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Research article

Facilitating nursing students' skill training in distance education via online game-based learning with the watch-summarize-question approach during the COVID-19 pandemic: A quasi-experimental study

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ABSTRACT

Background: Key challenges for clinical education during the COVID-19 pandemic include how to continue teaching and learning, how to teach core clinical skills, and how to demonstrate professional and practical skills in various clinical situations. Therefore, nursing students need to learn how to assist with in-patient intubation, eliminate accumulated sputum overflow, and the basic techniques of sputum suction.

Objectives: We proposed and investigated an approach to integrating online game-based learning with the watch-summarize-question strategy to improve nursing students' learning achievement, self-efficacy, learning engagement, and learning satisfaction in sputum suction skill training.

Design: A quasi-experimental study with pretest and posttest design.

Settings and participants: We randomly allocated 45 first-year nursing students to an experimental group ($n = 21$) or a control group ($n = 24$) at a school of nursing in a university.

Methods: The experimental group adopted the online game-based learning and watch-summarize-question strategy, while the control group used video-based learning. Participants were assessed on learning achievement of sputum suction skills, self-efficacy, learning engagement, and learning satisfaction before and after the intervention.

Results: The experimental group, which used the proposed approach, achieved statistically significant higher learning achievement, self-efficacy, learning engagement, and learning satisfaction than the control group.

Conclusions: The integration of online game-based learning with the watch-summarize-question strategy demonstrated a positive impact on nursing students' sputum suction skill training. Nurse educators and researchers should consider integrating computer technology and teaching strategies to facilitate nursing education.

1. Introduction

The COVID-19 pandemic has had significant direct and indirect impacts on global education (Ali, 2020). Educational challenges in the current crisis include the need to quickly switch to digital learning and teaching, ensuring support for students and teachers who study or teach at home, and ensuring that students acquire practical skills (Daniel, 2020). These challenges are compounded by uneven access to digital and other resources. Therefore, teachers have been forced to find or learn how to make remote, digital tools and materials within short timeframes (Hughes et al., 2020). A more sophisticated approach than a

standard class or lecture is to find a suitable and interesting interactive environment or to introduce teaching strategies into the course.

Particularly during the COVID-19 crisis, the maintenance of high-quality distance education, the volume of future nursing workforces, and the quality of care across fields worldwide are urgent public health issues (Labrague and de los Santos, 2021). Sputum suction is an important skill in clinical nursing, especially for patients with endotracheal tube placement, tracheostomy, and ventilator use (Seema et al., 2017). Improper sputum suction may damage the patient's upper respiratory tract, cause infection, or lead to hypogastric crisis, so sputum suction skills are requisite in nursing education (Yujiao et al., 2021). The

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COVID-19 nursing technical guidelines also detail the implementation steps of the closed sputum suction technique (Vargas and Servillo, 2020). Thus, nursing educators must teach and review many standard procedures in sputum suction skill training (Yilmaz et al., 2021).

Previous studies have focused on improving patient safety, reducing medical errors, and creating a safe medical environment (Bayatmanesh et al., 2019), which is also very important in the pandemic situation. Thus, there has been a research and teaching focus on reducing clinical mistakes, deviations, accidents, or damage caused during health care (So, 2020). Past research has examined different approaches to prevent such errors, the most important of which is to implement pre-employment training and continuing education (Lind et al., 2020). In response to the COVID-19 pandemic, patient safety issues are imperative, including the medical personnel's awareness of patient safety, differences in cognition and attitudes, and risk awareness. The awareness of the risk of patient harm due to cognitive bias is sufficient to endanger patients' safety (Royce et al., 2019). Previous studies have pointed out that nursing students' cognition and skills should be strengthened (Chang et al., 2020). Therefore, it is crucial to teach primary nursing care skills, such as safe sputum suction skills.

During the COVID-19 pandemic, online distance education is an option for education delivery. Online meetings, virtual conferences, and professional knowledge communication have become increasingly important for cross-disciplinary instructors worldwide (Aslan, 2021), but delivering basic professional skills in clinical scenarios is a significant challenge (Wittenberg et al., 2021). This is due to the fact that most online education applications primarily focus on cultivating practice cognition, but interactive learning contexts for skill applications are usually challenging (Paudel, 2021). Therefore, it is important to provide effective strategies to facilitate nursing students' skill training in an online learning context. Online game-based learning is one such strategy.

Online game-based learning is an approach that integrates game features with learning materials in an online interactive world to facilitate the acquisition of knowledge and skills (Cheung et al., 2008). Past research has shown that online game-based learning is an effective approach (Yang et al., *in press*) and has been increasingly adopted in educational settings as an innovative education method (Lorenzo-Alvarez et al., 2020). This is due to the fact that online game-based learning is a voluntary and enjoyable activity (Felszeghy et al., 2019). Therefore, the implementation of online game-based learning effectively increased students' engagement and active learning (Asniza et al., 2021). In addition, the competition feature of online game-based learning encourages learners to spend more time on learning tasks, and thus creates more flow experience, leading to better learning performance (Chen and Chang, 2020). Moreover, online game-based learning has positive effects on developing learners' higher-order skills such as decision making, critical thinking, problem solving, and collaboration skills (An, 2018). Therefore, online game-based learning could be a possible approach for nursing education. However, this approach has rarely been examined for nursing skill training.

In addition, past research has shown that appropriate teaching strategies are also needed to achieve better learning outcomes. One of the useful strategies is watch-summarize-question, which is a three-step learning activity whereby learners watch lecture videos, summarize key points, and raise questions during the lecture (Kirch, 2012). By encouraging students to participate in the three-step learning activity, students can be guided to pay attention to the focus of learning and reflect on their acquired knowledge, and the teacher can give detailed explanations to support students' understanding of the learning materials (Lin et al., 2019). Therefore, the watch-summarize-question strategy could be beneficial to students' learning from lower-level cognitive memory to higher-level in-depth thinking (Lin and Hsia, 2019). Previous studies have reported the effectiveness of the watch-summarize-question strategy for learners in distance education. For example, Lin et al. (2019) applied the watch-summarize-question strategy for nursing

skills training in a flipped learning context, and found that this approach effectively enhanced nurse practitioners' skills of physical assessment and differential diagnosis, while also increasing their self-efficacy and critical thinking. Another study by Liu et al. (*in press*) used the watch-summarize-question strategy in a vocal music course, and found that this approach provided students with scaffolding in the learning process, and effectively enhanced their vocal music skills. In addition, Hsia et al. (*in press*) adopted the watch-summarize-question strategy in a dance course, and found that this approach effectively improved students' dance performance skills and promoted their reflection on the learning process.

Therefore, it is important to guide nursing students in a step-by-step method with facilitation through recognizing key concepts, organizing what they have learned, and thinking deeply to inquire about potential problems. To this end, this study proposed an approach to integrating online game-based learning with the watch-summarize-question strategy to investigate its impact on nursing students' sputum suction skill training. We used a quasi-experimental design to answer the following research questions.

- (1) Does the proposed approach improve students' learning achievement compared to video-based learning for sputum suction skill training?
- (2) Does the proposed approach improve students' self-efficacy compared to video-based learning for sputum suction skill training?
- (3) Does the proposed approach improve students' learning engagement compared to video-based learning for sputum suction skill training?
- (4) Does the proposed approach improve students' learning satisfaction compared to video-based learning for sputum suction skill training?

2. Methods

2.1. Study design and setting

We adopted a quasi-experimental design and used an online game-based learning system with the watch-summarize-question strategy to intervene in a requisite clinical nursing course on sputum suction skill training. This study was conducted from August 2020 to January 2021 at a school of nursing in a university.

First-year nursing students were recruited as experiment participants. The average participant age was 20 years old, and all participants were taught by the same teacher. We randomly assigned 21 participants to the experimental group to conduct online game-based learning with the watch-summarize-question strategy and 24 participants to the control group to conduct video-based learning.

2.2. Development of an online game-based learning system with the watch-summarize-question strategy to facilitate sputum suction skill training

In response to the sudden increase in the demand for remote work during the COVID-19 crisis, the Gather.town (Gather) platform, which is different from traditional video conferencing software, can be used by multiple people online to work, socialize, and learn (McClure and Williams, 2021). We used Gather to develop an interactive role-playing game to teach sputum suction skills. Students can set roles and create game maps, virtual offices, desks, meeting rooms, and game areas. The technical learning steps and operation processes are integrated into Gather. Students assemble in this virtual space. They can use video, audio, and chat functions for discussion, and can form groups for interactive learning and instant role-playing. The characteristics and mechanisms of the game environment allow students to interact and connect with their classmates outside of the video screen, resulting in

warmer interactive learning. The role-playing game developed in this study verified the effectiveness of using this game by students acting as virtual characters in the game. Through role-playing, students were encouraged to complete learning tasks in the game. Fig. 1 shows the system structure of the Gather platform, including the gaming module, game interface, game rules, learner profile, watch-summarize-question interactive whiteboards, and interactive learning materials. The gaming module integrates learning tasks into the game environment to facilitate suction skill training. The game interface is saved in the game rules script, allowing students to perform role-playing, and learner data are recorded in the learner profile. The learning resources include professional knowledge content, interactive videos, and watch-summarize-question interactive whiteboards. The conditions for success were that students must complete the in-game learning tasks within a limited time, including completing the sputum suction learning content, collecting information on the preparations for the sputum suction skills, and completing the watch-summarize-question learning sheet.

The learning scenarios developed in the game were based on a nursing textbook and an official nursing protocol on basic nursing skills (Perry et al., 2014), especially on the suction skill scenarios (such as explain to the patient and family, auscultate the patient's breath sounds, set the suction regulator to appropriate values), which were reviewed for content validity by two experts in the field of nursing education. The Scale Level-Content Validity Index Average (S-CVI/Avg.) and Kuder-Richardson 20 (KR-20) were used to measure content validity and internal consistency reliability, and the values were 0.90 and 0.76 respectively, indicating that the developed learning scenarios were valid and reliable (Amaritakomol et al., 2019).

The storyline of this game is based on the developed scenarios of suction skills. Students need to learn the process of protocol in suction skills by completing the four steps of the learning tasks (i.e., assessment, preparation, procedure, and monitoring). In the first step, before conducting the suction skills, students need to be able to correctly assess the position of the chest cavity of the case, and explain the purpose of the suction skills to the case (Davies et al., 2018). In the second step, students need to properly prepare related equipment, such as the sputum extraction system (mobile or central sputum extraction system), suction tube, and sterile gloves (Nascimento et al., 2021). In the third step, students need to conduct the operational procedure of the suction skills, including providing the patient with high-concentration oxygen before and after the procedure to prevent hypoxia (Seema et al., 2017). In the final step, students need to monitor the patient's breathing pattern, chest sputum sounds, and changes in blood oxygen concentration to avoid hypoxia (Yilmaz and Özden, 2021).

Based on the developed learning scenarios and storyline in the game, students learn professional knowledge of sputum suction skills through this platform with the watch-summarize-question strategy. In the watch step, after checking the online game-based learning interface and clicking on the sputum suction tasks, students watch the videos related to scenarios of suction skills (see Fig. 2). They can watch the videos

repeatedly and take notes on unclear parts while watching the videos. Consequently, in the summarize step, students follow the guidance to summarize the main points of the learning scenarios from the videos (see Fig. 3). Finally, in the question step, students pose questions related to the learning scenarios on the interactive whiteboard, such as unclear or difficult parts, to discuss with other students to gain more in-depth learning (see Fig. 4).

2.3. Experimental procedure

Fig. 5 illustrates the experimental procedure of this study. After the teacher introduced the sputum suction skill syllabus and learning goals, all students took the learning achievement pretest and completed the self-efficacy pre-questionnaire. The students were then divided into the experimental group and the control group to learn about sputum suction skills in various scenarios by using different learning approaches. More specifically, the experimental group completed the watch-summarize-question learning sheets through the online game-based learning environment, while the control group completed the paper-based learning sheet after finishing the video-based learning tasks. Although the two groups of students used different learning approaches, their learning time was the same. More specifically, the intervention was carried out once a week for 100 min each time, for a total of 200 min over two weeks. In addition, the two groups were taught by the same teacher who acted as a facilitator to guide them to learn and to provide immediate assistance when students encountered problems during the learning process. However, most students carried out the learning activities autonomously. After the learning activities, all students completed the learning achievement posttest, and the post-questionnaires of self-efficacy, learning engagement, and learning satisfaction.

2.4. Instruments

The pretest and posttest were designed by two experienced nursing teachers to evaluate students' learning achievement of sputum suction skills. Each test had 10 multiple-choice questions, with 10 points awarded for correct answers and 0 points for incorrect answers, giving a maximum score of 100 points. The scores ranged from 0 to 100 points for each test, and the total score of each student in the pretest and posttest was calculated to compare the differences between the experimental and control groups. The questions of the pretest and posttest were the same, but the posttest questions were presented in random order.

In addition, three questionnaires were used to measure the students' self-efficacy, learning engagement, and learning satisfaction. The self-efficacy questionnaire adopted from Pintrich et al. (1991) included eight items, such as "I believe I can understand the basic concepts taught in this course" and "I am confident that I can do well in the sputum suction skill." The engagement questionnaire initiated by Dixon (2015) included 19 items, such as "Having fun in online chats, discussions or via email with the instructor or other students" and "Getting to know other

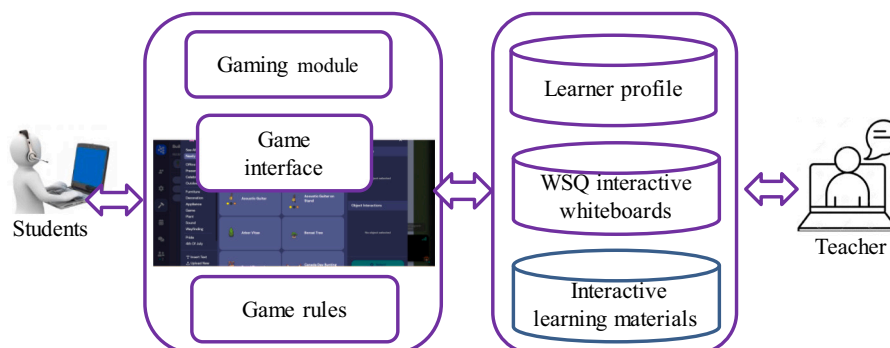


Fig. 1. System structure of the Gather platform.

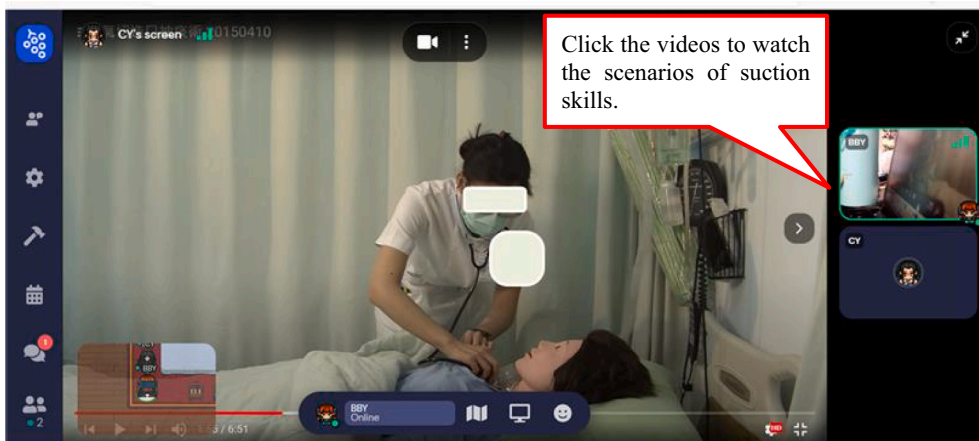


Fig. 2. Watch the videos related to scenarios of suction skills.

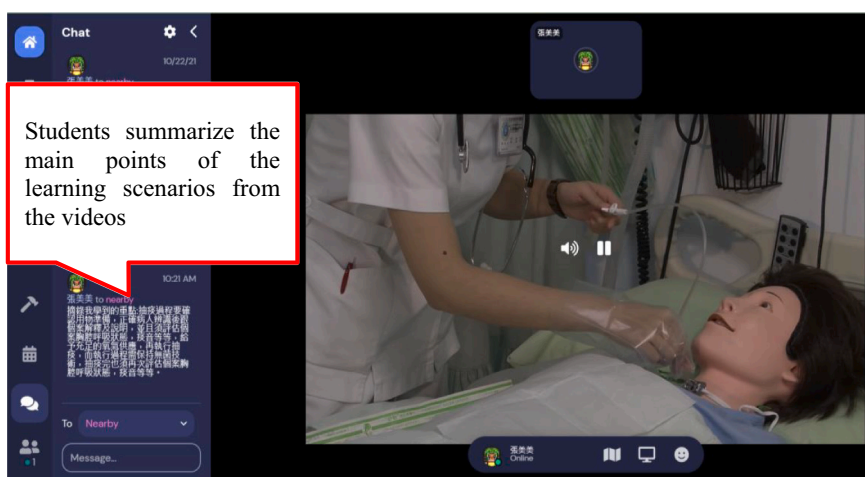


Fig. 3. Summarize the main points from the videos.

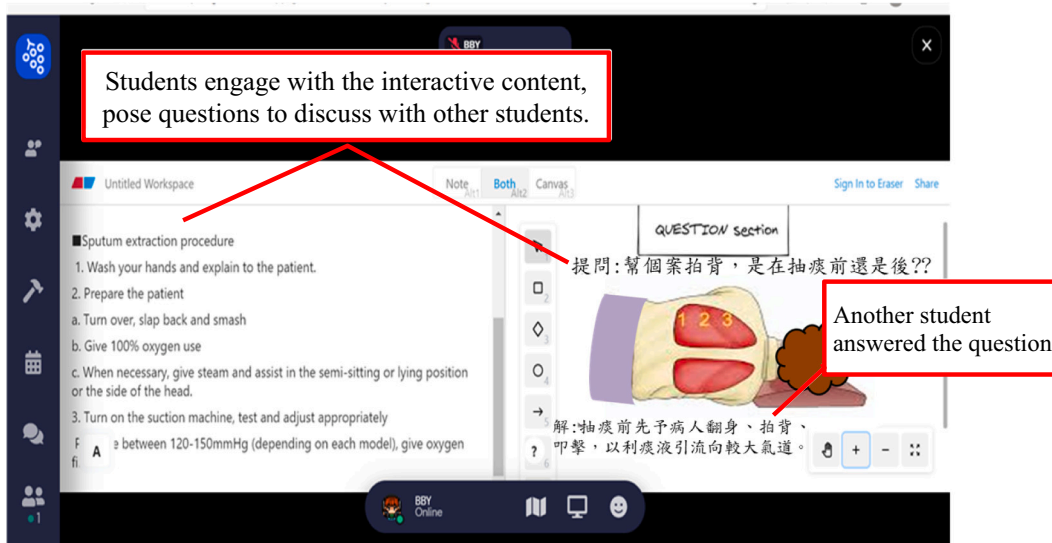


Fig. 4. Pose questions and discuss with other students.

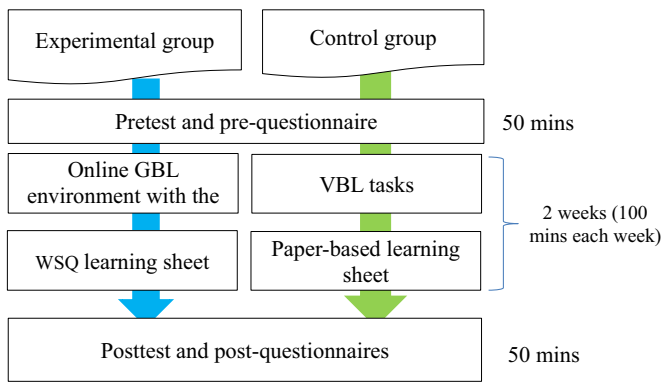


Fig. 5. Experimental procedure.

students in the class.” The learning satisfaction questionnaire initiated by Chu et al. (2010) comprised nine items, such as “The task of this learning activity was not easy to complete, but it was easy to understand the way of learning” and “I have tried new learning approaches or thinking styles because of this learning system.” All three questionnaires were scored using a 5-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The Cronbach’s alpha values of the questionnaires were 0.90, 0.86, and 0.91, respectively, indicating the high reliability of these questionnaires.

3. Results

3.1. Learning achievement and self-efficacy

ANCOVA was used to compare the two groups’ learning achievement posttest scores and post-questionnaire ratings of self-efficacy by excluding the influence of their pretest scores and pre-questionnaire ratings. To verify the assumption of ANCOVA of the learning achievement and self-efficacy measurements, we verified the regression coefficients’ homogeneity in each group. We found that *F* value did not violate the homogeneity assumption ($p > .05$). Then, we applied ANCOVA, as summarized in Table 1. After excluding the influence of the pretest and pre-questionnaire scores, the two groups’ posttest and post-questionnaire scores were significantly different in learning achievement ($F = 26.34, p < .01$) and self-efficacy ($F = 16.97, p < .001$). In the experimental group, learning achievement and self-efficacy had respective adjusted averages of 90.97 (standard error = 2.14) and 4.74 (standard error = 0.17), compared with 64.40 (standard error = 2.26) and 3.84 (standard error = 0.21) for the control group. These results showed that the approach of situational learning using the online game-based learning sputum suction scenarios combined with the watch-summarize-question strategy could effectively improve nursing students’ learning achievement and self-efficacy.

3.2. Learning engagement and learning satisfaction

Through an independent samples *t*-test of the learning engagement

Table 1 ANCOVA results for learning achievement and self-efficacy.

Variable	Groups	<i>N</i>	Mean	<i>S.D.</i>	Adjusted mean	Std. error	<i>F</i> value	η^2
Learning achievement	Experimental group	21	72.19 ^a	10.04	90.97	2.14	26.34**	0.882
	Control group	24	61.20 ^b	9.43	64.40	2.26		
Self-efficacy	Experimental group	21	4.68	0.51	4.74	0.17	16.97***	0.303
	Control group	24	3.67	0.64	3.84	0.21		

** $p < .01$.

*** $p < .001$.

^a Range: 70–100, total score: 100.

^b Range: 50–80, total score: 100.

and learning satisfaction scores of the two groups, we found no statistically significant difference in the two groups’ pre-learning engagement or pre-learning satisfaction scores ($t = 2.05, p > .05; t = 1.68, p > .05$). This result suggested that the two groups had similar initial learning engagement and learning satisfaction, so we used the independent samples *t*-test instead of ANCOVA. As shown in Table 2, the score of the experimental group was higher than that of the control group for learning engagement ($t = 2.11, p < .05$) and learning satisfaction ($t = 1.73, p < .05$). Thus, the approach of using the online game-based learning sputum suction scenarios combined with the watch-summarize-question strategy significantly improved nursing students’ learning engagement and learning satisfaction.

4. Discussion

In this study, we proposed an approach to integrating online game-based learning with the watch-summarize-question strategy for nursing education. We conducted an experiment for an online clinical nursing course on sputum suction skill training to evaluate the effectiveness of the proposed approach. According to the experimental results, the research questions are answered as follows.

- (1) The students who used online game-based learning combined with the watch-summarize-question strategy had significantly better learning achievement than the students using the video-based learning method. The approach of online game-based learning with the watch-summarize-question strategy provided clear learning goals and encouraged students to observe, compare, summarize, and ask questions to find clues to carry out learning goals and explorations in the game. By contrast, students in the control group only needed to watch the video to collect information to answer individual questions on the learning sheet. This may be why the experimental group showed better learning achievement than the control group. The success of this study is highly related to the watch-summarize-question strategy integrated with the online game-based learning activities, which can help students deal with learning tasks and construct knowledge. As Chen et al. (2018) suggested, the use of appropriate teaching strategies has great potential for cultivating students’ higher-level thinking and learning achievement. Eltahir et al. (2021) also pointed out that the coordination of learning tasks can

Table 2 The *t*-test results of learning engagement and learning satisfaction.

Variable	Groups	<i>N</i>	Mean	<i>S.D.</i>	<i>t</i>	<i>d</i>
Learning engagement	Experimental group	21	4.48	0.51	2.11*	0.61
	Control group	24	4.06	0.79		
Learning satisfaction	Experimental group	21	4.49	0.46	1.73*	0.50
	Control group	24	4.17	0.74		

* $p < .05$.

significantly affect students' learning performance in game-based learning activities.

- (2) The students who used the online game-based learning combined with the watch-summarize-question strategy showed significantly better self-efficacy compared with the students using the video-based learning method. The results show that the experimental group had considerably higher self-efficacy than the control group. This may be due to the fact that the experimental group could interact and discuss with classmates, while the control group watched videos independently. These findings support that online game-based learning integrated with the watch-summarize-question strategy could positively boost learning self-efficacy through the process of watching, summarizing and constructing the knowledge related to sputum suction, and posing questions and discussing with classmates. As suggested by [Lu and Lien \(2020\)](#), the more participation experienced by the students, the higher their levels of self-efficacy. Therefore, students can concentrate on acquiring the knowledge when they have a higher level of self-efficacy ([Fitriyana et al., 2021](#)).
- (3) The students who used the online game-based learning with the watch-summarize-question strategy showed significantly better learning engagement and learning satisfaction compared with the students using the video-based learning method. The experimental results show that the integration of the entertainment value of Gather online game-based learning and educational materials with the watch-summarize-question strategy led to better participation, learning engagement, and learning satisfaction in the distance education context. As [Moon and Ke \(2020\)](#) suggested, students' active participation can benefit from online game-based learning. Using the online game-based learning approach in distance education can help nursing students gain the knowledge and skills of sputum suction, engage in more competitive activities, and be satisfied with their learning outcomes ([Liu and Hou, 2021](#)). [Eltahir et al. \(2021\)](#) claimed that digital games could stimulate students' internal abilities, driving them to participate in learning activities fully. Our results support this claim as online game-based learning combined with the watch-summarize-question strategy produced better learning engagement and learning satisfaction than the video-based learning method.

In addition to the abovementioned benefits, the proposed approach is important for facilitating student interaction through learning tasks embedded in the game and the watch-summarize-question strategy. Previous studies have shown the importance of student interaction ([Zhang and Lin, 2020](#)). However, in most online teaching situations, such as online lectures, there is little direct student interaction, which does not encourage active learning ([Edwards and Lane, 2021](#)). In our approach, students can interact with peers through a private chat function or an interactive whiteboard. This is in contrast to the video-based learning method, where students only have direct video watching, but no interaction occurs during the learning process. Moreover, we found that students spent more time interpreting the learning materials in detail, completing knowledge construction, adopting the watch-summarize-question strategy to watch the videos of sputum suction skills, summarizing key points of the videos, and asking questions to engage in interactive discussions with classmates. Since students may encounter different operational problems, they can discuss points that they do not understand with classmates without worrying that the questions may be too simple. The teacher and classmates can then provide personalized help or answer questions through the course. By doing so, students may reduce their anxiety during the learning process, which in turn, can improve their learning outcomes. With such guidance, students deepen their skills of sputum suction operations, such as providing correct chest assessments and selecting the correct pressure for suction.

Based on the findings gained from this study, we demonstrate that the proposed approach of integrating online game-based learning with the watch-summarize-question strategy effectively enhanced nursing students' learning achievement, self-efficacy, learning engagement, and learning satisfaction in sputum suction skill training. By overcoming the challenges during the COVID-19 pandemic, these positive findings provide a useful case for nursing educators who are attempting to deliver online courses for skill training. As [Hwang and Chang \(in press\)](#) pointed out, nursing educators should find innovative teaching strategies to promote effective learning and improve students' professional knowledge and skills. Therefore, the proposed approach provides a good example that can be adopted by nursing educators. It could be applied to other nursing training courses by replacing learning scenarios, such as interpretation of clinical laboratory reports and understanding important physiological monitoring equipment. This approach can also be applied to other students under training to teach decision-making or cooperative problem-solving abilities.

5. Conclusions

There have been many studies verifying how computer technology and learning methods can support students' curriculum activity learning. To achieve this goal, we proposed an approach of integrating online game-based learning with the watch-summarize-question strategy to provide nursing students with practical and professional sputum suction skill training. We developed a game scene to emulate a real-life clinical learning environment and conducted an exploratory experiment to investigate the effectiveness of the proposed approach. The findings showed that students using the proposed approach had better learning achievement, self-efficacy, learning engagement, and learning satisfaction.

Although the experimental results showed that the proposed approach benefits nursing students' learning in sputum suction skill training, there are some limitations. The greatest difficulties in adopting online game-based learning in nursing education are the cost of the gaming platform and the time spent preparing learning materials. Regarding the cost, a gaming platform that can accommodate many users for larger classes or cross-school elective courses may be costly. Therefore, we suggest using a free gaming platform such as Gather, although it can only accommodate up to 25 concurrent users. Regarding the time, clinical nursing educators need to spend a great deal of time preparing the appropriate game scripts and learning materials corresponding to specific technical course content in the game scenes. Therefore, we suggest adopting an effective teaching strategy such as watch-summarize-question. By doing so, nursing educators can not only have a clear picture to follow the three-step learning activity to save time in designing in-game learning scenarios, but students' higher-level thinking can also be enhanced through the learning process. In addition, we suggest collaborating with individuals talented in digital technology to develop a gaming platform for nursing education to appropriately meet the needs of nursing educators. Once the learning scenarios on the gaming platform have been developed, they can be reused in the future. Another limitation is that only a small number of students participated in a short-term clinical nursing course on sputum suction skill training. Therefore, more experimental courses with larger samples and of longer duration need to be undertaken to evaluate whether our results can be replicated in other topics with different experimental designs. Finally, we can gain further insights by analyzing the in-game learning behavior of students and incorporating activities of group or individual debriefings to encourage students' reflective behavior.

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Ethical statements

This study was approved by the research ethics committee of National Taiwan University (202008ES008).

CRedit authorship contribution statement

Ching-Yi Chang: Writing - Original Draft, Conceptualization, Methodology. Min-Huey Chung: Investigation, Formal Analysis, Visualization. Jie Chi Yang: Writing- Review & Editing, Validation, Software.

Declaration of competing interest

None.

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