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Effects of contextual interactive healthcare training on caregivers of patients with suspected COVID-19 infection: Anxiety, learning achievements, perceived support and self-efficacies during quarantine

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Abstract

Background: The contextual and interactive learning research was motivated by the need to enhance the healthcare training effect of caregivers of patients with suspected COVID-19 infection during quarantine. However, there is a lack of effective approaches to integrating mobile contextual learning into interactive learning.

Objectives: Therefore, this study developed a mobile augmented reality-integration contextual interactive healthcare training system, and then investigated the effects of the proposed system on anxiety, learning effects, perceived support and self-efficacies.

Methods: To validate the effectiveness of the system, we conducted a quasi-experiment with a sample of 91 caregivers of patients with suspected COVID-19 infection.

Results and conclusions: Results showed that the experimental group with the developed system was superior to the control group with e-pamphlet instruction in mobile devices, in terms of learning effect, perceived support, self-efficacies and reduction of anxiety during quarantine. Therefore, the mobile contextual interactive healthcare training system could be useful to improve caregivers' self-efficacies as well as their ability to care for patients in the context of COVID-19 infection prevention.

Implications: This is one of the few studies of the effective approach for technology-enhanced healthcare education in the COVID-19 pandemic. Some corresponding suggestions are proposed: implementing mobile contextual interactive training activities to enhance caregivers' knowledge, skills and self-efficacies; involving social interactions to relieve caregivers' anxiety; providing professional communications and support while facing difficulties in taking care of patients with suspected COVID-19 infection.

KEYWORDS
anxiety, AR technology, caregivers, COVID-19, healthcare, interactive learning

1 | INTRODUCTION

The world is facing a global pandemic of the novel coronavirus (COVID-19). When battling the pandemic, most countries allocate scarce medical resources to critically ill patients with COVID-19. The World Health Organization (WHO) has also issued guidance related to 'home quarantine' for patients with suspected COVID-19 infection who exhibit mild symptoms (WHO, 2020). The guidance recommends that patients with mild symptoms (low fever, cough, nasal congestion, sore throat without other symptoms) and no underlying chronic diseases (lung diseases, heart diseases, renal failure and immunocompromising conditions) should be deemed as mild or suspected COVID-19 cases, and home quarantine may be considered (Cirrincione et al., 2020). However, patients and their caregivers should acquire knowledge on the maintenance of personal hygiene, basic means of infection prevention and control, and safe home care for caregivers of patients with suspected infection. They should also learn how to care for patients and how to minimize the risk of infection (Ros & Neuwirth, 2020).

There are infection prevention and control requirements for suspected COVID-19 patients. The benefits in terms of home quarantine, 14 days of quarantine after cross-regional travel and other prevention control requirements in China far outweigh the cost and disadvantages with regard to effective control. Therefore, prevention and treatment measures for patients with suspected COVID-19 infection tend to be family-centred quarantine. Family-centred care can facilitate interactions and emotional support among patients, caregivers and medical workers to improve patients' recovery and avoid being infected. Researchers have examined the requirements of families and pointed out new perspectives for treating many domains in individuals with suspected COVID-19 infection. For example, Lee (2020) conducted interviews with seven families of suspected COVID-19 cases and found that the caregivers felt extremely uneasy and anxious about having a family member with suspected COVID-19 infection and requiring related care knowledge. Nevertheless, studies have proved that caregivers are often dissatisfied with the instructions provided by the community hospital staff (Dominguez-Fernandez et al., 2020; Elgendy et al., 2020). The corresponding instructions and testing during the quarantine period are provided by professionals from the Centres for Disease Control and Prevention (the nation's health protection agency of China). However, concerning the care of suspected COVID-19 cases, further healthcare training and instructions are essential for both the individuals with suspected COVID-19 infection and their caregivers. For instance, the great challenge for medical staff is teaching caregivers about medical procedures with conventional pamphlet-based instructions. Moreover, most nurses are too occupied and cannot guarantee that the caregivers fully learn the required knowledge (Yusof, 2015).

One of the major problems and difficulties of further healthcare training and instructions is providing patients or their caregivers with instructions on care or quarantine environments using conventional pamphlet-based materials (Torke et al., 2016). Researchers seek useful technology-embedded intervention to enhance healthcare knowledge and outcome. Compared to conventional pamphlet-based instructions, the integration between interactive technologies (e.g., video, 3D, virtual reality, and augmented reality, etc.) and health education system represents a valuable alternative for users to engage in interaction, self-regulated learning and more practice (Lee, Wang, et al., 2019; Muangpoon et al., 2020). Compared with conventional pamphlet-based instructions, the use of contextual mobile learning and interactive learning is valuable for promoting users' nursing skills and self-efficacy (Chung et al., 2021). To sum up, the conventional pamphlet-based healthcare training could not address the problem of nurses shortage in the context of the outbreak of COVID-19. However, on combining the need of training caregivers with the intervention mentioned earlier, we gain the potentials of mobile and contextual interactive learning. The interventions of interactive learning and mobile learning for healthcare training during the quarantine of COVID-19 are very plausible by experience from previous studies. The effective designs of the contextual interactive learning and mobile learning may assist caregivers' healthcare training outcomes as well as minimize their risk of infection, then reduce nurses' burden and caregivers' anxiety. However, a systematic review from 1971 to 2016 regarding mobile nursing education showed that the use of contextual mobile learning and interactive learning for promoting users' self-efficacy and emotional status were seldom discussed (Chung et al., 2021). Since the design of how contextual learning integrates into interactive learning and its impact on caregivers of patients with suspected COVID-19 infection is still unclear, this study conducted a mobile augmented reality (AR)-integration contextual interactive healthcare training system to investigate the impact of the proposed system on the caregivers of patients with suspected COVID-19 infection, regarding anxiety, learning effects, perceived support and self-efficacies. AR-integration refers to the utilization of AR to support healthcare training in this study, which may facilitate interactions to develop medical one's professional knowledge, practical skills and social skills (Dhar et al., 2021). The research questions proposed in this study were as follows:

1. Compared with those who received conventional e-pamphlet instruction in mobile devices, can the mobile AR-integration contextual interactive healthcare training improve the care knowledge of caregivers?
2. Are there any significant differences in the anxiety levels, perceived support and perceived self-efficacies between caregivers who received instructions through the mobile AR-integration contextual interactive healthcare training and those who received e-pamphlet instruction in mobile devices?

To answer the above research questions, a literature review section of previous studies that shed light on the design of mobile AR-integration contextual interactive healthcare training is provided. After that, a description of such an interactive training system is introduced. The following two sections report the details of the experiment and the effects of the proposed system on the learning effects of caregivers. The 'Section 6' discusses the findings of the present

study. The article concludes with some implications for contextual interactive healthcare training and future research.

2 | LITERATURE REVIEW

One important challenge in training caregivers of patients with suspected COVID-19 infection is the difficulty in designing a reliable and suitable healthcare training system. Three bodies of literature on the intervention strategies and effects of contextual mobile learning and interactive learning may help us develop and make healthcare training effective.

First, an increasing number of studies have mentioned that incorporating interactive design into contextual learning environments could contribute to the learning and training outcomes. Situating healthcare practitioners in a contextualized environment to interact with simulated patients and make required decisions is a widely adopted approach to train their nursing skills (Lin, Hwang, & Hsu, 2019). Forristal and Kim (2021) conceptualized an interactive case for emergency medicine physicians during the COVID-19 pandemic, which influenced their practice and confidence by engaging them in multiple interactive pathways for case progression. As Maganty et al. (2018) informed that compared with conventional printed materials, interactive learning exhibited great potential in promoting patients' learning motivation and effects. It has now been demonstrated that interactive design tends to facilitate patients learning outcomes by presenting related knowledge in an interactive manner (Lee, Wang, et al., 2019). Research has tended to focus on the combination of interactive functions and learning content to provide tasks, guidance, and feedback to learners (Sung et al., 2019; Suppan et al., 2020). Learners who learned with role-playing in an interactive digital learning environment and received feedback had better learning achievement and motivation (Wang et al., 2018).

Second, previous work indicated that effective interactive training and learning highlighted the crucial role of incorporating contextual and immersive technologies (e.g., VR and AR) into the design of experience in terms of meaningful cognitive development and practices. It has been suggested that students seem to enhance their knowledge and practice with the in-depth experiential learning process of contextual interaction in VR (Huang et al., 2019). Tyerman et al. (2021) developed a high-quality virtual simulation module to strengthen the capacity of nurses to provide care during the COVID-19 health crisis. Erbas and Demirer (2019) investigated the AR-integration activities that might be effective in increasing students' academic knowledge and attitudes of motivation. Likewise, Muangpoon et al. (2020) presented an AR system for training and assessment to improve the users' teaching and learning skills, which has been proved applicability and usefulness. Related studies have confirmed the effect of AR technology on cognitive development in terms of motivation and cognitive load. In addition, the usage of technology can also strengthen learners' creativity tendency, reading, writing and other basic abilities, while reducing their cognitive load (Huang et al., 2019). As such, the use of contextual interactive learning in mobile devices in an educational environment is highly valued by scholars.

Third, researchers have indicated the role of suitable social interaction as emotional support in reducing the users' anxiety in contextual interactive learning. Krouska et al. (2021) revealed that learners' interaction effectively with peers has a significant and positive impact on satisfaction and self-esteem. This social interaction is essential to deal with loneliness and isolation during the COVID-19 pandemic. Perceived support from the contextual and interactive learning systems could be construed as verbal persuasion in the transitory emotional state caused by the perception of threats from certain stimuli (Lin et al., 2020). Previous studies have indicated that AR games have a beneficial impact on their players' physical activity and mental health during the COVID-19 pandemic, which helps them to decrease depression and anxiety (Ellis et al., 2020). Based on the previous literature, which indicated that compared with pamphlet-based healthcare education, contextual interactive learning could contribute to the enhancement of caregivers' communication and self-efficacy of learning, thereby reducing the patients' stress and anxiety.

Much work on the potential of related literature has been carried out with interactive design, contextual experience and emotional support of mobile contextual interactive learning. Therefore, this study combines these three viewpoints to design contextual interactive healthcare training in the context of COVID-19. First, mobile devices ensure that contextual interactive healthcare training could be conducted during the home quarantine of COVID-19. On the one hand, portable displays and mobile devices have become increasingly popular (Lin, Deng, et al., 2019), and almost every family is equipped with mobile devices. The major advantages of mobile devices include shareability, creativity and multimedia features (Shadiev et al., 2018). The mobile contextual interactive environment facilitates the delivery of healthcare education by nursing staff, as the interactive environment not only frequently updates the healthcare information but also provides interactions with audio-visual information and social networking applications (Lee, Wang, et al., 2019; Lin et al., 2020). Likewise, these advantages show the huge potential to facilitate remote information sharing and education for caregivers and minimize their risk of infection (Taylor et al., 2017). On the other hand, researchers incorporate AR into contextual interactive learning for providing learners' contextual and immersive experiences in cognitive development and practices. Lin, Wu, et al. (2019) reported that learners could obtain AR materials on the mobile terminal via scanning to help them participate in the real inquiry. Furthermore, on the basis of recommendations from the previous research (Edelhauser & Lupu-Dima, 2020; Lin, Tang, et al., 2019), the proper usage of related AR-integration activities should improve learners' perceived self-efficacies (i.e., perceived self-directed confidence and perceived problem-solving confidence). Existing studies have shown that teaching based on mobile devices could improve learners' perceived autonomy, intrinsic motivation (Jeno et al., 2019).

However, to the best of our knowledge, no studies regarding contextual interactive healthcare education on the care of patients who are suspected of COVID-19 infection with AR have been presented. Most of the existing studies focus on pamphlet- or video-based instructions. To fill this research gap and provide some suggestions for nursing education under this period of time, this study was

conducted mobile AR-integration contextual interactive healthcare training for caregivers of patients with suspected COVID-19 infection. One most important aspect in this study is with regard to incorporating interactive design into the contextual learning system. This interactive design could be applied to motivation to repeat practices with AR or 3D model interactive materials and interactive exercises. Therefore, caregivers enhance their learning effects and training outcomes of taking care of patients with suspected COVID-19 infection. The utility of interactive learning in contextual interactive healthcare training is thus reducing the nurse's burden during the outbreak of COVID-19. Another aspect is regarding the term designing a contextual and immersive experience mentioned in the literature. The contextual and immersive experience ensure caregivers' cognitive development and practices. For example, caregivers could understand the concept of SARS-CoV-2 prevention via role-playing activities to enhance their cognitive of wearing a mask during quarantine. As Wang et al. (2018) reveal that role-playing seems to promote students in interactive and effective learning. Finally, as mentioned in the literature, providing suitable social interaction in communication tasks could be essential in contextual interactive learning. The social interaction could provide caregivers instant contact with others and a synchronization-based help to reduce their anxiety at any time they needed. Therefore, we developed the mobile AR-integration contextual interactive healthcare training system based on the ideas of contexts, immersive experience and social interaction. The next section describes how such ideas are implemented in a mobile AR-integration contextual interactive healthcare training system.

3 | DESIGN OF A MOBILE AR-INTEGRATION CONTEXTUAL INTERACTIVE HEALTHCARE TRAINING FOR CAREGIVERS OF PATIENTS WITH SUSPECTED COVID-19

3.1 | Framework of the mobile AR-integration contextual interactive healthcare training system

The augmented reality integration contextual interactive software (Dreammaker) made by the Dreamer company was used as the development tool. We aimed to develop a mobile AR-integration contextual interactive healthcare training system to help caregivers understand the medical procedure used for the care of patients with suspected COVID-19 infection, the rules of care during quarantine and the ways to comfort patients.

Figure 1 shows the framework of the mobile AR-integration contextual interactive healthcare training system. The system has six functions of contextual interactive healthcare training: (1) Augmented reality or 3D model interactive materials. (2) Video or animation teaching materials. (3) Test items module. (4) Synchronization-based help-seeking module. (5) Asynchronization-based help-seeking module. (6) Role-playing module. The experimental group learned through the AR-integration contextual interactive healthcare training system in an authentic healthcare mobile setting. Caregivers could freely navigate and read through the contents in a contextual interactive system. They learned from the contextual features to understand the functions of relevant medical instruments.

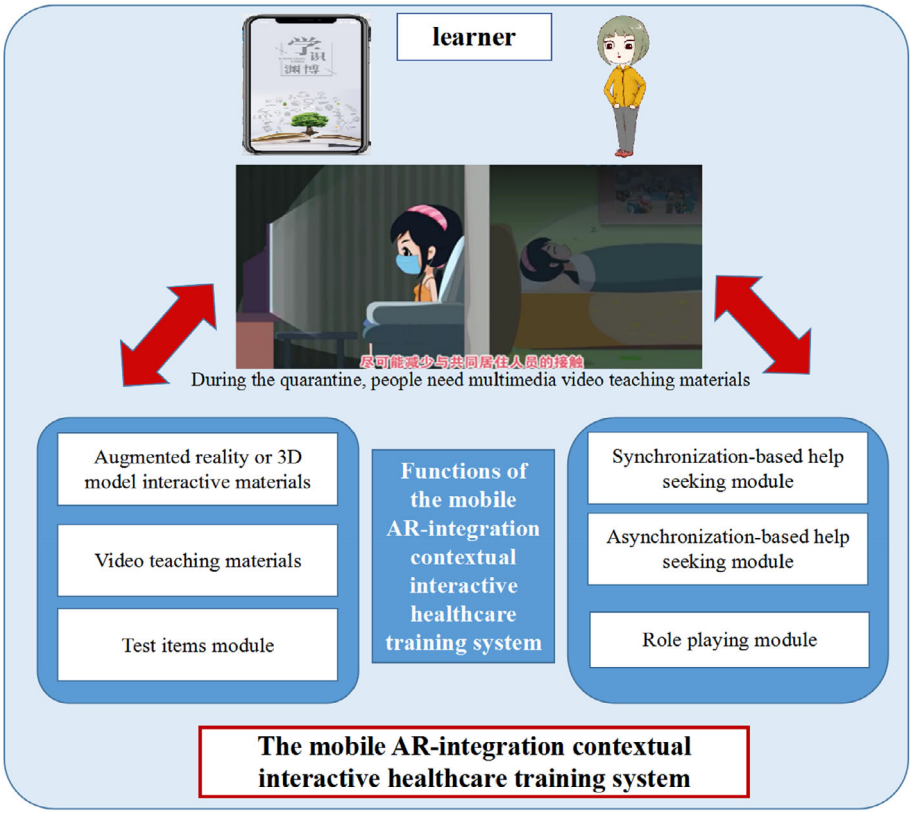


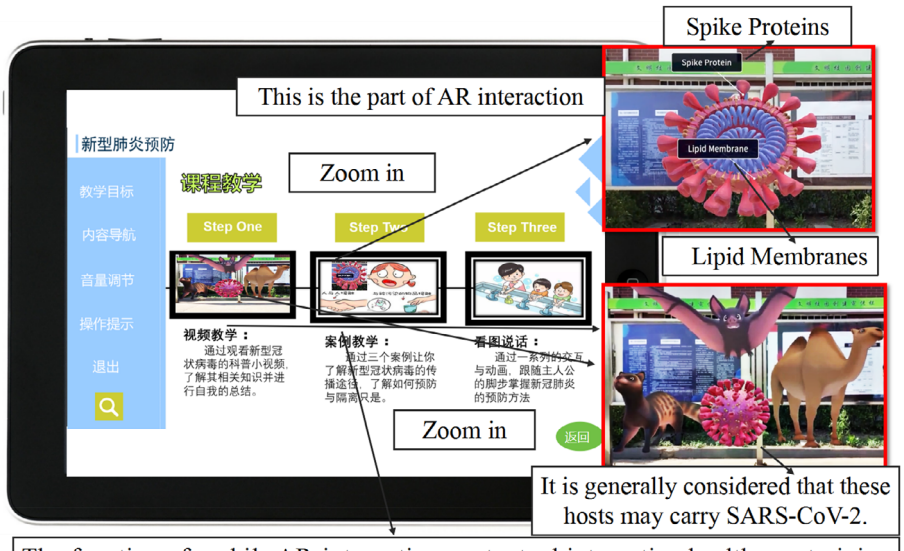
FIGURE 1 Framework of the mobile AR-integration contextual interactive healthcare training system

The experimental group used the contextualized environment involving interactive exercises. After learning the contents in the contextual interactive system, caregivers could perform the interactive exercises to understand the knowledge related to patient care, such as the devices, procedures and preventive measures when caring for patients. For instance, the mobile AR-integration contextual interactive healthcare training system set up situated learning sessions with AR technology to help caregivers understand SARS-CoV-2 prevention with interactions, which includes the 3D model or video of the SARS-CoV-2 concept. The function of this system could allow caregivers to upload voice or video about their views related to patient care for professional help (see Figure 2).

3.2 | Content structure and interface of the mobile AR-integration contextual interactive healthcare training

The material of the AR-integration contextual interactive healthcare training was divided into three parts: rules of quarantine wards, protective equipment and procedures, and comforting the patient. The material was adapted from a professional nursing brochure for suspected COVID-19 cases from the Centres for Disease Control and Prevention in China. Moreover, the content was summarized and re-organized with the help of eight medical workers at the medical centre and two educational technology researchers who experienced nursing education. There are several sections in each part. (1) Rules of quarantine wards included regulations for hospitalization, cleaning and disinfection, quarantine rooms and infection control. This part aimed to empower caregivers who were in close contact with patients with suspected COVID-19 with the relevant knowledge on the rules of care and to provide required knowledge on SARS-CoV-2 prevention. (2) Protective equipment and procedures were divided into instructions on the devices, procedures and tubes used in quarantine rooms. This part aimed to enable caregivers to use the protective equipment within the space dedicated to the quarantine of COVID-19 cases, and to allow them to understand the meaning of indicators in the test result. (3) The part of comforting the patient introduced clinical symptoms, regulated modalities and therapies. The possible scenarios that might occur during the care of patients with suspected COVID-19 infection were explained to the caregivers through videos and contextual dramas. This part provided basic information on treatment modalities and methods to comfort patients. The navigation structure of the AR-integration contextual interactive healthcare training is shown in Figure 3.

Furthermore, contextual interactive healthcare training involves a multitude of healthcare contexts. Figure 4 shows the screen of a selected contextual item. For example, in the 'Rules of care for patients with suspected COVID-19 infection' part, an interactive button was added to allow caregivers to perform a role-playing activity. Role-playing activity assigns a meaningful role to caregivers by creating a script, and it can greatly affect the motivation and actions of the learner when he or she assumes the responsibilities befitting the prescribed identity (Meij et al., 2019). Learners could click the buttons on the tablet to select a form of care that they considered appropriate, and they would receive instant feedback to remind them of the most suitable care practices. When a family member played the role of a



The function of mobile AR-integration contextual interactive healthcare training system allows caregivers to learn about the target learning objects through the interaction with the 3D model or video, to capture their observations, to upload voice or video on the images. For example, the upper right corner of the screen shows situated learning sessions with AR technology in order to help caregivers understand that its outer structure is composed of Lipid Membranes and Spike Proteins through the SARS-CoV-2 3D model or video.

FIGURE 2 The function and example of mobile AR-integration interactive learning

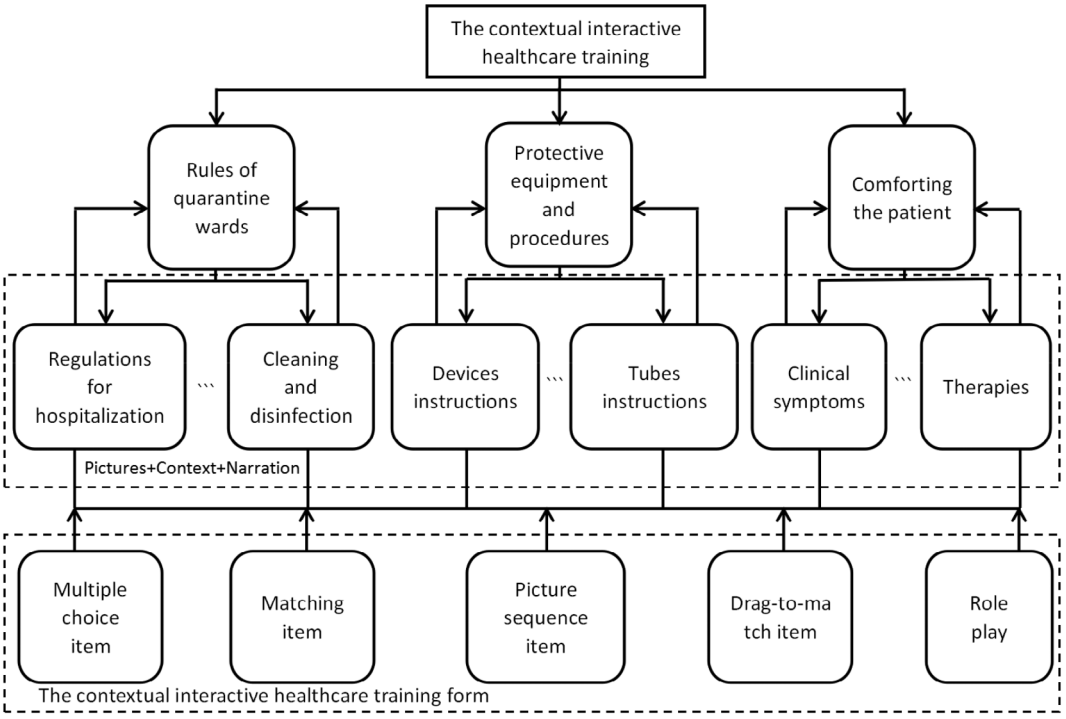


FIGURE 3 Navigation structure of the contextual interactive healthcare training

FIGURE 4 The screen of a selected contextual item of contextual role-playing healthcare training

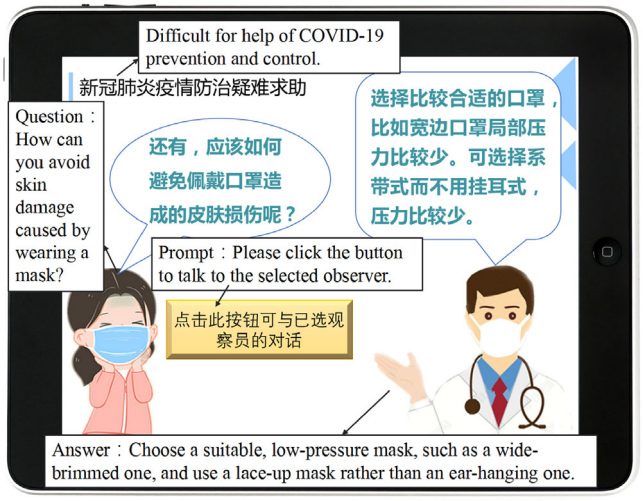


FIGURE 5 System interface of a synchronization-based help-seeking case

patient with suspected COVID-19 infection, they would realize that the way caregivers talked could have different impacts on the patient. Thus, they would be reminded to pay more attention to their way of communication and tone when talking to patients with suspected COVID-19 infection.

As the findings revealed by Lin et al. (2020), various types of media can support the learners. Our previous research proved that employing mobile devices and social networks allowed users to interact in different contexts (Lin, Deng, et al., 2019). Therefore, the online help service platform of mobile AR-integration contextual interactive healthcare training includes instant social communication tools (e.g., WeChat, QQ, Weibo, Blog), live broadcast we-media (e.g., Douyin, Bilibili), and asynchronous communication tools (e.g., Zhihu, Baidu Q&A). For instance, a family member of patients with suspected COVID-19 infection was anxious that they were wearing masks too long, causing damage to their skin. Then, she turned to instant social media for professional support, as shown in Figure 5.

Upon completion of each part, the caregivers could work on the interactive exercises provided at the end. These tests were expected to enhance the users' focus during the learning process. The interactive learning was designed with four interactive items, including multiple-choice, drag and drop, matching, and sequencing. Caregivers should wear medical surgical masks that closely fit their faces when in the same room as the patient with suspected COVID-19 infection. In this exercise, caregivers are asked to indicate the correct order of wearing a mask, and feedback will be provided based on their selection. Figure 6 shows the system interface of an assessment on mask-wearing. In the 'test', caregivers are asked to determine the correct order of mask-wearing procedures or operations by dragging the images to the corresponding positions.

4 | METHODS

This study sought to develop a mobile AR-integration contextual interactive healthcare training system by integrating contextual training and interactive exercises. The effects of the proposed system on healthcare education were investigated through a quasi-experiment. The impact of receiving ward teaching on healthcare education concerning the learning effect of care knowledge, the perceived support, anxiety and self-efficacies was also explored.

4.1 | Experimental procedures

Caregivers of patients with suspected COVID-19 infection were assigned to two groups. During the learning activity, both groups can learn nonlinear knowledge at their own pace. The time for the groups to complete their learning task was totally 80 min. The learning content was based on a nursing pamphlet for suspected COVID-19 cases. Both groups used the same learning content in the mobile learning activities. The experimental group learned through the mobile AR-integration contextual interactive healthcare training system, whereas the control group received e-pamphlet instruction in mobile devices. When launched on a tablet, caregivers in the experimental group could choose the learning content from navigation. They could learn in the default part order or select a desired part from the content list. They learned at their own pace by interacting with each button. They may watch AR models, animations or videos on mobile devices to understand knowledge. The control group received an introduction to the care environment and facilities for patients with suspected COVID-19 infection from nursing staff using a standard nursing e-pamphlet in mobile devices. The two groups completed the post-test and the post-questionnaire after 3 days of the learning activities. The experimental procedures are presented in Figure 7.

4.2 | Participants

The participants were the caregivers ($N = 91$) of 68 patients with suspected COVID-19 infection in South China. The mean age was 31.56 years, ranging from 25 to 42 years old. They participated in the study voluntarily and had signed the consent form. According to the experimental design, we randomly divided the caregivers of the 68 patients into experimental and control groups. The participants were allowed to terminate their participation at any time during data collection. As the number of caregivers could be different for each patient, and some participants might be reluctant to participate in the study or had withdrawn during the study, the final number of participants in the two groups varied greatly.

4.3 | Measuring scales

Three experienced nurses designed a healthcare knowledge test. It consisted of three sections: rules of care for patients with suspected COVID-19 infection in quarantine wards, protective equipment and

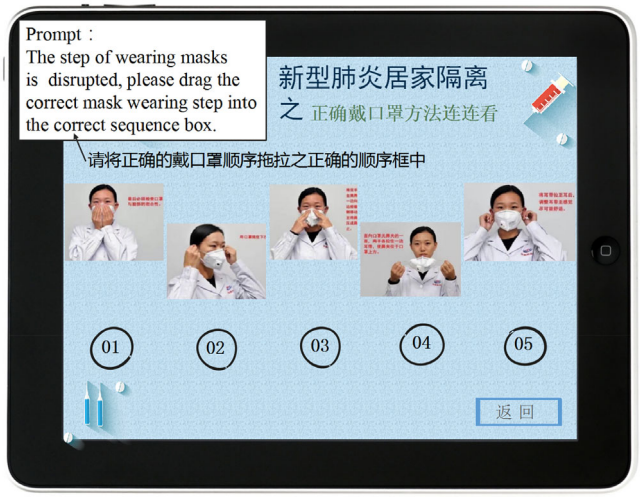


FIGURE 6 The system interface of an assessment on mask-wearing

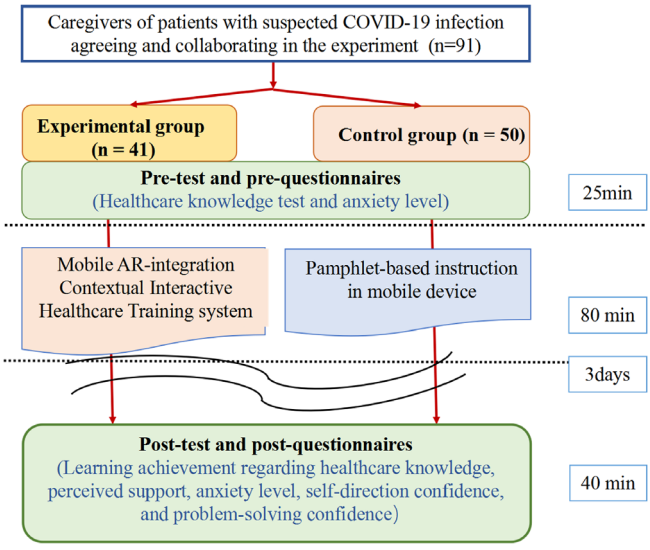


FIGURE 7 The experiment process

procedures and comforting the patient. There are three items in each section. The test consisted of seven multiple-choice items that were 10 points each, two matching items of 15 points each. The full score of the test was 100. To ensure the reliability and validity of the test items, two medical education experts were also involved in the development of the pre-test and post-test to inspect all items' content validity. The KR-20 reliability of pre-test and post-test were 0.84 and 0.86, respectively. The item discrimination index of pre-test and post-test were 0.36 and 0.35, respectively, implying that the knowledge test achieved its purposes (Doran, 1980).

Caregivers' anxiety was measured using an anxiety scale developed by Kao et al. (2014), and the questionnaire was modified by two experienced medical workers. The questionnaire consisted of five items scored on a five-point Likert scale. An example item was 'The outbreak of COVID-19 make me feel scared or terrified'. The alpha reliability coefficient for the scale is 0.88, showing good reliability in internal consistency.

The questionnaire on the perceived support of healthcare education was modified from the perceived technology-assisted questionnaire proposed by Lin et al. (2020). An example item was 'The social network of interactive learning help me with the medical healthcare of COVID-19 when I am in need'. There were five items in the questionnaire, which were scored on a five-point Likert scale. The Cronbach's α values were 0.89, indicating acceptable reliability.

The self-efficacies questionnaire was adapted from the measuring scale of the Mobile-assisted Learning questionnaire developed by Lin, Tang, et al. (2019). The Cronbach's α value of the two subscales (perceived self-direction confidence and perceived problem-solving confidence) were 0.91 and 0.89, respectively. Thus, the questionnaire is considered to have acceptable reliability. Each subscale included five items. An example item of perceived self-direction confidence is 'I feel confident to evaluate the status of my emotions with the aid of applications on the mobile devices'. An example item of perceived problem-solving confidence is 'I feel confident to devise a solution when coming across care problems in the outbreak of COVID-19'.

5 | RESULTS

This study developed a mobile AR-integration contextual interactive healthcare training. We investigated via experiment the effects of this system on the learning effects of caregivers who were responsible for providing care to patients with suspected COVID-19 infection. This section discusses the study results on various dimensions of mobile contextual interactive healthcare training, including learning effects regarding healthcare knowledge, anxiety level, perceived support, perceived self-directed confidence and perceived problem-solving confidence.

5.1 | Learning effect regarding healthcare knowledge

Table 1 illustrates the results of analysis of covariance (ANCOVA) on the medical healthcare knowledge test score of the two groups. First, the test of the homogeneity of regression coefficients between groups did not reach the significant level ($F = 0.324$, $p = 0.591 > 0.05$), which meant that a further statistical test of ANCOVA could be carried out. Second, excluding the impact of the covariate (pre-test score of learning effect of caregivers), it showed that $F = 7.301$ and $p = 0.019 < 0.05$, indicating that the two groups differed significantly. Based on the findings, the knowledge of health care for the caregivers of the experimental group (M = 92.33, $SD = 14.92$) was significantly higher than that of the control group (M = 80.23, $SD = 20.19$). Such results indicate that the experimental group learned through the mobile AR-integration contextual interactive healthcare training system brought better learning effects on knowledge of health care than the control group received e-pamphlet instruction.

5.2 | Anxiety levels

To explore whether the perception of anxiety was significantly different between the groups, an ANCOVA was used to analyze the pre- and post-questionnaire anxiety scores of the two groups. This method elucidates the impact of different healthcare education instruction modes on anxiety levels. The test of homogeneity of regression revealed that the regression coefficients were similar ($F = 3.159$, $p = 0.088 > 0.05$). The assumption of homogeneity of regression shows that an ANCOVA could be performed.

Table 2 shows the results of the ANCOVA. After excluding the impact of the covariate (pre-questionnaire anxiety score of caregivers) on the dependent variable (post-questionnaire anxiety score of caregivers). The items in the anxiety questionnaire were scored in a

TABLE 1 Result of analysis of covariance on the knowledge of health care questionnaire for caregivers

Group	*N*	Mean	*SD*	Adjusted mean	*SE*	F	η2
Experimental group	41	92.33	14.92	91.93	2.97	7.301*	0.097
Control group	50	80.23	20.19	80.64	2.93		

*$p < 0.05$.

TABLE 2 Result of analysis of covariance on anxiety questionnaire

Group	*N*	Mean	*SD*	Adjusted mean	*SE*	*F*	*η2*
Experimental group	41	4.16	0.06	4.16	0.06	4.013*	0.031
Control group	50	3.96	0.07	3.96	0.07		

*$p < 0.05$.

reverse manner. The means of the experimental group and the control group were 4.16 and 3.96, respectively. The greater number means a lower level of anxiety. The *SD* of the experimental group and the control group were 0.06 and 0.07, respectively. The ANCOVA result found that the anxiety of the experimental group was significantly lower than that of the control group ($F = 4.013$, $p < 0.05$, $\eta 2 = 0.031$). This result suggested that providing instructions with the mobile AR-integration contextual interactive healthcare training system could significantly reduce the anxiety levels of caregivers.

5.3 | Perceived support

The degree of perceived support among the participants in the pre-questionnaire showed no significant difference ($t = 2.546$, $p > 0.05$). Thus, before the experiment, the two groups had equivalent perceptions of support of receiving instructions on the rules of care for patients with suspected COVID-19 infection.

Table 3 shows the *t* test results comparing the post-questionnaire scores of the two groups. The means and *SD* of the questionnaire result of perceived support were 4.29 and 0.82 for the experimental group, 3.98 and 0.95 for the control group. The perception of support was significantly different between the two groups of participants ($t = 3.078$, $p < 0.01$), implying that most caregivers who learned through the mobile AR-integration contextual interactive healthcare training system perceived more aid from the instructions on the care of patients with suspected COVID-19 infection, compared with the conventional approach (e-pamphlet instruction in mobile devices).

5.4 | Self-efficacies regarding the mobile AR-integration contextual interactive healthcare training system

In terms of self-efficacies, the *t* test results of the pre-questionnaire showed no significant difference between the two groups ($t = 6.187$, $p > 0.05$). The two groups had equivalent self-efficacies before the intervention. As shown in Table 4, the post-test scores of perceived self-directed confidence showed a significant difference between the experimental and control groups ($t = 5.156$, $p < 0.05$). This implies that the mobile AR-integration contextual interactive healthcare training system had great potential for improving the perceived self-direction confidence of self-efficacies. In addition, as shown in Table 4, the post-test scores of perceived problem-solving confidence ($t = 6.097$, $p < 0.05$) between the two groups also differed significantly. The mobile AR-integration contextual interactive healthcare training system enhanced students' self-efficacies, especially in the perceived problem-solving confidence. Caregivers with the mobile AR-integration contextual interactive healthcare training system performed better in terms of self-efficacies than those with e-pamphlet instruction in mobile devices.

TABLE 3 Questionnaire result of analysis of perceived support

Group	*N*	Mean	*SD*	*t*
Experimental group	41	4.29	0.82	3.078**
Control group	50	3.98	0.95	

**$p < 0.01$.

6 | DISCUSSION

The purpose of this study was to investigate the impact of using mobile AR-integration contextual interactive healthcare training on knowledge gain, anxiety level, perceived support, and perceived self-efficacies of caregivers of patients with suspected COVID-19 infection. The contextual interactive healthcare training was designed based on a nursing brochure for patients with suspected COVID-19 infection. The content included information on rules of quarantine wards, protective equipment and procedures and approaches for comforting patients. Results showed that these caregivers positively perceived the value of using the mobile AR-integration contextual interactive healthcare training system. By using contextual role-play, the contextual interactive healthcare training system significantly improved the learning effects, perceived support of the quarantine care instructions, as well as the self-efficacies (perceived self-directed confidence and perceived problem-solving confidence) of caregivers of patients with suspected COVID-19 infection. The anxiety levels of caregivers were reduced significantly after the experiment. These findings are consistent with those of Ros and Neuwirth (2020), whose study also found that the caregivers feel more confident and ready to care for the COVID-19 patients after tutorials in training.

This study has added value to current research, given the lack of studies addressing the use of contextual interactive healthcare training to help caregivers learn health care knowledge with suspected COVID-19 infection. Questionnaires and knowledge tests were

TABLE 4 Questionnaire result of analysis of self-efficacies

Dimensions	Group	*N*	Mean	*SD*	*t*
Perceived self-direction confidence	Experimental group	41	4.31	0.43	5.156*
	Control group	50	3.66	0.35	
Perceived problem-solving confidence	Experimental group	41	4.58	0.29	6.097*
	Control group	50	3.79	0.37	

*$p < 0.05$.

conducted. The results showed that the experimental group was superior to the control group regarding the perception of self-efficacies (perceived self-directed confidence and perceived problem-solving confidence), perceived support, anxiety level and test scores relating to the instructions provided for the rules of care for patients with suspected COVID-19 infection during quarantine. This finding suggested that healthcare education instructions could be provided via incorporating mobile AR-integration contextual interactive learning into the healthcare training system in place of the conventional e-pamphlet instruction in mobile devices. This system could help caregivers learn the rules and knowledge for the care of patients with suspected COVID-19 infection. These results were consistent with the findings by Hu et al. (2021), who reported the potential of using a contextual interactive environment or multimedia to improve learners' knowledge of COVID-19 and their perception of the learning process.

The benefit of contextual interactive learning may lie within their authentic contexts and interactive design, as interactive interfaces are believed to promote learning (Sung et al., 2019). Simeone et al. (2017) pointed out that proper care instructions for patients with severe diseases or injuries can reduce their anxiety and increase their satisfaction with medical services. However, most healthcare instructions are conventionally provided by nurses using printed materials or e-pamphlet on mobile devices, with minimal interactions in the situation of the COVID-19 pandemic. Especially, caregivers often have difficulty remembering things after the instruction session. They are unfamiliar with the care environment and equipment for patients with suspected COVID-19 infection as they do not have the opportunity to practice and use their knowledge, thereby limiting the effectiveness of the instructions. The use of contextual interactive healthcare training provides an opportunity to fill this gap. The contextual designs of interactive learning are compatible with the habits of the public. Interactive learning thus has the edge over the conventional learning mode. The replacement of conventional e-pamphlet care instruction in mobile devices is not only significant in the economic sense (e.g., more frequent updates of the guidance of preventing the spread of SARS-CoV-2 infection), it can also provide emotional value to patients through videos, games or other interactive activities.

Meanwhile, analysis of anxiety in the present study showed that interactive learning leads to a reduction in anxiety of the caregivers. The anxiety levels of caregivers may be primarily affected by the patient's condition. The main goal of using contextual interactive learning is to help increase their understanding of the care environment of patients with suspected COVID-19 infection and the means to care for the patients. Several studies have shown that the levels of anxiety of caregivers are highly correlated with the patients' conditions, and their anxiety may last until the patients recover (Lee, 2020). These values correlate favourably with Chen et al. (2020) and further support the idea that the interactive learning approach could be helpful in reducing parental levels of anxiety. Thus, incorporating interactive learning into contextual healthcare training may have a direct or indirect effect on the relief of anxiety of caregivers. This effect may become apparent with long-term studies in the future.

7 | CONCLUSIONS, INSIGHTS AND LIMITATIONS

To sum up, this study contributes to the literature by providing empirical evidence for the effects of using the contextual interactive healthcare training system compared with the e-pamphlet instruction in mobile devices on caregivers of patients with suspected COVID-19 infection. The contextual interactive healthcare training system is effective in terms of caregivers' learning achievements, perceived support, self-efficacies and reducing anxiety during quarantine. The implications of our findings are discussed as follows.

First, during the outbreak of the novel coronavirus (COVID-19), most regional medical centres were unable to provide sufficient medical resources and conditions for quarantining patients with suspected COVID-19 infection. Therefore, the proposed contextual interactive healthcare training system on caregivers of patients with suspected COVID-19 infection is considered as one of the important means of self-protection and blocking the spread of COVID-19. Moreover, it has been suggested that the responsibility of patient care does not lie solely on nursing staff but also on caregivers. Support from caregivers with proper knowledge and attitude can significantly affect patient recovery (Lee, Jakab, et al., 2019; Merodio et al., 2020). Thus, providing effective instructional strategies that equip caregivers with the required knowledge for taking care of patients with suspected COVID-19 infection can be an important reference for nursing services and healthcare education. Authorities or institutes are encouraged to use the mobile AR-integration contextual interactive training system to develop the caregivers' ability to provide proper care for the patients with suspected COVID-19 infection. The mobile AR-integration contextual interactive healthcare training system can be put into healthcare training more widely and are worth developing.

Second, relieving the anxiety of caregivers and avoiding them from infection is attainable with the proposed system when taking care of patients with suspected COVID-19 infection. This situation is similar to that of providing care for patients in the intensive care unit (ICU). Given the unique environment of the ICU, caregivers are often not allowed to enter the wards; thus, they cannot always accompany the patients (Lee, Wang, et al., 2019). The medical equipment in the ICU is complex and diverse, which may bring heavy mental burdens and anxiety to the caregivers (Edelhauser & Lupu-Dima, 2020; Lam et al., 2020). Hence, the mobile AR-integration contextual interactive healthcare training system is also applicable to the training of caregivers who provide care for ICU patients.

Nonetheless, this study had several limitations. First, the mobile AR-integration contextual interactive healthcare training system was developed for adults. The study population was limited; thus, the results may not be generalized to special cases, such as caregivers in gynaecology, obstetrics or anesthesiology. Future research should take into consideration the characteristics and needs of different medical departments to explore additional applications and conditions (Edwards et al., 2017; Sonneville et al., 2017). Second, although both groups learned from the same material content that was adapted from a professional nursing brochure, the subtle differences in the content

structure of the material between the groups caused by the interaction design may affect the experimental results. In addition, other effective learning tools or strategies (such as the motivation instrument) may be integrated into the implementation of mobile AR-integration contextual interactive healthcare training system, which may be a desirable direction for providing better instructional facilities for caregivers. When the related literature and the results of this study are taken into consideration, it could be beneficial to use AR-integration contextual interactive learning when training healthcare caregivers.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. This article does not contain any studies with human participants or animals performed by any of the authors.

PEER REVIEW

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DATA AVAILABILITY STATEMENT

Data is available upon request from the first author. The data is not openly available elsewhere. The research obtained the Institutional Review Board (IRB) from the Guangdong Provincial Engineering Technology Research Centre for Smart Learning.

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