

Impact of the nursing comprehensive skill training course (NCST-C) on nursing students' metacognitive awareness: A quasi-experimental study

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Research Article

Keywords: nursing comprehensive skill training course, metacognition awareness, nursing students

Posted Date: March 31st, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1424208/v1>

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Abstract

Background: Developing students' metacognition awareness is a goal of university education as it can help equip students with life-long learning skills and promote holistic personal development. This study aimed to explore the effect of nursing comprehensive skill training course (NCST-C) on metacognitive awareness of nursing students in China, to provide a scientific foundation for improving metacognitive awareness.

Design: A quasi-experimental two-group, matched pretest, post-test, and follow-up test.

Methods: A total of 96 Junior nursing students were recruited using a convenience sampling and assigned to 2 groups by drawing lots with odd and even numbers in a nursing school at Huzhou University, China. The control group was received the traditional skill-training course. The intervention group was received training in NCST-C. Nursing students were evaluated metacognitive awareness inventory (MAI) at the baseline, 16-week, and 20-week follow-up points, respectively. A repeated-measures, two-way analysis of variance, and a simple effect test were used to compare each outcome measure of 2 groups.

Results: The NCST-C resulted in a greater benefit for nursing students' metacognition awareness and various dimensions (knowledge of cognition and regulation of cognition) in the intervention group. Combined with a simple effects test, the MAI and dimensions scores of those in the intervention groups significantly improved at 16 weeks after the baseline ($F = 44.03-9.78$); all $P < 0.01$; and the sustainable effect of NCST-C lasted for 1 month after the intervention ($F = 14.24-$

56.75, all $P < 0.01$), which reached statistical significance ($P < 0.05$).

Conclusions: The NCST-C was an effective course to develop metacognition awareness of nursing students, which design provides a new form of experimental course to improve metacognition awareness.

Trial registration: <http://www.chictr.org.cn/listbycreator.aspx>

Registration number: ChiCTR2200057910. First registration date 22/3/2022

Background

Rapid development of science has made a positive difference in the quality of education^[1]. Online courses teaching has facilitated a development of student-centered education and innovative development of diversified teaching models^[2]. Giving students a necessary skills for sustainable social and professional development had becomes focus on educational research^[3]. Recent studies had shown that these necessary skills are driven by a shift in students' metacognitive awareness^[4].

Metacognition awareness was defined as an ability to reflect upon, understand and control one's learning, it includes knowledge of cognition and regulation of cognition^[5,6]. Knowledge of cognition could helps students to recognize their strengths and weaknesses and it affects learning motivation^[7]. Regulation of cognition was correspond to a final evaluation and modification of learning strategies, it includes planning, implementing, monitoring, debugging, and evaluating strategies^[8]. Knowledge of cognition and regulation of cognition were correlated but not compensatory^[9]. Students with higher knowledge of cognition have higher test performance^[10]. Students with low regulation of cognition had the most problem with planning, organization, and elaboration strategies^[11]. Recent study has shown that metacognitive awareness contributes to development ability of positive learning, critical thinking and problem solving^[12,13]. Students with low metacognitive awareness often adopt ineffective learning strategies and ultimately fail to use their thinking or develop practical skills to overcome learning challenges^[14]. Therefore, paying attention to metacognitive awareness as means to adjust learning motivation, students' learning ability, and nursing professional thinking was important to improving the quality of nursing education.

Research evidence suggests that active learning could improve students' metacognitive awareness^[15,16]. Active learning was defined as a process where the learner takes a dynamic and energetic role in their education^[17]. Online and offline mixed teaching modes and group cooperative learning were active learning modes^[18]. Online and offline mixed teaching modes could provide the multi-spatial nature of teacher and student interaction. Teachers need to establish online teaching content platform, design how to teach method in online courses, and design offline classroom teaching organization form and content^[19,20]. Recent research evidence suggests that the design of teaching links before, during and after class were the key content of online and offline hybrid teaching design^[20]. Group cooperative learning could be a teaching form of online and offline teaching mode, which can effectively promote students' learning interaction and knowledge exchange^[21]. Research shown that instructional design of group cooperative learning was an important technical key to successful teaching^[22,23]. Therefore, whether teaching method incorporating group cooperative learning in the online and offline mixed teaching mode could replace traditional teaching depends on the course content and scientific feasible teaching design.

In China, undergraduate nursing courses were subject-oriented. Strong theoretical knowledge, nursing technical training and job competence were important characteristics of nursing practice^[24]. In theory course, the combination of online and offline teaching mode with group cooperative learning method had achieved remarkable results^[25,26], but they have not been found in the nursing skills training courses. Previous studies have shown that online and offline mixed and cooperative group learning needs to be guided by case problems, the integration of diversified teaching methods, and scientifically feasible teaching design^[27]. According to scholar' research shows, undergraduate nursing education should focus on the high-level construction of nursing skills training content and assessment format courses^[28]. Therefore, we tried to developed students' metacognitive awareness by using an online and offline mixed teaching model and group cooperative learning that integrated experimental technology curriculum content and multi-station nursing skill examination design.

China's National Nursing Skills Competition adopted a new form of multi-stop nursing skills examination for the first time in 2021^[29]. This form consists of personal operations and team cooperation. A case-oriented assessment proposition is a type of examination. The number of test stations can be set to three or eight stations. Starting from the first test station, each student conducts nursing assessment, preparation, planning, and integration using the advanced simulation model to implement individual or team skill operations^[30]. Each station requires six or ten min until all the station case operations are completed. The scoring is done using a combination of computer scoring and manual scoring. The multi-stop nursing skill examination establishes higher standards for nursing students' skill operation accuracy.

An integrated curriculum is to break the framework of disciplines and traditional knowledge, reintegrate the internal related content, and form a new curriculum^[31]. In our study, constructed comprehensive nursing skills training course was an integrated experimental course. It was integrated the experimental technology of five courses in basic nursing, internal medicine nursing, surgical nursing, and emergency and critical care. The curriculum is student-centered, case-oriented, multi-station nursing skills examination, using online and offline hybrid teaching modes and group cooperation learning to evaluate the impact of comprehensive nursing skills training courses on the development of nursing students' awareness. The objectives were: (1) Integrate experimental content; (2) Design online and offline hybrid teaching models; (3) Use multiple teaching methods; (4) Design multi-stop nursing skill examination; (5) To evaluate the impact of implementation comprehensive nursing skills training courses on nursing students' meta-cognition awareness.

Methods

Design

Two-group, matched pretest, post-test, and follow-up test designs were created for a quasi-experimental study.

Sample size

The sample size calculations were performed using G*Power 3.1. A power (1- β) of 0.84 tests, NOVA was selected: repeated measures were used, and an error value was 0.05, the effect size was 0.25, the number of groups was 2, and the number of measurements was 3. Based on the pre-experimental data, we established a correlation among the repeated measures of 0.50. Consequently, the total sample size consisted of 96 people, 48 of whom were in the experimental group and the remaining 48 were in the control group.

Participants

A convenience sample approach was adopted to total of 96 junior year nursing students were recruited who came from Huzhou University, Zhejiang Province in China. The inclusion criteria were as follows: ☐ Students in the second semester of junior year on nursing profession; ☐ voluntary selection course; ☐ Informed consent, willing to cooperate. The exclusion criteria were as follows: ☐ Students were not interested; ☐ Research objects who are participating in other teaching reform. Recruited students were randomly assigned with odd and even numbers by computer, and the odd number was the intervention group and the even number was the control group. There were 48 people, respectively.

Control group

Control group students were given the traditional skill training course. Traditional skill training course forms of teaching organization include teacher demonstration, student practice, and one-way technical examination. Based on principle of ethical equality, relevant training was conducted after experiment according to the needs of students in control group.

Intervention group

Curriculum content

Curriculum content breaks through curriculum boundaries and integrates teaching content. According to the independence and team nature of technology application, integration nursing experiment technology 30 items (Fig. 1).

Curriculum design

The curriculum designs a three-module, online and offline mixed teaching mode. The curriculum is 64 class hours in total, 16 class hours online and 48 class hours offline. One class hours is 45 minutes. Module one, first week, online and offline 2 class hours each, curriculum introduction, learning methods training; Module two, 12 weeks, every two weeks is a unit module (online 2 class hours, offline 6 class hours), a total of 6 Unit modules. Implementation of online problem-oriented skills self-learning, classroom skills guidance and training, multi-station nursing skill examination. Module three, 3 weeks, online 2 class hours, offline 10 class hours, implement online team skills self-learning, classroom team multi-station nursing skill examination guidance and exercises, team multi-station nursing skill examination and nursing practice module (Fig. 2).

Teaching method

Online teaching adopts "four ones" task-oriented approach: one hour of video learning, one-quarter of an hour of online practice, one minute of discussion and interaction, and one thousand words of operation process writing. Solve online students' problems of learning, what to think, and what to do. Offline teaching adopts multiple teaching methods, it contains group cooperative learning, group scenario simulation, group discussion. After class realizes on the online teaching platform to publish learning tasks, clarify that what teachers teach, what to guide, what to do, and what students discuss, practice, and examination, completion of individual or cooperative skill exercises, nursing service practice and problem feedback online (Fig. 3).

Teaching organization

Online teaching is organized and managed by a teacher, who posts online videos, tasks, assignments and interactions. Offline teaching organization in class adopts the form of group cooperative learning. Firstly, before the class starts, the whole class will be stratified randomly into 4 groups according to the random number table method, each with 12 people. Secondly, after the end of each lesson, each group leader extracted the name of each group from an 'ABCD' label ,teacher A guided group A, teacher B guide group B, teacher C guide group C and teacher D guide group D.The matching of teachers and student groups is determined by lottery for each lesson. All 4 teachers conducted collective lesson preparation and training before class.

Course assessment

Course assessment adopts the form of combining online and offline. The curriculum design includes thirty learning tasks, seven multi-station nursing skill examinations and three nursing social practices. Online course assessment according to published tasks online, after teachers' review, calculates the total score with platform big data. Offline course assessment using the skill learning and multi-station nursing skill examination individual and team. Each multi-station nursing skill examination includes 3 stations, individual multi-station nursing skill examination 6 minutes a station, team multi-station nursing skill examination 10 minutes a station.

Instruments

Demographic information

A general demographic information, including age, gender, the situation of the only child and family location.

Metacognitive awareness inventory

Metacognitive awareness inventory (MAI) was developed by Schraw (1994). The scale consisted of 52 items and 2 dimensions: regulation of cognition and knowledge of cognition. Regulation of cognition includes 5 sub-categories: planning, information management, monitoring, debugging, and evaluation.Knowledge of cognition includes 3 sub-categories: declarative knowledge, procedural knowledge, and conditional knowledge. Each item was scored on a 5-point Likert scale that ranged from 1 to 5. Total score ranged from 52 to 260.The higher the score, the stronger the metacognitive awareness.To revise the MAI for the population of nursing students in China, we conducted a factor analysis to examine the indicator relations in the measurement model. Based on model modification suggestions from factor analysis, we used the total knowledge of cognition scores in the proposed model in the study. In our study, the total scale and sub-scales of Cronbach's alphas were 0.93, and 0.81 – 0.95.

Data collection and management

All students completed the survey with informed consent. Data were collected over three stages in one semester via self-report.The metacognitive awareness inventory (MAI) was used to evaluate at start of the course (T_0) , end of the course (T_1) , 1 month after the end of the course (T_2). All investigators participated in one-day training before the survey, who was independent of research team. The same investigators completed collection, inspection and analysis of the scales with a recovery rate of 100% (Fig. 4).

SPSS version 22.0 was used for data analysis. Descriptive analysis was used to describe the collected demographic data and MAI scores at T_0 , T_1 and T_2 . The T test and χ^2 test were applied to compare the demographic information data and MAI variables of the two groups. ANOVA was conducted to determine the effect of the time factors, group factors, and the interaction effects of 2 factors on the effectiveness of the MAI. A p-value of less than 0.05 was considered statistically significant. A simple effect test was used to examine the difference between 3 time points within each group and the difference among groups within each time point. Cohen's d was used to calculated the effect sizes at post-intervention, mainly using the mean and combined standard deviation of conditional measures (less than 0.33 as considered small, 0.33–0.55 as moderate, and effect size of 0.56 – 1.2 was large)^[32] .

Results

Participant characteristics

Recruited 96 students' mean age was 21.07 (SD = 1.03). Table1 shows that there were no significant differences in demographic information between the two groups of students ($p > 0.05$) seen in Table 1.

Intervention efficacy

As seen in Table 2, a 2-way analysis of variance, mean values (standard deviations) of this study outcomes and their independent uni-variate F values between groups across 3 measurements. For metacognitive awareness and sub-categories outcome measures significant interactions effect were found ($F_{(2, 96)} = 11.43 - 50.30$, all $p < 0.01$). It also demonstrates that the statistically significant main effect for the group factor was observed for debugging ($F_{(1, 48)} = 4.93$, $p = 0.03$) and evaluation ($F_{(1, 48)} = 9.60$, $p = 0.01$), other sub-categories outcome measures significant group factor were found ($F_{(1, 48)} = 14.87 - 23.10$, all $p < 0.01$). whereas the statistically significant main effect for the time factor was observed ($F_{(2, 96)} = 15.52 - 64.20$, all $p < 0.01$) for metacognitive awareness and sub-categories outcome measures.

Simple effect test on interaction effects for metacognitive awareness

To evaluate the attribution of interaction effects, table 3 shows a simple effect test was conducted. On the T_0 level, group factor had no effects for metacognitive awareness and sub-categories outcome measures ($F_{(2,96)} = 0.01 - 0.87$, all $p > 0.05$ and Cohen's $d < 0.33$), meaning that there were no significant differences at baseline on nursing student between two groups. On the T_1 level, group factor had significant effects on metacognitive awareness and sub-categories outcome measures ($F_{(2,96)} = 9.78 - 44.03$, all $p < 0.01$ and Cohen's $d > 0.56$), meaning that the amelioration of metacognitive awareness and sub-categories outcomes were related to the effectiveness of the NCST-C intervention constructed in our study. On the T_2 level, group factor had significant effects on metacognitive awareness and sub-categories outcome measures ($F_{(1,48)} = 14.24 - 62.36$, $p < 0.01$ and Cohen's $d > 0.56$), meaning that the NCST-C intervention effect persisted for 1 month. On metacognitive awareness and sub-category outcome measures, high effect sizes were found for intervention group compared with control group from post-intervention to follow up.

Each group was compared at three time points [T WITHIN G (1), G (2)]. The results demonstrated that there were statistically significant differences ($F_{(1,48)} = 17.83 - 63.31$, $p < 0.01$) in intervention group before and after the intervention for all the outcome measures. Between-group effect sizes at post-intervention (Cohen's $d = -1.41 - 0.37$) and follow-up (Cohen's $d = -1.63 - 0.40$) were considered moderate or large, which indicated that the level of metacognitive awareness and sub-categories for all the students come improved after post-intervention and 1 month follow-up of the intervention compared to the baseline. Metacognitive awareness and sub-categories outcome measures in control group showed a changing trend of the control group was not obvious at 3 time points, there were no statistically significant differences before or after the intervention ($F_{(1,48)} = 0.24 - 2.88$, $P > 0.05$).

Discussion

Our study found that nursing students' metacognitive awareness status significantly improved in the intervention group, but there was no statistically significant difference in the control group. This shows that traditional skill training courses can not cultivate students' metacognitive awareness. On the contrary, the intervention group results show that NCST-C can improve the metacognitive awareness of nursing students. This may be partially due to our study's three-module online and offline hybrid structure design, multiple teaching methods and multi-stop nursing skills examination intervention design that effectively improved the nursing students' metacognitive awareness^[33]. Bandura's social learning theory emphasized that maximum learning occurs when individuals are reinforced and motivated^[34]. NCST-C provides periodic feedback from three dimensions of online data feedback, classroom skills examination, and practical service testing. Students can observe the academic achievement performance dynamics in real-time, thereby gaining a sense of satisfaction and accomplishment, which effectively stimulates internal learning motivation and affects metacognitive awareness^[10].

Our findings indicated that a significant improvement in regulation of cognition score was found at 16-weeks intervention compared with a control group. This improvement is long-lasting (over 1 month, Cohen's $d = 1.31$), and almost identical to Gholami found in a problem-based learning intervention^[15]. Studies on metacognitive have shown a positive relationship between students' knowledge of cognition and their problem-solving, case analysis, and blended learning module can act as a catalyst for the exercising on knowledge of cognition in nursing students^[21]. NCST-C integrating curriculum content, online and offline teaching, implementing case-based problem-oriented individuals and teams skills examination would improve students' knowledge of cognition in many aspects. A recent study showed guided reciprocal peer questioning strategy improved nursing students' knowledge of cognition^[16]. This is similar to our study in that NCST-C stimulates students to think about how to use online learning resources and group cooperative learning, adapt to a new form of examination and smoothly complete the course. This process improves declarative knowledge, procedural knowledge and conditional knowledge contained in cognitive knowledge, respectively.

In this study, a significant improvement in the regulation of cognition scores was found at post-intervention and 1-month post-intervention compared with the control group. The results show that experimental group student's regulation of cognition **ability** showed improvement was significant, it includes student's planning, information, management, monitoring, debugging, evaluation **ability** in the process of completing the course. This might be attributed to metacognitive awareness is a multidimensional process that involves individual awareness in recalling and thinking information and transforming it into behavior^[35,36]. Previous research has shown more examination setting and team-based learning could promoted to student's ability of information and time management, Which in turn enhances the student's metacognitive awareness and self monitoring^[37,38]. The NCST-C focuses on multi-station nursing skill examination, group cooperative learning and experiential of online resources. The classroom teaching focuses on group teamwork, which is case problem-oriented and inspires students to seek teamwork, solve skills and knowledge problems together, and complete the assessment. These put forward higher requirements for students' planning, information management, team monitoring, self-debugging and effective response to the assessment. In addition, developing these capabilities would probably take at least 16 weeks to immersion in a university learning environment. NCST-C can do that. The results of 1-month follow-up showed that these abilities were maintained.

Study recruitment, adherence rates, and open-ended comments of the students online results indicate that NCST-C was well-planned, flexible, acceptable, and reflected their appreciation of the teaching and learning environment. The adherence rate of the intervention groups in this study was 100%. Our intervention approach is feasibly acceptable to the nursing students because it fits into the current Chinese culture and educational development. Firstly, this high adherence rate may be attributed to the curriculum integrating learning methods and teaching methods. Curriculum module one mainly completes the training of learning methods and teaching methods, and students are familiar with the new curriculum and learning forms^[39]. Secondly, integrate experimental content, three-module design of course, group cooperative learning, online and offline course evaluation were the key to controlling teaching quality and enhancing students' interest in learning^[40]. The smooth implementation of NCST-C can also be attributed to the efforts of our course team teachers to build online course resources and offline courses professional guidance.

Limitations

As envisioned, although findings from this study supported the effects of NCST-C for facilitating nursing student' metacognitive awareness, limitations need be acknowledged. First, this was a quasi-experimental study. The limitations of this design include its small sample size, potential desirability bias, selection bias, and limited external validity of the findings. Future studies are needed to address these methodological weaknesses and investigate the applicability and effects of NCST-C using larger and more diverse samples. Second, the self-reported questionnaires had inherent limitations, such as subjectivity, although such instruments are commonly used to assess educational research outcomes. Third, we did not follow up with the participants beyond 1 month. Therefore, the long-term impact of NCST-C is unclear.

Conclusion

With the construction and development of online courses, nursing students' metacognitive awareness has attracted much attention. This study through integrating content construction of NCST-C, structured instructional design, multiple instructional methods and multidimensional assessment system, we were not only paying attention to the reform of online and offline mixed teaching design for nursing comprehensive skills training for students but also improves the metacognitive awareness and various dimensions (knowledge of cognition and regulation of cognition). We hope that the findings can inspire the multi-dimensional structural design of nursing curriculum reform and provide a practical basis for constructing higher education nursing curriculum.

Declarations

Ethical approval and consent to participants

Ethical approval for the study was obtained from the Medicine College of Huzhou University's Ethics Committee (No.202012-JG01) and completed following the Declaration of Helsinki. The research team introduced and explained the purpose of the study to subjects and/or their legal guardian and informed consent was obtained from all subjects and/or their legal guardian.

Consent to publication

The article passed the review and met the requirements, and all the participating researchers agreed to publish.

Data availability

The datasets generated and/or analyzed during the current study are not publicly available due the study is ongoing, but are available from the corresponding author on reasonable request.

Author contribution

Shasha Li: conceiving, designing the study and writing the paper. Minerva B. De Ala:guiding research design. Dandan Mao: data survey and analyzing the data. Shasha Li, Afeng Wang and Congwen Wu Participation in teaching. The authors gave final approval of the version to be published.

Conflicts of interest

The authors declare that they have no conflict of interest.

Funding sources

The study was funded by the Teaching Reform of Higher Education, Zhejiang Province, China. (kg2015612).Ministry of Education Humanities and Social Sciences Research Youth Fund Project, China (No.17YJCZH092)

Acknowledgments

We thank all students who participated in the study. We would like to thank Minerva B. De Ala Professor, Dean at School of nursing, Philippine Women's University for her professional review of this manuscript.

References

1. Curran V-R., Fairbridge N-A, Deacon D. Peer assessment of professionalism in under graduate medical education.BMC Med Educ. 2020;20(1):504.<https://doi.org/10.1186/s12909-020-02412-x>.
2. Sezer H, Şahin H.Faculty development program for coaching in nursing education: a curriculum development process study. Nurse Educ Pract. 2021;55:103165. <https://doi.org/10.1016/j.nepr.2021.103165>.
3. Medina M-S, Castleberry A-N, Persky A- Strategies for improving learner metacognition in health professional education.Am J Pharm Educ. 2017;81(4):78. <https://doi.org/10.5688/ajpe81478>.
4. Abdelrahman R-M. Metacognitive awareness and academic motivation and their impact on academic achievement of Ajman university students. Heliyon.2020;6(9): e04192. <https://doi.org/10.1016/j.heliyon.2020.e04192>.
5. Flavell J-H. Cognitive Development, 2nd Edn. Upper Saddle River, NJ: Prentice-Hall.1988.
6. Shea N. Metacognition and abstract concepts. Philos Trans R Soc Lond B Biol Sci. 2018;5: 373(1752). <https://doi.org/10.1098/rstb.2017.0133>.

7. Schraw G, Dennison R-S. Assessing Metacognitive Awareness. *Contemp Educ Psychol.* 1994;19:460-475.
8. Akturk A-O, Sahin I. Literature review on metacognition and its measurement. *Proc Soc Behav Sci.* 2011;15:3731–6. <https://doi.org/10.1016/j.sbspro.2011.04.364>.
9. Song J-HH, Loyal S, Lond B. Metacognitive awareness scale, domain specific (MCAS-DS): assessing metacognitive awareness during raven's progressive Matrices. *Front Psychol.* 2020;11:60757. <https://doi.org/10.3389/fpsyg.2020.607577>.
10. Sandars J, Homer M. Metacognitive awareness and academic achievement in medical students. *Med Teach.* 2010;32(5) :441-442.
11. Bernstein A, Hadash Y, Lichtash Y, Fresco D-M. Decentering and related constructs: a critical review and metacognitive processes model. *Perspect Psychol Sci.* 2015;10(5):599-617. <https://doi.org/10.1177/1745691615594577>.
12. Desender K, Teuchies M, Gonzalez-Garcia C, Brass M. Metacognitive awareness of difficulty in action selection: The role of the cingulo-opercular network. *J Cogn Neurosci.* 2021;33(12): 2512-2522. https://doi.org/10.1162/jocn_a_01773.
13. Shekhar M, Rahnev D. Sources of metacognitive inefficiency. *Trends Cogn Sci.* 2021;25(1):12-23. <https://doi.org/10.1016/j.tics.2020.10.007>.
14. Bektas I, Bektas M, Ayar D, Celik I. The predict of metacognitive awareness of nursing students on self-confidence and anxiety in clinical decision-making. *Perspect Psychiatr Care.* 2021; 57(2): 747-752. <https://doi.org/10.1111/ppc.12609>.
15. Rashwan Z-I, Busebaia T-J, Al-Sabbagh A-S, Eweida R-S. Effect of guided reciprocal peer questioning strategy on pediatric nursing students' self-esteem and metacognitive awareness: Current approach and future directions. *Nurse Educ Today.* 2021;107: 105153. <https://doi.org/10.1016/j.nedt.2021.105153>.
16. Chan C-WH, Tang F-WK, Chow K-M, Wong C-L. Enhancing generic capabilities and metacognitive awareness of first-year nursing students using active learning strategy. *BMC Nurs.* 2021;20(1) :3-8. <https://doi.org/10.1186/s12912-021-00601-7>.
17. Petress K. What is meant by "Active learning?". *Education.* 2008;128:566–569.
18. Waltz C-F, Jenkins L-S, Han N. The use and effectiveness of active learning methods in nursing and health professions education: a literature review. *Nurs Educ Perspect.* 2014;35:392-400. <https://doi.org/10.5480/13-1168>.
19. Hsu L-L, Hsieh S-I. Factors affecting metacognition of undergraduate nursing students in a blended learning environment. *Int. J. Nurs. Pract.* 2014;20(3):233–241. <https://doi.org/10.1016/j.nedt.2021.105164>.
20. Mahmoud H. The effect of cooperative learning strategy on undergraduate nursing students enrolled in nursing administration course. *Int. J. Learn.* 2017 ;7:22–38. <https://doi.org/10.5296/ijld.v7i1.11021>.
21. Siqueira M-AM, Gonçalves J-P, Mendonça V-S, Martins M-A. Relationship between metacognitive awareness and motivation to learn in medical students. *BMC Med Educ.* 2020; 20(1):393. <https://doi.org/10.1186/s12909-020-02318-8>.
22. Gholami M, Moghadam P-K, Mohammadipoor F, Pour A-H. Comparing the effects of problem-based learning and the traditional lecture method on critical thinking skills and meta-cognitive awareness in nursing students in a critical care nursing course. *Nurse Educ Today.* 2016;45:16-21. <https://doi.org/10.1016/j.nedt.2016.06.00>.
23. Martirosov A-L, Moser L-R. Team-based learning to promote the development of metacognitive awareness and monitoring in pharmacy students. *Am J Pharm Educ.* 2021;85(2):848112. <https://doi.org/10.5688/ajpe848112>.
24. Hao X, Peng X, Ding X, Li K. Application of digital education in undergraduate nursing and medical interns during the COVID-19 pandemic: A systematic review. *Nurse Educ Today.* 2022; 108:105183. <https://doi.org/10.1016/j.nedt.2021.105183>.
25. Meng X-H, Xu X-Y, Chen H-L, Zhang L. The effectiveness of combining e-learning, peer teaching, and flipped classroom for delivering a physiology laboratory course to nursing students. *Adv Physiol Educ.* 2022;46(1):21-26. <https://doi.org/10.1152/advan.00062.2020>.
26. Schramm J, Uranga T, Birkle A, Taylor L. Improving holistic care skills for advanced practice registered nurses: integration of a complementary and alternative medicine course into a doctor of nursing practice curriculum. *J Dr Nurs Pract.* 2021. <https://doi.org/10.1891/JDNP-D-20-00077>.
27. Jiang Y, Chen Y, Lu J, Wang Y. The effect of the online and offline blended teaching mode on English as a foreign language learners' listening performance in a Chinese context. *Front Psychol.* 2021 ;12 :742742. <https://doi.org/10.3389/fpsyg.2021.742742>.
28. Liu H-Y. Promoting creativity of nursing students in different teaching and learning settings: a quasi-experimental study. *Nurse Educ Today.* 2022;108:105216. <https://doi.org/10.1016/j.nedt.2021>.
29. General Office of the Ministry of Education of China. The 10th Medical Technical Skills Competition for Chinese College Students (Nursing professional track 1st race), 2021.
30. Hwang G-J, Chang C-Y, Ogata H. The effectiveness of the virtual patient-based social learning approach in undergraduate nursing education: A quasi-experimental study. *Nurse Educ Today.* 2022;108:105164. <https://doi.org/10.1016/j.nedt.2021.105164>.
31. Brauer D-G, Ferguson K-J. The integrated curriculum in medical education: AMEE Guide No. 96. *Med Teach.* 2015;37(4):312-22. <https://doi.org/10.3109/0142159X.2014.970998>.
32. Lipsey M-W, Wilson, D-B. The efficacy of psychological, educational, and behavioral Treatment: confirmation from meta-analysis. *Am Psychol.* 1993;48(12):1181–209.
33. McCabe J. Metacognitive awareness of learning strategies in undergraduates. *Mem Cognit.* 2011;39(3) :462-76. <https://doi.org/10.3758/s13421-010-0035-2>.

34. Bandura A. Self-efficacy: The exercise of control. W H Freeman/Times Books/ Henry Holt & Co. Brown, AL. 1978. Knowing when, where, and how to remember: a problem of metacognition. *Adv Instr Psychol.* 1997;1:77–165.
35. Mohamed HM, Mohamed AI, Abdeen MA. The impact of metacognitive skills educational program on metacognitive awareness, self-efficacy, and problem solving skills among nursing students. *Am J Nurs.* 2020;8(2):289-296.
36. Sart G.. The effects of the development of metacognition on project-based learning. *Procedia - Soc. Behav. Sci.* 2014;152:131–136. <https://doi.org/10.1016/j.sbspro.2014.09.169>.
37. Rivers M-L, Dunlosky J, Persky A-M. Measuring metacognitive knowledge, monitoring, and control in the pharmacy classroom and experiential settings. *Am J Pharm Educ.* 2020; 84(5): 7730. <https://doi.org/10.5688/ajpe7730>.
38. Turan S, Demirel O, Sayek I. Metacognitive awareness and self-regulated learning skills of medical students in different medical curricula. *Med Teach.* 2009; 31(10) :e477-83. <https://doi.org/10.3109/01421590903193521>.
39. Khodaei S, Hasanvand S, Gholami M, Amini, M. The effect of the online flipped classroom on self-directed learning readiness and metacognitive awareness in nursing students during the COVID-19 pandemic. *BMC Nurs.* 2022;21(1) :2-11. <https://doi.org/10.1186/s12912-022-00804-6>.
40. Desender K, Teuchies M, Gonzalez-Garcia C, Brass, M. Metacognitive awareness of difficulty in action selection: The role of the Cingulo-opercular network. *J Cogn Neurosci.* 2021,33(12) :2512-2522. https://doi.org/10.1162/jocn_a_01773.

Tables

Table 1 Sociodemographic Characteristics of Participants in the Two Groups

Sociodemographic characteristics	Invention Group(n = 48)	Control Group(n = 48)	value	P value
Age, mean (SD)	21.20 ± 1.60	20.99 ± 1.01	0.7689	0.4439
Sex, n (%)			0.334	0.563
Male	6(12.5)	8(16.6)		
Female	42(87.5)	40 (83.4)		
an only child in a family , n (%)			0.421	0.838
yes	25(52.1)	26(54.2)		
No	23(47.9)	22(45.8)		
Family location, n (%)			0.042	0.838
rural area	24(50.0)	23(47.91)		
town	24(50.0)	25(52.09)		

Table 2 Impact of the Intervention on Metacognitive Awareness Outcome Measures at Three Time-points (Group × Time) test (N = 96)

Outcome measures	Measure Time			Group Factor		Time Factor		Interaction Effect	
	T0 (Mean T SD)	T1 (Mean T SD)	T2 (Mean T SD)	<i>F</i>	<i>P-value</i>	<i>F</i>	<i>P-value</i>	<i>F</i>	<i>P-value</i>
Knowledge of cognition				17.30	0.00	59.12	0.00	47.09	0.00
Experimental group (G1)	66.56±6.40	74.46±6.90	74.95±5.80						
Control group (G2)	67.00±7.18	67.75±5.11	67.23±4.64						
Regulation of cognition				20.81	0.00	49.36	0.00	34.86	0.00
Experimental group (G1)	130.92± 29.86	165.23±29.08	167.50 ±24.29						
Control group (G2)	132.73±34.43	135.63±29.06	136.77±22.47						
Planning				15.86	0.00	57.89	0.00	44.82	0.00
Experimental group (G1)	26.58±5.91	33.77±5.36	34.54±4.81						
Control group (G2)	27.06±7.04	27.79±5.97	27.37±5.08						
Information management				21.11	0.00	93.17	0.00	46.19	0.00
Experimental group (G1)	37.50±5.80	45.97±6.17	46.16±4.99						
Control group (G2)	37.10±6.99	39.29±5.13	39.12±4.76						
Monitoring				23.10	0.00	64.20	0.00	50.30	0.00
Experimental group (G1)	26.56±5.81	34.94±6.07	35.35±4.96						
Control group (G2)	27.00±7.18	27.31±5.15	27.71±4.51						
Debugging				4.93	0.03	30.80	0.00	11.43	0.00
Experimental group (G1)	18.58±6.35	23.91±6.17	24.31±4.96						
Control group (G2)	19.12±6.89	20.29±5.14	20.62±4.60						
Evaluation				9.60	0.01	15.52	0.00	13.80	0.00
Experimental group (G1)	21.68±6.37	26.62±6.09	27.12±5.41						
Control group (G2)	21.91±7.45	22.25±4.96	21.93±4.16						
Total score				14.87	0.00	53.80	0.00	32.90	0.00
Experimental group (G1)	197.48±36.05	239.69±35.48	242.64±29.18						
Control group (G2)	199.21±42.72	204.69±30.98	204.48±27.05						

Notes: T0, baseline; T1, post-intervention (16 weeks after baseline); T2, 1-month follow-up (20 weeks after baseline); ANOVA, Analysis of variance; *P < 0.05; **P < 0.01

Table 3 Results of Simple Effects of Interaction Effects on All Outcomes

Source of Variation	Knowledge of cognition			Regulation of cognition			Planning			Information management			Monitoring			f
	F	value	Cohen's d	F	value	Cohen's d	F	value	Cohen's d	F	value	Cohen's d	F	value	Cohen's d	
G WITHIN T0	0.01	0.75	-0.06	0.00	0.98	-0.06	0.13	0.72	-0.07	0.01	0.92	0.06	0.11	0.74	-0.07	0.00
G WITHIN T1	29.28	0.00	1.11	38.32	0.00	1.02	26.62	0.00	1.05	33.36	0.00	1.17	44.03	0.00	1.36	0.00
G WITHIN T2	51.95	0.00	1.47	56.75	0.00	1.31	50.22	0.00	1.45	49.99	0.00	1.44	62.36	0.00	1.61	0.00
T WITHIN G1	63.54	0.00	-	54.75	0.00	-	63.31	0.00	-	79.85	0.00	-	73.86	0.00	-	0.00
G1(T0 v. T1)			-0.37			-1.16			-1.27			-1.41			-1.41	
G1(T0 v. T2)			-0.40			-1.34			-1.48			-1.60			-1.63	
G1(T1 v. T2)			-0.08			-0.08			-0.15			-0.03			-0.07	
T WITHIN G2	1.30	0.28	-	0.69	0.51	-	1.05	0.35	-	2.88	0.06	-	0.59	0.56	-	0.00
G2(T0 v. T1)			-0.12			-0.09			-0.11			-0.36			-0.05	
G2(T0 v. T2)			-0.04			-0.14			-0.05			-0.34			-0.12	
G2(T1 v. T2)			0.11			-0.04			0.08			0.03			-0.08	

Notes: G, group; G1, Experimental group; G2, Control group; T, time point; T0, baseline; T1, post-intervention (16 weeks after baseline); T2, 1-month follow-up(20 weeks after baseline) .

Figures

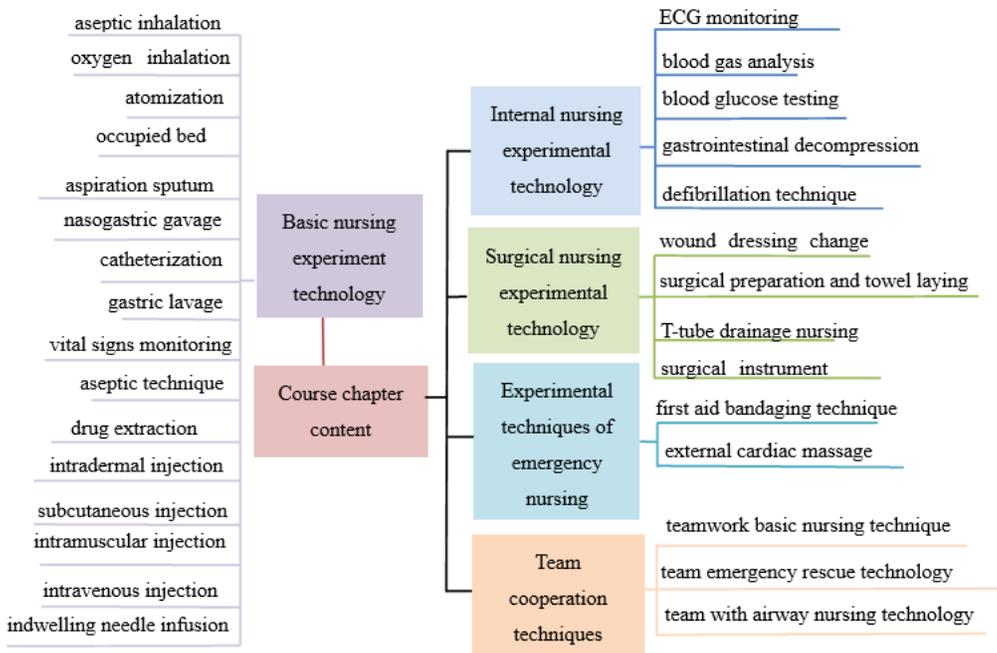


Figure 1

Nursing comprehensive skill training(NCST-C) curriculum content

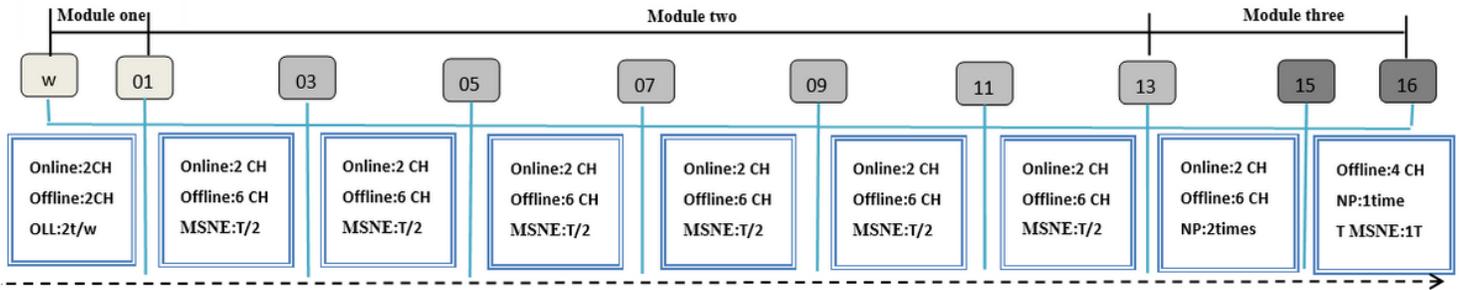


Figure 2

Online and offline mixed curriculum design

Abbreviations:W: week; CH: Class hour; NP:nursing practice;OLL: Open laboratory learn;2t/w: Twice a week;MSNE: multi-station nursing examination;T/2:Once every two weeks;T MSNE: team multi-station nursing skill examination; Module one: curriculum introduction, earning methods training;Module two: Implementation of online problem-oriented skills self-learning-

classroom skills guidance and training, multi-station nursing skill examination;Module three: implement online team skills self-learning, classroom team multi-station nursing skill examination guidance and exercises, team multi-station nursing skill examination and nursing practice module.

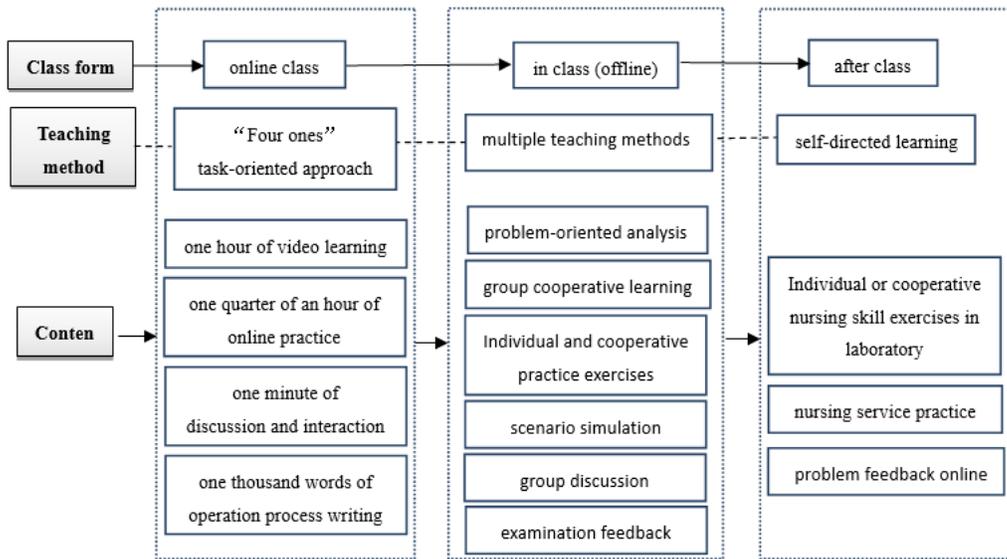


Figure 3

Online and offline mixed diversified teaching methods

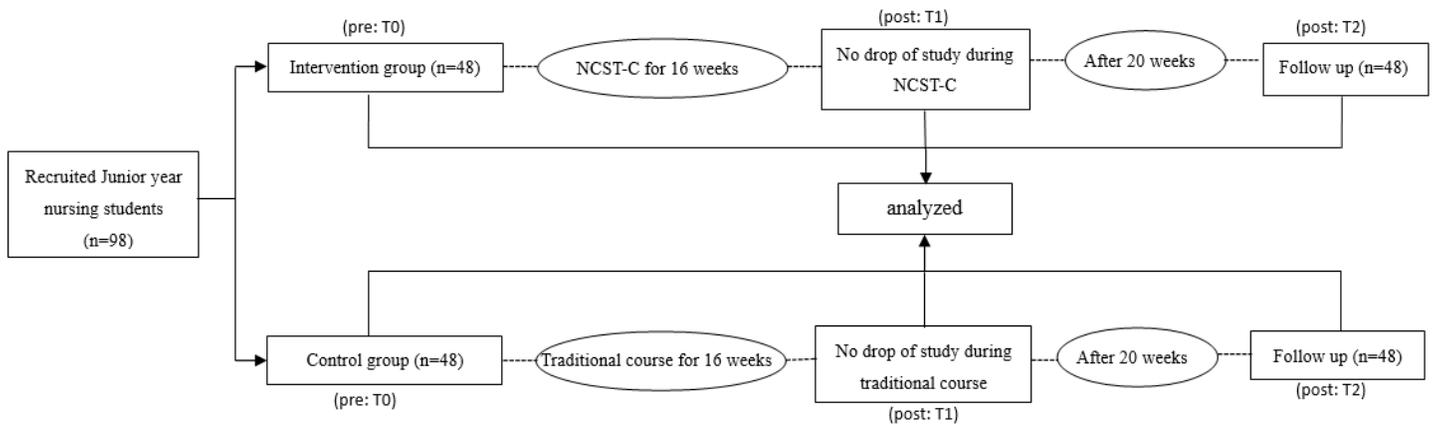


Figure 4
Flow chart for quasi-experimental study