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Major Article

The effectiveness of serious games designed for infection prevention and promotion of safe behaviors of senior nursing students during the COVID-19 pandemic

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Key Words:

Serious game
Nursing student
Education
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Background: Reminding health care workers, especially senior students, of the critical role they play in preventing COVID-19 transmission is more important than ever, therefore it is vital to reinforce graduate students' intrinsic motivation to implement infection prevention and control guidelines. Serious games are an interesting intervention that could improve adherence to COVID-19 safe behaviors to lower the high prevalence of nosocomial infections. These games, as a type of technology-enhanced simulation, can increase student satisfaction and engagement while still conveying vital ideas. For this reason, this study aimed to develop a serious game and evaluate its effectiveness to prevent the spread of infection and develop safe behaviors during the COVID-19 pandemic.

Methods: In total, 62 nursing students completed a socio-demographic questionnaire, COVID-19 information form, and game usability form, with the students' responses analyzed pre-test and post-test.

Results: Serious game implementation significantly increased senior students' knowledge of infection and safe behaviors concerning COVID-19. The students also considered the practice of serious games an effective teaching strategy. Favorite aspects of the serious game according to students' statements; It was reported as reflecting the real hospital environment, including the nursing care process and roles, being informative, being compatible by phone, and each stage of the game tested a new knowledge.

Conclusion: Employing serious games for nursing skills development is an appropriate teaching method for infection prevention and promotion of safe behaviors among senior nursing students during the COVID-19 pandemic. This game can be obtained free of charge for research and educational purposes.

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BACKGROUND

The COVID-19 pandemic has been problematic for the implementation of traditional nursing education with a rapid transition to distance learning. However, distance learning is difficult for nursing educators as they must provide students with clinical skills, teach bedside nursing, and be involved in the nursing care and treatment

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process. Since nursing education could not perform clinical applications for gaining clinical and psychomotor skills, students' experiences were negatively affected, thus alternative learning methods were applied to maintain the quality of education during the pandemic. The most preferred approaches adopted were simulation and game applications (Dewart et al., 2020).^{1,2}

In this challenging period, games developed with e-learning tools create a safe, stimulating, and experiential learning environment to prepare students for the clinical setting.^{3–5} The games allow students to have realistic, immersive experiences that can be used anywhere and at any time for learning or skill development. Providing students with feedback in the game enables them to make sense of earlier decisions, encouraging deeper reflection and active learning in later games with a fixed cycle of decision making.^{2,6,7}

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Using games as a teaching strategy can be very useful in creating an essentially motivational learning environment, allowing students to be challenged, curious, and develop a sense of control, thus, increasing the student's interest in learning and motivating them by revealing individual characteristics^{8,9} state that "Serious Games (SGs) can do more than entertain; they can provide deep, epistemic learning that traditional education techniques may lack" and drew attention to the use of SGs in education.⁹ Furthermore, games facilitate the learning experience and make it unique to the individual by providing a learning tool that they can use whenever they want.¹⁰ Learning by providing a realistic environment can go beyond simple knowledge acquisition to develop the skills necessary to recognize, analyze, select and apply knowledge of different clinical situations. This complex learning focuses on problem-solving and critical reasoning^{11–13} reported that SGs were efficient to encourage and promote COVID-19 infection prevention and control in hospital staff, with Hu et al. showing that the SGs was an effective tool to increase medical students' knowledge about COVID-19.^{13,14}

In this context, the acquisition of knowledge and skills of students about COVID-19 increases with interaction, further increasing with game mechanics.^{15,16} Moreover, insufficient information on COVID-19 management adversely affects the willingness among senior nursing students to participate in internships at contagious disease departments.^{17,18} Consequently, the development of an e-learning tool, such as a SGs, could support nursing students in the pandemic. SGs were the preferred approach in this study to create a realistic alternative learning environment as they differ from simulation applications because they can be played repeatedly without time restrictions, are easily accessible, and are both entertaining and instructive.^{2,19}

We developed a game to enhance senior nursing students' knowledge of coronavirus and the processes needed to care for COVID-19 patients.

METHODS

The study utilized a non-randomized allocated pretest and a post-test with a quasi-experimental design. The study was conducted in cooperation with The Faculty of Nursing, the Department of Internal Medicine, Hacettepe University, and The Department of Nursing, Yıldırım Beyazıt University. The sample group comprised senior nursing students of Yıldırım Beyazıt University.

Participants

The study participants were recruited by a purposive sampling method. Senior nursing students (1) gave written consent to the volunteering form prepared by the authors (2) were included in the study. The study sample consisted of 63 senior nursing students, with one student excluded because they had problems with internet access (n = 1).

Training

The training was given in compliance with the COVID-19 pandemic precautions set by the Ministry of Health, Turkey.²⁰ The training content comprised: Theoretical knowledge of coronavirus, Quarantine and isolation times, General measures in the hospital (services, intensive care units, cafeteria), Health checks of health workers, Sequence for putting on and taking off personal protective equipment (PPE), and PPE knowledge. Students were asked the order in which they would don (put on) and doff (remove) PPE equipment, with the correct order for donning and doffing defined per the Ministry of Health guidelines as follows: (1) put on gown, (3) put on mask or N95 respirator, (4) put on eye protection, and (5) put on gloves;

(1) remove gloves, (2) remove eye protection, (3) remove gown, (4) remove mask or N95 respirator.²⁰

Theoretical background of SGs

A literature review of COVID-19, gamification, SGs, mobile apps, and e-learning was conducted, only using information and recommendations concerning COVID-19 from the WHO website (WHO, 2021). In addition, periodic queries were conducted on the websites of WHO and the Turkish Ministry of Health to obtain updates on recommendations and guidelines for action. A team of specialists including nurses, professors, senior nursing students, graduate nursing students, reviewed and validated all content used in the SGs.

Learning objectives of the SGs

The learning content was grouped into 4 topics as follows: virus incubation time, symptoms: cough, fever, loss of smell and taste, donning and removing PPE, and quarantine/isolation periods.

Learning and game mechanics

The Learning Mechanics-Game Mechanics (LM-GM) model proposed by Arnab²¹ was used in this study. In this model, the learning mechanics are determined according to the learning objectives, then transformed into game mechanics to achieve the intended goal.²¹ The scientific foundations for the module were first translated into learning mechanics and then, when appropriate, into game mechanics.

SGs development

The storyboard was prepared after the learning objectives were determined under the following titles: screen time, sample screen, learning outcomes, and animation, then applied to the Articulate program. In line with the theoretical basis, the game was tested on various platforms such as smartphones, tablets, laptops, and desktop computers by different users at the end of each development loop and before its final release. Five senior nursing students from different universities tested the SGs, providing feedback regarding the game music, multiple attempts, and using different game mechanics. The game was revised according to the feedback and can be accessed through the following link: https://storage.googleapis.com/covidgame/COVID_Game/story.html.

Photos of the game are given below:

The game sequence was as follows: Login screen, Choose avatar screen, Game progress screen, Wear PPE screen, COVID-19 symptoms selection screen, Quarantine period screen, Flowchart showing data collection procedure (Figs 1-7).

Data collection

The data were collected through distance education methods from the senior nursing students between the March 24 and the May 26, 2021. One week of Infection and Safe Behaviors training was provided to the students after the pre-test. The training content was prepared and approved by all researchers, with one researcher providing the training to the students. The training consisted of one online session which lasted 40 minutes. The SGs was played after the training, with the students given unlimited access to the game for a week. A post-test was administered to the students one week later.



Fig 1. Login screen.



Fig 2. Choose avatar screen.



Fig 3. Game progress screen.

Data collection instruments

The pre-test collected information regarding the sociodemographic characteristics of the participants (9 questions) and their knowledge of the pandemic (10 questions). The knowledge questions consisted of true, false and I do not know options, with 5 correct and 5 wrong answers (Table 3). The validity of these items was

established by a panel of experts including an infectious disease specialist, 2 expert internal medicine specialists, 2 master's nursing students, and 3 senior nursing students. A correct answer was assigned 1 point and an incorrect answer or 'I don't know' was assigned 0 points. The post-test collected information about their pandemic knowledge and user experience comprising a 6-item open-ended questionnaire designed to measure the usability of the game.



Fig 4. Wear PPE screen.

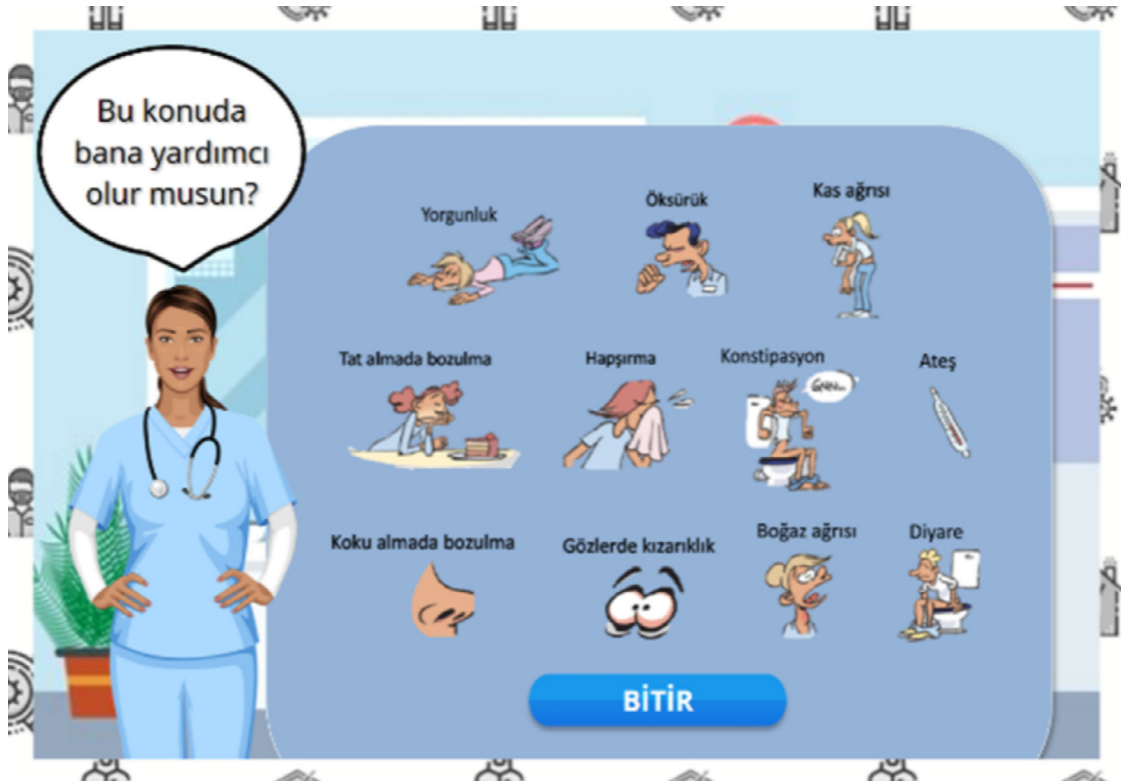


Fig 5. COVID-19 symptoms selection screen.

Data analysis

Data analysis was performed using IBM SPSS Statistics software (version 26.0), with demographic data described using frequency and

percentage for categorical variables, mean (M), and standard deviation (SD) for continuous variables. Significant differences between the 2 groups at baseline were compared using an independent t-test or chi-square test. Pearson's correlation coefficients were used to

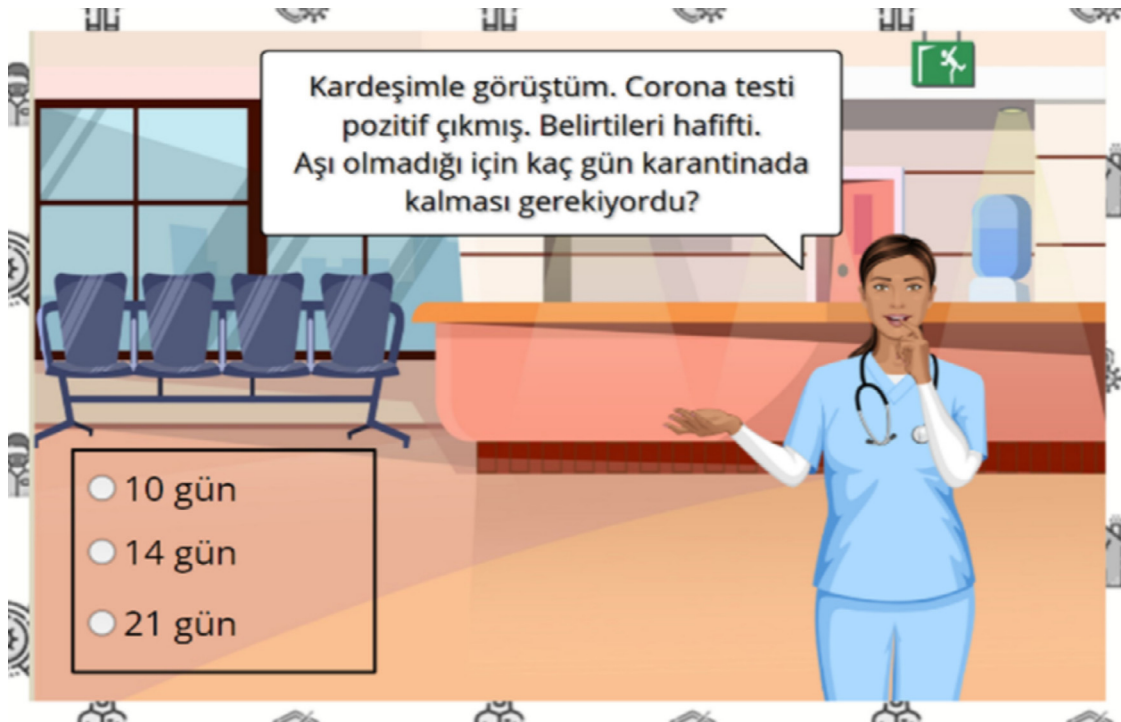


Fig 6. Quarantine period screen.

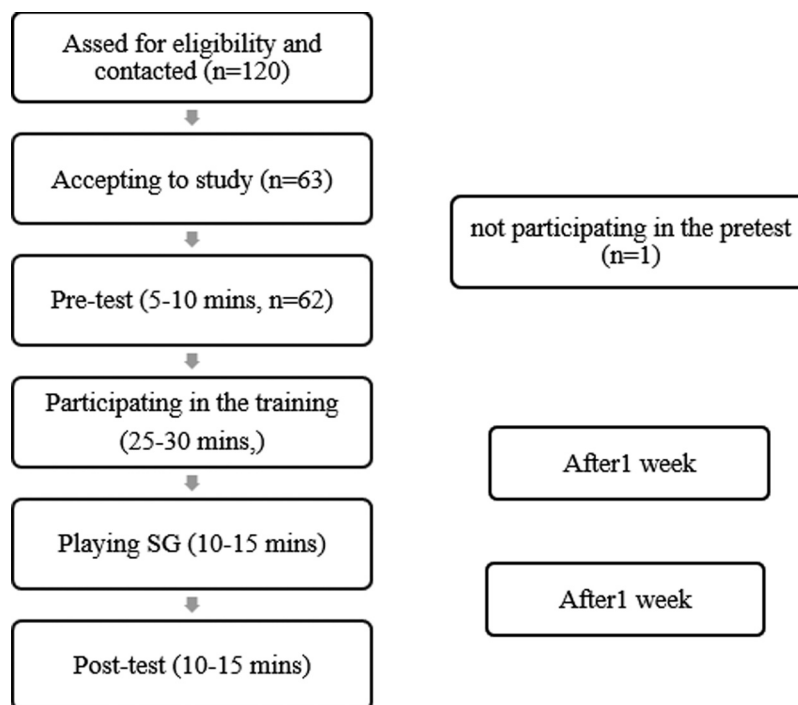


Fig 7. Flowchart showing data collection procedure.

analyze the associations between the primary outcome variables at baseline. These tests assumed normality of standardized residuals that fail to hold in about half of the comparisons according to Kolmogorov-Smirnov and Shapiro-Wilk tests. The P-values for efficacy tests were set at $P \leq .005$ to adjust for multiple tests.

The responses to the 6 open-ended questions were analyzed by comparing the meaning of answers' similarities and differences and identifying repetitive answers. Answering the open-ended questions was voluntary, thus some students did not respond to all open-ended questions.

Table 1
Sociodemographic characteristics of the participants

Variable	Responses	N Frequency (n and %)
Gender	Female	57 (%91.9)
	Male	5 (%8.1)
Age	21 years	9 (%14.5)
	22 years	34 (%54.8)
	23 years	17 (%27.4)
	24 years	2 (%3.2)
Living place	Village	6 (%9.7)
	Town	18 (%29.0)
	Centre	38 (%61.3)
Getting an education	Yes	21 (%33.9)
	No	41 (%66.1)
COVID diagnosis	Yes	9 (%14.5)
	No	53 (%85.5)
Same home live	Yes	23 (%37.1)
	No	39 (%62.9)
Getting information	Social media	24 (%38.7)
	Official website	35 (%56.5)
	Health professionals	3 (%4.8)
Entering crowded environments	Yes	56 (%90.3)
	No	6 (%9.7)
Fear of death	Yes	24 (%38.7)
	No	38 (%61.3)
Total	N	62 (%100.0)

Ethical approval

This study was approved by the Ethics Committee of the related university and all participants provided written informed consent.

RESULTS

Most respondents ($n = 57$; 91.9%) were female with a mean age of 22.19 years and did not receive infection prevention and safe behaviors training but were informed by information obtained from official websites (Table 1).

There was a significant relationship between the total mean scores of the pretest and posttest ($r = 0.061$, $P = .001$). The PPE donning sequence initially displayed in the survey increased by 29.5% of the participants but this did not reach significance. There was a significant difference in the responses regarding the isolation times of the patients with a diagnosis of COVID-19 who had mild symptoms, had no symptoms during the quarantine period, and their PCR tests were negative and the patients who had not any symptoms ($P < .00$) (Table 2).

Table 2
Pretest and posttest score comparison of questions

Pretest-posttest questions	Mean± SD	T	P
1. Isolation time	-0.19± 0.47	-3.21	<.001*
2. Hospitalization indications	-0.06±0.48	-1.07	.28
3. Mask usage rules	-0.04±0.38	-1.00	.32
4. In-hospital pandemic rules	-0.01± 0.28	-0.44	.65
5. Quarantine period	-0.29±0.52	-4.35	<.001*
6. Interpreting the PCR test	-0.17±0.46	-3.02	<.001*
7. PPE dressing order	-0.14±0.47	-2.41	.01
8. COVID-19 symptoms	-0.01±0.12	-1.00	.32
9. Hand hygiene	-0.03±0.17	-1.42	.15
10. Social Distance	-0.11±0.44	-1.98	.05

* $P < 0.005$

Table 3
User experience open-ended questions

What was your favorite aspect of the game? (n = 58)
Everything was fine. The game evoked real hospital environment. The game created an opportunity for us to practice the nursing process. The game was informative. The game app was compatible with the phone. The game included nursing roles. It was nice to be given a right, for every mistake made during the game. I liked the content of the game It was nice that each stage of the game tested a new knowledge. Every information tried to be given in the game was quite clear. The game was trying to teach by entertaining. The game was easy to play and the image quality was good. The game was easy to play and the graphics were good. Having a reward at the end of the game increased our desire to play.
What aspect of the game did you dislike the most? (n = 58)
Sometimes the game was frozen or stopped responding because of a temporary issue. The game was easy. The game was short. The game could only be played with one person. The game characters were difficult to manage. The number of questions asked during the game was few. The answers to the questions asked during the game were not shown. Not enough hints were given during the game.
Was the website easy to use? (n = 58)
The game was easy to use. The game was somewhat easy to use. The game was easy to use but the transition speed between game sections was slow. Playing the game on the phone was a bit difficult.
Would you suggest any changes to improve the game? (n = 58)n
The game can be extended by adding new stages. At each step of the game, more information about nursing approaches can be added. After each question asked during the game, the answer can be displayed. The game should be playable with the keyboard other than the mouse. The infrastructure of the game should be strengthened. Games that teach nursing approaches in different subjects should be developed. I do not recommend any changes
Would you recommend the game to others? (n = 58)
Yes (n = 55) No (n = 3)
Do you have any additional comments? (n = 44)
It is a successful study and I think it has benefited me. It was a very nice and teachable game. It was a different work. Thanks a lot.

Most of the students answered open-ended questions with [Table 3](#) providing the most frequently given answers.

DISCUSSION

This study assessed the effectiveness of a SGs developed to improve the knowledge of senior nursing students regarding COVID-19 infection prevention and safe behaviors.

The increase in the PPE knowledge level score between the pre-test and post-test was not significant but the game influenced this increase. Playing the game allowed students to feel more confident about patient safety issues and as the students had the opportunity of playing the game as much as they wanted for a week, they reported that their feeling of confidence increased.^{22–24}

In the study, it was observed that the students became more interested in developing an awareness of infection control and patient safety as they spent most of their playtime observing virtual

patients and practicing communication and teamwork. Recently, the quality of the nursing approach has gained great attention from politicians, the mass media, and the public in the management of COVID-19. These developments have increased the responsibilities of nurses in addition to affecting their emotional, psychological, and physical states as the pandemic continues.²⁵ Nowadays, graduate students are more likely to care for COVID-19 patients, thereby increasing their stress and insecurity for them.²⁶

The present study is one of the few studies investigating the effectiveness of an e-learning module as a tool for teaching COVID-19. In the study, the students were asked to answer open-ended questions to provide a better understanding of the study results. Opinions and answers of the students to these questions are summarized in [Table 3](#). Several statements taken from the students expressing their interest in the game design can be presented as follows: *'evoked real hospital environment', 'an opportunity for us to practice the nursing process', 'content of the game', 'quite clear and informative', 'given a right, for every mistake'*. The answers of the students to the open-ended questions will shed light on the improvement of the game. According to the statements of the nursing students, it is clearly understood that the nursing students have learned and retained information about COVID-19 better thanks to this study. Moreover, the students who participated in the SGs study reported significant improvements in their understanding of several aspects of the nursing responsibilities in the clinical practice. It is seen that the study results are compatible with the existing literature.^{27,28}

A greater understanding of the COVID-19 management and nursing activities in hospitals may help to increase awareness of nursing students of their occupation and encourage them to accomplish their roles. The current study recommends that using game tools to educate the nursing students for the COVID-19 process and management is likely to be an effective learning method. Several statements taken from the students expressing their criticisms and recommendations about the game can be presented as follows: *'it sometimes freezes or becomes unresponsive', 'difficult to manage', 'played only with one person', 'easy', 'short', 'should adding new stages and nursing knowledge', 'infrastructure of the game should be strengthened'*. Furthermore, this study recommends that using game tools to educate the nursing students regarding COVID-19 management is an effective learning method, as the students expressed their criticisms and provided recommendations about the game rather than dislikes during their gaming experience. These results are compatible with the findings of other studies which indicate that it is important that negative emotions are absent so that the SGs experiences are improved.^{29,30}

This study has some limitations, such as the single-center design. The importance of developing multicenter research that addresses the adoption of the SGs as a learning strategy for best practice is given by obtaining larger samples for more generalizable results and by sharing resources between collaborative sites and promoting networks.³¹ Also, our study did not have a control group, therefore the findings cannot be compared to another training method and the results may pose risks in terms of reliability. Nonetheless, a control group is only necessary when the research question involves a comparison with another method, and any differences between the educational intervention against which the game is compared and the game itself could lead to an erroneous comparison.³²

Limitations

Besides the above-mentioned limitations, the ever-increasing knowledge regarding SARS-CoV-2 and COVID-19 might render both the guideline and the gamified e-learning module used in this study. However, current technological tools might mitigate this effect as they allow for a quick adaptation, even of highly interactive content.

Another limitation is that a relatively small number of questions were asked pre-and post-intervention in the study. Keeping the total number of questions and the time required to complete either study path relatively low was necessary to limit attrition.³³

As all answers were electronically recorded, there was no risk of an outcome assessment bias. Finally, as neither the control nor the e-learning path requires the physical presence of either participants or instructors, the framework used in this study can serve as the building ground for courses in a pandemic such as the current COVID-19 situation.

CONCLUSION

The development of COVID-related Infection Prevention and Safe Behaviors Promotion training of senior nursing students who will graduate soon plays a critical role in the pandemic period. Different teaching models are used to strengthen students in order to increase their confidence and reduce their stress. This study has a positive effect on increasing the knowledge of infection and safe behavior development with the SGs applied to the senior nursing students studying distance education. In this respect, SGs can be used for senior nursing students which will raise them for the post-graduation process that every health worker should be prepared for. Rigorous efforts are needed to improve the interface and technical issues to enhance the user's learning experience.

Besides the negative effects of the pandemic, students' virtual experiences have helped to increase their knowledge. Furthermore, it is an educational tool that can be used effectively in preparing students for the professional nursing role of putting the patient at risk.

There is a need to set a quality standard and security measures when developing future game-based competencies. This study supports the need to adopt new teaching and assessment methods, such as SGs to best match the future generation's learning styles and needs. The results should provide useful information for designing future teaching strategies in nursing programs.

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