Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Clinical Simulation in Nursing (2021) 57, 31-40

Clinical Simulation in Nursing

www.elsevier.com/locate/ecsn

Featured Article

The Evaluation of the Distance Learning Combining Webinars and Virtual Simulations for Senior Nursing Students during the COVID-19 Period

Yiqing Luo, MSN[1], Cong Geng, MSN[1], Xianbo Pei, PhD*, Xiaoli Chen, PhD*, Zhijie Zou, MSN

School Of Health Sciences, Wuhan University, Located on No. 115 Donghu Road, Wuhan, Hubei Province, 430071, China

Keywords
distance learning;
webinar;
virtual simulation;
clinical thinking;
Academic self-efficacy;
Student engagement

Abstract

Background: The outbreak of COVID-19 has forced many schools to adopt distance teaching. This study developed a distance learning program that combines webinars and virtual simulations to meet students' learning needs.

Methods: A descriptive and quasi-experimental design was used. Thirty-five students participated in this distance learning program. Toward the middle and the end of the webinars, computer-based examinations were conducted to assess students' theoretical knowledge. The Clinical Thinking Ability Scale was administered before and after virtual simulation. Academic Self-efficacy, Student Engagement, and Students' Satisfaction Scales were administered after completing the learning program.

Results: The students obtained high scores on the theoretical knowledge examinations and virtual simulation scenarios. The virtual simulation led to an improvement in clinical thinking ability. Students displayed high levels of academic self-efficacy and student engagement and expressed high satisfaction with this program. Moreover, there were significant differences between genders in learning behavior self-efficacy, and learning effectiveness.

Conclusion: This distance learning program could meet the learning requirements of senior nursing students, in a flexible manner, in a safe environment during the COVID-19 outbreak.

Cite this article:
Luo, Y., Geng, C., Pei, X., & Zou, Z. (2021, Month). The Evaluation of the Distance Learning Combining Webinars and Virtual Simulations for Senior Nursing Students during the COVID-19 Period. *Clinical Simulation in Nursing*, 57, 31-40. https://doi.org/10.1016/j.ecns.2021.04.022.

* Corresponding author luoyiqing@whu.edu.cn (Y. Luo), gengcong@whu.edu.cn (C. Geng), peixb@whu.edu.cn (X. Pei), chenxl72@whu.edu.cn (X. Chen), zouzhijie@whu.edu.cn (Z. Zou).

[1] Yiqing Luo and Cong Geng are the co-first authors.

1876-1399/
https://doi.org/10.1016/j.ecns.2021.04.022

Introduction

The outbreak of COVID-19 has forced many schools to shift from their traditional teaching methods and adopt distance teaching. Senior nursing students who should have participated in classroom learning and clinical practice have also had to use online learning for training (Rose, 2020). A suitable distance learning program should be designed for senior nursing students so that they can meet the knowledge and clinical competence requirements as per the National Standards for Nursing Undergraduates and successfully pass the 2020 Chinese Registered Nurse Licensure Exam (Jiang & Hu, 2019).

Key Points

- Students demonstrated a high degree of academic self-efficacy and student engagement for distance learning program combining webinars and virtual simulations.
- The webinars had a good effect on theoretical knowledge training, and a statistically significant improvement in the students' clinical thinking ability was observed after they received the virtual simulation training.
- Female students achieved higher scores on knowledge examinations, virtual simulation scenarios, learning behavior self-efficacy and showed greater improvement in clinical thinking ability than male students.

A webinar is a type of distance education method which is very similar to the traditional classroom—with synchronous characteristics. Teachers can interact with students synchronously through pictures, texts, and sounds to impart knowledge and provide real-time feedback (Ebner & Gegenfurtner, 2019). This overcomes the shortcomings of asynchronous online classroom and video teaching method based on recording and broadcasting, including insufficient interaction, poor engagement, and difficulty in maintaining learners' attention (Cheung et al., 2013). Additionally, the synchronous mode enables teachers to conduct lectures and provide case-based learning (CBL), which is conducive to students' cooperation in analyzing actual clinical cases to promote the acquisition and application of knowledge (McLean, 2016). Currently, few investigations of webinar-based learning in senior nursing students have been conducted, and its effectiveness in promoting learners' knowledge needs to be further evaluated.

Clinical practice is the traditional way of cultivating students' clinical competence. When students cannot be trained directly in the clinical environment, virtual simulation is a feasible distance education way to improve students' participation and remove the obstacles between clinical practice and theoretical knowledge (Foronda et al., 2013). Both the Chinese Registered Nurse Licensure Exam and the competence requirements of nursing undergraduates emphasize the importance of clinical thinking ability. Clinical thinking ability refers to comprehensively analyzing the patients' existing or potential medical problems using knowledge, experience, and the best evidence, followed by a judgment and decision regarding the possible solution, and finally implementing it successfully (Zeng et al., 2005). This refers to the cognitive processes of a health professional at work and is a broader concept that encompasses clinical reasoning, clinical judgment, decision-making, etc. (Locke et al., 2020). Previous studies have shown that virtual simulation can enhance the development of clinical reasoning (Caylor et al., 2015), decision-making (Guise et al., 2012), and clinical judgment (Hege et al., 2016). However, there is a paucity of research focused on the effectiveness of virtual simulation in cultivating comprehensive clinical thinking ability.

In addition, learners' academic self-efficacy, student engagement, and satisfaction are related to learner's perceptions of learning program, and ultimately influences learning effectiveness. Academic self-efficacy represents an individual's confidence to successfully complete academic tasks and achieve academic expectations based on ability and previous experience (Mercer et al., 2011; Schunk, 1991). A study by Margolis and McCabe found that students can gain a stronger sense of academic self-efficacy in distance learning (Margolis & McCabe, 2006), but there are still few existing studies on this topic. Student engagement refers to the fulfilling mental state shown by an individual in learning (Gray & Diloreto, 2016). Asynchronous online learning is often proposed to suffer from low student engagement, which can negatively affect learning outcomes (Bote-Lorenzo & Gómez-Sánchez, 2017). Therefore, determining whether synchronous distance learning has a high level of student engagement is a key point for evaluating the learning program. Moreover, Study has shown that students' satisfaction with distance learning is highly correlated with learning motivation and success rate (Bote-Lorenzo & Gómez-Sánchez, 2017). In addition, assessing student satisfaction helps educators identify areas for improvement in learning program.

In recent years, the impact of gender differences on learning outcomes has attracted the attention of researchers. Previous studies have reached different conclusions about the differences in students' performance and learning effectiveness between males and females (Grassini et al., 2020;(Severiens et al., 2012)), and there was a study in distance learning proposed that males are more enthusiastic about information and communication technology (Reime et al., 2008).

Outcome-based education theory (OBE) was used to guide this program, which emphasizes on student-centered learning and focuses on the cultivation of

knowledge and comprehensive abilities (Mukhopadhyay & Smith, 2010). A distance learning program combining webinars and virtual simulations was developed to train senior nursing students during the COVID-19 period. This study aimed to (a) understand students' performance, learning effectiveness, and satisfaction with their participation in distance learning, (b) compare the differences in students' performance, learning effectiveness, and satisfaction between male and female students.

Methods

Study Design

A descriptive and quasi-experimental design was used in this study.

Participants

Thirty-five fourth-year nursing students from a university in central China were enrolled in this learning program during February to May 2020. Before the start of this study, we obtained verbal consent from the participants via a distance meeting. We also guaranteed that the collected data would be kept confidential and used only in this study. In the questionnaire survey, we obtained informed consent through the questionnaire form, and all students participated in this study voluntarily.

Intervention

The learning goal was that the participants could pass the 2020 Chinese Registered Nurse Licensure Exam and meet the knowledge and clinical competence requirements specified in the National Standards for Nursing Undergraduates (Jiang & Hu, 2019). This learning program was designed by nursing educators from a university in central China and included two parts: webinars and virtual simulations.

The webinar part of the program included lectures and CBL. First, 64-hour lectures incorporated five core clinical courses (Medical, Surgical, Obstetrics and Gynecology, Pediatrics, Fundamental Nursing) that aligned with comprehensive theoretical knowledge requirements for nursing undergraduates. The courses focused on the clinical manifestations, treatment principles, nursing procedures and techniques of various diseases. Second, 32 hours of CBL were broken down into 16 two-hour online meetings to facilitate the transfer and comprehensive application of the knowledge imparted by lectures. Throughout the CBL, students were presented with clinical cases using progressive disclosure in a fixed order. Next, the students were required to discuss and express their opinions about the clinical issues raised in each case. Teachers would assist students in solving problems in the discussion and provide feedback. The learning activities of these webinars were organized through the Tencent Meetings and DingTalk platform. Both Tencent Meetings and DingTalk are free and reliable online videoconferencing platforms. Their special features include webinar, live broadcast, screen sharing, course replay, testing, homework function, etc. Students were required to participate in all webinars through computers or other terminals and complete their homework and assessments in time. Students interacted with their teachers and peers by sending messages through the video and chat features of the online platforms. After the live broadcast of webinars, students could repeatedly watch the content of the courses.

In this study, virtual simulation was conducted using vSim — a software which provides an immersive experience through environmental objects and people's pronunciation. After students completed training through webinars, they logged into vSim using their student ID for clinical ability training. Each student was assigned 10 virtual simulation cases, with two scenarios corresponding to a single course subject. These 10 virtual simulation cases were conducted from April 20 to May 1. At the beginning of each scenario, students were given a brief introduction, and then the patient explained what was wrong with him. Students were required to take care of the patient by pointing out the most appropriate nursing action. Meanwhile, the virtual patient showed different disease progressions, depending on the student's intervention. The virtual system automatically recorded every choice made by the students and generated personalized feedback at the end of the simulation.

Instruments and Measures

Demographic data included age, gender, and experience in previous distance learning. The Academic Self-efficacy Scale (Liang, 2000), Student Engagement Scale (Li and Huang, 2010), and Students' Satisfaction Scale were administered after the implementation of the entire learning program. The Clinical Thinking Ability Scale was administered pre- and post-virtual simulation (Song, 2015). The instruments will be described in detail below. All data collections were implemented online, and all questionnaires were completed (100% completion rate).

The Evaluation of the Student's Performance In Distance Learning

Academic Self-Efficacy. The Academic Self-efficacy Scale was created by Pintrich and Degroot (Pintrich & Degroot, 1990), and later translated and revised in Chinese by Liang Yusong (Liang, 2000). This 22-item scale has two dimensions: learning ability self-efficacy and learning behavior self-efficacy. The scale is based on a 5-point Likert scale (1 = completely disagree-5 = completely agree), and higher scores indicated better academic self-efficacy. Moreover, this scale contains four reverse scoring items: 14, 16, 17, and 20. While previous research has indicated that Cronbach's alpha for this scale was 0.932 (Liang, 2000), in this study, it was 0.803.

Student Engagement. The Utrecht Work Engagement Scale-student (UWES-S) was developed by Schaufeli based on the Utrecht Work Engagement Scale (UWES) (Schaufeli et al., 2002), and then translated and revised in Chinese by Li Xiying (Li and Huang, 2010). This 17-item instrument evaluates students' performance in three dimensions: motivation (six-items), vigor (six-items), and absorption (five-items). For each of the 17 items, students were asked to identify their student engagement using a seven-point Likert scale (1 = never to 7 = always). The higher the score, the higher the student engagement. While in a previous research, Cronbach's alpha for the UWES-S scale was reported to be 0.92 (Li and Huang, 2010), in this study, it was 0.942.

The Evaluation of Effectiveness of Distance Learning

Computer-Based Theoretical Knowledge Examination. To assess the course's effect on students' theoretical knowledge, the examinations were developed by the nursing educators based on the 2020 Chinese Registered Nurse Licensure Exam syllabus. In the middle and end of webinars, students were administered a 240-question computer-based multiple-choice test comprising two sections: basic science knowledge and knowledge related to nursing skills. Each section lasted for 120 minutes, consisting of 120 questions. Each question had five possible answers, among which only one was correct. The total score ranged between 0 and 240 and was converted into a percentile score. Students were required to log on to the blackboard platform at the appointed time and complete all questions. After the researchers obtained the results of the automatic scoring performed by the computer, the average score of the two exams was taken to be the final score of students' theoretical knowledge in webinars.

Scores for Virtual Simulation. Students' achievements in the 10 virtual simulation scenarios were automatically recorded by the computer. Their scores, out of a possible total of 100 points for each scenario, were provided to them at the end. The mean score of the 10 scenarios was taken to be the students' virtual simulation results.

Clinical Thinking Ability for Virtual Simulation. To measure the effect of virtual simulation, the Clinical Thinking Ability Scale was administered before and after the virtual simulation (Song, 2015). This instrument consists of three dimensions: critical thinking ability, systems thinking ability, and evidence-based thinking ability, with a total of 24 items. The format of all items is a five-point Likert scale with answer options ranging from 1 = very bad to 5 = very good. While Cronbach's alpha was previously reported to be 0.91 for this scale (Song, 2015), in the present study, it was 0.931.

Chinese Registered Nurse Licensure Exam. After completing the course, all students signed up to participate in the Chinese Registered Nurse Licensure Exam. The National Health Commission of China sent the health professional qualification certificate of students who pass the exam to school, and the school was responsible for issuing the certificate to the students. The researchers calculated the passing rate of the exam with students' consent.

Students' Satisfaction

The Students' Satisfaction Scale was compiled by the teaching team. The scale has 19 items and contains five dimensions: teacher teaching, course content, classroom interaction, learning environment, and assessment situation. The scale used a five-point Likert scale ranging from 1to 5 points, indicating opinions from "strongly disagree" to "strongly agree", and higher scores indicated better student satisfaction. The scale was reviewed by experts, and in this study, Cronbach's alpha coefficient was 0.948.

Ethical Considerations

This study was approved by the Ethics Committee of Wuhan University School of Medicine (2020YF0053). The researchers were not faculty in this course. Before the start of this program, the researchers introduced the study content to the students. Students were informed that their course grades (theoretical knowledge examination scores and virtual simulation scores) and the pass rates of Chinese Registered Nurse Licensure Exam would be included in the study analysis. Students could voluntarily choose whether to participate in the questionnaire survey and to provide their course grades and the results of the Chinese Registered Nurse Licensure Exam.

Statistical Analysis

SPSS software (IBM, Armonk, NY, USA), version 26.0, was used for data analysis. Quantitative variables were examined using mean and standard deviation (SD), and qualitative variables were examined using relative frequencies (percentages). The Mann-Whitney U and Wilcoxon signed ranks test were used to examine the changes in clinical variables. The statistical significance level was set at $p < .05$.

Results

The study sample (N = 35) consisted of 25 female nursing students (71.4%) and 10 male nursing students (28.6%). Their average age was 21.80 ± 1.023 years. All students reported having experienced distance learning. All students were enrolled in and completed the learning program.

Table 1 Academic Self-Efficacy Scores and Comparison Between Male and Female Nursing Students

Variable	Total Mean ± SD	Male Mean ± SD	Female Mean ± SD	z	*p*
Learning ability self-efficacy	3.81 ± 0.50	3.78 ± 0.44	3.82 ± 0.54	0.202	.840
Learning behavior self-efficacy	3.40 ± 0.26	3.21 ± 0.16	3.47 ± 0.26	2.615	.009
Academic self-efficacy total score	3.60 ± 0.32	3.50 ± 0.28	3.65 ± 0.33	1.082	.279

Table 2 Student Engagement scores and Comparison Between Male and Female Nursing Students

Variable	Total Mean ± SD	Male Mean ± SD	Female Mean ± SD	z	*p*
Student engagement: Motivation	4.98 ± 1.03	4.62 ± 0.79	5.13 ± 1.09	1.385	.166
Student engagement: Vigor	4.69 ± 0.94	4.63 ± 0.82	4.71 ± 1.00	0.074	.941
Student engagement: Absorption	4.73 ± 0.91	4.62 ± 0.89	4.78 ± 0.93	0.575	.565
Student engagement total score	4.81 ± 0.88	4.62 ± 0.75	4.88 ± 0.93	0.696	.486

Student's Performance in Distance Learning

Academic Self-Efficacy

Students had a moderately high level of academic self-efficacy, with a total mean score of 3.60 ± 0.32. Academic self-efficacy scores of female students in two dimensions were higher than that of male students (Table 1), and the difference was statistically significant in the dimension of learning behavior self-efficacy ($p = .009$).

Student Engagement

Student engagement scores were high during this distance learning program. The range of mean scores for each dimension of student engagement was 4.69 ± 0.94 to 4.98 ± 1.03, and the scores from high to low were motivation, absorption, and vigor. There was no statistically significant difference in student engagement between different genders (Table 2).

The Effectiveness of Distance Learning Program

Theoretical Knowledge Examination Results for Webinars

In the computer-based knowledge tests, the accuracy rate of students was about 85% (the first test: 84.96 ± 9.25, the second test: 85.96 ± 8.64, mean score of two exams: 85.46 ± 8.45), indicating that students had a high level of theoretical knowledge. Regarding the distribution by gender, female students' theoretical knowledge scores were significantly higher than that of male students (mean score of two exams: male vs. female: 78.79 ± 8.02 vs. 88.13 ± 7.15, $z = 2.940$, $p = .003$) (Appendix A Table A.1).

Scores for Completing 10 Virtual Simulation Scenarios

The mean score of nursing students for the virtual simulation was 94.59 ± 8.06, showing a good performance level overall. Female students performed better than male students, and the difference was statistically significant (male vs. female: 87.05 ± 11.14 vs. 97.61 ± 3.50, $z = 3.701$, $p = .000$) (Appendix A Table A.2).

Pre-test and Post-Test Clinical Thinking Ability Scores for Virtual Simulation

The mean pre-test clinical thinking ability scores were 3.52 ± 0.43, which showed an average level of ability among the students, overall. After the 10 simulation scenarios were completed, a higher mean score of 3.88 ± 0.60 was obtained. A statistically significant improvement in the students' clinical thinking ability was observed after performing the virtual simulation ($p = .001$). In addition, the virtual simulation intervention led to an improvement in all dimensions (Table 3). The improvement in systems thinking ($p = .000$) and evidence-based thinking ($p = .007$) were statistically significant. However, the difference in critical thinking ($p = .316$) was not statistically significant.

A comparison of the mean scores of male and female students is presented in Table 4. Female students only obtained higher mean scores on evidence-based thinking ability in the pre-test ($p = .015$). However, after the virtual simulation, female students showed better abilities in all three dimensions of clinical thinking ability.

Chinese Registered Nurse Licensure Exam result

All thirty-five students passed the 2020 Chinese Registered Nurse Licensure Exam.

Table 3 Comparison of Pre- and Post- Virtual Simulation Training on Clinical Thinking Ability Scores

	Pre Mean ± SD	Post Mean ± SD	z	*p*
Critical thinking	3.60 ± 0.43	3.76 ± 0.62	1.00	.316
Systematic thinking	3.54 ± 0.42	4.14 ± 0.59	4.27	.000
Evidence-based thinking	3.40 ± 0.43	3.73 ± 0.52	2.68	.007
clinical thinking ability scale	3.52 ± 0.43	3.88 ± 0.60	3.30	.001

Table 4 Comparison of Clinical Thinking Ability Scores Between male and Female Nursing Students

		Male Mean ± SD	Female Mean ± SD	z	*p*
Pre-test	Critical thinking	3.53 ± 0.44	3.63 ± 0.43	0.726	.468
	Systematic thinking	3.34 ± 0.36	3.62 ± 0.42	1.950	.051
	Evidence-based Thinking	3.10 ± 0.46	3.53 ± 0.36	2.437	.015
	clinical thinking ability scale	3.32 ± 0.35	3.60 ± 0.35	1.957	.050
Post-test	Critical thinking	3.40 ± 0.51	3.90 ± 0.61	2.168	.030
	Systematic thinking	3.50 ± 0.51	3.89 ± 0.52	2.109	.035
	Evidence-based thinking	3.46 ± 0.37	3.85 ± 0.53	2.154	.031
	clinical thinking ability scale	3.47 ± 0.44	3.88 ± 0.51	2.251	.024

Students' Satisfaction With This Distance Learning Program

The total mean score for satisfaction was 4.13 ± 0.50. Results demonstrated that students were highly satisfied with this distance learning program. However, there was no significant difference in satisfaction scores between male and female students (male vs. female: 3.91 ± 0.41 vs. 4.23 ± 0.51, $z = 1.585$, $p = .113$) (Appendix A Table A.3).

Discussion

The senior nursing students' distance learning program that combines webinars and virtual simulations offers access to knowledge and clinical thinking ability, and it is a good alternative when traditional classroom teaching and clinical practice are not available. The study supports the positive results of distance learning on senior nursing students' performance, learning effectiveness, and satisfaction. Meanwhile, the program guaranteed the completion of learning goals for senior nursing students during the COVID-19 outbreak.

This study aimed to investigate students' performance in distance learning. The results of academic self-efficacy suggested that students believed they could achieve success in this learning process and were willing to put in effort to overcome challenges and finally meet the course expectations. Bandura argued that experience was the most important component of self-efficacy improvement (Bandura et al., 1997). Virtual simulation provided students with the opportunity to complete learning tasks independently and reflect on their performances according to the feedback received. In the CBL by webinar, students could also observe the performance of others while cooperating in case analysis and care formulation. In the process of accumulating experience, students become confident in solving clinical problems, and ultimately create a strong sense of academic self-efficacy (Warren et al., 2021). Simultaneously, timely encouragement and constructive feedback were also key to improving students' self-efficacy (Margolis & McCabe, 2006). In this learning program, synchronization techniques and simulation software were implemented to facilitate interactive learning among students and to increase access to feedback.

Moreover, students had a high degree of engagement, reflecting that they not only had a continuous, positive, and fulfilling mental state but also a high level of interest and a positive attitude in this synchronous learning activity. Students' engagement was strongly associated with positive learning outcomes as well as high retention rates and was one of the keys to evaluating learning programs (Bote-Lorenzo & Gómez-Sánchez, 2017). Bernard's study proposed that increasing any of the three interaction types (student-student, student-teacher, or student-content) enhanced student engagement in distance

learning (Bernard et al., 2009). The synchronous model provided students with opportunities to participate in social interaction (Giesbers et al., 2013), and enhanced students' feeling of connection to teachers and other students, and resolved negative emotions, such as loneliness caused by social isolation in asynchronous learning (Strang, 2013; Watts, 2016).

The data of the computer-based exams for the webinars showed that the mean score of the students' knowledge reached above 85 points, which reflected the effectiveness of the webinars in knowledge training. Currently, few studies have been conducted to evaluate the potential of webinars in delivering knowledge training. Alnabelsi indicated that webinars are as effective as traditional face-to-face teaching in promoting student learning (Alnabelsi et al., 2015). This is good news for all educators who wish to offer distance instruction for their students during COVID-19, as students can attend webinars at their homes and achieve good results. After the training, the passing rate of students in the 2020 Chinese Registered Nurse Licensure Exam was 100%.

In the virtual simulation, students got good grades. Moreover, a statistically significant improvement in students' clinical thinking ability was observed after completing ten virtual simulation scenarios. Virtual simulation emerged as a solution to provide students with more clinical ability training opportunities when clinical practice cannot be carried out (Foronda & Bauman, 2014). In addition, virtual simulation enabled students to learn in a safe environment and incorporated effective, real-time, formative feedback into the experience (Byron et al., 2014).

Students' systems thinking and evidence-based thinking abilities significantly improved after the virtual simulation intervention. Virtual simulation integrated system-based practice into education environments and placed patients at the core of the medical system to improve patient outcomes. Students had repeated opportunities to reinforce concepts they had learned over time, so that they could comprehensively consider the clinical situation and dynamically deal with problems, by checking the connections of various components in the system. A multicenter study conducted by Sanko also proved that the systems thinking abilities of different health major students significantly improved after virtual simulation (Sanko et al., 2021). Moreover, virtual simulation fostered experiential learning for nursing students to make use of evidence and practice decision-making (Foronda et al., 2017). Students were required to accurately use the best available evidence, combine professional skills, and consider the wishes of the patient to make a comprehensive judgment, and then select the most appropriate nursing operation. Nurse educators may benefit from exploring virtual simulation for clinical competence training.

On the contrary, there was no significant improvement in students' critical thinking ability. A previous study has also shown that simulation training did not significantly improve students' critical thinking ability (Allaire, 2015). The development of critical thinking skills depends largely on people's personality and educational background and might not be improved easily in the short term (Adib-Hajbaghery & Sharifi, 2017). Furthermore, the acquisition of critical thinking skills requires long-term continuous intervention and frequent exposure to virtual simulation (Weatherspoon et al., 2015; Zarifsanaiey et al., 2016).

In this study, students were highly satisfied with distance learning. Students commented that this program allowed them to explore cases and simulated scenarios to fully comprehend the intricacies of nursing problems. Webinars and virtual simulations provide students with the opportunity to learn repeatedly, according to different degrees of absorption after class, which makes students feel satisfied.

Female students achieved higher scores on theoretical knowledge examinations and virtual simulation scenarios and showed greater improvement in clinical thinking ability than male students. Current research suggests that the main factor of gender differences in learning was not the cognitive characteristics but the non–cognitive skills, such as self-efficacy, motivation, and time management (Severiens et al., 2012), (Sheard, 2009). The present study revealed that female students had higher scores in learning behavior self-efficacy. People with higher learning behavior self-efficacy were more willing to conduct learning activities, and they spent more energy in formulating effective strategies for difficulties encountered (Yilmaz, 2016). Learning behavior self-efficacy beliefs increased female students' participation in learning activities, which provided them with the possibility of achieving higher grades than male students. In addition, the different career choices of male and female students had an impact on learning behavior self-efficacy. Few male students in this study took clinical nursing as a future career. In China, there are few male nurses, because of gender stereotypes, and lack of visible male role models, leading to male nurses having less sense of a professional identity in the nursing profession (Chen et al., 2020; Zhang & Tu, 2020). These have negative effects on the learning motivation of male nursing students. Therefore, the learning program should consider the learning style of the male students, provide support, and use different strategies to improve their self-efficacy.

Limitations

Regarding the limitations of this study, it is noteworthy that the study lacked a control group. Due to the impact of COVID-19, we ensured that all students had the same educational opportunities. Future research should conduct efficacy analysis and divide students into two groups to compare synchronous distance learning with asynchronous

distance learning or traditional learning. In addition, this study was a single site study with a small sample size, future research needs more participants to conduct multi-site study to assess a wide range of effectiveness. And the Students' Satisfaction Scale was compiled by the teaching team and has not been subjected to rigorous psychometric testing, which may have affected the study findings and limit generalizability. Moreover, since this study was only based on the evaluation results of questionnaire survey, theoretical knowledge exams, the pass rate of Chinese Registered Nurse Licensure Exam and virtual simulation scores, there was no evidence that the knowledge can be transferred to clinical practice.

Conclusion

The results showed that distance learning combining webinars and virtual simulations could meet the learning requirements of senior nursing students in a safe environment in a flexible manner, and students could obtain theoretical knowledge and grow their clinical thinking ability. Distance learning not only relieved students' pressure of being unable to participate in traditional learning and clinical practice, but also maintained high engagement and academic self-efficacy. Given the overall positive feedback, we believe that this study was successful in providing timely education for senior nursing students during the COVID-19 pandemic.

Declaration of Competing Interest

Authors declare that there is no conflict of interest.

Author Contributions

Study design: YQ L, CG, XL C & XB P; Data collection: YQ L & CG; Data analysis: YQ L, CG& ZJ Z; Manuscript writing and revise: YQ L, CG, XL C & XB P.

Funding

This work was supported by research fund of the Wuhan University Teaching and Research Reform Project(YB-3).

Acknowledgments

In the process of jointly setting up the high-fidelity simulation laboratory, we have established a good cooperative relationship with Laerdal Medical Corporation. To further promote the cooperation, Laerdal Medical Corporation provides us with the authorization of the trial run account of the vSim software. We greatly appreciate the support provided by Laerdal Medical Corporation for this study.

Appendix A

Table A1 Theoretical Knowledge Scores of Computer-Based Knowledge Testing and Comparison Of Scores Between Male and Female Nursing Students

Variable	Total Mean ± SD	Male Mean ± SD	Female Mean ± SD	z	*p*
The first stage	84.96 ± 9.25	75.54 ± 9.68	88.73 ± 5.87	3.343	.001
The second stage	85.96 ± 8.64	82.04 ± 6.83	87.53 ± 8.90	2.888	.004
Average score of two exams	85.46 ± 8.45	78.79 ± 8.02	88.13 ± 7.15	2.940	.003

Table A2 Comparison of Mean Score for the 10 Scenarios Between male and Female Nursing Students

Variable	Total Mean ± SD	Male Mean ± SD	Female Mean ± SD	z	*p*
Mean score for the 10 scenarios	94.59 ± 8.06	87.05 ± 11.14	97.61 ± 3.50	3.701	.000

Table A3 Comparison of Students' Satisfaction Scores Between Male and Female Nursing Students

Variable	Total Mean ± SD	Male Mean ± SD	Female Mean ± SD	z	*p*
Teacher teaching	4.25 ± 0.51	3.92 ± 0.41	4.38 ± 0.49	2.029	.042
Course content	4.10 ± 0.52	3.88 ± 0.43	4.19 ± 0.53	1.298	.194
Class interaction	4.04 ± 0.69	3.90 ± 0.45	4.09 ± 0.77	1.069	.285
Learning environment	4.14 ± 0.56	3.95 ± 0.44	4.22 ± 0.60	1.534	.125
Assessment situation	4.06 ± 0.58	3.90 ± 0.50	4.13 ± 0.60	1.104	.270
Questionnaire total score	4.13 ± 0.50	3.91 ± 0.41	4.23 ± 0.51	1.585	.113

References

Adib-Hajbaghery, M., & Sharifi, N (2017). Effect of simulation training on the development of nurses and nursing students' critical thinking: A systematic literature review. *Nurse Education Today*, *50*, 17-24. https://doi.org/10.1016/j.nedt.2016.12.011.

Allaire, J. L (2015). Assessing critical thinking outcomes of dental hygiene students utilizing virtual patient simulation: A mixed methods study. *Journal of Dental Education*, *79*(9), 1082-1092. https://doi.org/10.1002/j.0022-0337.2015.79.9.tb06002.x.

Alnabelsi, T., Al-Hussaini, A., & Owens, D. (2015). Comparison of traditional face-to-face teaching with synchronous e-learning in otolaryngology emergencies teaching to medical undergraduates: A randomised controlled trial. *European Archives of Oto-Rhino-Laryngology*, *272*(3), 759-763. https://doi.org/10.1007/s00405-014-3326-6.

Bandura, A., Freeman, W. H., & Lightsey, R (1997). Self-efficacy: The exercise of control. *Journal of Cognitive Psychotherapy*, *13*(2), 158-166. https://doi.org/10.1891/0889-8391.13.2.158.

Bernard, R. M., Abrami, P. C., Borokhovski, E., Wade, C. A., Tamim, R. M., Surkes, M. A., & Bethel, E. C (2009). A meta-analysis of three types of interaction treatments in distance education. *Review of Educational Research*, *79*(3), 1243-1289. https://doi.org/10.3102/0034654309333844.

Bote-Lorenzo, M. L., & Gómez-Sánchez, E (2017). Predicting the decrease of engagement indicators in a MOOC. In *Proceedings of the 7th International Conference on Learning Analytics and Knowledge, Vancouver* (pp. 143–147). https://doi.org/10.1145/3027385.3027387.

Byron, J. K., Johnson, S. E., Allen, L. C. V., Brilmyer, C., & Griffiths, R. P (2014). Development and pilot of case manager: A virtual-patient experience for veterinary students. *Journal of Veterinary Medical Education*, *41*(3), 225-232. https://doi.org/10.3138/jvme.1113-151R1.

Caylor, S., Aebersold, M., Lapham, J., & Carlson, E (2015). The use of virtual simulation and a modified TeamSTEPPS (TM) training for multi-professional education. *Clinical Simulation in Nursing*, *11*(3), 163-171. https://doi.org/10.1016/j.ecns.2014.12.003.

Chen, Y., Zhang, Y., & Jin, R (2020). Professional identity of male nursing students in 3-year colleges and junior male nurses in China. *American Journal of Mens Health*, *14*(4), Article 1557988320936583. https://doi.org/10.1177/1557988320936583.

Cheung, J. J., Koh, J., Mackinnon, K., Brett, C., Bägli, D., Kapralos, B., & Dubrowski, A (2013). The use of web-based learning for simulation-based education and training of central venous catheterization in novice learners. *Studies in Health Technology and Informatics*, *184*, 71-77. https://doi.org/10.3233/978-1-61499-209-7-71.

Ebner, C., & Gegenfurtner, A (2019). Learning and satisfaction in webinar, online, and face-to-face instruction: A meta-analysis. *Frontiers in Education*, *4*, 92. https://doi.org/10.3389/feduc.2019.00092.

Foronda, C., & Bauman, E. B (2014). Strategies to incorporate virtual simulation in nurse education. *Clinical Simulation in Nursing*, *10*(8), 412-418. https://doi.org/10.1016/j.ecns.2014.03.005.

Foronda, C., Godsall, L., & Trybulski, J. A (2013). Virtual clinical simulation: The state of the science. *Clinical Simulation in Nursing*, *9*(8), e279-e286. https://doi.org/10.1016/j.ecns.2012.05.005.

Foronda, C. L., Hudson, K. W., & Budhathoki, C (2017). Use of virtual simulation to impact nursing students' cognitive and affective knowledge of evidence-based practice. *Worldviews on Evidence-Based Nursing*, *14*(2), 168-170. https://doi.org/10.1111/wvn.12207.

Giesbers, B., Rienties, B., Tempelaar, D., & Gijselaers, W (2013). Investigating the relations between motivation, tool use, participation, and performance in an e-learning course using web-videoconferencing. *Computers in Human Behavior*, *29*(1), 285-292. https://doi.org/10.1016/j.chb.2012.09.005.

Grassini, S., Laumann, K., & Rasmussen Skogstad, M (2020). The use of virtual reality alone does not promote training performance (but sense of presence does). *Frontiers in Psychology*, *11*, 1743. https://doi.org/10.3389/fpsyg.2020.01743.

Gray, J. A., & Diloreto, M. (2016). The effects of student engagement, student satisfaction, and perceived learning in online learning environments. *International Journal of Educational Leadership Preparation*, *11*(1), 98-119.

Guise, V., Chambers, M., & valimaki, M (2012). What can virtual patient simulation offer mental health nursing education? *Journal of Psychiatric and Mental Health Nursing*, *19*(5), 410-418. https://doi.org/10.1111/j.1365-2850.2011.01797.x.

Hege, I., Kononowicz, A. A., Tolks, D., Edelbring, S., & Kuehlmeyer, K. (2016). A qualitative analysis of virtual patient descriptions in healthcare education based on a systematic literature review. *Bmc Medical Education*, *16*(1), 146. https://doi.org/10.1186/s12909-016-0655-8.

Jiang, X., & Hu, R. (2019). Interpretation of the National Standards for Nursing Teaching Quality:Educational resources. *Chinese Journal of Nursing Education*, *16*(1), 16-20.

Li, X. Y., & Huang, R (2010). A revise of the UWES-S of Chinese college samples. *Psychological Research*, *3*(1), 84-88.

Liang, Y. S. (2000). *Study on achievement goals, attribution styles and academic eelf-efficacy of collage students. [Master*. Central China Normal University.

Locke, R., Mason, A., Coles, C., Lusznat, R. M., & Masding, M. G (2020). The development of clinical thinking in trainee physicians: The educator perspective. *Bmc Medical Education*, *20*(1), 226. https://doi.org/10.1186/s12909-020-02138-w.

Margolis, H., & McCabe, P. P (2006). Improving self-efficacy and motivation: What to do, what to say. *Intervention in School and Clinic*, *41*(4), 218-227. https://doi.org/10.1177/10534512060410040401.

McLean, S. F (2016). Case-based learning and its application in medical and health-ccare fields: A review of worldwide literature. *Journal of Medical Education and Curricular Development*, *3*, 39-49. https://doi.org/10.4137/jmecdecdecd.S20377.

Mercer, S. H., Nellis, L. M., Martínez, R. S., & Kirk, M (2011). Supporting the students most in need: Academic self-efficacy and perceived teacher support in relation to within-year academic growth. *Journal of*

School Psychology, *49*(3), 323-338. https://doi.org/10.1016/j.jsp.2011.03.006.

Mukhopadhyay, S., & Smith, S. (2010). Outcome-based education: Principles and practice. *Journal of Obstetrics and Gynaecology*, *30*(8), 790-794. https://doi.org/10.3109/01443615.2010.505305.

Pintrich, P. R., & Degroot, E. V (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology*, *82*(1), 33-40. https://doi.org/10.1037/0022-0663.82.1.33.

Reime, M. H., Harris, A., Aksnes, J., & Mikkelsen, J (2008). The most successful method in teaching nursing students infection control - E-learning or lecture? *Nurse Education Today*, *28*(7), 798-806. https://doi.org/10.1016/j.nedt.2008.03.005.

Rose, S (2020). Medical student education in the time of COVID-19. *Journal of the American Medical Association*, *323*(21), 2131-2132. https://doi.org/10.1001/jama.2020.5227.

Sanko, J. S., Gattamorta, K., Young, J., Durham, C. F., Sherwood, G., & Dolansky, M (2021). A multisite study demonstrates positive impacts to systems thinking using a table-top simulation experience. *Nurse educator*, *46*(1), 29-33. https://doi.org/10.1097/nne.0000000000000817.

Schaufeli, W. B., Martinez, I. M., Pinto, A. M., Salanova, M., & Bakker, A. B (2002). Burnout and engagement in university students - A cross-national study. *Journal of Cross-Cultural Psychology*, *33*(5), 464-481. https://doi.org/10.1177/0022022102033005003.

Schunk, D. H (1991). Self-efficacy and academic motivation. *Educational Psychologist*, *26*(3-4), 207-231. https://doi.org/10.1207/s15326985ep2603&4_2.

Severiens, S., & Ten Dam, G (2012). Leaving college: A gender comparison in male and female-dominated programs. *Research in Higher Education*, *53*(4), 453-470. https://doi.org/10.1007/s11162-011-9237-0.

Sheard, M (2009). Hardiness commitment, gender, and age differentiate university academic performance. *British Journal of Educational Psychology*, *79*, 189-204. https://doi.org/10.1348/000709908x304406.

Song, Y. L. (2015). *A study on the evaluation index system of clinical thinking ability of medical students and demonstration. [Master*. Qingdao University.

Strang, K. D (2013). Cooperative learning in graduate student projects: Comparing synchronous versus asynchronous collaboration. *The Journal of Interactive Learning Research*, *24*(4), 447-464.

Warren, L., Reilly, D., Herdan, A., & Lin, Y (2021). Self-efficacy, performance and the role of blended learning. *Journal of Applied Research in Higher Education*, *13*(1), 98-111. https://doi.org/10.1108/jarhe-08-2019-0210.

Watts, L (2016). Synchronous and asynchronous communication in distance learning: A review of the literature. *The Quarterly Review of Distance Education*, *17*(1), 23-32.

Weatherspoon, D. L., Phillips, K., & Wyatt, T. H (2015). Effect of electronic interactive simulation on senior bachelor of science in nursing students' critical thinking and clinical judgment skills. *Clinical Simulation in Nursing*, *11*(2), 126-133. https://doi.org/10.1016/j.ecns.2014.11.006.

Yilmaz, R (2016). Knowledge sharing behaviors in e-learning community: Exploring the role of academic self-efficacy and sense of community. *Computers in Human Behavior*, *63*, 373-382. https://doi.org/10.1016/j.chb.2016.05.055.

Zarifsanaiey, N., Amini, M., & Saadat, F (2016). A comparison of educational strategies for the acquisition of nursing student's performance and critical thinking: Simulation-based training vs. integrated training (simulation and critical thinking strategies). *Bmc Medical Education*, *16*, 294. https://doi.org/10.1186/s12909-016-0812-0.

Zeng, Y., Wang, G. M., Cai, Y. Y., & Lu, Y. Q. (2005). Understanding and cultivation of "clinical thinking". *Fudan Education Forum*, *3*(1), 90-93. https://doi.org/10.3969/j.issn.1672-0059.2005.01.023.

Zhang, H., & Tu, J (2020). The working experiences of male nurses in China: Implications for male nurse recruitment and retention. *Journal of Nursing Management*, *28*(2), 441-449. https://doi.org/10.1111/jonm.12950.