

Effects of blended versus offline case-centered learning on academic performance and the development of critical thinking among undergraduate nursing students—a quasi-experimental study

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Abstract

Background: Educational reform, especially methods of teaching, has been a focus among nursing educators. This study explored the impact of blended versus offline case-centered learning on academic performance and the development of critical thinking among undergraduate nursing students. Methods: A quasi-experimental study design was used, with assessments immediately before and 1 school year after the intervention. All second-year undergraduate nursing students were enrolled in the study (without any sampling). The two classes (taking Medical Nursing) were randomly allocated to either the experimental group, which undertook blended case-centered learning, or the control group, which undertook offline case-centered learning. The academic performance included final exam and process assessment, and the Critical Thinking Disposition Inventory-Chinese Version (CTDI-CV) was used to assess critical thinking. A Shapiro-Wilk test was first performed to verify the normal distribution of the academic performance data. ANCOVA analyses were also performed to examine the two teaching methods' effect on critical thinking. Results: Both of the two classes got excellent academic performance in Medical Nursing, and the blended case-based learning class tend to make greater progress. At baseline, the students in the offline case-based learning class exhibited superior performance regarding all seven Professional Basic courses which they have completed. However, the median score in the Medical Nursing course was slightly higher in the experimental group than in the control group after 1 academic year, although was no significant difference in statistics. In addition, compared with the control group, the pre-post difference in competency in critical thinking self-confidence in the experimental group was significantly greater. In the experimental group, there was significant improvement compared with baseline in dimension of critical thinking self-confidence ($p < 0.05$). In the control group, there was significant improvement compared with baseline in the total score ($p < 0.05$) and two of the seven dimensions: truth-seeking ($p < 0.05$) and systematicity ($p < 0.05$). Conclusions: Our study confirms the effectiveness of blended and offline learning (both based on case-centered learning) for academic performance and components of critical thinking among undergraduate nursing students. Blended and offline case-centered learning could be applied to other nursing subjects in future studies. Moreover, further efforts to improve teaching are warranted.

Background

Nursing educational reform is needed to increase the quality of teaching

With the development of the social economy and the transition to the modern medical model and concept of health, developing comprehensive high-quality skills among nursing personnel is increasingly important. However, nowadays, much of nursing pedagogy relies on a traditional didactic approach that focuses on passive lecture-based delivery of content, leaving the students as passive participants who largely only take notes. Using this method, students do not have the opportunity to engage in contemplation, which is necessary during the learning process. Calls to change traditional educational strategies in order to provide effective and efficient education for nursing students are of increasing importance.

The goals of university nursing education are to teach theoretical knowledge, as well as develop the ability of students to critically analyze evidence [1]. Critical thinking is an important component of nursing education and integral to the discipline of nursing [2, 3]. Critical thinking is an essential professional development core skill in nursing education and practice [4]. Worldwide, there is a need for nursing education to assist students in developing critical thinking, clinical reasoning, and clinical judgment skills [5]. Educational reform, especially regarding methods of teaching, has been a focus among nursing educators.

Case-based learning and the flipped classroom are feasible in nursing curricula

Active learning strategies applied to nursing education can enhance student understanding, stimulate inquiry, and encourage critical thinking [6]. To best engage students and promote learning, there has been a shift toward student-centered learning and engagement of students as active learners. Case-based learning (CBL) is an instructional method within the context of student-centered learning for facilitating learning through the use of case studies [7]. It is a long-established pedagogical method that is defined in a number of ways depending on the discipline and type of “case” employed [8]. McLean’s definition of CBL is “an inquiry structured learning utilizing live or simulated patient cases to solve, or examine a clinical problem, with the guidance of a teacher and stated learning objectives” [9]. In nursing education, CBL can be applied to prepare students for clinical practice through the use of authentic clinical cases [10, 11] and increase their capacity to ask questions, reflect, and deal with problems [12, 13]. Previous research has indicated that CBL is a more effective technique than traditional didactic lectures for improving communication skills, problem-solving ability, and motivation in undergraduate nursing students [14, 15]. In addition, the advantages of using CBL include increased focus on learning objectives, flexibility in the use of the cases, opportunity for the teacher to have more input toward the direction of learning, and enabling deeper learning. Owing to these benefits, CBL is likely to become part of numerous curricula for medical and health professional courses [9].

In addition to CBL, flipped classroom pedagogy has attracted the attention of educators and has been widely implemented and studied in many disciplines, including nursing [16-19]. Some studies have found that the strategy of flipped classroom in nursing education presents certain advantages over traditional lecture-based learning in terms of improving students’ examination scores, grades and satisfaction [20, 21]. Conversely, some studies showed the flipped classroom not to be superior to traditional models with respect to student examination scores and satisfaction [22, 23]. A meta-analysis on the effects of the flipped classroom model among Chinese baccalaureate nursing students showed that flipped classrooms are more effective than traditional lectures at improving students’ theoretical knowledge and skills [24].

Blended approaches have become more prevalent in the information age

Nowadays, technological advancements are rapidly changing nursing education in higher education settings. This has led to a push toward flexible delivery, online delivery, and blended learning. Blended learning refers to an educational approach that combines traditional classroom-based face-to-face

teaching methods with online materials and activities [25]. Garrison and Kanuka, early promoters of the blended learning approach, have highlighted several advantages of blended learning [26]. They describe blended learning as having the potential to transform the educational landscape by giving students more responsibility, control, and independence, while also increasing their capacities for critical and reflective thinking.

Blended learning is considered crucial for the education of today's health students [27]. In recent years, blended learning has been used in nursing and medicine, and many studies have been conducted in this area [28-32]. However, the implementation of blended learning in nursing education remains controversial. Some investigations have shown that blended learning is favored by undergraduate nursing students, facilitates communication and active learning, and enhances self-efficacy regarding communication skills [33-35]. On the other hand, one study did not find a direct impact on knowledge acquisition or self-learning readiness [31]. Another study did not show differences regarding overall satisfaction with the teaching received [28]. Hence, there is concern regarding the outcomes associated with this method.

Although blended learning has been extensively used, there is limited knowledge regarding the effective application of blended learning based on CBL in nursing curricula to support critical thinking [34, 36]. Therefore, the main objective of this study was to compare blended and offline learning (both based on case-centered learning) in terms of their impact on academic performance and the development of critical thinking among undergraduate nursing students.

Methods

Design

This study used a quasi-experimental study design with pretest and posttest assessments undertaken immediately before the intervention and 1 school year after the intervention, respectively, to examine the effects of blended and offline case-centered learning for undergraduate nursing students. The study was conducted between September 2018 and July 2019.

Samples and setting

It takes 4 years to complete a Bachelor of Nursing in China. Students received nine years of compulsory education and three years of senior school, then they have an access to bachelor nursing college after college entrance examination. The main features of undergraduate nursing curricula in Fujian Medical University are shown in an additional file [Additional file 1: Table S1]. The study population comprised second-year undergraduate nursing students with the average age of (19.95±0.81) starting the Medical Nursing course in the fourth semester at the Nursing School of Fujian Medical University (Fuzhou, China), with no sampling. The Medical Nursing course was conducted for 1 academic year, in the fourth and fifth semesters, and it involved 144 teaching hours and 8 credits, which is the highest number of credits of all undergraduate nursing courses.

The students were randomly assigned by Zhengfang software (Zhengfang Corp., West Lake District, Hangzhou, China) to two classes (classes 1 and 2) upon entry to the university, with 164 and 131 students in class 1 and 2, respectively. Thus, randomization in this study occurred at the class level. An administrator employed by the university, who had no information regarding the recruitment or data collection, conducted the random allocation. Two labels (numbered 1 and 2) were placed in opaque envelopes, and the administrator then requested that the Medical Nursing teacher to selected one envelope at random. If “number 1” was picked, class 1 was to be the experimental group; otherwise, class 2 was to be the experimental group. As “number 1” was selected, there were 164 students (141 females and 23 males) in the experimental group and 131 (119 females and 12 males) in the control group at the beginning of the study. The experimental group involved eight groups, while the control group involved seven groups, with each group consisting of approximately 20 students.

Intervention

Teaching arrangements

The learning objectives of the Medical Nursing course are: (i) to master the theoretical knowledge of this course; (ii) to improve students’ capability regarding holistic nursing; (iii) to equip students with the ability to analyze and solve problems as well as the ability of clinical reasoning and critical thinking; (iv) to cultivate nursing students’ professional ethics. Twelve teachers teach Medical Nursing. All of them underwent the same training regarding the specific processes of blended learning and offline case-centered learning. In addition, collective lesson preparation (involving all the teachers) was conducted before teaching each chapter in order to guarantee high-quality teaching.

The same teachers, textbook, and references were provided to both groups. The experimental group underwent blended case-centered learning including online and offline learning, whereas the control group totally underwent offline case-centered learning (Table 1). Notably, whether in lectures, flipped classrooms, or seminars, the teaching method involved case-based learning. Although blinding of the students and teachers was not possible, the data analyst was blinded.

Experimental group

Apart from traditional face-to-face lectures in class, there were three stages in the implementation of the blended case-centered learning, comprising before, in, and after each flipped classroom (Figure 1).

Before the flipped classroom

All students were required to log in the Chaoxing platform (<http://i.mooc.chaoxing.com/space/index.shtml>), which allowed them to watch the pre-recorded lecture videos and access the online forums, and study materials. Before the flipped classroom, group cases study was also required and necessary. Students subsequently divided into subgroups (approximately five students per subgroup) to discuss the cases and the questions that the teacher provided prior to the

class. In addition, they recorded the whole process of their discussion, produced a report, and handed in the recording and the report after the discussion. Questions could be asked online anytime.

In the flipped classroom

Each flipped classroom involved one group, with approximately 20 students, and they were divided into four subgroups (with approximately five students per subgroup) based on the pre-class group discussions. To assess the students' mastery of the lesson prior to class, online quizzes, which lasted approximately 10 min, were performed at the beginning of the flipped classroom. Subsequently, the teacher provided detailed explanations of the quiz questions according to the students' results, then the students reported what they had discussed prior to class. After each subgroup completed the reporting, other subgroups asked questions or provided supplementary answers. The teacher commented on each report and summarized the results of the group discussions. Additionally, the teacher pointed out the problems that the students needed to pay attention to in their study, and guided the students to think and discuss according to the discussions and feedback. Towards the end of the class, the teacher guided the students to review and summarize the important knowledge points of the lesson.

After the flipped classroom

After the flipped classroom, the students were requested to submit homework to the platform, raise questions in the online forums or review teaching videos. All study data were recorded via the platform and could be accessed by the teachers.

Control group

The control group underwent offline case-centered learning via traditional face-to-face lectures and seminars throughout the two semesters (Figure 2). Before the seminar, the students were required to preview the textbook. Each seminar involved one group, with approximately 20 students. During each seminar, students formed subgroups to discuss the cases under the guidance of the teacher. Subsequently, the teacher randomly selected subgroups to answer questions. Comments and explanations were provided by the teacher according to the answers. Additionally, the teacher guided the students to think, discuss, and summarize the knowledge points of the class. When class was almost over, a quiz was conducted to monitor the students' mastery of the lesson. After the seminar, the students were required to finish the homework and summarize the key knowledge points and then submit the learning notes.

Measurements

Academic performance

The Medical Nursing assessment contains two parts, the final exam and the process assessment. The maximum total score for the course was 100. The total score was determined using the weights (Table 1).

Both the experimental and control groups underwent exactly the same final exam, quizzes, and homework. All the questions in the exam and quizzes were carefully developed by the teacher team. The content validity of the examination questions was 0.9. The test-retest reliability method was impossible to be calculated, we could only improve the reliability by keeping the examination questions confidential, ensuring strict examination discipline, and conducting unified examinations.

Assessment of the critical thinking ability of students

The California Critical Thinking Disposition Inventory (CTDI) has been specifically developed and used for nursing students [37]. It has been shown to be a valid instrument for assessing critical thinking ability among nursing students in different cultural contexts [38]. The population included in the present study consisted of Chinese students. Hence, the CTDI-Chinese Version (CTDI-CV), which was translated, modified, and validated by Chinese researchers, was more suitable than the original [39]. The CTDI-CV exhibits a good overall content validity index (0.89) and Cronbach's alpha (0.90), indicating satisfactory content validity and internal consistency, respectively [39].

The CCTDI measures overall critical thinking disposition. It consists of seven subscales that measure the following dispositions: truth-seeking, open-mindedness, analyticity, systematicity, critical thinking self-confidence, inquisitiveness, and cognitive maturity. Potential scores range from 5 to 60 for each subscale, with a maximum total score of 420. The students in the two classes completed the questionnaire prior to and following the teaching experiment. The internal reliability coefficients (Cronbach's alpha) in our study were 0.86 (pretest) and 0.87 (posttest), and the values for the subscales ranged from 0.73 to 0.82.

Ethical considerations

Approval was obtained from the Research Ethics Committee of Fujian Medical University. The participants were informed that they had the right not to participate and could withdraw from the study at any time. Written informed consent was obtained from all students who agreed to participate in the study. We informed the participants of the purpose, content, and extent of the study, and guaranteed that their responses were confidential.

Data collection procedure

The data collection procedure was explained to all participants, and information regarding the estimated time and number of contacts with participants was provided. Students who agreed to participate in the study were asked to provide demographic data and outcome data (critical thinking assessment) in a pretest assessment conducted during the meeting in which they were enrolled in the study. Outcome variables were measured again 1 school year after the intervention, as a posttest assessment.

Additionally, we collected the final course grades of the participants. The participants were not subject to any physical, psychological, social, or economic harm or risk, as the data collection procedure primarily relied on a descriptive, noninvasive questionnaire on each student's demographic characteristics and critical thinking ability.

Data analysis

All statistical analyses were conducted using Statistical Package for the Social Sciences (SPSS), version 22.0 (IBM Corp., Armonk, NY, USA). Mean and standard deviation were used to represent the normally distributed continuous data, while median (M) and quartiles (P_{25} - P_{75}) were used to represent the non-normally distributed continuous data. If the continuous variables were normally distributed and exhibited homogeneity of variance, the t-test was used to assess the difference in learning outcomes between the two groups. Otherwise, the nonparametric rank-sum test was used. A Shapiro-Wilk test was first performed to verify the normal distribution of the academic performance data, and the Mann-Whitney U test was subsequently used. We used the two-tailed approach for the unpaired t test. In addition, ANCOVA analyses were performed to examine the two teaching methods' effect on critical thinking. The significance level was set at 0.05.

Results

Participant characteristics

Prior to starting the Medical Nursing course, 295 students completed the CTDI-CV questionnaire (164 and 131 in the experimental and control groups, respectively). However, in the second semester, 24 students changed their major to Midwifery, three students changed their major to Public Health, and one student discontinued the course. Consequently, at the end of the Medical Nursing course, 269 students met the inclusion criteria (151 and 118 students, respectively) (Figure 3).

Academic performance of participants

Prior to the initiation of the Medical Nursing course, the students in the control group were significantly superior to those in the experimental group in terms of academic performance regarding the seven Professional Basic courses ($p < 0.05$, Table 2). After the 1-year Medical Nursing course, there was no significant difference in the academic performance between the two classes (median (P_{25} - P_{75}) scores of 81 (77-85) and 80 (76-84) in the experimental and control groups, respectively; $p = 0.112$).

Critical thinking ability of participants

Compared with the control group, the pre-post difference in competency in critical thinking self-confidence in the experimental group was significantly greater ($p = 0.037$). There were no significant differences in other variables related to critical thinking ability between the two classes, either prior to or after the course. In the experimental group, the score of the critical thinking self-confidence dimension was significantly improved while in the control group, there were significant improvements in the total CTDI-CV score and two of the seven dimensions: truth-seeking and systematicity (Table 3,4).

Discussion

Effect on academic performance

In this study, both the experimental and control groups with the blended case-centered learning and offline case-centered learning had excellent academic performance, particularly the experimental group.

The majority of previous studies have compared blended learning with traditional didactic teaching, and the effect of blended learning on academic performance remains controversial. Some researchers found a significant increase in the academic performance of students taught using blended learning [40]. In contrast, other researchers reported no significant increase in academic performance [41]. This may be partly explained by the difference in the design of the course and the inconsistency in the use of instruments to assess student performance. In our study, the more carefully teaching design and the more comprehensive assessment were adopted on student learning outcomes.

Effect on critical thinking ability

As shown in Table 3 and 4, there was significant difference in critical thinking self-confidence in the experimental group, compared with the control group. And no significant differences were found in other variables related to critical thinking ability between the two classes, either prior to or after the course. However, both of the two classes slightly improved the critical thinking ability. These results are consistent with those of other studies conducted among nursing students, showing improvements in critical thinking skills based on effective teaching methods [36, 37, 42, 43]. Notably, blended case-centered learning focused on the subject status of the students, and provided the students with opportunities to express themselves in class. Students who expressed their ideas in the process of learning and discussion gained recognition from teachers and classmates, thereby enhancing their confidence and increasing their willingness to express themselves in subsequent classes. It is difficult to increase students' overall critical thinking ability in a relatively short period of time because Chinese basic education system from primary to high school was exam oriented in the past decades, which leads to students paying a lot of attention to exam skills but ignores the cultivation of creativity, critical thinking, etc.

In this study, offline case-centered learning led to improvements in two CTDI-CV dimensions of truth-seeking and systematicity. Offline case-centered learning focused on holistic learning with 74 teaching hours in teacher-lead lectures and 44 teaching hours for group seminars. In the group seminars, the discussion was under the teachers' guidance, thus, students can discuss more deeply and systematic. Thus, the systematicity of students was improved by the offline case-centered learning. A previous study supported the use of scientific discussions as beneficial educational tools to develop critical thinking [44]. Further studies should assess the discussion strategies used in blended learning.

In summary, the findings of our study imply that blended and offline case-centered learning both have potential for promoting students' academic performance and critical thinking. Optimization of the teaching design in future studies is vital to explore the effects of blended learning among undergraduate nursing students.

Limitation

There were certain limitations in this study. First, the study was conducted for only two semesters in one subject, which may limit the validity and reliability of the findings regarding the promotion of critical thinking. Thus, studies assessing the effectiveness of blended learning in other nursing subjects are necessary. Secondly, we did not interview students regarding their feelings and experiences. Therefore, qualitative research is also warranted. Moreover, it would be useful to follow up the students in this study by evaluating their performance in clinical practice.

Conclusions

As we know, this is the first study to comprehensively developed the blended case-centered learning and compared with the offline case-centered learning in Medical Nursing. The results confirmed that the two teaching models contributed to the improvement of undergraduate nursing students' academic performance and critical thinking. In the future, blended and offline case-centered learning could be implemented in other nursing subjects.

Abbreviations

CTDI-CV: Critical Thinking Disposition Inventory-Chinese Version; CBL: case-based learning; ANOVA: Analysis of variance

Declarations

Ethics approval and consent to participate

Ethical approval was granted by the Education Department of Fujian Medical University (reference number: +86-0591-22862100). Students were informed regarding the study and signed consent forms.

Consent for publication

Not applicable

Availability of data and materials

The dataset used during the study is available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

RH organized the data collection and wrote the application for ethical approval. All authors made substantial contributions to the design of teaching. All authors contributed to data analysis and the drafting and reviewing of the manuscript. All authors approved the final manuscript for submission and have agreed to be accountable for the accuracy and integrity of the work.

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References

1. Simpson E, Courtney M. Critical thinking in nursing education: literature review. *Int J Nurs Pract.* 2002;8:89-98.
2. Kong LN, Qin B, Zhou YQ, Mou SY, Gao HM. The effectiveness of problem-based learning on development of nursing students' critical thinking: a systematic review and meta-analysis. *Int J Nurs Stud.* 2014;51(3):458-469.
3. Chang MJ, Chang YJ, Kuo SH, Yang YH, Chou FH. Relationships between critical thinking ability and nursing competence in clinical nurses. *J Clin Nurs.* 2011;20(21-22):3224-32.
4. 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.
5. Sommers CL. Measurement of critical thinking, clinical reasoning, and clinical judgment in culturally diverse nursing students - a literature review. *Nurse Educ Pract.* 2018;30:91-100.
6. Carley A. Using technology to enhance nurse practitioner student engagement. *Nurse Pract.* 2015;40(7):47-54.
7. Kaddoura MA. Critical thinking skills of nursing students in lecture-based teaching and case-based learning. *Int J Scholarship of Teaching and Learning.* 2011;5(2):1-18.
8. Thistlethwaite JE, Davies D, Ekeocha S, Kidd JM, MacDougall C, Matthews P, et al. The effectiveness of case-based learning in health professional education. A BEME systematic review: BEME Guide No. 23. *Med Teach.* 2012;34(6):e421-44.
9. McLean SF. Case-based learning and its application in medical and health-care fields: a review of worldwide literature. *J Med Educ Curric Dev.* 2016;27:3.

10. Kantar LD, Massouh A. Case-based learning: What traditional curricula fail to teach. *Nurse Educ Today*. 2015;35(8):e8-14.
11. Gholami M, Saki M, Toulabi T, Kordestani Moghadam P, Hossein Pour AH, Dostizadeh R. Iranian nursing students' experiences of case-based learning: a qualitative study. *J Prof Nurs*. 2017;33(3):241-9.
12. Hofsten A, Gustafsson C, Haggstrom E. Case seminars open doors to deeper understanding - Nursing students' experiences of learning. *Nurse Educ Today*. 2010;30(6):533-8.
13. Majeed F. Effectiveness of case-based teaching of physiology for nursing students. *Journal of Taibah University Medical Sciences*. 2014;9(4):289-92.
14. Yoo MS, Park HR. Effects of case-based learning on communication skills, problem-solving ability, and learning motivation in nursing students. *Nurs Health Sci*. 2015;17(2):166-72.
15. Yoo MS, Park JH. Effect of case-based learning on the development of graduate nurses' problem-solving ability. *Nurse Educ Today*. 2014;34(1):47-51.
16. Lichvar AB, Hedges A, Benedict NJ, Donihi AC. Combination of a flipped classroom format and a virtual patient case to enhance active learning in a Required Therapeutics Course. *Am J Pharm Educ*. 2016;80(10):175.
17. Hsu SD, Chen CJ, Chang WK, Hu YJ. An Investigation of the outcomes of PGY students' cognition of and persistent behavior in learning through the intervention of the flipped classroom in Taiwan. *Plos One*. 2016; 11(12):e0167598.
18. Liebert CA, Lin DT, Mazer LM, Bereknyei S, Lau JN. Effectiveness of the surgery core clerkship flipped classroom: a prospective cohort trial. *Am J Surg*. 2016;211(2):451-457.e451.
19. Huang HM, Cheng SF. Application of flipped classroom teaching strategy in nursing education (Article in Chinese). *The journal of nursing*. 2018;65(6):5-12.
20. Geist MJ, Larimore D, Rawiszer H, Sager AWA. Flipped versus traditional instruction and achievement in a baccalaureate nursing pharmacology course. *Nurs Educ Perspect*. 2015;36(2):114-115.
21. Lee MK, Park BK. Effects of flipped learning using online materials in a surgical nursing practicum: a pilot stratified group-randomized trial. *Healthcare informatics research* 2018;24(1):69-78.
22. Harmon RB, Hills RL. Transforming psychiatric mental health nursing education with team based learning. *Arch Psychiatr Nurs*. 2015;29(6):413-418.
23. Simpson V, Richards E. Flipping the classroom to teach population health: increasing the relevance. *Nurse Educ Pract*. 2015;15(3):162-167.
24. Hu R, Gao H, Ye Y, Ni Z, Jiang N, Jiang X. Effectiveness of flipped classrooms in Chinese baccalaureate nursing education: A meta-analysis of randomized controlled trials. *Int J Nurs Stud*. 2018;79:94-103.
25. Park JY, Woo CH, Yoo JY. Effects of blended cardiopulmonary resuscitation and defibrillation E-learning on nursing students' self-efficacy, problem solving, and psychomotor skills. *Comput Inform Nurs*. 2016;34(6):272-80.

26. Garrison DR, Kanuka H. Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education*. 2004; **7**(2):95-105.
27. Walker S, Dwyer T, Moxham L, Broadbent M, Sander T. Facilitator versus preceptor: which offers the best support to undergraduate nursing students? *Nurse Educ Today*. 2013;**33**(5):530-5.
28. Pereira JA, Pleguezuelos E, Meri A, Molina-Ros A, Molina-Tomas MC, Masdeu C. Effectiveness of using blended learning strategies for teaching and learning human anatomy. *Med Educ*. 2007;**41**(2):189-95.
29. Ireland J, Johnson N, Adams D, Eboh W, Mowatt E. Blended learning in education: effects on knowledge and attitude. *Br J Nurs*. 2009;**18**(2):124-30.
30. Hsu L, Hsieh S. Effects of a blended learning module on self-reported learning performances in baccalaureate nursing students. *J Adv Nurs*. 2011;**67**(11):2435-44.
31. Gagnon MP, Gagnon J, Desmartis M, Njonya M. The impact of blended teaching on knowledge, satisfaction, and self-directed learning in nursing undergraduates: a randomized, controlled trial. *Nurs Educ Perspect*. 2013;**34**(6):377-82.
32. Shorey S, Kowitlawakul Y, Devi MK, Chen HC, Soong SKA, Ang E. Blended learning pedagogy designed for communication module among undergraduate nursing students: a quasi-experimental study. *Nurse Educ Today*. 2018;**61**:120-6.
33. Coyne E, Rands H, Frommolt V, Kain V, Plugge M, Mitchell M. Investigation of blended learning video resources to teach health students clinical skills: an integrative review. *Nurse Educ Today*. 2018;**63**:101-7.
34. McCutcheon K, O'Halloran P, Lohan M. Online learning versus blended learning of clinical supervisee skills with pre-registration nursing students: a randomised controlled trial. *Int J Nurs Stud*. 2018;**82**:30-9.
35. Zolfaghari M, Negarandeh R, Eybpoosh S. Developing a blended learning program for nursing and midwifery students in Iran: Process and preliminary outcomes. *Iran J Nurs Midwifery Res*. 2013;**18**(1):20-6.
36. Carter AG, Creedy DK, Sidebotham M. Efficacy of teaching methods used to develop critical thinking in nursing and midwifery undergraduate students: a systematic review of the literature. *Nurse Educ Today*. 2016;**40**:209-18.
37. Fero LJ, O'Donnell JM, Zullo TG, Dabbs AD, Kitutu J, Samosky JT, et al. Critical thinking skills in nursing students: comparison of simulation-based performance with metrics. *J Adv Nurs*. 2010;**66**(10):2182-93.
38. Yeh ML. Assessing the reliability and validity of the Chinese version of the California Critical Thinking Disposition Inventory. *Int J Nurs Stud*. 2002;**39**(2):123-32.
39. Peng M, Wang G, Chen J, Chen M, Bai H, Li S, et.al. Validity and reliability of the Chinese critical thinking disposition inventory (Article in Chinese). *Chinese J Nurs*. 2004;**39**(9):644-7.
40. Kiviniemi MT. Effects of a blended learning approach on student outcomes in a graduate-level public health course. *BMC Med Educ*. 2014;**14**:47.

41. Sajid MR, Laheji AF, Abothenain F, Salam Y, AlJayar D, Obeidat A. Can blended learning and the flipped classroom improve student learning and satisfaction in Saudi Arabia? *Int J Med Educ.* 2016;**7**:281-5.
42. Gyeong JA, Myung SY. Critical thinking and learning styles of nursing students at the Baccalaureate nursing program in Korea. *Contemp Nurse.* 2008;**29**(1):100-9.
43. Hong S, Yu P. Comparison of the effectiveness of two styles of case-based learning implemented in lectures for developing nursing students' critical thinking ability: a randomized controlled trial. *Int J Nurs Stud.* 2017;**68**:16-24.
44. Borglin G, Fagerstrom C. Nursing students' understanding of critical thinking and appraisal and academic writing: a descriptive, qualitative study. *Nurse Educ Pract.* 2012;**12**(6):356-60.

Tables

Table 1 Teaching strategies and evaluation for Medical Nursing between two groups

	Experimental group	Control group
ing	Blended case-centered learning	Case-centered learning
ies	1. Online learning and group case study(43h)	1. Face to face lectures in class(74h)
ng	2. Face to face lectures in class(26h)	2. Seminar in groups(44h)
	3. Offline flipped classroom(49h)	3. Laboratory teaching(11h)
	4. Laboratory teaching(11h)	4. Clinical practice(15h)
	5. Clinical practice(15h)	
tion	1. Academic performance	1. Academic performance
	(1) Final exam, 50%	(1) Final exam, 50%
	(2) Process assessment, 50%	(2) Process assessment, 50%
	a. Quiz in the flipped classrooms, 20%;	a. Quiz in seminars, 20%;
	b. Online learning progress requirements, 15%;	b. Offline learning notes, 15%;
	c. Performance in the flipped classrooms, 10%	c. Performance in seminars, 10%
	d. Homework, 5%	d. Homework, 5%
	2. Critical Thinking Disposition Inventory-Chinese Version	2. Critical Thinking Disposition Inventory-Chinese Version

*One teaching hour equal to 40minutes

Table 2 Comparison of academic performance in the Professional Basic courses in the previous academic year

basic	Experimental group (n=151)		Control group (n=118)		z/t value	P value
	Median(P ₂₅ -P ₇₅)	Mean ± SD	Median(P ₂₅ -P ₇₅)	Mean ± SD		
	66 (60-72)	/	/	70.38±9.84	3.878	<0.001
	67 (61-72)	/	/	71.36±8.30	3.944	<0.001
to Nursing	64 (61-68)	/	65 (62-70)	/	2.342	0.019
nd	/	69.77±8.42	/	75.07±9.07	-5.008	<0.001
logy						
biology and	70 (65-76)	/	73 (68-78.25)	/	2.694	0.007
gy	71 (64-77)	/	/	73.79±10.14	3.248	0.001
ssment	74 (70-78)	/	78 (74-83)	/	4.607	<0.001

Table 3 Results of two-way ANOVA of critical thinking

source	Between-subjects(groups)			Within-subjects(intervention)			Groups and intervention		
	Mean square	F	P value	Mean square	F	P value	Mean square	F	P value
inking	381.015	0.953	0.329	2327.768	5.821	0.016	300.612	0.752	0.386
ing	3.412	0.161	0.689	106.641	5.026	0.025	39.668	1.870	0.172
dedness	41.343	2.393	0.122	16.620	0.962	0.347	0.018	0.001	0.974
/	34.735	2.260	0.133	56.515	3.678	0.056	6.963	0.453	0.501
city	7.227	0.539	0.463	139.590	10.403	0.001	13.531	1.008	0.316
inking self-e	86.079	5.190	0.023	3.709	0.193	0.660	6.578	0.343	0.559
ness	23.855	1.242	0.265	3.709	0.193	0.660	6.578	0.343	0.559
maturity	49.765	2.394	0.122	9.799	0.471	0.493	28.209	1.357	0.245

Table 4 Differences in CTDI-CV scores between experimental and control groups

dependent variable	Experimental group Mean ± SD	Control group Mean ± SD	F	P value
Critical Thinking (Total) Pretest				
Posttest	273.54±1.57	273.73±1.75	0.006	0.937
Pretest	276.17±1.63	279.30±1.84*	1.625	0.203
Self-seeking				
Posttest	36.89±4.27	36.51±4.27	0.489	0.484
Pretest	37.23±5.68	37.82±3.81*	1.495	0.222
Open-mindedness				
Posttest	40.25±0.33	40.81±0.36	1.307	0.253
Pretest	40.61±0.34	41.14±0.38	1.096	0.296
Analyticity				
Posttest	40.63±0.31	40.91±0.34	0.361	0.548
Pretest	41.05±0.32	41.77±0.36	2.265	0.133
Systematicity				
Posttest	37.03±0.29	36.94±0.32	0.038	0.845
Pretest	37.72±0.30	38.26±0.34*	1.444	0.230
Critical thinking self-confidence				
Posttest	37.42±0.32	36.89±0.36	1.238	0.266
Pretest	38.48±0.33*	37.43±0.38	4.358	0.037
Openness				
Posttest	41.65±0.34	41.85±0.38	0.147	0.702
Pretest	41.60±0.36	42.23±0.40	1.381	0.240
Cognitive maturity				
Posttest	39.67±0.36	39.82±0.40	0.077	0.782
Pretest	39.48±0.37	40.53±0.42	3.517	0.061

*correspond to the comparison of the same group, P<0.05

Additional File Legends

Additional file 1: Table S1. The main features of undergraduate nursing curricula in Fujian Medical University in China

Figures

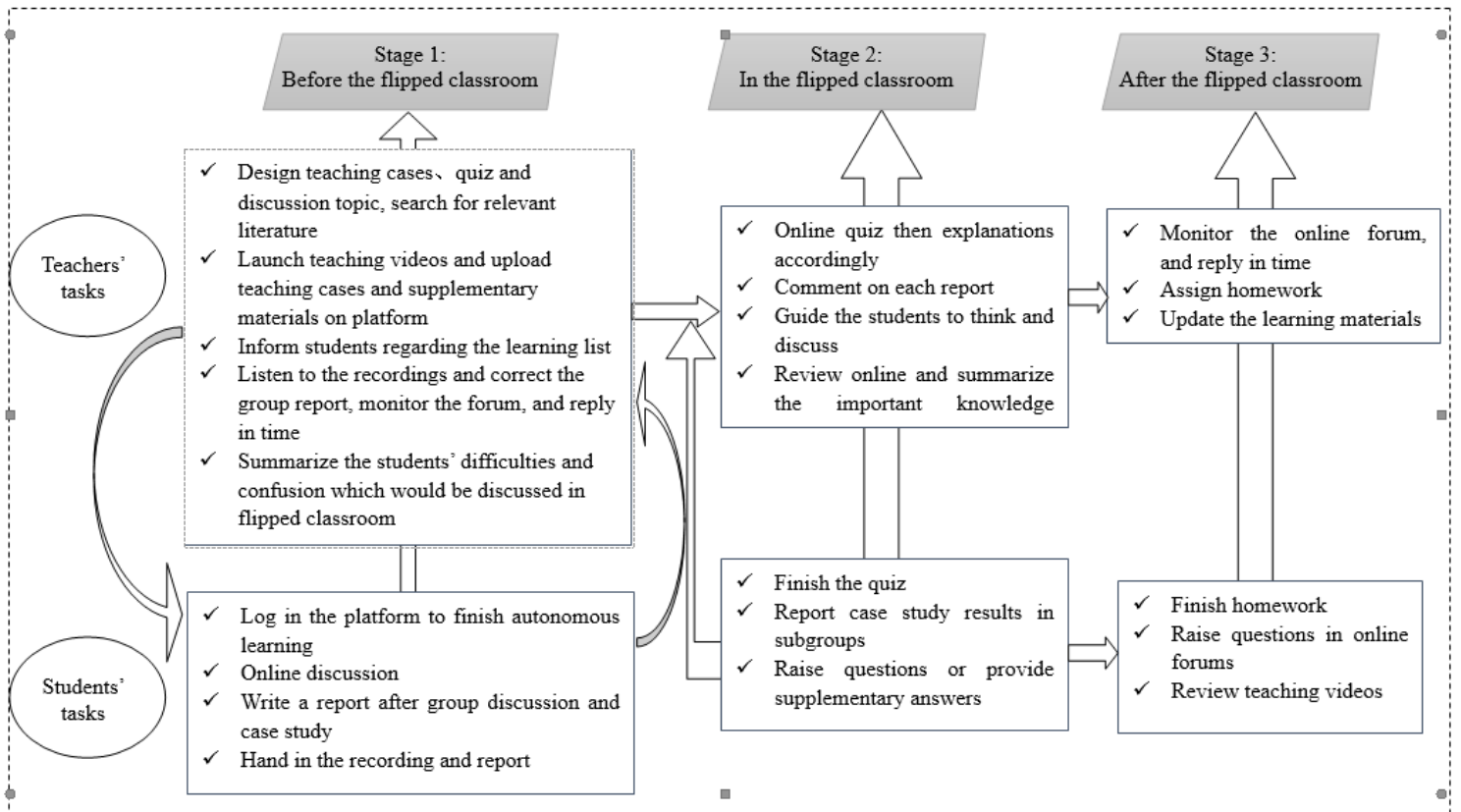


Figure 1

Blended case-centered learning in the experimental group

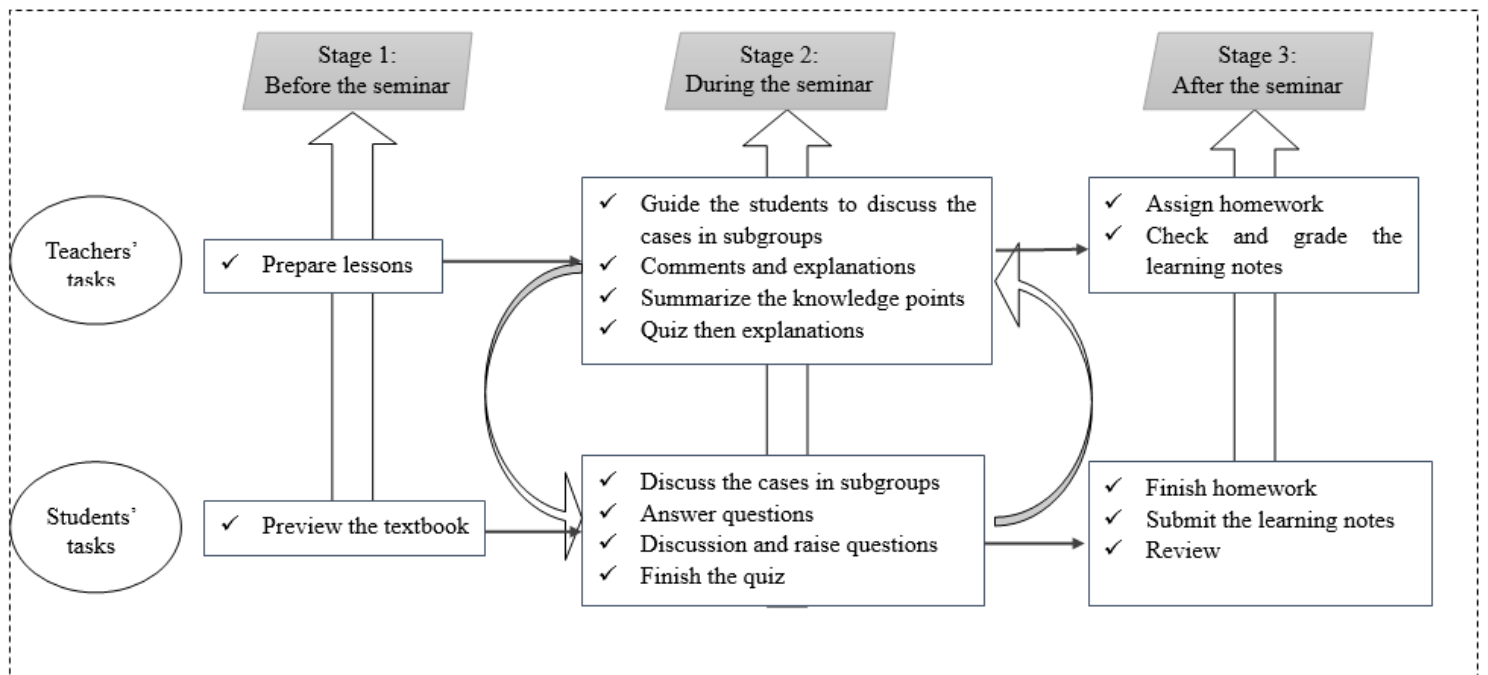


Figure 2

Offline case-centered learning in the control group

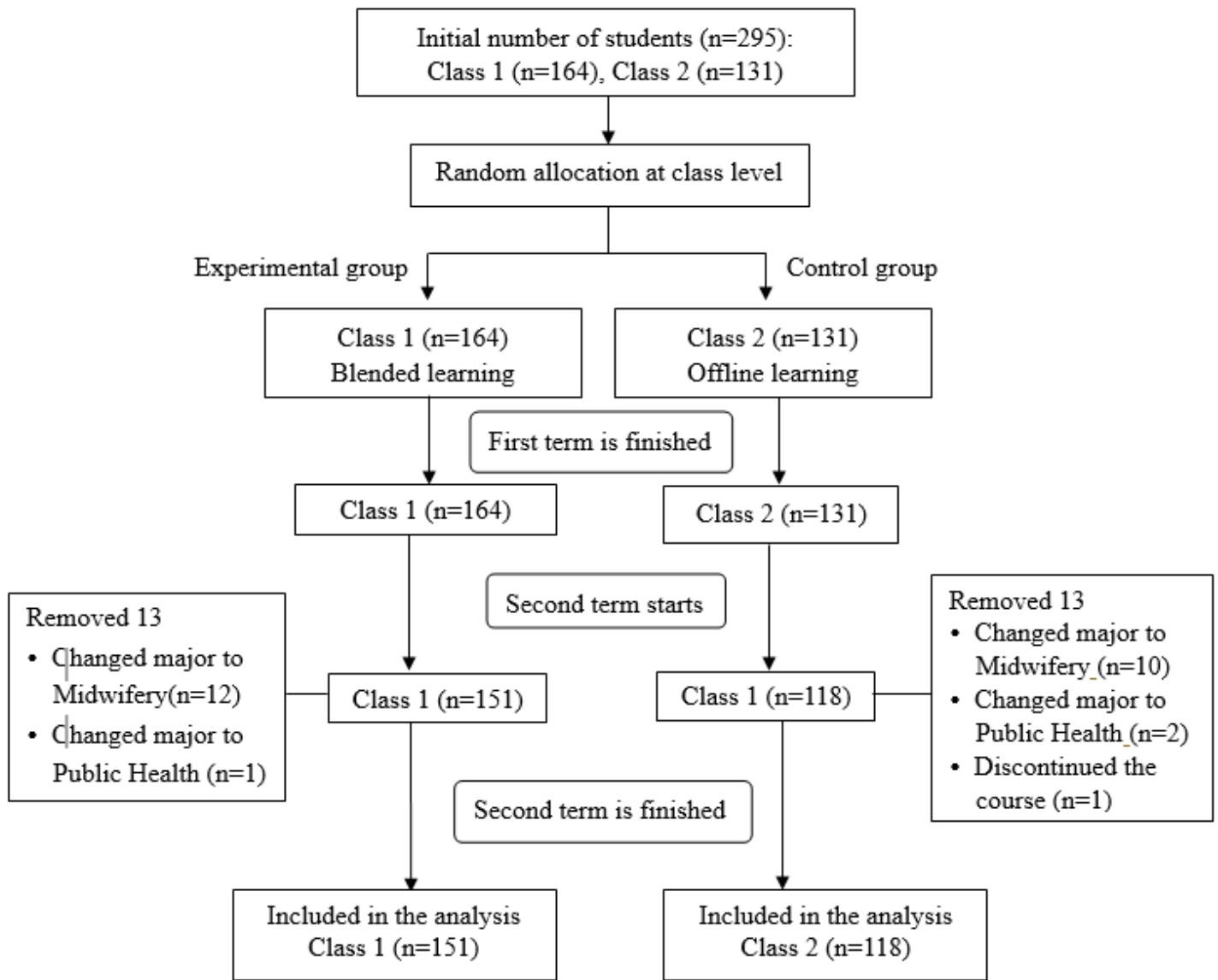


Figure 3

Study flow diagram