere and improve operation technology.

Operation – formulate the evaluation system, systematically evaluate the nurses in the middle of the training, summarize the deficiencies in the training process, and put forward improvement measures to correct and improve after the later training. At the same time, the nursing operation process and specifications were compiled as the assessment standard manual to provide a quantifiable reference for the training effect of nurses.

Observation indicators

Assessment results, core competence, critical thinking ability, emergency response ability, post-competence, self-efficacy, self-learning ability, work efficiency, and patient satisfaction were compared between the two groups.

Assessment results: a unified assessment was conducted after the training, including theoretical knowledge, basic nursing skills, and professional nursing skills. The scores range from 0 to 100, 0 to 60, and 0 to 40, respectively. A higher score indicates superior performance.

Core competence: assessed before and after the training using the Competency Inventory for Registered Nurses (CIRN) scale with five features, a five-level scoring technique (1–5 points), and a total score for each item. The higher the score, the better.

Critical thinking ability: evaluated before and after the training using the Critical Thinking Disposition Inventory–Chinese Version (CTDI-CV) scale, which includes thirst for knowledge, seeking the truth, analytical ability, an open mind, cognitive maturity, and confidence. To compute the average score for each item, the 6-level scoring system is used. The greater the score, the better [12].

Emergency response-ability: the evaluation should be conducted before and after the training, including condition observation, emergency cooperation, and first aid operations.

There are 10 questions in total, and a 6-level scoring method is adopted. The higher the score, the better [13].

Post-competency: evaluated before and after the training, with 8 items including theory, skills, management, and teaching, for an overall score of 100 points. The greater the score, the better [14, 15].

Self-efficacy: assessed before and after the training using the General Self-Efficacy Scale (GSES), which has 10 items and adopts the 4-level scoring method (1–4 points). The overall score ranges from 10 to 40 points. The greater the score, the better [16].

Autonomous Learning Ability: evaluated before and after the training using the autonomous learning ability evaluation scale, which includes self-motivation belief, task analysis, self-monitoring and adjustment, self-evaluation, and the overall score calculation for each item. The higher the score, the better [17].

Work efficiency: includes drug preparation time, instrument and equipment preparation time, venous access opening time, and rescue time.

Patient satisfaction: evaluated after the training, according to the nurses' nursing service to the patients, the patients were guided to fill out the questionnaire. The evaluation contents included service attitude, communication skills, nursing operation, problem-solving, etc., with an overall score of 100 points. According to the scoring results, they were divided into very satisfied (> 90 points), satisfied (70–90 points), and dissatisfied (< 70 points). Patient satisfaction = (very satisfied cases + satisfied cases) / total cases × 100%.

Statistical analysis

SPSS 21.0 software was used to analyze the measurement data presented as mean ± standard deviation, run t-tests, analyze count data in percentages, and perform the Chi-square test. The value of $p < 0.05$ was considered statistically significant.

Results

OG and CG were examined for their nurses' theoretical knowledge, fundamental nursing abilities, and professional nursing skills. The basic nursing skills of CG were 51.17 ± 2.42, while those of OG were 56.84 ± 1.97, which also showed significant differences ($p < 0.05$). The professional nursing skills of CG were 31.52 ± 2.38, while those of OG were 36.19 ± 2.04. There is a significant difference ($p < 0.05$) (Table 1).

The CTDI-CV scores of nurses in both groups were comparable before training ($p > 0.05$). However, following the training, the CTDI-CV score of nurses in OG was significantly higher than that of CG ($p < 0.05$) (Table 2). Figure 1 illustrates the projected rate of survival in the external validation group of hospitals, as determined by the CTDI-CV

Table 1

Comparison of nurses' assessment scores (expressed as points)

Group	Theoretical knowledge	Basic nursing skills	Professional nursing skills
CG (n = 30)	87.11 ± 2.82	51.17 ± 2.42	31.52 ± 2.38
OG (n = 30)	95.34 ± 1.97	56.84 ± 1.97	36.19 ± 2.04
p	< 0.05	< 0.05	< 0.05

CG – control group; OG – observation group.
Values are given as mean ± standard deviation.

Table 2

Effect of CDIO-based training on certain work characteristics according to nurse groups

Parameter	Before training*	After training**
CTA		
CG	1.95 ± 0.15	4.93 ±0.90
OG	0.91 ± 0.08	2.68 ± 0.74
NJC		
CG	67.68 ± 5.19	78.07 ± 5.84
OG	67.70 ± 5.15	85.38 ± 6.23
NSE		
CG	23.68 ± 4.69	28.89 ± 5.16
OG	23.70 ± 4.65	34.61 ± 5.01

CDIO – Conceive, Design, Implement, and Operate; CTA – critical thinking ability of nurses (according to Critical Thinking Disposition Inventory–Chinese Version Scale); CG – control group; OG – observation group; NJC – nurse job competencies; NSE – nurse self-efficacy (according to General Self-Efficacy Scale).
Values (in points) are given as mean ± standard deviation.
Both nurses' groups consisted of 30 respondents each.
Note: *–A statistically significant difference was not found between CG and OG groups for CTA, NJC, and NSE ($p = 0.08$, $p = 0.752$, and $p = 0.067$, respectively); **– A statistically significant difference was found between CG and OG groups for all observed parameters ($p < 0.05$).

score. The survival rate was significantly lower in risk classes V and VI (i.e., Respiratory Extracorporeal Membrane Oxygenation Survival Prediction – RESP score < -2) compared to risk classes III, II, and I (i.e., CTDI-CV score ≥ -1) (15.5% vs. 91.5%, respectively). The CTDI-CV score showed outstanding performance in external validation [c = 0.92 (95% confidence interval – CI: 0.89–0.97)], but the Simplified Acute Physiology Score (SAPS) II showed substantially weaker discrimination [c = 0.60 (95% CI: 0.51–0.70)].

The pre-training competence scores of nurses in both groups were statistically equivalent ($p > 0.05$). However, the post-training competency score of nurses in OG was significantly greater than that of CG ($p < 0.05$) (Table 2).

GSES scores of nurses in both groups before training showed no significant difference ($p > 0.05$). However, after the training, the GSES score of nurses in OG surpassed that of CG ($p < 0.05$) (Table 2). Further, the influence of GSES score on patient in-hospital survival was evaluated, which revealed a significant positive connection (Figure 2). GSES
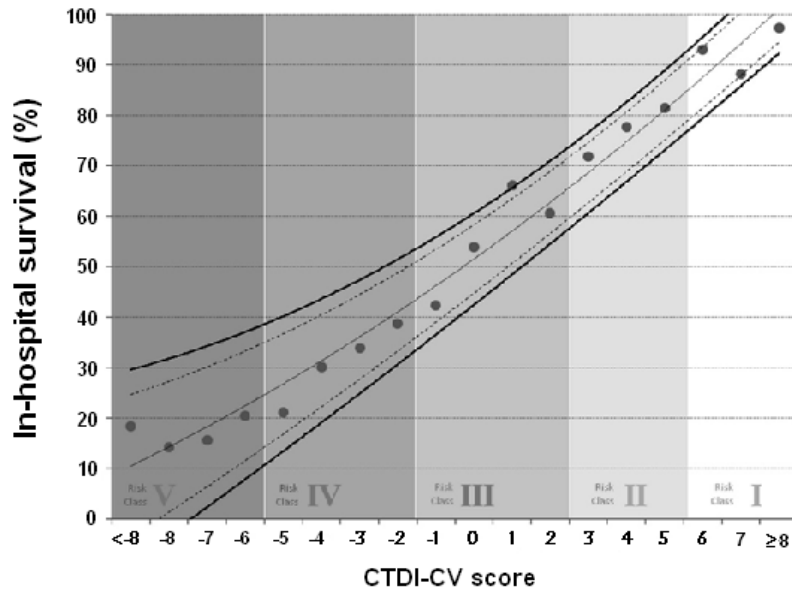

**Fig. 1 – Individuals observed survival regarding
CTDI-CV score within a 95% confidence interval.
Each dot represents the observed survival percentage in the study
population. Curved dotted gray lines and curved black lines represent 95 and
99% confidence intervals, respectively, for predicted survival at each score level.
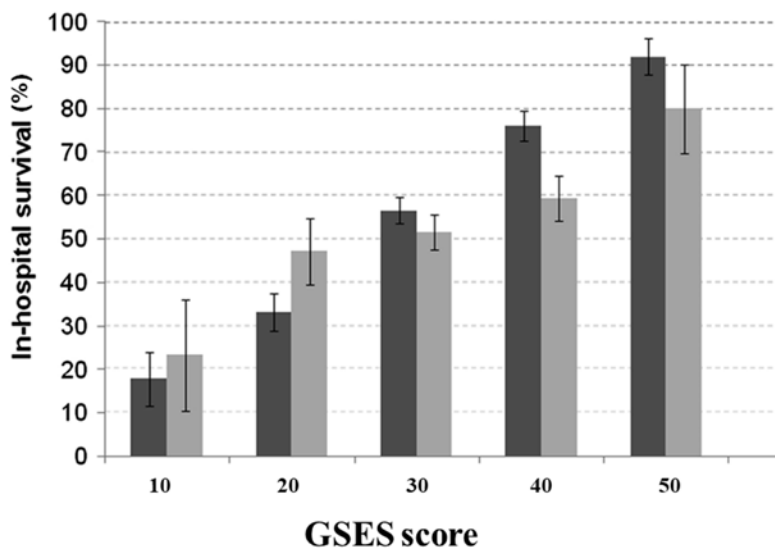CTDI-CV – Critical Thinking Disposition Inventory-Chinese Version.**

**Fig. 2 – Correlation of GSES score and in-hospital survival of patients.
Observed survival is expressed as mean ± standard deviation.
Missing GSES score variables were allocated a zero score.
GSES – General Self-Efficacy Scale.
Note: the darker gray columns indicate the observation group
and the lighter gray columns indicate the control group.**

score was internally validated and showed fair discrimination [c = 0.73 (95% CI: 0.71–0.75)] and satisfactory calibration with a Hosmer-Lemeshow C statistic of 12.81 ($p = 0.12$).

After training, the mean ± standard deviation of the combined scores of CIRN, CTDI-CV, and GSES for nurses in the OG was 75.84 ± 9.59, while for those in the CG, it was 67.35 ± 8.43. The difference was statistically significant ($p < 0.05$).

Discussion

With the advancement of people's living standards, patients' expectations for the quality of nursing care have risen in recent years [18]. Especially for ICU patients, because of the critical condition and high mortality, it is particularly important to do a good job of nursing [19]. ECMO is an important means to rescue critically ill patients. Statistics show that the success rate of this treatment method for critically ill patients can reach 57% [20]. However, ECMO has high technical requirements for operation, and there are great nursing risks in practice. Therefore, standardized training is a top priority [21].

Empirical evidence has shown that implementing scientific and efficient training programs may greatly enhance nurses' expertise and abilities, prevent nursing mistakes, and contribute to the general advancement of the department's diagnostic and treatment capabilities [22]. The conventional training mode is a "cramming and inculcating" training mode, which mainly focuses on teaching, helping, and leading. The teacher is the main body of the training [23]. The nursing students listen and absorb, and the teaching content is mainly theoretical knowledge, lacking training in clinical practice and operation technology, resulting in poor results. In addition, the status of nursing students is weakened under this mode, so their learning enthusiasm is also low, resulting in a poor learning effect [24]. Therefore, it is essential to innovate the ECMO training mode for nurses in the ICU. CDIO training mode has been widely used in many fields. This training mode advocates "doing while learning" and "learning by doing". It not only attaches importance to the accumulation of theoretical knowledge but also to the improvement of practical ability and the cultivation of professional quality. In this mode, the teachers first investigate and understand the current situation of nurses, evaluate their abilities in all aspects, and then conceive and design training programs and objectives, which lay a good foundation for the smooth development of later training. During the training, the nurses should preview and mark the places they do not understand. This will help improve the nurses' initiative in classroom learning and improve their understanding of knowledge and learning effects. Group discussion was conducted before the end of the class to cultivate nurses' team spirit and ability to solve problems independently. In practice teaching, situational teaching has been adopted to improve nurses' sense of clinical experience and clinical thinking, which helps stimulate nurses' analysis ability and emergency response-ability.

The present investigation was conducted to clarify the application advantages of CDIO-based training modes and provide references for the formulation of training programs.

This study has compared the application effects of the conventional training mode and the CDIO-based training mode. The findings indicated that the nurses in OG exhibited superior assessment outcomes. Specifically, their CIRN score, CTDI-CV score, emergency response ability score, post-competency score, GSES score, and self-learning ability score all demonstrated higher values following the training. These results suggest that the patients in OG experienced significant enhancements in their abilities after the training, thereby instilling greater confidence in their post-work performance. In contrast, previous situations and research on nursing innovation education in our country are not objective. As a first-level discipline, the nursing specialty needs to keep up with medical development, carry out innovative education for nurses, and cultivate innovative abilities, the driving force for the development of the discipline. We cannot ignore that nurses are currently limited to the role of doctors' assistants and finish the nursing work passively. They ought to give full play to their subjective initiative, find work-related problems on time, innovate and improve constantly, and apply the results to clinical practice to improve patient service quality and realize self-value. Innovation education is fundamental for enhancing innovation ability, but nursing innovation education and research in China started late. From the perspective of this study, we need to seek to set up a "nursing innovation" course, advocating the combination of professional education and innovation. The study's drawback was attributed to the absence of lucidity in the mechanism. Furthermore, the patient population is not substantial, which necessitates further verification.

Conclusion

In a nutshell, the application of Conceive, Design, Implement, and Operate-based training mode in intensive care unit nurse extracorporeal membrane oxygenation training has a notable effect, which can significantly improve nurses' assessment results, core competence, critical thinking ability, emergency response ability, post competence, self-efficacy, and self-learning ability, and can improve nurses' work efficiency and patient satisfaction. The training quality is significantly higher than that of the conventional training mode, which is worthy of promotion and application.

R E F E R E N C E S

1. *Almenyan AA, Albuduh A, Al-Abbas F*. Effect of Nursing Workload in Intensive Care Units. Cureus 2021; 13(1): e12674.

2. *Shibiru S, Aschalew Z, Kassa M, Bante A, Mersha A*. Clinical Competence of Nurses and the Associated Factors in Public Hospitals of Gamo Zone, Southern Ethiopia: A Cross-Sectional Study. Nurs Res Pract. 2023; 2023: 9656636.

3. *Mosier JM, Kelsey M, Raz Y, Gunnerson KJ, Meyer R, Hypes CD*, et al. Extracorporeal membrane oxygenation (ECMO) for critically ill adults in the emergency department: history, current applications, and future directions. Crit Care 2015; 19:431.

4. *Azer SA, Guerrero AP, Walsh A*. Enhancing learning approaches: practical tips for students and teachers. Med Teach 2013; 35(6): 433–43.

5. *Li Z, Shi H, Liu H*. Research on the concentration, potential and mission of science and technology innovation in China. PloS One 2021; 16(10): e0257636.

6. *Skela-Savič B*. Nursing Development should Now Become a Priority for Health Systems in Europe. Zdr Varst 2023; 62(4): 162–6.

7. *Ding S, Deng S, Zhang Y, Wang Q, Liu Z, Huang J*, et al. Experiences and needs of front-line nurses during the COVID-19 pandemic: A systematic review and qualitative meta-synthesis. Front Public Health 2022; 10:805631.

8. *Mansour S, Nogues S*. Advantages of and Barriers to Crafting New Technology in Healthcare Organizations: A Qualitative Study in the COVID-19 Context. Int J Environ Res Public Health 2022; 19(16): 9951.

9. *Asgari P, Navab E, Bahramnezhad F*. Comparative study of nursing curriculum in nursing faculties of Canada, Turkey, and Iran according to SPICES model. J Educ Health Promot 2019; 8:120.

10. *Xia L, Meng F*. Integrated prediction and control of mobility changes of young talents in the field of science and technology based on convolutional neural network. Heliyon 2024; 10(4): e25950.

11. *Kim GW, Koh Y, Lim CM, Huh JW, Jung SH, Kim JB*, et al. The effect of an improvement of experience and training in extracorporeal membrane oxygenation management on clinical outcomes. Korean J Intern Med 2018; 33(1): 121–9.

12. *Zhang C, Fan H, Xia J, Guo H, Jiang X, Yan Y*. The Effects of Reflective Training on the Disposition of Critical Thinking for Nursing Students in China: A Controlled Trial. Asian Nurs Res (Korean Soc Nurs Sci) 2017; 11(3): 194–200.

13. *Skryabina E, Riley P, Reedy G, Amlôt R*. A scoping review of evaluation methods for health emergency preparedness exercises. Am J Disaster Med 2018; 13(2): 107–127.

14. *Jiménez-Rodríguez D, Molero Jurado MDM, Pérez-Fuentes MDC, Arrogante O, Oropesa-Ruiz NF, Gázquez-Linares JJ*. The Effects of a Non-Technical Skills Training Program on Emotional Intelligence and Resilience in Undergraduate Nursing Students. Healthcare (Basel) 2022; 10(5): 866.

15. *Fan Y, Zhang X, Xie X*. Design and Development of a Course in Professionalism and Ethics for CDIO Curriculum in China. Sci Eng Ethics 2015; 21(5): 1381–9.

16. *Dahlberg K, Stenberg E, Liang Y, Nilsson U, Jaensson M*. The General Self-Efficacy Scale in a population planned for bariatric surgery in Sweden: a psychometric evaluation study. BMJ Open 2022; 12(11): e061509.

17. *Aldosari MS, Alsager HN*. A step toward autonomy in education: probing into the effects of practicing self-assessment, resilience, and creativity in task supported language learning. BMC Psychol 2023; 11(1): 434.

18. *Marzban S, Najafi M, Agolli A, Ashrafi E*. Impact of Patient Engagement on Healthcare Quality: A Scoping Review. J Patient Exp 2022; 9: 23743735221125439.

19. *Xu X, Zhang H, Ding J, Liu Y, Zhang J*. Nursing resources and patient outcomes in intensive care units: A protocol for systematic review and meta-analysis. Medicine (Baltimore) 2021; 100(6): e24507.

20. *Ma X, Liang M, Ding M, Liu W, Ma H, Zhou X*, et al. Extracorporeal Membrane Oxygenation (ECMO) in Critically Ill Patients with Coronavirus Disease 2019 (COVID-19) Pneumonia and Acute Respiratory Distress Syndrome (ARDS). Med Sci Monit 2020; 26: e925364.

21. *Duinmeijer WC, Fresiello L, Swol J, Torrella P, Riera J, Obreja V*, et al. Simulators and Simulations for Extracorporeal Membrane Oxygenation: An ECMO Scoping Review. J Clin Med 2023; 12(5): 1765.

22. *Papathanasiou IV, Kleisiaris CF, Fradelos EC, Kakou K, Kourkouta L*. Critical thinking: the development of an essential skill for nursing students. Acta Inform Med 2014; 22(4): 283–6.

23. *Salmerón Aroca JA, Moreno Abellán P, Martínez de Miguel López S*. Teachers' Professional Development and Intelligent Ways of Coping with It: A Systematic Review in Elementary and Middle School Education. J Intell 2022; 11(1): 1.

24. *Rezakhani Moghaddam H, Aghamohammadi V, Jafari M, Absalan M, Nasiri K*. Challenges Faced by Nursing Students to Work with Nursing Personnel: A Qualitative Study. Adv Med Educ Pract 2020; 11: 313–9.