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RESEARCH ARTICLE

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Development and evaluation of virtual reality simulation education based on coronavirus disease 2019 scenario for nursing students: A pilot study

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Abstract

Aim: This research is designed to establish and evaluate the effectiveness of a virtual reality simulation program using COVID-19 scenario for nursing students.

Design: This is a quasi-experimental study using a non-equivalent control group pre-test-posttest design.

Methods: The participants were 65 students in their fourth year in nursing college. The knowledge about communicable infectious diseases in the respiratory system, self-efficacy, clinical reasoning capacity and learning satisfaction was evaluated.

Results: The experimental group showed a significantly higher learning satisfaction ($t = 3.01$, $p = .004$). Both groups presented statistically significant differences in knowledge on infectious respiratory diseases, self-efficacy and clinical reasoning between pre-test and posttest. However, knowledge ($t = 0.47$, $p = .643$), self-efficacy ($t = 0.70$, $p = .944$) and clinical reasoning were not different between the groups.

KEYWORDS
COVID-19, education, nursing, simulation, virtual reality

1 | INTRODUCTION

Coronavirus disease 2019 (hereinafter referred to as COVID-19) began in November 2019 and was declared a global pandemic on March 11, 2020 (World Health Organization, 2020). As of March 8, 2021, a total of 117,333,176 cases were confirmed worldwide and 92,471 cases were confirmed in Korea (Korea Disease Control and Prevention Agency, 2020). According to the American Heart Association (2020) in the US, out of 138 patients admitted to medical institutions for COVID-19, 19.6% develop acute respiratory distress syndrome, 16.6% develop arrhythmia, 8.7% develop shock and 7.2% develop acute heart damage. As COVID-19 shows a higher incidence of complications and higher proportion of treatment in the intensive care unit compared with other infectious diseases, professional medical staff for managing infectious diseases is urgently required.

Nurses provide patient care with a high risk of infection when a new infectious disease occurs (Liu et al., 2012). In particular, nurses are in direct contact with the patients and are exposed to various samples and contaminated medical equipment; however, they are working in an environment with a high risk of infection coming from the limited supply of personal protective equipment (PPE) and accurate protocols (Catton, 2020). According to recent studies conducted on emergency room nurses in Spain (García-Martín et al., 2020), nurses complained of difficulties in initial response and fear of virus transmission in the COVID-19 pandemic. These studies emphasized the importance of providing accurate information, guidelines and education on infectious diseases in the respiratory system.

As the deployment of manpower for infectious diseases in a short period of time is limited, long-term manpower planning and education are required. Nursing students as soon-to-be healthcare providers are important resources to the professional manpower needed for managing infectious diseases.

During pandemic of infectious diseases, teamwork and situational coping skills are important, and those abilities could be educated to nursing students through clinical practicum (Dobrowolska et al., 2015). However, social distancing caused by COVID-19 prevented most nursing students in Korea from practicing directly in the clinical environment. The practice was conducted in a limited form, such as online lectures (Im et al., 2020). This restriction of nursing students' clinical practice goes beyond a learning issue. It is related to a decline in the expertise of the healthcare professionals who will care for the public with infectious diseases (Sim, 2021). Considering the current situation of infectious diseases is a phenomenon that could be continuously repeated, alternative education to supplement the limitations of clinical practice for nursing education is required.

Simulation education using standardized patients and/or high-fidelity simulators is being conducted as a replacement and complementary education for nursing students' clinical practice (Tuzer et al., 2016). This simulation education has advantages of providing repeated hands-on content that cannot be implemented on-site and offering communication between patients and medical staff based on realistic scenarios (Doolen et al., 2016). However, the disadvantage of the current simulation education is that it demands high costs for installation, maintenance and repair of the simulation equipment, and it requires space for simulation and a pre-planned schedule (Padilha et al., 2018). In particular, if group education is restricted in a specific place because of the current outbreak of infectious diseases, there is a limitation in that education using standardized patients and simulators cannot be conducted; therefore, education methods to supplement this must be devised (Foronda & Armstrong, 2020). During the pandemic of COVID-19, nursing educators in many countries are trying to apply virtual reality simulation as an effective practical education method (Turrise et al., 2020).

Virtual reality (VR) simulation is a 3D program for users to interact with VR objects or other participants in real-time through the internet or facility network. Unlike previous simulation education, it does not have restrictions on place and time, and it is possible to implement high-level interactions and realistic situations and to design scenarios in various situations (Berman et al., 2016). According to previous studies (Alim et al., 2015; Dubovsky et al., 2017; Ulrich et al., 2014), VR is not only effective in educating nursing students for infection, emergency, disaster or national-level events, but it also has been proven to be effective in psychological health such as stress or anxiety of students about clinical situations. Moreover, virtual simulation education promotes knowledge (Chen et al., 2020; Kim & Kim, 2015), self-efficacy (Franklin & Lee, 2014; Reinhardt et al., 2012), clinical reasoning capacity (Kang & Kang, 2020; Simmons, 2010) and learning satisfaction (Turrise et al., 2020). Especially, the current nursing environment for infectious diseases is a special circumstance that is irreplaceable by any situation.

Virtual reality allows students to experience this special medical circumstance indirectly and allows for repeated exposure to the situation. Therefore, it reduces anxiety and stress about work that students will experience in the future and improves the coping ability for such situations (Morin, 2020). With the current pandemic of COVID-19, the Nursing Education Association of the USA has emphasized the importance of nursing education in infectious diseases (Swift et al., 2020). Many universities switched their classes to VR simulation, and the government is operating a VR simulation program to cope with the crisis situation related to public health (Walia et al., 2017). To date, for nursing students in Korea, education on infectious diseases is mostly composed of theoretical classes called “Infection control” and research on simulation classes about infectious diseases is limited (Jeong, 2018). To improve the initial nursing competence of students for the patients with infectious diseases, it is necessary to provide clinical education by VR in this pandemic era. The purposes of this study were to improve nursing students' competence in providing initial nursing care for the patients with infectious diseases by developing the VR simulation program on the COVID-19 scenario and assessing the effectiveness of the program. In this study, we tested the effects of the VR program on knowledge, self-efficacy, clinical reasoning capacity and learning satisfaction.

2 | METHOD

2.1 | Research design

This is a quasi-experimental study using a non-equivalent control group pre-test–posttest design to develop and assess the effectiveness of the VR simulation program for patients with respiratory infectious diseases based on a COVID-19 scenario for fourth-year students in nursing college and to assess knowledge about infectious respiratory diseases, self-efficacy, clinical reasoning capacity and learning satisfaction of them.

2.2 | Research participants

Participants in this study were fourth-year nursing students in two universities in Seoul, Korea. They were students who understood the purpose of this study and agreed to voluntarily participate through the participant recruitment announcement, and who also had no experience in taking education related to nursing for COVID-19 suspected or confirmed patients. The sample size was calculated using the G*Power 3.1.9.2 program (Faul et al., 2007). Based on the effect size of 0.75 of clinical reasoning capacity from the simulation research for nursing students (Kim & Kim, 2015), this research required a minimum of 60 samples total (minimum of 30 in each group) to maintain a significance level of 0.05, the effect size of 0.75 and power of 80.0%. Each group comprised 33 samples considering a dropout rate of 10.0%. During the study period, a student refused to participate in the study, saying that he was reluctant to

have face-to-face access because of covid-19, although there was one-on-one contact and no group meeting. There were 65 participants in the final study, 32 in the experimental group and 33 in the control group (Figure 1).

2.3 | Measurements

2.3.1 | Knowledge

The knowledge related to respiratory infectious diseases was evaluated by 10 questions developed by researchers, based on the "Guidelines for Coronavirus Infectious Disease-19 Response," "Coronavirus Infectious Disease-19 Response Procedures, Nationally Designated Inpatient Treatment Beds and Hospital-level Medical Institutions" distributed by the Korea Centers for Disease Control and Prevention and the COVID-19 data from WHO. Each correct answer was scored 1 and each incorrect answer or "don't know" answer scored 0. Total scores range from 0–10. The higher scores indicate better knowledge of respiratory infectious diseases. The Kuder–Richardson formula 20 (KR-20) in this study was 0.60.

2.3.2 | Self-efficacy

Self-efficacy for nursing care of respiratory infectious diseases was evaluated using five items with a 5-point Likert scale developed by Kim et al. (2014) after modification. Total scores range from 5–25 points. A higher score indicates a higher level of self-efficacy in nursing care of the patients with infectious diseases. Cronbach's alpha of this study was 0.77, whereas the reported Cronbach's alpha by Kim et al. (2014) was 0.79.

2.3.3 | Clinical reasoning capacity

Clinical reasoning capability was measured using 15 questions (5-point scale) developed by Liou et al. (2016). We used the Korean

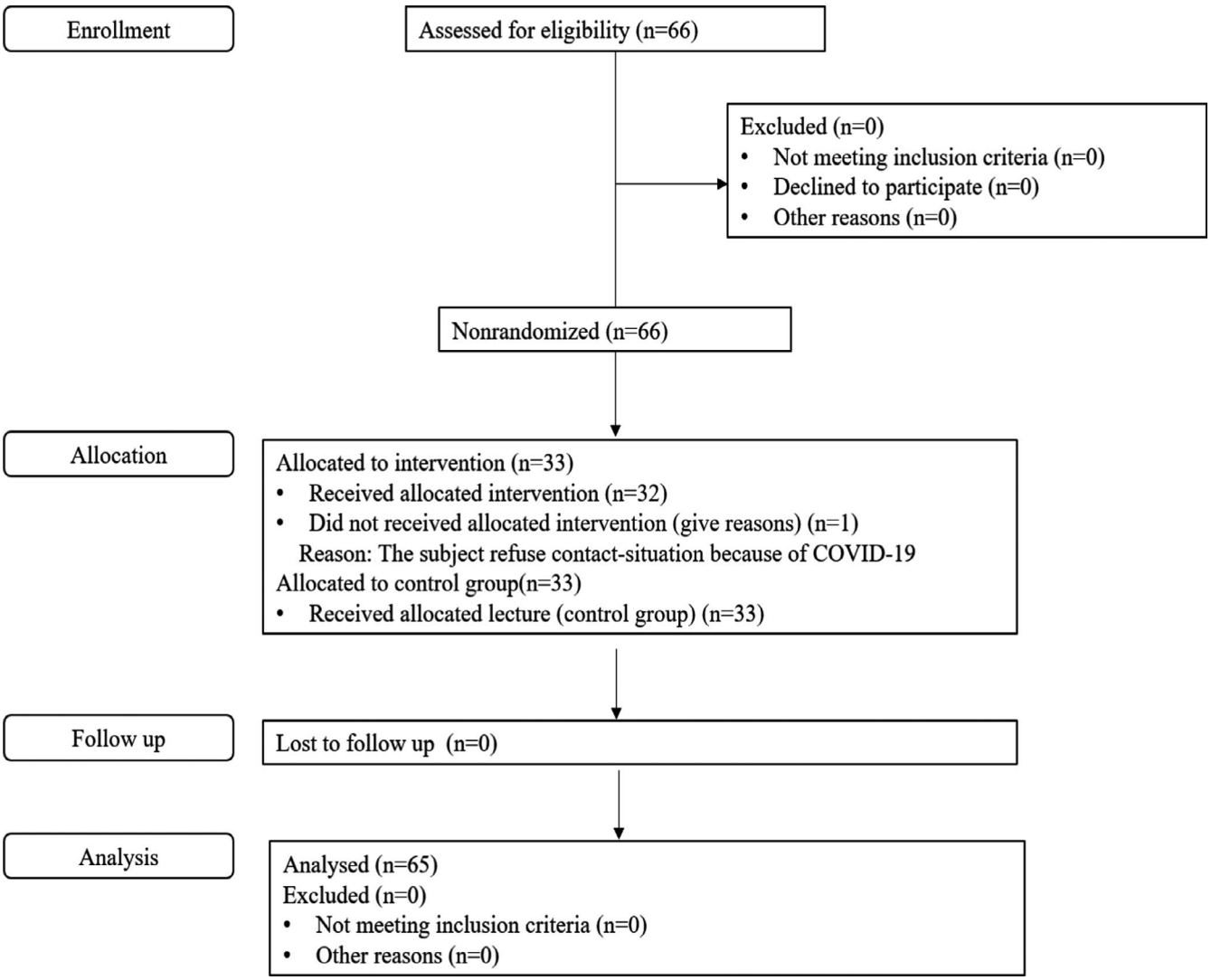


FIGURE 1 Research subjects

version, which was validated by psychometric tests by Jung and Han (2017). A higher score indicates a higher level of clinical reasoning capacity. Cronbach's alpha of this study was 0.93, whereas the reported Cronbach's alpha by Jung and Han (2017) and Liou et al. (2016) was 0.94 and 0.93, respectively.

2.3.4 | Learning satisfaction

Learning satisfaction was measured using a numerical rating scale. It comprises 10 points for "very satisfied" and 0 points for "very unsatisfied," meaning a higher score indicates a higher level of satisfaction.

2.4 | Procedures

The process of program development and research procedure is detailed below.

2.4.1 | Program development

The program development of this study was executed in five stages based on the Analysis, Design, Development, Implementation and Evaluation (ADDIE) model, which is applied to developing teaching and learning methods (Molenda et al., 1996; Figure 2).

2.5 | Analysis steps

The analysis step was to acquire basic data necessary to develop VR simulation scenarios and educational programs. It comprised a literature review of VR simulation related to infectious diseases and a survey of the educational requirements of clinical nurses, nursing professors and nursing students. Nine databases were used for literature review as following: global databases, including PubMed, Scopus, ProQuest, Google Scholar and Cumulative Index to Nursing and Allied Health Literature and Korean databases, including DBpia, Korean Studies Information Service System, National Assembly Library and Korea Education and Research Information Service. A total of 46 studies from nine databases were reviewed. Five studies that did not include infectious diseases contents, five studies without simulation program application, 24 studies without intervention and six duplicated studies were excluded, and the final six studies were included. The final six studies selected for this research were two studies on Ebola and three studies on severe acute respiratory syndrome, middle east respiratory syndrome (MERS) and COVID-19. From the composition of the program from six studies, it was confirmed that prerequisite learning on disease and management was performed before simulation education was provided. The common content of all programs was wearing and changing PPE. According to a systematic review on VR simulation program to medical staff education (Liaw et al., 2018), the length of simulation program varied from 10 min–2 hr.

To assess educational needs, interviews were conducted from students and experts in nursing and education. Interviews had been conducted to tow nurses and specialist who looked after severely ill patients diagnosed with COVID-19 in the medical field from September 8 to September 9, 2020, one nursing professor who had been operating simulation lectures and two fourth-year nursing students who experienced the simulation education. The results of the interviews suggested that it was necessary to include instruction for PPE and the sample collection and management process as basic contents for nursing students.

2.6 | Program design

In the program design step, the learning aims of the program were set based on the results from the analysis step, and the research design and program operation method were determined to achieve these aims. The program of this study was developed focusing on the nursing role in a screening clinic based on the COVID-19 scenario. The scenario reflected the common contents extracted by literature review and interviews, which included how to wear the PPE, a nursing interview and sample collection and packaging. The VR simulation education in this research adopted the protocol of a simulation study for the patients with respiratory infections (Kim & Song, 2019) consisting of three steps, including prerequisite learning, VR simulation education program drive and debriefing for 85 min.

2.7 | Program contents development step

The contents for a prerequisite learning video, VR program and debriefing were developed at this stage (Table 1). The prerequisite learning video was developed to instruct relevant knowledge before performing the VR simulation. It comprised the basic elements of the management of patients with confirmed COVID-19, application of PPE and management of subject samples. To develop a VR program, algorithms and scenarios were prepared for nursing care (wearing PPE, nursing assessment interviews and sample collection and packaging) when a patient suspected of having a respiratory infectious disease, which was COVID-19 in this scenario, visited a screening clinic. Debriefing consisted of a reflection on what they learned and felt throughout the simulation by open discussion.

To evaluate the validity of the study, experts reviewed contents of the prerequisite learning, the composition of the VR simulation algorithm and scenario and application of the program using a content validity index (CVI). The experts consisted of an emergency medicine specialist in charge of patients with COVID-19, two nurses who had experiences in caring for patients with COVID-19 and two professors who had experience in VR programs. The final CVI ranged from 0.8–1.0. Based on the VR program experts' opinion that long-term use of a headset might cause tiredness or dizziness, VR duration was limited to

Analysis

- Literature review: VR simulation education program of infectious diseases
- Confirmation of education needs: Nurses, nursing professors, and nursing students

Design

- Establish the goals and purposes of the program
- Develop contents and format of the preliminary program
- Plan research study testing the effects of the program

Development

- Develop detailed contents and teaching strategies
- - Teaching plan, exercise scenarios
- - Instructional materials
- Evaluate the preliminary program
- - Expert review and validity evaluation
- - Pilot test and modification of the program

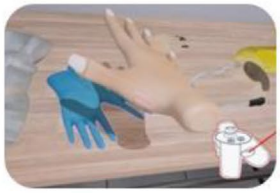
Implementation

Prerequisite learning (40min)

Orientation (5min)

VR simulation education program (15min)

Wear of VR equipment



Putting on PPE

Nursing assessment

Management of collected samples

Taking off PPE

Debriefing (20min)

Evaluation

- Evaluate the effects of VR simulation program
  - Knowledge (Pre and post measurement)
  - Self-efficacy(Pre and post measurement)
  - Clinical reasoning capacity(Pre and post measurement)
  - Education satisfaction (post measurement)

FIGURE 2 Program development

TABLE 1 Contents of the Final Program

Category	Content	
Prerequisite learning	Introduction	Learning objectives Explanation of learning contents
	Progression	1. Management of COVID−19 1) Definition of COVID 19 2) Epidemiological characteristics and symptoms 3) Transmission route 4) Prevention 5) Standard precaution 6) Infection Control (Contact, droplet, airborne precaution) 2. Personal protective equipment (PPE) application 1) Structure of the isolation room 2) Movement of medical staff in the isolation room 3) Types of PPE 4) Putting on/taking off PPE (LEVEL D) 5) Putting on PPE 6) Taking off PPE 3. Management of COVID 19 specimen 1) Examination method 2) Sample packaging method
	Termination	Quiz
VR simulation program	1. Orientation 1) Explain the use of VR equipment 2) Explain what to do when side effects occur during practice 2. Practice 1) Putting on PPE 2) Admission to the COVID 19 screening clinic 3) Nursing assessment to patient 4) Management of collected samples 5) Taking of PPE	
Debriefing	Proceed to the stages of scenario situation description–analysis–application	

15 min. To assess feasibility of the study, pilot tests were performed on a clinical nurse who has experience in nursing patients with COVID-19 and a student who did not participate in this research, before initiating the program to the research participants. The program was revised and finalized by reflecting opinions from the pilot test.

2.8 | Execution step

To improve the research fidelity, researchers ran the program simulations three times with two assistant researchers. The VR simulation program developed in this research was performed on the participants after pre-test.

2.9 | Program evaluation step

The developed program was applied from December 16, 2020, to January 25, 2021. Study participants were recruited using electronic flyers, web pages and social network media in two nursing colleges in Seoul from December 16, 2020, to January 25, 2021. Bulletin boards were not used because classes had changed from offline to online during the study period. The participants who were interested were provided with contact information of researchers so that they could contact researchers by themselves. There were no disadvantages regardless of participation. The detailed process is as follows.

2.9.1 | Pre-test

Before the VR program and lectures, the experimental group and the control group were tested on their knowledge related to respiratory infectious diseases, self-efficacy, clinical reasoning capacity and their level of learning satisfaction.

2.9.2 | Experimental intervention

The same preliminary prerequisite learning program was provided to the control and the experimental group. To provide the same contents to the control and the experimental group, the pre-recorded video about wearing PPE, nursing interviews and sample collection and packaging process was played. The lectures were delivered using the Zoom program (ZOOM Video Communications, Inc) to the

control group for reducing the risk of spreading infectious diseases by gatherings.

To prevent the diffusion of intervention, the experimental intervention was provided to the experimental group after completion of the control group study. A trained research assistant provided an orientation to the participants about the VR program and equipment. The final VR simulation education program was applied to the experimental group (Figure 2) using Oculus Quest 2 (®Oculus) headset.

In consideration of ethical issues, after the experiments, the VR simulation education program was provided to whoever wants face-to-face interviews among the control group, considering social distance policy because of COVID-19. All interventions were conducted in compliance with the quarantine regulations.

2.9.3 | Posttest

After the VR program and lectures, the experimental group and the control group were tested on their knowledge related to respiratory infectious diseases, self-efficacy, clinical reasoning capacity and the level of learning satisfaction.

2.10 | Data analysis

IBM SPSS Statistics Version 22.0 (IBM) was used for data analysis. Data were summarized using means, standard deviations, frequency and percentage. Homogeneity of the experimental and control groups was tested using Chi-squared test and Fisher's exact test. Before running a *t* test, a normality test was performed using skewness, kurtosis and Shapiro–Wilk test. Because the normality assumption was met, parametric tests were used in the analysis. Paired *t* tests were used to analyze changes of the dependent variables before and after application of the program. Independent *t* tests were used to test differences between the experimental and control groups.

2.11 | Ethical considerations

This study was conducted after approval by the Institutional Review Board (KHSIRB-20–291–1[RA]). All participants were informed of the purpose of study. They were also informed that their responses would be used for research purposes only. Participants were given the options to discontinue or withdraw from the study at any time. The signed consent form was obtained from the participants after the full explanation was given.

3 | RESULTS

A total of 65 students participated in the study, 33 (50.8%) in the control group and 32 (49.2%) in the experimental group. There were 11 males (16.9%) and 54 females (83.1%). Twenty-five participants had religion (38.5%), whereas 40 participants did not have religion (61.5%). The grade point average of last semester was 16 students (24.6%) under 3.5, 30 students (46.2%) between 3.5–3.9 and 19 students (29.2%) above 4.0. Forty-four participants (67.7%) answered that they were satisfied with clinical practice, whereas 21 participants (32.4%) were unsatisfied. Fifty-one participants (78.5%) were satisfied with their major participants, whereas 14 participants

TABLE 2 Homogeneity Test of General Characteristics of Subjects

Variables	Category	Control ($N = 33$) N (%)	Intervention ($N = 32$) N (%)	χ^2/t	p
Gender	Male	3 (9.1)	8 (25.0)	2.93	.108[a]
	Female	30 (90.9)	24 (75.0)		
Religion	Yes	9 (27.3)	16 (50.0)	3.55	.060
	No	24 (72.7)	16 (50.0)		
Grade point average (a 5.0 scale)	<3.5	7 (21.2)	9 (28.1)	0.71	.702
	3.5–3.9	15 (45.5)	15 (46.9)		
	≥4.0	11 (33.3)	8 (25.0)		
Satisfaction with clinical practice	Satisfaction	22 (66.7)	22 (68.8)	0.032	.857
	Dissatisfaction	11 (33.3)	10 (15.4)		
Satisfaction with the major subject	Satisfaction	27 (81.8)	24 (75.0)	0.45	.504
	Dissatisfaction	6 (18.2)	8 (25.0)		
Satisfaction with their college	Satisfaction	25 (75.8)	23 (71.9)	0.13	.772
	Dissatisfaction	8 (24.2)	9 (28.1)		
Satisfaction with simulation practice	Satisfaction	30 (90.9)	31 (96.9)	1.00	.613[a]
	Dissatisfaction	3 (9.1)	1 (3.1)		

[a]Fisher's exact test.

TABLE 3 Effects on Virtual Simulation Program

Variables	Group	Pre-test $M \pm SD$	Posttest $M \pm SD$	t (p)	Mean differences (post–pre) t (p)
Knowledge	Control	7.09 ± 0.98	7.36 ± 1.14	2.28 (.029)	0.47 (.643)
	Experimental	6.93 ± 1.24	7.62 ± 1.09	3.67 (.001)	
Self-efficacy	Control	3.54 ± 0.59	4.26 ± 0.40	6.77 (<.001)	0.70 (.944)
	Experimental	3.60 ± 0.55	4.32 ± 0.49	7.96 (<.001)	
Clinical reasoning capacity	Control	3.06 ± 0.55	3.93 ± 0.47	7.59 (<.001)	0.27 (.788)
	Experimental	3.17 ± 0.68	4.08 ± 0.58	8.81 (<.001)	
Satisfaction of education	Control	–	8.24 ± 1.48	3.01 (.004)	–
	Experimental		9.12 ± 0.99		

Abbreviatios: M, Mean; *SD*, Standard deviation.

(21.5%) were not satisfied. Forty-eight participants (73.8%) were satisfied with their college, whereas 17 participants (26.2%) were unsatisfied. Regarding the simulation practice course, 61 participants (93.8%) were satisfied, whereas four participants (6.2%) were unsatisfied. Table 2 shows the frequency and percentage of each variable for each group. Homogeneity tests showed that there was no statistically significant difference in knowledge ($t = 1.44$, $p = .155$), self-efficacy ($t = -0.38$, $p = .704$) and clinical reasoning ability ($t = -0.72$, $p = .476$) between the experimental group and the control group.

There was no statistically significant difference in knowledge on respiratory infectious diseases between the groups ($t = 0.47$, $p = .643$), whereas there were statistically significant differences between pre- and posttest in both the experimental group with VR simulation ($t = 3.67$, $p = .001$) and the control group ($t = 2.28$, $p = .029$). There was no statistically significant difference in self-efficacy for nursing care of patients with respiratory infectious diseases between groups ($t = 0.70$, $p = .944$), whereas there were statistically significant differences between pre- and posttest in both the experimental group ($t = 7.96$, $p < .001$) and the control group ($t = 6.77$, $p < .001$). The experimental group did not show a statistically significant change in clinical reasoning capacity compared with the control group as well ($t = 0.27$, $p = .778$), whereas there were statistically significant differences between pre- and posttest. However, there was a statistically significant difference between the experimental and control groups in learning satisfaction (mean ± SD = 9.12 ± 0.99 and 8.24 ± 1.48, respectively; $p = .004$; Table 3).

4 | DISCUSSION

In this study, we developed a VR simulation program with COVID-19 scenario for nursing students and examined the effects of the program on knowledge, self-efficacy, clinical reasoning capability in nursing care and learning satisfaction. The final education program with VR simulation was developed by the ADDIE model, and it was applied to the experimental group. The experimental group did show a higher level of knowledge related to respiratory infectious diseases compared with the control group who received lectures only. This result is contrary to the previous research (Kim & Kim, 2015), which reported statistically significant differences between the experimental and control groups about gastrointestinal bleeding–related knowledge after simulation training from 94 nursing students in Korea. Moreover, it is not consistent with the meta-analysis research using VR nursing education intervention (Chen et al., 2020), which reported that VR education effectively improves knowledge compared with the control group. In this research, knowledge was improved after simulation in both the control and experimental groups. In the last year, medical information about COVID-19 was continuously provided through various media. Furthermore, at the time of the research, most students were pre-employed; therefore, it is considered that participants were highly interested in COVID-19 and acquired related knowledge. Moreover, the same information on wearing PPE and processing samples was provided to both groups with the same methods in the prerequisite learning lecture. Therefore, it is suggestive that the contents in the prerequisite learning session provided adequate information to improve knowledge in both groups.

In this study, there was no statistically significant difference in self-efficacy in nursing care for respiratory infectious disease. The results are consistent with the study by Padilha et al. (2018) that reported no statistically significant differences in self-efficacy of Portuguese nursing students after VR simulation training. However, it is inconsistent with a meta-analysis study that reported simulation-based training improved self-efficacy compared with the conventional didactic lecture (Franklin & Lee, 2014). According to Bandura (2012), self-efficacy theory states that the perception of self-efficacy occurs in the interaction of different variables over time. In this study, because of COVID-19 and social distancing policy, the participants in the experimental group experienced the VR simulation only once. In addition, the posttest was done immediately after the simulation. Thus, there was a possibility that there was not enough time to improve self-efficacy for the participants. Although there was variability in effects of simulation on self-efficacy, many studies reported that simulation education (Adamson, 2012; Andrighetti et al., 2012; White et al., 2013) and VR simulation (Verkuyl et al., 2017) improved self-efficacy.

Therefore, in the future, it is necessary to allow students to experience the VR simulation repeatedly rather than one time and to examine the effect.

There was no significant difference in clinical reasoning capacity in nursing care for respiratory infectious disease. The results are consistent with the study of Kang and Kang (2020). However, there was no statistically significant differences between two groups in this study. Turrise et al. (2020) reported that students with virtual simulation program did not significantly differ from the control group in terms of critical thinking. It is considered that the results of Turrise et al.'s study are consistent with this study. Turrise et al. (2020) measured critical thinking, not clinical reasoning, but critical thinking and clinical reasoning are comparable concepts (Victor-Chmil, 2013). In contrast to our study, Hu et al. (2021) reported that clinical reasoning capacity improved after a simulation-based education. They adopted a group debriefing method and measured clinical reasoning capacity 2 weeks after simulation. In both this study and Turrise et al.'s study, clinical reasoning or critical thinking was measured immediately after the VR simulation. To examine the effects of VR simulation on clinical reasoning, it is suggestive that further studies are needed.

The experimental group was significantly satisfied with their education compared with the control group in this study. Because there was an association between satisfaction and motivation (Goulimaris, 2015), an increase in learning satisfaction may motivate students' ongoing learning. Therefore, VR simulation education would be more effective if it provides a variety of scenarios and provides opportunities for repeated learning.

There are various simulation educations in nursing, and equivalent or higher learning outcomes compared with traditional methods have been reported (Padilha et al., 2018; Sherwood & Francis, 2018). Although the effectiveness has been known, high-fidelity human patient simulators (HPSs) are expensive and require space with fully equipped devices and materials and trained operating personnel (Shorey & Ng, 2021). VR simulation is less expensive and requires less additional cost than HPS (Farra et al., 2019). Therefore, it is suggested to consider VR as an option when planning simulation education for nursing students or nurses.

There are some limitations in this study. To develop and implement a COVID-19-related scenario in a timely manner, we could not apply a randomized controlled research design. Despite this limitation, general characteristics and pre-test values of study variables were homogenous. As previously described, another limitation is that VR simulation was not repeated, and posttest was done immediately after one-time simulation education. These may influence non-significant differences on self-efficacy and clinical reasoning between groups in this study. In addition, the participants in this study were from two universities only. Although it reflects the gender ratio of nursing students in Korea, the proportion of male students among the total participants was low. Further studies are needed at a time when social distancing is eased.

Despite these limitations, our study has strengths. We developed a VR simulation program based on the COVID-19 scenario through a systematic literature review and need assessments from experts and students. The VR simulation developed in this program is an innovative method and is timely and relevant in this pandemic era. However, the effects of the VR simulation program need further investigation to determine a definite conclusion.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors developed a hypothesis, searched the literature, reviewed the relevant articles, analyzed the data, interpreted the findings, and wrote a manuscript. All authors have read and approved the manuscript.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

This study was conducted after deliberation by the institutional bioethics committee to which the researcher belongs (KHSIRB-20–291–1[RA]).

DATA AVAILABILITY STATEMENT

The data sets used for the current study are available from the corresponding author on reasonable request.

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