



## Research article

# Perceptions and needs for a community nursing virtual simulation system for Chinese nursing students during the COVID-19 pandemic: A qualitative study

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## ABSTRACT

**Background:** Virtual simulation systems are being increasingly used in the field of nursing education. However, these systems are mostly designed based on the perspective of developers, and the needs of the end users are often neglected. The purpose of this study was to explore the perceptions and needs of Chinese undergraduate nursing students for the development of a community nursing virtual simulation system.

**Methods:** This was a descriptive qualitative study enrolling 12 undergraduate nursing students at a University in China. Data were collected through semi-structured interviews. The content analysis method was used for data analysis.

**Result:** Three themes and 15 sub-themes were extracted from this study: (1) Positive perceptions regarding virtual systems: a) Provides space for trials and errors, b) Not limited by time and space, c) Provides auxiliary tools; (2) Design and use requirements: a) Performance needs, b) Contents design needs, c) Appearance design needs, d) Support Needs; (3) Competency enhancement needs: a) Community nursing practice ability, b) Critical thinking ability, c) Independent thinking ability, d) Ability to deal with emergencies, e) Teamwork skills, f) Self-efficacy, g) Resilience, h) Interpersonal communication skills.

**Conclusion:** Designers and engineers should consider students' needs, aim to improve students' abilities, improve the diversity, the scientific and rigor of content, and enhance user immersion and interest. The system should be programmed to provide real-time feedback, timely technical and professional support, in order to optimize use experience of nursing students.

## 1. Introduction

Community health nursing is a course that combines nursing and public health-related knowledge. The course aims to develop students' ability to provide continuous, dynamic, and integrated care for populations in community settings [1,2]. In China, the teaching model of community health nursing practice mainly consists of situational simulation and clinical novice teaching, by which students gain community experience to augment their ability for clinical thinking, interpersonal communication, and case management [3–5]. However, traditional practice teaching does not equip nursing students with adequate skills to face real-world

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scenarios [6]. In addition, since the outbreak of COVID-19 pandemic, the training of nursing students was affected. The students received theoretical courses online and were not able to practice at community health centers, resulting in a lack of awareness of community health nursing. Therefore, there is a need to develop a new teaching model to help nursing students enhance their ability to practice in community nursing settings and improve the effectiveness of learning.

Virtual reality is a modern computer-based technology that generates a virtual environment with realistic visual, auditory, and tactile integration [7]. Virtual simulation systems enable users to explore and operate in the virtual environment with the help of electronic devices or software, thus recreating the experience of the real environment [8]. Depending on the degree of immersion, virtual simulation can be divided into 2 types: non-immersive and fully immersive. The former entails the use of a computer monitor or television as the medium, while the latter uses a head-mounted display as the medium [9].

In recent years, virtual simulation technology is being gradually applied in the field of nursing education [10]. Because of its immersive, interactive, and conceptual features, virtual simulation systems have been shown to compensate for the shortcomings of traditional nursing practice teaching and improve the quality of undergraduate nursing teaching [11–14]. Several studies have shown that virtual simulation systems can help nursing students grasp clinical skills such as handling of foreign objects in the airway, intravenous catheterization, and phlebotomy [15–17]. Studies have also shown that the use of virtual simulation systems can significantly improve nursing students' clinical thinking skills, self-directed learning, self-efficacy, and reflective skills [18,19]. Besides, virtual reality technology was successfully applied to interprofessional education (IPE), especially in the context of the COVID-19 pandemic [20]. Students who received virtual IPE exhibited better interprofessional competencies [21]. However, virtual simulation systems are largely designed based on the perspective of developers without considering the needs of users. Therefore, there are some shortcomings in the application of virtual simulation systems to nursing education, such as the lack of flexibility and insufficient simulation, which hamper student participation and lead to poor usage perception [22–24]. To fully leverage the advantages of virtual simulation systems, the functionalities of virtual simulation systems for nursing students should be tailored to their usage needs [25, 26].

User-centered design (USD) is an evidence-based design approach that takes into cognizance the needs, expectations, and constraints of end users when designing information systems. The aim of USD is to optimize the user experience and improve engagement with the target users over time [27–29]. Several studies have shown that USD can improve the effectiveness of telemedicine tools [30, 31]. The World Health Organization recommends that USD be incorporated into the entire process of information system design [32].

We have developed a prototype of a virtual simulation system in the early stage. The aim of this study was to understand the attitudes, perspectives, and needs of undergraduate nursing students towards the developed community nursing home visit virtual simulation system prototype, in order to help designers optimize and iterate the system prototype, and provide a reference for the development of other virtual simulation systems.

## 2. Methods

### 2.1. Study design

We adopted a descriptive qualitative research approach. Data were collected using semi-structured interviews. The descriptive qualitative method can better elicit the participants' perspectives regarding the requirements and needs pertaining to community nursing virtual simulation systems in factual terms [33].

This study was reported using the Consolidated Criteria for Reporting Qualitative Studies (COREQ) to minimize the risk of incomplete data reporting [34](Appendix 1).

### 2.2. Setting and sampling

We used purpose sampling method to select students from the School of Nursing at Capital Medical University for inclusion in this study. Due to the COVID-19 pandemic, the interviews of this study were held in the Tencent Meeting (a Chinese online conferencing software) from July to August 2022. There is no third person except for the researchers and participants.

Inclusion criteria were the following.

1. Third-year nursing undergraduates who had completed the community nursing course within one month.
2. Had experience in using virtual simulation experimental teaching system.

Exclusion criteria were the following.

1. Students who had studied abroad or had taken a break from school were not eligible for inclusion.
2. Students who required sick leave were also excluded from this study.

Participants continued to be enrolled until data saturation [35].

A total of 12 students (One male, 11 female; numbered P1–P12) participated in the study. The mean age of the participants was (21.0 ± 0.7) years. Ten interviewees were of Han ethnicity nationality, one was Mongolian, and one was of Miao ethnicity. Seven of the respondents lived in Beijing, two in Henan Province, and the remaining three in Tianjin, Jiangxi, and Sichuan provinces, respectively. The characteristics of participant were shown in Table 1.

### 2.3. Participant recruitment

The researcher contacted a class cadre, who issued a recruitment notice to all third-year nursing students at the undergraduate level. Using the principle of maximizing differences, students with different demographic and sociological characteristics, including gender, ethnicity, and place of residence, who met the inclusion criteria, were selected for inclusion in the study.

### 2.4. Data collection

One of the researchers (ZL) conducted face-to-face interviews. The interview outline were designed according to the purpose of the study. Then, pilot interviews were conducted with 2 students to improve the questions. The final interview outline was shown in Table 2.

Before starting the interview, the researcher (ZL) has received systematic training in qualitative research and has interview experience. The researcher informed the participant about the purpose and significance of the interview. The participants were assured that all information obtained during the interview would only be used for research purposes. After obtaining consent for recording, the portable recorder was turned on. During the interview, the interviewer listened carefully to the interviewee's statements, using appropriate techniques such as follow-up questions, repetition, clarification, response, and summary, to elicit appropriate responses. The interviewer avoided baiting questions to the students and recorded key information of the interview. At the same time, attention was paid to observing and recording the non-verbal cues, such as pauses, smiles, body language, and emotional changes. The duration of the interviews ranged from 30 to 60 min. A reflective diary was maintained after each interview. At the end of the interview, the interviewees were thanked for their participation and the possibility of re-contact was indicated for subsequent additions to the information.

### 2.5. Data analysis

Data collection and analysis were conducted simultaneously. The researcher (ZL) transcribed the audio recordings into text within 24 h after each interview, reconfirmed with the interviewees for any uncertainties, and combined them with memos to form the final text. The content analysis method was used for data analysis [36]. Two researchers (ZL and QHZZ) read the text through several times to obtain an overall sense. The selection criteria were determined by the purpose and questions of the research. Based on this standard, the text content was classified, and meaningful statements were extracted and encoded. The semantic units were carefully read, analyzed, and summarized to identify sub-themes. Subsequently, the researchers analyzed the similarity and differences of the sub-themes and condensed them into several main themes. The cycle was continued until saturation was observed, i.e., when no new themes or sub-themes emerged [37].

### 2.6. Validity and rigor

To ensure the rigor of the study, this study was conducted in accordance with the four criteria proposed by Lincoln and Guba [38]: credibility, fittingness, auditability, and confirmability. First, to improve data credibility, two researchers independently analyzed the transcripts. Moreover, the interview transcripts were provided to the respondents to elicit their feedback regarding the consistency between the recordings and the text. Second, to ensure the suitability of the research subjects, only undergraduate nursing students who had participated in virtual simulation experimental teaching were selected for this study. To ensure the auditability of the study results, the data were independently coded by two researchers, and inconsistencies in coding were discussed and decided by a third researcher (WWL). Finally, to ensure the confirmability of the study, all interviews were recorded, making it easy for the researcher to review the record at any time.

**Table 1**  
Characteristics of participants.

Number	Gender	Age	Ethnic	Family Location
P1	Female	21	Han	Beijing
P2	Female	21	Han	Beijing
P3	Female	21	Han	Tianjing
P4	Female	21	Han	Beijing
P5	Male	22	Han	Sichuan
P6	Female	21	Han	Beijing
P7	Female	21	Han	Beijing
P8	Female	20	Mongolian	Beijing
P9	Female	20	Han	Henan
P10	Female	23	Han	Henan
P11	Female	21	Miao	Jiangxi
P12	Female	21	Han	Beijing

**Table 2**  
Interview outline.

1.	Have you ever known about virtual reality simulations system before? What do you think are the advantages of virtual reality simulations? What are the disadvantages?
2.	If you are invited to participate in the development of a community nursing virtual simulation system, what functions would you add to the system?
3.	If you are invited to participate in the development of a community nursing virtual simulation system, what elements do you want that can enhance your interest in using the system? What elements don't you want?
4.	If the virtual simulation system were to be intergrated into education, what capabilities do you want to improve through the virtual simulation system?
5.	If a virtual simulation system for community home visits was to be developed, what are your needs for the development of the virtual simulation system?

### 3. Results

Data analysis identified the following three main themes from the interviews: positive perceptions regarding virtual systems; design and use requirements; capacity enhancement needs (Table 3).

#### Theme 1. Positive perceptions regarding virtual systems

##### 3.1. Provides space for trials and errors

Nursing students believed that the virtual system provides space for trials and errors which may not be available in the real-world setting. This enables them to master the operation process and consolidate their knowledge.

P5: "While using the virtual system, one can try many times and one can be more proficient in the process and in the mastery of knowledge."

In addition, the virtual simulation system also plays a role in checking the gaps.

P4: "The operation of the system shows a lot of details that we usually do not pay attention to otherwise. This can provide us a wake-up call."

##### 3.2. Not limited by time and space

Nursing students believed that the virtual simulation system was not limited by laboratory equipment and experimental time, enabling any-time any-where use of the system by nursing students.

P5: "I think one of the advantages of virtual simulation system is that it is not limited by time and space. Students can use virtual simulation systems wherever they are, as long as the Internet is good."

##### 3.3. Provides auxiliary tools

Nursing students believe that the virtual simulation system can be used as an auxiliary learning tool to help students consolidate their knowledge and skills to prepare for future clinical practice.

P10: "I think the virtual simulation system can serve as a complement to classroom learning."

P12: "The system can be a good aid, but it cannot be used as the primary learning tool."

#### Theme 2. Design and use requirements

##### 3.4. Performance needs

Performance needs refer to the level and ability of performance required by the system to ensure a good user experience when performing specific tasks, including high-capacity system memory and fluency.

**1) Automatic save function:** Nursing students expressed hope that the virtual simulation system can be programmed to save the steps completed by the student anytime they are forced to exit due to operational errors. This would avoid the need to start again from the beginning reducing the time wasted in repeating actions, thereby achieving a positive user experience.

P3: If you do it wrong, you have to do it all over again. There is no way to go back to the previous step. So I would like to be able to go back to the previous step instead of starting all over again when I make a mistake while using the virtual system."

P4: "When using the virtual system, I think there should be an automatic saving function."

**2) Fluency:** Nursing students believed that the fluency of the virtual simulation system was important for a positive experience.

**Table 3**  
Themes and sub-themes concerning Chinese nursing students' perceptions and needs for a community nursing virtual simulation system.

Themes	Sub-themes	Quotes
1 Positive perceptions regarding virtual systems	1.1 Provides space for trials and errors	P5: "If you use the virtual system, you can try many times and you can be more proficient in the process and in the mastery of knowledge."
	1.2 Not limited by time and space	P5: "I think one of the advantages of virtual simulation system is that it is not limited by time and space. Students can use virtual simulation systems wherever they are, as long as the internet is good."
	1.3 Provides auxiliary tools	P10: "I think the virtual simulation system can serve as a complement to the classroom learning."
2 Design and use requirements	2.1 Performance needs	
	1) Automatic save function	P3: "I would like to be able to go back to the previous step instead of starting all over again when I make a mistake while using the virtual system."
	2) Fluency	P12: "I wish the virtual system to be more fluid and keep up with my pace."
	2.2 Contents design needs	
	1) Diverse scenarios	P4: "It would be more interesting if we could get a deeper understanding of community health nursing through different scenarios."
	2) Close to the real workplace	P7: "I would like to get more practical experience of real community nursing work so that I do not feel unfamiliar when I participate in community nursing practice in the future."
	3) Real-time updated cases	P5: "If they are very classic cases, they should be kept. But if some of them are old, they need to be eliminated in time."
	4) Needs to be Interesting	P5: "I think the system design can draw lessons from some games, such as setting daily goals, getting rewards after completing tasks, etc."
	2.3 Appearance design needs	
	1) Easy to read	P5: "I wish the system had a larger font, so that I could read it more easily."
	2) Attractive appearance	P5: "The modeling or characters must be aesthetically pleasing. For me it is the most important thing."
	3) Clear module layout	P9: "The interface should be simple so that common functions can be easily found."
	2.4 Support Needs	
	1) System support needs	
① Provide timely and detailed feedback	P1: "I hope the virtual system could tell me why I am wrong and show me the right way."	
② Navigation function	P2: "I hope that when I do not know how to proceed to the next step, the system can prompt me by showing a small screen or animation to guide me after a period of time."	
2) Professional support needs	P1: "The virtual simulation system is a completely new thing to us and I hope that the teacher can introduce the procedure for the first time."	
3) Technical support needs	P8: "I think the virtual system should provide a phone number or mailbox for at least two technical staff members."	
4) Information support needs	P5: "There should be a separate module in the virtual system to provide some information about future developments in community nursing."	
3 Capacity enhancement needs	3.1 Community nursing practice ability	
	1) Community assessment ability	P8: "In the virtual simulation system, I hope that we can find out which aspects of the patient's living environment are not conducive to the patient's health."
	2) Family assessment and individual assessment ability	P10: "In my opinion, the virtual patient's situation should be assessed in detail, such as inquiring about the patients' health condition, medication, family members, living environment etc., and we should also perform a simple checkup of the patient. Then we can finally assess what kind of guidance the patient really needs."
	3) Health education ability	P1: "I hope that the virtual simulation system enables us to practice how to provide health education to patients, so that we can accumulate relevant experience in health guidance."
	3.2 Critical thinking ability	P3: "I think the virtual simulation system can help develop my problem identification and solving skills."
	3.3 Independent thinking ability	P4: "I think the virtual system can develop our ability to think independently."
	3.4 Ability to deal with emergencies	P11: "Some cases of emergencies can be designed in the virtual system so that we can try to solve them by ourselves."
	3.5 Teamwork skills	P12: "In my opinion, a good virtual simulation system should not only help us to improve our health management ability, but also improve the teamwork ability."
	3.6 Self-efficacy	P6: "I have not independently completed any nursing operations for patients in the hospital because of the epidemic, so I have some fears about operations and cannot overcome the psychological barriers."
	3.7 Resilience	P2: "I hope that (when using the virtual system) I can exercise my psychological tolerance because I think I will encounter situations in which my colleagues or patients may give me a hard time during my internship."
	3.8 Interpersonal communication skills	P12: "I hope that the virtual system can help us to build an emotional connection with residents in the community."

Therefore, nursing students wanted the community virtual simulation teaching system to be more fluent.

P12: "I have encountered problems with the system not being able to keep up with my pace of operation. For example, I want to perform a medication dispensing, but the system may still be displaying the intravenous infusion via an indwelling needle. So I wish the virtual system to be more fluid and keep up with my pace."

### 3.5. Content design needs

Content design needs refer to users' requirements for the functions and module contents contained in the system, including diverse scenarios, close to the real workplace, real-time updated cases, and needs to be interesting.

**1) Diverse scenarios:** The virtual simulation system should be able to present a variety of case scenarios so that nursing students can fully understand the content and process of community nursing practice in different scenarios.

P4: "It would be more interesting if we could get a more comprehensive understanding of community health nursing through different scenarios."

P9: "We can design cases for community emergency response, or refer to real chronic disease cases in the community."

**2) Close to the real workplace:** Nursing students hoped to experience the real community nursing service process through the virtual simulation system. Therefore, developers should refer to the real community practice environment and the work content of community nurses to design cases for a better-simulated experience.

P7: "We lack the opportunity to go to community practice. I hope that the virtual simulation system can present actual community nursing work scenarios. In this way, I can get more practical experience and would not feel unfamiliar when I participate in community nursing practice in the future."

**3) Real-time updated cases:** Nursing students believe that the community virtual simulation system should update the cases and eliminate cases that have been presented for a long time.

P5: "You can choose real cases from the community and keep them up to date. If they are very classic cases, they should be kept. But if some of them are old, they need to be eliminated with time."

**4) Needs to be interesting:** Nursing students wanted designers to learn from electronic games to enhance nursing students' interest in learning. For example, set daily goals, get rewards after completing tasks, set different endings according to the completion of tasks, set ranking lists, etc.

P5: "I think the system design can draw lessons from some games, such as setting daily goals, getting rewards after completion of tasks, etc."

P6: "I think we can learn from the different endings in the game. For example, when I choose one sentence I will get a normal ending, and after choosing another sentence I will get a better ending."

P8: "I think we can get a ranking list to motivate students."

P11: "I hope the system can be designed with reference to the escape room game to enhance the fun of the system."

### 3.6. Appearance design needs

Nursing students wanted the virtual environment and character modeling to be as realistic, simple, and beautiful as possible to increase immersion. The nursing students also emphasized that the interface of the virtual simulation system should have soft tones and a logical flow of modules.

**1) Easy to read:** Nursing students hoped that the fonts in the operation interface of the virtual simulation system were big enough and easy to read.

P5: "I wish the system had a larger font so I could read it more easily."

**2) Attractive appearance:** Nursing students wanted the virtual environment and character modeling to be as realistic, beautiful, and brightly colored as possible to increase immersion.

P5: "The modeling or characters must be aesthetically pleasing. For me, it is the most important thing."

P8: "Because the interface of the virtual system I used was gray and dull, I felt a little depressed. I hope that the color scheme of virtual system can be a little bit attractive."

**3) Clear module layout:** Nursing students emphasized that the module layout in the virtual simulation system should be clear. An automatic navigation function should be added to guide the nursing students appropriately in order to facilitate their operation.

P9: "The interface should be simple and intuitive so that common functions can be easily found."

P2: "There could be a small map in the upper right corner. For example, when I take a patient to the examination room, I could just click on the small map and go straight in."

### 3.7. Support Needs

Support requirements refer to the support expected by users when using the system, including system support needs, technical

support needs, professional support needs and information support needs.

**1) System support needs:** System support refers to the support provided by the system to users. Good system support can help users solve the difficulties encountered during the operation, including providing timely and detailed feedback and navigation function.

①**Provide timely and detailed feedback:** Nursing students hoped that they can receive timely feedback from the virtual simulation system so that they can understand the reasons for their mistakes and avoid errors as much as possible. This would help improve learning efficiency and reduce the time and effort cost due to repeated trials and errors.

P1: "The downside is that you can only see what you got right or wrong when you use the virtual system, but it does not show why you were wrong. So I hope the virtual system could tell me why I am wrong and show me the right way."

P10: "I hope the system can provide more detailed feedback. If I make a mistake in any step, the system can provide some explanation instead of just listing the simple information."

②**Navigation function:** Nursing students hoped that in training mode, the system can provide automatic navigation and reminder functions to guide their subsequent operations, reduce trial and error during the operation process to save time.

P2: "I hope that when I do not know how to proceed to the next step, the system should prompt me with a small screen or animation to guide me after some time."

**2) Professional support needs:** Nursing students expressed the need for the availability of nursing teachers to answer their questions about the operation when using the virtual simulation system. Interact between the teacher and students during the use of the system can improve the students' enthusiasm and improve the efficiency of knowledge transformation.

P1: "The virtual simulation system is a completely new thing to us and I hope that the teacher can introduce the procedure. "

P5: "I think the teacher can also interact with the students when using the virtual system, such as asking open questions during operation or posting tasks for students to complete, and then the teacher can provide feedback based on the student's answers."

**3) Technical support needs:** Nursing students expressed the need to get timely support from the technical staff when using the virtual simulation system.

P8: "I think the virtual system should provide a phone number or mailbox for at least two technical staff members. "

**4) Information support needs:** Nursing students wanted to have access to new information such as the current status of community health nursing development and disease guidelines through the virtual simulation system.

P5: "There can be a separate module in the virtual system to provide some information about future developments in community health nursing."

P11: "On the home page, a link can be provided to all the latest guidelines for the care of common diseases in the community so that we can check them anytime."

### Theme 3. Capacity enhancement needs

#### 3.8. Community nursing practice ability

Community nursing practice ability refers to the ability of nursing students to apply their knowledge to community nursing practice, accurately evaluate and analyze the health status of communities, families, and individuals, formulate and implement health intervention plans, carry out health education, and conduct community nursing assessments, so as to provide high-quality nursing services for community residents.

**1) Community assessment capability:** Nursing students hoped that the community virtual simulation system will help improve their competency in community nursing assessment, thereby preparing them for the delivery of community nursing services in the real-world setting.

P8: "In the virtual simulation system, I hope that we can find out which parts of the patient's living environment are not conducive to the patient's health, such as residential buildings that are very high and require use of stairs, which are not easy for the elderly to move around, or doors that are very old and difficult to open."

**2) Family assessment and individual assessment ability:** Nursing students hoped that the community virtual simulation system would help improve their family assessment ability in order to identify the health problems and needs of the family and to make corresponding home care plans.

P11: "I hope that we can walk around the virtual patient's house, look carefully, and assess the patient thoroughly."

P10: "In my opinion, the virtual patient's situation should be assessed in detail, such as inquiring about the patient's health condition, medication, family members, living environment, etc., and we should also perform a simple checkup of the patient. Then we could finally assess what kind of guidance the patient needs."

**3) Health education ability:** Nursing students hoped to improve their health education ability through community virtual simulation systems so that they can correctly apply health knowledge in the future and provide health education and health management-related consulting services for community residents.

P1: "Sometimes I did not know how to educate patients correctly. I hoped the virtual simulation system could enable us to practice how to provide health education to patients so that I can accumulate relevant experience in health guidance."

### 3.9. Critical thinking ability

Some nursing students hoped that the virtual system for community nursing practice can improve their assessment, problem-identification, and problem-solving skills, in order to provide quality community nursing services.

P3: "I think the virtual simulation system can develop my problem-identification and solving skills. Because I need to observe the surrounding environment and patients to identify nursing problems during community home visits. However, this aspect is largely neglected in classroom learning."

### 3.10. Independent thinking ability

Nursing students hoped to practice independent thinking ability through the community virtual simulation system so that they can analyze and solve problems on their own in the future.

P4: "In the simulation teaching, we mostly work in groups to complete cases. But in the virtual system, we do it all by ourselves. So I think the virtual system can develop our ability to think independently."

### 3.11. Ability to deal with emergencies

Some nursing students expressed that their ability to deal with emergencies was insufficient. They hoped to improve their ability to deal with emergencies through the community virtual simulation system.

P11: "In the community practice, we may encounter some unexpected situations. It is important for us to solve these problems. The virtual system can include simulated case scenarios of emergencies so that we can try to solve them by ourselves."

P2: "I would like to improve my ability to deal with emergencies. I hope the virtual simulation system can provide some case scenarios such as injuries sustained by elderly people due to falls, cases of hypertension, or fainting, for me to practice. This will help me to stay calm when I encounter these situations in reality."

### 3.12. Teamwork ability

Nursing students believed that teamwork ability is one of the core competencies of community health nurses. They hoped to work with other doctors or nurses in the virtual simulation system in order to practice their teamwork skills.

P12: "The virtual simulation system I used before had only nurses. There were no doctors in the virtual system. In my opinion, a good virtual simulation system should not only help us to improve our health management ability, but also improve teamwork ability."

### 3.13. Self-efficacy

Due to the COVID-19 pandemic, nursing students lacked opportunities to practice in the laboratory and had low self-confidence for practice. The nursing students hoped that the community nursing virtual simulation system can familiarize them with community healthy nursing, thus increasing their self-confidence and better preparing them for future clinical practice.

P6: "I have not independently performed any nursing operations for patients in the hospital because of the epidemic. So I have some fears about operations and cannot overcome the psychological barriers."

P5: "I think my practical skills are the worst because I have not really operated with my hand. When I hold the indwelling needle, I feel like holding a sharp instrument. I would like to learn more about the operation process through the virtual simulation system."

### 3.14. Resilience

Nursing students hoped to accumulate experience in handling emergencies by using the virtual simulation system in order to enhance their psychological tolerance. This can enable students to quickly adjust their psychological state and face nursing work with a



positive attitude in the future.

P2: "I hope that (when using the virtual system) I can exercise my psychological tolerance because I think I will encounter situations in which my colleagues or patients may give me a hard time during my internship."

### 3.15. Interpersonal communication skills

Nursing students believed that interpersonal communication skills are one of the core competencies of community nurses, and they hoped to be able to communicate with virtual patients in the virtual simulation system to improve their communication skills.

P12: "The biggest difference between community nurses and clinical nurses is that they are more closely connected with patients. So I hope the virtual system can help us to build an emotional connection with residents in the community."

P1: "Because community nursing is more of a job that deals with people, I think it is more important to practice communication."

## 4. Discussion

This study used a qualitative descriptive research method to assess the perceptions and needs of undergraduate nursing students regarding the development of the community nursing virtual simulation system. The results of the study can be divided into three themes and 15 sub-themes. All respondents had a positive perception of using the virtual simulation system. This study shows that the virtual simulation system can complement the traditional nursing experiment teaching. Nursing students expect that the community virtual simulation system will help improve their core competencies, such as critical thinking skills, teamwork, interpersonal communication skills, and resilience, and enable them to better cope with the complex community environment and patient needs. Based on the needs of nursing students, developers should ensure the scientific and accuracy of the contents, and adopt the concept of game design to increase the attractiveness of virtual simulation systems [39]. The interface should be designed to be as realistic and attractive as possible. In addition, engineers should minimize the technology gap [40]. System and professional technical support should be provided to students during their use of the virtual simulation system.

This study found that nursing students generally held a positive attitude toward virtual simulation systems. Consistent with the results of other studies, all nursing students found the virtual simulation system as a novel, flexible, and interesting learning tool, which could help them familiarize themselves with the different scenarios encountered in nursing practice [41]. Virtual simulation systems provide nursing students with a realistic and immersive environment to improve the efficiency of theoretical knowledge transfer, without any barriers of time or space [42]. In addition, it can provide nursing students with a safe and private operating environment for trial and error. Therefore, most nursing students reported that it can reduce their fear of nursing operations and improve their self-confidence [43]. A study demonstrated that virtual simulation technology is an important means to promote equity among students [44]. The traditional experimental teaching approach does not allow for equitable participation of all nursing students in the simulation teaching, which limits the efficacy of classroom teaching. In contrast, virtual simulation systems can provide nursing students with more equitable learning opportunities, allowing them to obtain the same training skills at the same time.

In terms of system performance design needs, nursing students hope that when they are forced to exit the system due to operational errors or other reasons, the system can automatically save the progress of use before exiting, thereby reducing the time waste and boredom caused by repetitive operations. In addition, nursing students hope to minimize the lag when using the system, in order to obtain a smooth experience. Research shows that when nursing students encounter technical problems such as system incompatibility when using virtual simulation systems, and are unable to use the system smoothly, their learning enthusiasm and learning efficiency will be greatly reduced [45]. Therefore, when developing the community virtual simulation system, engineers should improve the performance of the virtual simulation system, such as adding automatic save function, optimizing the server, improving the system response speed, and continuously updating the system to meet the needs of students.

In terms of content design, most nursing students stated that the system should be based on real cases capturing the diverse service scenarios in the real-world community nursing practice as much as possible. This would help students to build a comprehensive understanding of community nursing and prepare them for clinical practice. As for interesting needs, designers can draw on the concept of gamification design to promote user immersion and pleasurable experience. In previous studies, game-based teaching methods were shown to enable nursing students to focus on the tasks, and improve their decision-making ability and learning outcomes [46,47]. Thus, besides developing scientifically sound case scenarios of community nursing practice, the developers should add gamification design elements to enhance the motivation and satisfaction of students.

In terms of appearance design, nursing students hoped that virtual patients can be as realistic and aesthetically pleasing as possible to increase the sense of immersion. Plotzky. et al. found that realistic virtual patient images can develop empathy and interpersonal communication skills in nursing students. In this way, students can better provide care services to community residents in real environments [48]. As a result, developers of virtual simulation system should focus on the system's appearance design while ensuring good performance, ensuring a simple interface and beautiful virtual characters, complete functional modules, to stimulate the interest of nursing students.

As for support needs, nursing students wanted that the virtual simulation system should be programmed to provide immediate feedback so that they can understand the causes of errors, which is consistent with findings reported by Jeon et al. [49]. In the absence of real-time feedback, nursing students may not fully understand the reasons for operation errors. This can be detrimental to the

student's knowledge acquisition and can reduce their experience of using the system. Therefore, the developers should add the functionality of automatic feedback in case of operating errors occurring in the practice mode of the virtual simulation system. This would enable students to understand the reasons for the errors and take appropriate corrective actions. Besides, students hoped that the navigation system should be intuitive and user-friendly. Kleven et al. developed a virtual hospital system and invited volunteers to try it out. After using the system, both medical and non-medical participants expressed the hope that the system would provide accurate navigation functions and necessary novice tutorials for novices, making it easier for users to use [50]. The participants hope that when encountering difficulties in using virtual simulation systems, they can receive timely support from technical personnel and professional teachers. In this way, they can solve problems encountered in operating systems and obtain a better user experience. A study found that faculty involvement is a key determinant of the motivation of nursing students to use the virtual system [51]. Therefore, better technical and faculty support should be provided to enable timely redressal of operational problems. In addition, some respondents stated that the virtual simulation system should also have links to resources related to the latest developments of community nursing and disease management guidelines in order to broaden their knowledge and meet their information needs.

In this study, the respondents expressed their concern about the lack of practice opportunities and were eager to improve their core competencies such as critical thinking and emergency response ability as soon as possible. Previous studies have shown that these skills can be improved with the virtual simulation system [52,53]. Moreover, nursing students who used the virtual system showed stronger self-efficacy and better performance in operational assessments compared to those who received traditional instruction [54]. In addition, the use of virtual simulation systems increases nursing students' confidence in communicating effectively with patients, which provides a distinct advantage in clinical practice [55]. Besides, nursing students are expected to use the virtual simulation system to enhance their professional competencies related to community nursing practice, such as community assessment ability, family and individual assessment ability, and health education ability, in order to develop family and community nursing plans, thereby promoting personal, family, and community health. A study by Azimirad et al. similarly pointed out that assessing the health needs of individuals and families and making decisions were the core competencies required by family and community nurses [56]. Thus, the designers and developers should aim to design scientific and rigorous cases that can help improve the critical thinking ability, emergency response ability, and communication ability of nursing students. This would help ameliorate the anxiety experienced by students about the transition from theoretical learning to clinical practice and enhance their self-efficacy to engage in clinical practice.

## 5. Limitations

We used a qualitative descriptive research approach to conduct interviews with Chinese nursing students who had experience of using the virtual simulation system. The insights obtained from this study can inform the development and improvement of the virtual simulation systems for community nursing as well as other disciplines. However, there are some limitations of this study. Firstly, although the data reached saturation, the sample size of this study was small and all participants were third-year nursing undergraduates from the same university. Therefore, the perceptions and design needs of our study population may not entirely reflect the needs of all nursing undergraduates. Besides, the study did not explore the perceptions and needs of nursing teachers involved in the community nursing virtual simulation teaching system.

## 6. Conclusion

Virtual simulation system has good prospects of application in nursing practical teaching as a supplement to the traditional teaching approach. This study identified three themes and 15 sub-themes which can provide some reference for the development of the virtual simulation system for nursing students. The developers of community nursing virtual simulation system should adopt a user-centered design approach which considers the views and needs of students. They should also highlight the scientific nature of the content, enhance the fun, and make the interface more intuitive and attractive. Issues such as technology gap and inadequate support from technical personnel should be addressed to meet the needs of students using virtual simulation system.

## Ethics statement

This study was reviewed and approved by the Ethics Committee of Capital Medical University, with the approval number Z2022SY079. All participants provided informed consent to participate in the study. All participants provided informed consent for the publication of their anonymized case details. They were also informed that they had the right to withdraw at any time without negative repercussions. While transcribing the interviews, the personal information of participants was anonymized.

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## Data availability statement

The data are not publicly available due to privacy and ethical restrictions.

## CRedit authorship contribution statement

**Zhe Liu:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis, Data curation. **Qianhuizi Zhang:** Writing – review & editing, Formal analysis. **Weiwei Liu:** Writing – review & editing, Supervision, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix 1

COREQ: Consolidated Criteria for Reporting Qualitative Studies.

We used this reporting guideline for the qualitative component.

No.	Item	Description
<b>Domain 1: Research team and reflexivity</b>		
Personal characteristics		
1.	Interviewer/facilitator	The Student- ZL, QHZZ
2.	Credentials	ZL- Student- master candidate (Nursing) QHZZ- Student- master candidate (Nursing) WL- Associate professor – (Nursing)
3.	Occupation	ZL – RN, candidate in nursing (Capital medical university, China) QHZZ – RN, candidate in nursing (Capital medical university, China) WL – Associate professor (Capital medical university, China)
4.	Gender	Three female
5.	Experience and training	ZL –has learned the knowledge of qualitative research and interview skills, and had the experience of using virtual simulation system QHZZ – has learned the knowledge of qualitative research and interview skills and had the experience of using virtual simulation system WL – has a series of experience in qualitative research interviews and deep understanding of virtual system and nursing education
Relationship with participants		
6.	Relationship established	At the beginning of interview, ZL introduced herself to nursing students and explained the aim of the study to gain interviewees' trust.
7.	Participant knowledge of interviewer	ZL is a student who has received an undergraduate degree and is currently pursuing a master's degree. ZL studies in the same school with participants.
8.	Interviewer characteristics	ZL is a master' student majored in nursing. ZL have learned community nursing before and are interested with community nursing. ZL also read lots of articles on virtual simulation and nursing education. Therefore, ZL was able to interview students to get enough information with less bias.
<b>Domain 2: Study design</b>		
Theoretical framework		
9.	Methodological orientation and theory	We used a qualitative descriptive research design to take into account nursing students' views and requirements for virtual simulation systems in community nursing.
Participant selection		
10.	Sampling	Purposive sampling
11.	Method of approach	We used purposive sampling to choose 12 students in school of nursing, Capital medical university. We contacted them through the internet.
12.	Sample size	12 nursing students
13.	Non-participation	N/A
Setting		
14.	Setting of data collection	Tencent Meeting
15.	Presence of non-participants	N/A
16.	Description of sample	Gender, age, ethnic, family location
Data collection		
17.	Interview guide	According to the interview purpose, WL drew up the interview outline and ZL interviewed two students prior the interview in order to Modify the outline.
18.	Repeat focus group	N/A
19.	Audio/visual recording	Audio and visual recording
20.	Field notes	Field notes were taken during the interview by ZL.

(continued on next page)

(continued)

No.	Item	Description
<b>Domain 1: Research team and reflexivity</b>		
21.	Duration	The interview lasted for 60–70 min.
22.	Data saturation	When none of the new themes/topics emerged from interviews, we defined it as data saturation.
23.	Transcripts returned	After the recordings were dedicated to the text, the researchers returned the text to the respondents for verification.
<b>Domain 3: Analysis and findings</b>		
Data analysis		
24.	Number of data coders	Two researchers (ZL, QHZZ) coded the data independently
25.	Description of the coding tree	We didn't describe the coding tree, but we clearly defined the themes.
26.	Derivation of themes	We used content analysis method to analysis the themes. Transcripts were repeatedly read by ZL, QHZZ, and meaningful statements for each key question were underlined. Then ZL and QHZZ categorized the key contents in the meaningful statements/expressions and grouped them into larger categories. Researchers structured meanings from meaningful statements to form themes, theme clusters, and categories. Finally, the common components of the experiences were integrated to define the fundamental thematic structure.
27.	Software	N/A
28.	Participant checking	Participants were invited to check records
Reporting		
29.	Quotations presented	Illustrative quotes support the presentation of findings while participants' anonymity was respected
30.	Data and findings consistent	The findings are strongly supported by the qualitative data.
31.	Clarity of major themes	Major themes are clearly identified.
32.	Clarity of minor themes	Subthemes are clearly identified and related to major themes.

VR:Virtual reality; N/A: not applicable.

## References

- [1] B.E. Cohen, D. Gregory, Community health clinical education in Canada: part 1—"state of the art", *Int. J. Nurs. Educ. Scholarsh.* (6) (2009), <https://doi.org/10.2202/1548-923X.1637>.
- [2] R.L. Escolar Chua, J. Magpantay, Moral distress of undergraduate nursing students in community health nursing, *Nurs. Ethics* 26 (7–8) (2019) 2340–2350, <https://doi.org/10.1177/0969733018819130>.
- [3] S. Yuan, F. Peng, X. Jiang, Community health nursing in China: status, challenges, and development strategies, *Nurs. Outlook* 60 (4) (2012) 221–227, <https://doi.org/10.1016/j.outlook.2012.03.002>.
- [4] S. Wang, W. Chen, Y. Du, Improving the curriculum for a community nursing training program in Guangzhou City, China, *Publ. Health Nurs.* 36 (1) (2019) 70–78, <https://doi.org/10.1111/phn.12562>.
- [5] C. Jackson, T. Leadbetter, A. Martin, T. Wright, K. Manley, Making the complexity of community nursing visible: the Cassandra project, *Br. J. Community Nurs.* 20 (3) (2015) 128–133, <https://doi.org/10.12968/bjcn.2015.20.3.126>.
- [6] E.M. Pijl-Zieber, S. Barton, O. Awosoga, J. Konkin, Disconnects in pedagogy and practice in community health nursing clinical experiences: qualitative findings of a mixed method study, *Nurse Educ. Today* 35 (10) (2015) e43–e48, <https://doi.org/10.1016/j.nedt.2015.08.012>.
- [7] A. Gorini, G. Riva, Virtual reality in anxiety disorders: the past and the future, *Expert Rev. Neurother.* 8 (2) (2008) 215–233, <https://doi.org/10.1586/14737175.8.2.215>.
- [8] X. Jiang, R. Hong, Y. Yan, X. Wang, Design and application of a virtual simulation experiment teaching project in Labor and Delivery Nursing, *Chinese Journal of Nursing Education* 17 (3) (2020) 197–201, <https://doi.org/10.3761/j.issn.1672-9234.2020.03.001>.
- [9] P. Cipresso, I. Giglioli, M.A. Raya, G. Riva, The past, present, and future of virtual and augmented reality research: a network and cluster analysis of the literature, *Front. Psychol.* 9 (2018) 2086, <https://doi.org/10.3389/fpsyg.2018.02086>.
- [10] S.L. Farra, S.J. Smith, D.L. Ulrich, The student experience with varying immersion levels of virtual reality simulation, *Nurs. Educ. Perspect.* 39 (2) (2018) 99–101, <https://doi.org/10.1097/01.NEP.0000000000000258>.
- [11] E. Weiner, R. McNew, P. Trangenstein, J. Gordon, Using the virtual reality world of second life to teach nursing faculty simulation management, *Stud. Health Technol. Inf.* 160 (Pt1) (2010) 615–619, <https://doi.org/10.3233/978-1-60750-588-4-615>.
- [12] B. Holland, K. Landry, A. Mountain, M.A. Middlebrooks, D. Heim, K. Missildine, Weaving the tapestry of learning: simulation, standardized patients, and virtual communities, *Nurse Educat.* 38 (6) (2013) 269–272, <https://doi.org/10.1097/01.NNE.0000435265.53612.06>.
- [13] J. Steuer, Defining virtual reality: dimensions determining telepresence, *J. Commun.* 42 (1993) 7393, <https://doi.org/10.1111/j.1460-2466.1992.tb00812.x>.
- [14] J.L. McGrath, J.M. Taekman, P. Dev, D.R. Danforth, D. Mohan, N. Kman, A. Crichlow, W.F. Bond, Using virtual reality simulation environments to assess competence for emergency medicine learners, *Acad. Emerg. Med.* 25 (2) (2018) 186–195, <https://doi.org/10.1111/acem.13308>.
- [15] B.S. Botha, L. de Wet, Y. Botma, Undergraduate nursing student experiences in using immersive virtual reality to manage a patient with a foreign object in the right lung, *Clin Simul Nurs.* 56 (2021) 76–83, <https://doi.org/10.1016/j.ecns.2020.10.008>.
- [16] E.G. İsmailoğlu, N. Orkun, İ. Eşer, A. Zaybak, Comparison of the effectiveness of the virtual simulator and video-assisted teaching on intravenous catheter insertion skills and self-confidence: a quasi-experimental study, *Nurse Educ. Today* 95 (2020) 104596, <https://doi.org/10.1016/j.nedt.2020.104596>.
- [17] V.L. Vidal, B.M. Ohaeri, P. John, D. Helen, Virtual reality and the traditional method for phlebotomy training among college of nursing students in Kuwait: implications for nursing education and practice, *J. Infusion Nurs.* 36 (5) (2013) 349–355, <https://doi.org/10.1097/NAN.0b013e318243172f>.
- [18] I. Dubovi, S.T. Levy, E. Dagan, Now I know how! The learning process of medication administration among nursing students with non-immersive desktop virtual reality simulation, *Comput. Educ.* 113 (2017) 16–27, <https://doi.org/10.1016/j.compedu.2017.05.009>.
- [19] J.L. LeFlore, M. Anderson, M.A. Zielke, K.A. Nelson, P.E. Thomas, G. Hardee, L.D. John, Can a virtual patient trainer teach student nurses how to save lives—teaching nursing students about pediatric respiratory diseases, *Simulat. Healthc. J. Soc. Med. Simulat.* 7 (1) (2012) 10–17, <https://doi.org/10.1097/SIH.0b013e31823652de>.
- [20] D.D. Samarasekera, C.N. Nyoni, E. Amaral, J. Grant, Challenges and opportunities in interprofessional education and practice, *Lancet* 400 (10362) (2022) 1495–1497, [https://doi.org/10.1016/S0140-6736\(22\)02086-4](https://doi.org/10.1016/S0140-6736(22)02086-4).
- [21] S.O. Watts, F.J. Tuggle, J. Sewell, J.L. Slay, K.J. Ellison, A.D. Frugé, Achievement of interprofessional competencies in live and virtual community clinics: a comparative study, *Nurse Educ. Today* 119 (2022) 105578, <https://doi.org/10.1016/j.nedt.2022.105578>.
- [22] J.C. De Gagne, J. Oh, J. Kang, A.A. Vorderstrasse, C.M. Johnson, Virtual worlds in nursing education: a synthesis of the literature, *J. Nurs. Educ.* 52 (7) (2013) 391–396, <https://doi.org/10.3928/01484834-20130610-03>.

- [23] S. Shorey, E. Ang, J. Yap, E.D. Ng, S.T. Lau, C.K. Chui, A virtual counseling application using artificial intelligence for communication skills training in nursing education: development study, *J. Med. Internet Res.* 21 (10) (2019) e14658, <https://doi.org/10.2196/14658>.
- [24] D.A. Cook, P.J. Erwin, M.M. Triola, Computerized virtual patients in health professions education: a systematic review and meta-analysis, *Acad. Med.* 85 (10) (2010) 1589–1602, <https://doi.org/10.1097/ACM.0b013e3181edfe13>.
- [25] A.K. Lange, J. Koch, A. Beck, T. Neugebauer, F. Watzema, K.J. Wrona, C. Dockweiler, Learning with virtual reality in nursing education: qualitative interview study among nursing students using the unified theory of acceptance and use of technology model, *JMIR nursing* 3 (1) (2020) e20249, <https://doi.org/10.2196/20249>.
- [26] J.C. De Gagne, J. Oh, J. Kang, A.A. Vorderstrasse, C.M. Johnson, Virtual worlds in nursing education: a synthesis of the literature, *J. Nurs. Educ.* 52 (7) (2013) 391–396, <https://doi.org/10.3928/01484834-20130610-03>.
- [27] T. McCurdie, S. Taneva, M. Casselman, M. Yeung, C. McDaniel, W. Ho, J. Cafazzo, mHealth consumer apps: the case for user-centered design, *Biomed Instrum Technol. Suppl.* (2012) 49–56, <https://doi.org/10.2345/0899-8205-46.s2.49>.
- [28] G. Konstantinidis, G.C. Anastasopoulos, A.S. Karakos, E. Anagnostou, V. Danielides, A user-centered, object-oriented methodology for developing health information systems: a clinical information system (CIS) example, *J. Med. Syst.* 36 (2) (2012) 437–450, <https://doi.org/10.1007/s10916-010-9488-x>.
- [29] A.W. Kushniruk, V.L. Patel, Cognitive and usability engineering methods for the evaluation of clinical information systems, *J. Biomed. Inf.* 37 (1) (2004) 56–76, <https://doi.org/10.1016/j.jbi.2004.01.003>.
- [30] D. Luna, M. Quispe, Z. Gonzalez, A. Alemreres, M. Risk, M. Garcia Aurelio, C. Otero, User-centered design to develop clinical applications. Literature review, *Stud. Health Technol. Inf.* 216 (2015) 967, <https://doi.org/10.3233/978-1-61499-564-7-967>.
- [31] A.L. Russ, S. Chen, B.L. Melton, E.G. Johnson, J.R. Spina, M. Weiner, A.J. Zillich, A novel design for drug-drug interaction alerts improves prescribing efficiency, *Joint Comm. J. Qual. Patient Saf.* 41 (9) (2015) 396–405, [https://doi.org/10.1016/s1553-7250\(15\)41051-7](https://doi.org/10.1016/s1553-7250(15)41051-7).
- [32] World Health Organization, mHealth: New Horizons for Health through Mobile Technologies: Second Global Survey on eHealth, WHO Global Observatory for eHealth, 2011 [2023-12-5], <https://iris.who.int/handle/10665/44607>.
- [33] M. Sandelowski, Whatever happened to qualitative description? *Res. Nurs. Health* 23 (4) (2000) 334–340, [https://doi.org/10.1002/1098-240x\(200008\)23:4<334::aid-nur9>3.0.co;2-g](https://doi.org/10.1002/1098-240x(200008)23:4<334::aid-nur9>3.0.co;2-g).
- [34] A. Tong, P. Sainsbury, J. Craig, Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups, *Int. J. Qual. Health Care* 19 (6) (2007) 349–357, <https://doi.org/10.1093/intqhc/mzm042>.
- [35] M. Hennink, B.N. Kaiser, Sample sizes for saturation in qualitative research: a systematic review of empirical tests, *Soc. Sci. Med.* 292 (2022) 114523, <https://doi.org/10.1016/j.socscimed.2021.114523>.
- [36] S. Elo, H. Kyngäs, The qualitative content analysis process, *J. Adv. Nurs.* 62 (1) (2008) 107–115, <https://doi.org/10.1111/j.1365-2648.2007.04569.x>.
- [37] B. Saunders, J. Sim, T. Kingstone, S. Baker, J. Waterfield, B. Bartlam, H. Burroughs, C. Jinks, Saturation in qualitative research: exploring its conceptualization and operationalization, *Qual. Quantity* 52 (4) (2018) 1893–1907, <https://doi.org/10.1007/s11135-017-0574-8>.
- [38] Y.S. Lincoln, E.G. Guba, *Naturalistic Inquiry*, Newbury Park, 1985.
- [39] J.Y. Yeo, M.S. Jang, Nursing students' self-directed learning experiences in web-based virtual simulation: a qualitative study, *Jpn. J. Nurs. Sci.* 20 (2) (2023) e12514, <https://doi.org/10.1111/jjns.12514>.
- [40] S.Y. Liaw, T. Choo, L.T. Wu, W.S. Lim, H. Choo, S.M. Lim, C. Ringsted, L.F. Wong, S.L. Ooi, T.C. Lau, "Wow, woo, win"- Healthcare students' and facilitators' experiences of interprofessional simulation in three-dimensional virtual world: a qualitative evaluation study, *Nurse Educ. Today* 105 (2021) 105018, <https://doi.org/10.1016/j.nedt.2021.105018>.
- [41] Y. Gao, X. Zhu, Research on the learning experience of virtual simulation class experimental teaching and learning based on the perspective of nursing students, *BMC Nurs.* 22 (1) (2023) 367, <https://doi.org/10.1186/s12912-023-01534-z>.
- [42] D.S. Thompson, A.P. Thompson, K. McConnell, Nursing students' engagement and experiences with virtual reality in an undergraduate bioscience course, *Int. J. Nurs. Educ. Scholarsh.* 17 (1) (2020), <https://doi.org/10.1515/ijnes-2019-0081> /ijnes.2020.17.issue-1/ijnes-2019-0081/ijnes-2019-0081.xml.
- [43] M. Benham-Hutchins, M.P. Lall, Perception of nursing education uses of second life by graduate nursing students, *Comput Inform Nurs* 33 (9) (2015) 404–409, <https://doi.org/10.1097/CIN.0000000000000170>.
- [44] M.M. Saab, J. Hegarty, D. Murphy, M. Landers, Incorporating virtual reality in nurse education: a qualitative study of nursing students' perspectives, *Nurse Educ. Today* 105 (2021) 105045, <https://doi.org/10.1016/j.nedt.2021.105045>.
- [45] J.K. Anderson, A.M. Anderson, D.M. Wendorf, Avatar-assisted case studies, *Nurse Educ. Pract.* 38 (3) (2013) 106–109, <https://doi.org/10.1097/NNE.0b013e31828dc260>.
- [46] C. Mackavey, S. Cron, Innovative strategies: increased engagement and synthesis in online advanced practice nursing education, *Nurse Educ. Today* 76 (2019) 85–88, <https://doi.org/10.1016/j.nedt.2019.01.010>.
- [47] M.C. Saiz Manzanares, S. Rodríguez Arribas, C. Pardo Aguilar, M.A. Queiruga-Dios, Effectiveness of self-regulation and serious games for learning STEM knowledge in primary education, *Psicothema* 32 (4) (2020) 516–524, <https://doi.org/10.7334/psicothema2020.30>.
- [48] C. Plotzky, U. Lindwedel, M. Sorber, B. Loessl, P. König, C. Kunze, C. Kugler, M. Meng, Virtual reality simulations in nurse education: a systematic mapping review, *Nurse Educ. Today* 101 (2021) 104868, <https://doi.org/10.1016/j.nedt.2021.104868>.
- [49] J. Jeon, J. H Kim, E.H. Choi, Needs assessment for a VR-based adult nursing simulation training program for Korean nursing students: a qualitative study using focus group interviews, *Int. J. Environ. Res. Publ. Health* 17 (23) (2020) 8880, <https://doi.org/10.3390/ijerph17238880>.
- [50] N.F. Kleven, E. Praselova-Førland, M. Fominykh, A. Hansen, G. Rasmussen, L.M. Sagberg, F. Lindseth, Training nurses and educating the public using a virtual operating room with Oculus Rift. 2014 International Conference on Virtual Systems & Multimedia (VSM), 2014, pp. 206–213, <https://doi.org/10.1109/VSM.2014.7136687>.
- [51] P. Irwin, R. Coutts, A systematic review of the experience of using second life in the education of undergraduate nurses, *J. Nurs. Educ.* 54 (10) (2015) 572–577, <https://doi.org/10.3928/01484834-20150916-05>.
- [52] S. Shin, J.H. Park, J.H. Kim, Effectiveness of patient simulation in nursing education: meta-analysis, *Nurse Educ. Today* 35 (1) (2015) 176–182, <https://doi.org/10.1016/j.nedt.2014.09.009>.
- [53] M. Pears, M. Yiasemidou, M.A. Ismail, D. Veneziano, C.S. Biyani, Role of immersive technologies in healthcare education during the COVID-19 epidemic, *Scot. Med. J.* 65 (4) (2020) 112–119, <https://doi.org/10.1177/0036933020956317>.
- [54] K.A. Kim, D.W. Choi, The effect of virtual simulation in nursing education: an application of care for acute heart disease patients, *Journal of Korean Society for Simulation in Nursing* 6 (2) (2018) 13, <https://doi.org/10.17333/JKSSN.2018.6.2.1>.
- [55] M. Peddle, L. Mckenna, M. Bearman, D. Nestel, Development of non-technical skills through virtual patients for undergraduate nursing students: an exploratory study, *Nurse Educ. Today* 73 (2019) 94–101, <https://doi.org/10.1016/j.nedt.2018.11.008>.
- [56] M. Azimirad, R. Paloniitty, I.V. Papathanasiou, G. Aleo, G. Catania, F. Pozzi, A. Bagnasco, H. Turunen, Examining family and community nurses' core competencies in continuing education programs offered in primary health care settings: an integrative literature review, *Nurse Educ. Pract.* 67 (2023) 103561, <https://doi.org/10.1016/j.nepr.2023.103561>.