

가상현실을 적용한 방문건강관리 간호교육 콘텐츠 개발

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Development of Virtual Reality-Based Home-Visiting Healthcare Education Content

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[요약]

간호 실습 교육은 기술 발전에 따라 패러다임의 전환을 겪고 있다. 이러한 변화에 발맞춰 본 연구에서는 대상자 인권 보호, 실습 교육의 한계를 극복하기 위해 가상현실 기술을 적용한 교육용 콘텐츠를 개발하고자 한다. 본 연구 방법은 가상현실을 적용한 방문 건강관리 간호교육 프로그램을 개발하고, 개발된 프로그램의 사용성을 평가하는 것이다. 본 연구는 사용자 중심 디자인에 근거하여 분석-개념화-개발-평가 단계의 체계적인 방법으로 진행되었으며, 개발업체와 협력하여 본 연구 프로그램 개발 기간은 2022년 7월부터 2023년 7월까지이다. 가상현실 분야 전문가 3명과 간호학 교수 5인으로 구성된 전문가 집단에서 2023년 8월, 개발된 프로그램의 사용성 평가를 시행하였고, 검증 결과에 따라 본 연구 프로그램을 보완하여 최종 프로그램을 완성하였다. 본 연구를 통해 개발된 Alive Background Community Nursing-Simulation Virtual Reality (ABC Nur-sim VR Program)은 가상현실 기술을 활용해 지역사회가 요구하는 방문 건강 관리 실무 역량 개발 교육에 대한 높은 활용 가능성을 제시함으로써 중요한 의미를 갖는다.

[Abstract]

Nursing practice education is undergoing a paradigm shift owing to advancements in technology. In response to this change, this study was conducted to develop educational content using virtual reality (VR) technology to address the challenges of protecting patient rights and the limitations of nursing practice education. A VR-based home-visiting healthcare education program (Alive Background Community Nursing-Simulation; ABC Nur-sim VR Program) was developed and its usability was evaluated. This study was conducted using a systematic approach based on user-centered design, encompassing analysis, conceptualization, development, and evaluation. In cooperation with the development company, the program was developed from July 2022 to July 2023. In August 2023, a group of experts, three VR experts and five nursing professors, conducted a usability evaluation of the developed program, and the final program was completed by supplementing this research program based on the verification results. The developed VR-based ABC Nur-sim VR Program indicates a high potential for use in instilling home healthcare practice capabilities.

색인어 : 가상현실, 간호, 교육, 만성질환, 방문건강관리

Keyword : Virtual-reality, Nursing, Education, Chronic Disease, Home Health Nursing

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I . Introduction

The advent of the technological innovation opens up new possibilities for nursing practice education. Recently, clinical practice in nursing education has been conducted based on observation due to issues such as increased awareness of patient rights and safety[1]. Recently, due to the global spread of infectious diseases such as coronavirus disease-19 (COVID-19), opportunities for nursing students to receive nursing practice education in hospitals and communities have been limited, and the gap in clinical practice education is widening[2]. The International Association for Clinical Simulation and Learning in Nursing (INACSL) proposes simulation education methods to overcome the limitations of clinical practice education and expand opportunities for systematic clinical practice education[3].

The Korean Accreditation Board of Nursing Education emphasizes that nursing practice education is an essential part of the nursing curriculum and recognizes simulation education as an educational method for learners to integrate knowledge and competencies in nursing practice education[4],[5]. Simulation education provides learners with opportunities to repeatedly practice appropriate nursing performance in a safe learning environment that is similar to a clinical situation[6]. Simulation practices vary in form, including low-fidelity simulations, medium-fidelity and high-fidelity, depending on the degree of realism, and combining effective fidelity levels to achieve educational goals [6]. High-fidelity simulators have the advantage of reproducing the actual clinical symptoms more precisely, but face limitations in repeated learning due to high costs and environmental constraints for setup, maintenance, and repair[7],[8].

Nursing education is developing various simulation education contents using virtual reality. Virtual reality (VR) is a learning tool with high educational value, an environment where users can experience situations similar to real life in a 3D[9]. Learners can experience various clinical situations and learn repetitively without the constraints of time and place in VR. According to previous studies, simulation using VR is developing its effectiveness in enhancing knowledge acquisition, retention, procedural memorization, and

fostering empathy and clinical competencies[10]. Learners perform essential nursing activities such as collecting health information, communicating, and nursing techniques in a safe environment without harming real patients, experiencing decision-making and problem-solving processes[11]. In this process, learners were shown to improve their nursing competencies in an actual clinical environment with confidence[11]. In other words, virtual reality education is very useful in resource-limited educational environments, increasing its utility in the field of nursing education[5]. Therefore, it is necessary to develop various nursing education contents using virtual reality to enhance the competencies of the next generation of nurses.

Currently, simulation education using VR is limited to nursing skills training such as subcutaneous injections, medication administration, and hospital environment education for specific clinical situations such as chronic obstructive pulmonary disease and abdominal pain[10],[11]. However, these programs do not sufficiently reflect the various situations actually required in clinical practice, and their utilization is limited, especially in community-based nursing education. According to previous studies, difficulties in using machines and disconnection of interaction between learners and systems are major factors that hinder learning immersion during the process of experiencing a virtual reality education program[10],[11]. To address these problems, it is necessary to develop a more advanced virtual reality education program that strengthens the learner-centered approach, increases learning immersion, and enhances interactive elements in VR.

Especially, with the increase in the elderly population and the prevalence of chronic diseases, the importance of the nurse's role in continuously monitoring the health of patients with chronic diseases in the community and providing appropriate medical services is being emphasized[12]. Hypertension and diabetes are major chronic diseases that are intensively managed in community health care[13]. Hypertension has increased rapidly in the elderly, with one in two people being diagnosed with it, but the control rate among patients with hypertension was relatively low at 47.1%[14]. The prevalence of diabetes was also high at 23.0% in the elderly aged 65 years or older, but the treatment rate was 77.6%, and

the control rate of symptom management such as diet therapy was relatively low at 23.3%[15]. Thus, continuous and comprehensive health care intervention is important for the subjects to manage hypertension and diabetes on their own, and community nurses are required to have clinical performance capabilities to effectively manage these diseases. Community health care practice education focusing on these diseases plays an important role in improving the clinical capabilities of nursing students[16],[17]. Therefore, at this time, there is a need for community nursing practice education that integrates nursing knowledge and skills required for home visiting healthcare to meet the social demand for community chronic disease health managers. Thus, this study aims to develop and assess the applicability of a virtual reality simulation-based chronic disease home visiting healthcare education to maximize the potential of virtual reality-based nursing education.

II. Methods

2-1 Research Design

The virtual reality-based home health care nursing education simulation was developed by applying the user-centered design (UCD) method as shown in Fig. 1[18]. User-centered design (UCD) provides practical guidelines for designing learner-centered curricula in digital utilization education through the participation of actual users.

2-2 Analysis

To develop the content of the VR-based home visiting healthcare education, a survey on the demand for the program and descriptive surveys related to home visiting healthcare management of hypertension and diabetes were conducted among nursing students.

Simulation-based education was the most preferred method for home health management training, with 41.3% of respondents favoring it. Additionally, 73.2% of participants expressed the necessity of simulation education for home health management in community practice. The need for HMD immersive virtual reality home health management practical training content

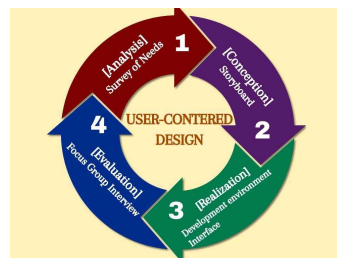


Fig. 1. Program development procedure

was rated at 74.6%, its usefulness at 73.9%, and the intention to use such content if developed was notably high at 86.2%. Clinical competency significantly correlated with self-efficacy and clinical judgment ability. The content of the virtual reality-based home visiting healthcare education was developed to include the community integrated health promotion project Home visiting healthcare manual[18] and the 2022 home visiting healthcare manual[19].

2-3 Conception

The development process of a home health care practical training program using virtual reality involved continuous feedback exchange between developers and researchers. The development team continuously received feedback from the initial design stage to the construction of a specific virtual environment, and then revised and supplemented it by reflecting the feedback. In this process, actual feedback from actual home visit health care service personnel, community nursing experts, and nursing students was reflected in the implementation. Feedback at each stage has become an important standard for improving the realism and educational effectiveness of the virtual reality environment.

The importance of 3D asset modeling in a virtual reality-applied home health care practical education program lies in the realism of character and environment implementation. The main character of this program is a woman in her late 70s. She has a slightly chubby body and weather-beaten facial features to portray the character vividly. This female character's hair style is set to a short, round perm commonly seen in this age group, and she has a slightly hunched posture, reflecting the natural aging process. In terms of environmental modeling, it was constructed with reference to the home environment of actual home visit health care recipients in order to

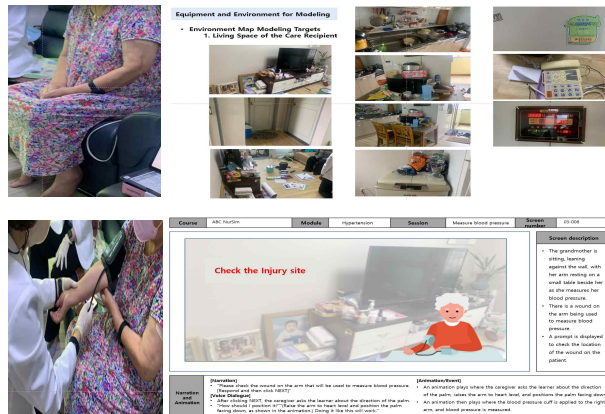


Fig. 2. Program development storyboard example

realistically reproduce the recipient's living space. Through this, learners can have an experience similar to conducting actual home health care in a virtual environment. In addition, the office space of visiting health care officials was modeled by replicating the office of a public health center in the field to provide learners with a working environment identical to the real one. The design and improvement process was carried out iteratively, ultimately creating a user-centered, realistic, and effective virtual reality (Fig. 2).

2-4 Realization

The virtual reality program in this study was developed in collaboration with BizWave, a virtual training development company, from July 2022 to July 2023. The program was developed through a systematic and iterative process following the version specified in Table 1 to complete the program's functions and performance.

2-5 Evaluation

The usability evaluation of the produced virtual reality nursing education program was conducted in August 2023 by forming an expert group that included 3 experts in the VR development field and 5 nursing professors and home visiting nurse practitioners employing a multidisciplinary approach. The questionnaire was based on 15 items presented by Park[20] for considering usability in content production, evaluating the program from various aspects including hardware interface, dynamic

Table 1. Head mounted display virtual-reality (VR) development version

Categories	Subcategories	Contents
Development environment	Software configuration	VR Content Development Engine: Unity 3D 2021.3.11.f1 ver. 3D Modeling Development Software: 3D MAX, Maya, Blender 2D Graphics Development Software: Adobe Photoshop, Illustrator, etc. Other Software: Adobe XD, Zeplin
	Hardware configuration	Development PC Specifications: CPU: Intel i7 VGA: GTX 3060 Storage: 1TB SSD OS: Windows 10 Pro VR Hardware Specifications: Resolution: 2×1832×1920 Refresh Rate: 60/72/80/90/120Hz RAM: 6G FOV (Field of View): 100°
Interface	Input device	Meta Touch Controller
	Processing unit	PC Specifications: Intel i7, GTX 3060, 1TB SSD, Windows 10 Pro HMD (Meta Quest 2)
	Output Devices	Display Output Devices: Monitor, HMD (Meta Quest 2) Sound Output Device: 2-Channel Stereo Speaker

viewpoint, and VR content characteristics.

Each measurement item is composed of a 5-point Likert scale, and a higher score means higher usability appropriateness. For each item, the evaluation score was 3 points or less, and the reason was described. In addition, when evaluating usability, a remarks column was added to describe the excellent points and supplementary points for the interaction and completeness of the content function, thereby deriving improvement points.

III. Results

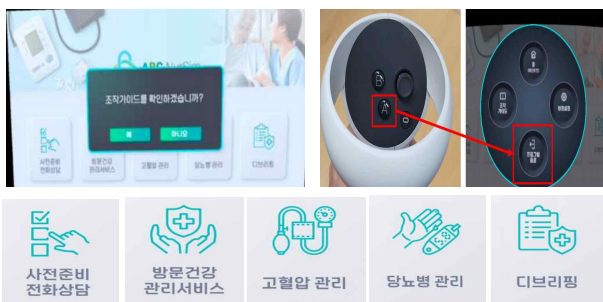
3-1 Development of a Virtual Reality-Based Home Visiting Healthcare Education

The development process of the ABC Nur-sim VR-based nursing education program was carried out through a systematic procedure. The basic data was established by analyzing the needs of VR education for home visiting healthcare education through a descriptive survey. In collaboration with community health nursing practitioners, we finalized a customized

home visiting healthcare training scenario that reflects the individual needs of actual community chronic disease patients. The scenario's storyboard included setting educational goals, composing scenes, directing target behaviors, presenting practical tasks, and providing debriefing. In addition, in order to increase the fidelity and practicality of the ABC Nur-sim program, an expert meeting consisting of three experts in the VR development field and five nursing professors decided on the direction of implementation and proceeded with program development based on this. Through this process, a program was completed that could provide learners with a practical and effective educational experience.

The developed ABC Nur-sim VR Program displays a pop-up on the Meta Quest 2 screen with the question, "Would you like to check the operation guide?" A pop-up appears on the Meta Quest 2 screen with the question: If the user selects 'Yes' using the Meta Quest 2 controller, a diagram illustrating how to operate the controller appears on the screen, and if the user selects 'No', the operation guide is skipped and the user moves directly to the main content screen (Fig. 3).

The main screen of the program consists of a menu where users can select the content they want to learn and provides an interactive learning experience centered on the home visit health management scenario. When you press the 'A' button on the right controller of Meta Quest 2, the content tool menu is activated. This tool menu includes functions such as home (main screen), operation guide, environment settings, and program termination. The user interface of this VR system is designed so that users can easily navigate and intuitively understand it. The title of the program is clearly displayed at the top center, helping users select a menu that suits their learning purposes. Five core menus are placed at the bottom of the



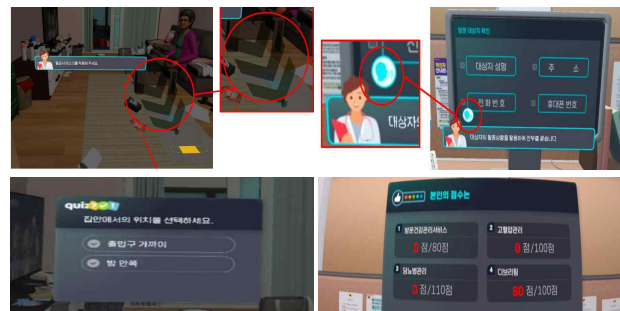
*Actual screen of the developed virtual reality program
Fig. 3. ABC Nur-sim VR content operation guide

program, and each menu is directly connected to the corresponding home health care scenario.

The 'Preparation' menu consists of a scene where users can check the necessary information before starting the simulation and practice the process of making a visit reservation through a phone consultation. The 'Start Visit' menu is set as a scene where a home visit in a virtual environment begins. The 'Hypertension Management' and 'Diabetes Management' menus that follow are linked to scenes where they can perform home visit health management nursing activities focused on the management of the corresponding disease, respectively. Through this menu, users can practice visiting health management methods for patients with hypertension and diabetes and apply clinical nursing through communication.

Lastly, the 'Debriefing' menu consists of scenes that provide feedback to users after completing the simulation and help them organize their learning experience. Each scene is composed by imitating realistic environments and situations so that users can develop and practice nursing competencies required in actual visiting health management situations, providing users with an immersive learning experience and supporting the achievement of the educational goals of the nursing education program.

The developed ABC Nur-sim VR Program includes various interactions as shown in Fig. 4. Guide arrows are included to help learners easily find necessary learning objects within VR content. These guide arrows serve as useful guides when learners cannot find the objects they need to interact with. Learning objects within the content are marked in yellow so that learners can easily identify and access them, and this design supports learners to smoothly interact and proceed with the learning process in the VR



*Actual screen of the developed virtual reality program
Fig. 4. Diversity of interactions in ABC Nur-sim VR educational content

environment.

The ABC Nur-sim VR Program developed focuses on improving learners' communication skills. In particular, it is designed so that learners can directly participate in conversations through the 'speaking icon' within VR content. When the speak icon is activated above the script window, learners can directly answer the given question verbally, and this 'speak button' is deactivated about 10 seconds after activation. After the 'speaking icon' disappears, the 'next' button appears in the script window, and selecting it proceeds to the next learning stage. At each stage of the program, recorded voices and subtitles are used to guide learners through the process to be performed within the virtual environment. When a learner asks a question to a subject in VR or performs a nursing activity, the subject's pre-recorded voice is played, providing a realistic conversation environment. This interaction supports learners to practice and develop communication skills in actual clinical situations.

The developed ABC Nur-sim VR Program integrates interactive quiz elements to systematically assess the clinical judgment of users. This quiz is designed to improve immersion in the virtual reality education program and at the same time evaluate learners' clinical judgment and clinical performance abilities in a realistic environment. The quiz is based on various clinical scenarios and evaluates whether learners can make appropriate decisions and clinical responses to various situations faced in a virtual environment. Through the quiz presented in the virtual environment, the learner applies clinical knowledge and practices responding to real patient situations. In this process, the learner has the opportunity to check his or her clinical thinking process and improve it if necessary. The feedback mechanism included in this program provides the learner with immediate feedback on his or her decision making, making the learning process more effective.

The developed ABC Nur-sim VR Program has improved the educational effectiveness by integrating functions that effectively record and review the learner's simulated clinical performance. Through this function, the learner is provided with an opportunity to review their performance and provide self-feedback after the learning session ends, as the VR system automatically records all the processes they practiced. As learners study the ABC Nur-sim VR program, they

can check the scores earned for each learning category, and through this, evaluators can evaluate the learner's learning content and performance. These functions are implemented to help learners develop clinical judgment ability, self-efficacy, and clinical performance ability while performing visiting health care nursing, and to hone the communication skills necessary as a nurse in situations similar to actual clinical environments.

3-2 Expert Usability Evaluation of the Developed Program

In August 2023, an expert group consisting of three experts in the virtual reality field and five nursing professors individually conducted program usability evaluation and expert advice. The usability evaluation results of the developed program showed that all items scored 3 points or higher, which is the usability evaluation standard, and were judged to be usable. The highest score among the evaluation items was the adequacy of visual feedback, which was 4.62 ± 0.43 points out of 5 points, and the lowest score was the user's autonomy in arranging menus and icons, which was 3.23 ± 0.70 points out of 5 points. The reason why the user's autonomy in arranging menus and icons was evaluated lower than other items was that the height of the icon location was fixed for the consistency of the educational program. To supplement this problem, the researcher included a customizable layout function so that users can conveniently arrange various educational materials within the virtual reality scene.

The detailed consultation results for each usability evaluation item are as follows. The usability evaluation of the produced virtual reality (VR) nursing education program evaluated the program in various aspects such as hardware interface, dynamic viewpoint, and VR content characteristics. In the development process of the ABC Nur-sim VR-based nursing education program, user accessibility and convenience were given top priority. The program was implemented using the Meta Quest2 VR headset and was designed to allow users to easily access the system menu even while wearing the HMD. In particular, a function is included that allows users to easily access system settings by pressing the menu button while immersed in the VR environment. The system's visual feedback provides immediate responses based on the user's actions, allowing learners to immediately check

feedback on related items when selecting an answer to a quiz item.

Each icon is designed intuitively so that users can easily understand its meaning. For example, the 'Speak' icon encourages users to participate in a conversation, and the 'Next' icon clearly indicates progression to the next learning step. In addition, 3D graphic elements were used based on actual size, allowing users to experience a feeling of size similar to the real thing. Tables, TVs, furniture, etc. in the virtual environment are expressed close to their actual size, providing users with a sense of reality. Users can easily perform various operations within the virtual environment using the controller. The shortcut key function supports users to access specific functions quickly and efficiently. For example, if you press the 'A' button on the right controller, the content tool menu will be activated and you can select the desired item. The user-customized arrangement function allows users to arrange various educational materials used in virtual reality scenes according to the user's convenience.

The layout of the menu and icons is easy to use and intuitive, allowing users to easily find and use the functions they need. The layout of input/output windows and help is consistent and intuitive so that users can easily check and understand information. The response function for work errors helps users easily respond and correct errors when they occur. The design, which does not require excessive information or actions, provides users with maximum effects with minimal manipulation. The font design of menus and icons was selected considering visual completeness so that users can easily read and understand. Tutorial and help functions are provided in Korean to help users easily understand and use the system.

IV. Discussion and Conclusion

To prepare the next generation of nurses to lead in the community chronic disease management, this study developed and discussed the applicability of a virtual reality-based home visiting healthcare education.

The evaluation results of the program developed in this study showed that it had high user accessibility.

This is the result of the application of a user-centered design method in the development phase of this program, and human-computer interaction (HCI)[21] focusing on the needs and experiences of users was reflected in the program, which ultimately led to the program improving learner interaction. In a previous study[21], it was explained that the program's interaction with users requires the integration of digital technology to bridge the gap between learners' needs and actual needs. Accordingly, this program focused on utilizing virtual reality technology for 3D asset modeling and creating a realistic virtual environment to provide learners with an experience similar to an actual Home visiting healthcare situation. Accurate modeling contributes to increasing the level of immersion in a virtual reality education platform [22], and immersion has a positive effect on the learners' learning outcomes such as knowledge and clinical performance[22],[23]. Therefore, the virtual reality program developed in this study is expected to improve learners' immersion and enhance their ability to perform home visiting healthcare tasks.

This study utilized various multimedia such as quizzes and icons provided to learners within the program to provide clinical meanings of health indicators required for home visiting healthcare knowledge, scientific basis for nursing assessment and intervention in virtual reality. The content of the quizzes and icons developed in this study was confirmed for content appropriateness through expert meetings during the development stage. Learners were provided with immediate feedback after performing clinical judgments through quizzes and multimedia in a virtual reality environment, which is thought to have shown similar facilitation and interaction as conventional simulations. This principle is a learning method that can enhance cognitive processing and understanding through continuous interaction[24], and it is thought that participants in this program will enhance cognitive, emotional, and psychomotor learning outcomes by deeply understanding and processing information within virtual reality.

The usability evaluation results of the ABC Nur-sim VR program developed in this study showed that the hardware interface, dynamic viewpoint, and VR content characteristics were appropriate. The hardware interface of the VR device is important for user immersion and learning effectiveness[25]. The

HMD-based virtual reality nursing education program developed in this study was judged to be key in that it displayed items in a visualized manner so that users could effectively control the VR content, and increased interaction by using a dedicated VR controller[25]. In order to improve the quality of nursing education, it is emphasized that it is important to introduce various interaction methods to provide learners with practical experience in a realistic nursing environment[26]. Therefore, the program developed in this study is expected to provide nursing learners with a more effective and realistic educational experience through such technological innovation.

The usability evaluation results of this study showed that the visual feedback was the most appropriate. All visual elements presented in the virtual reality, such as nursing supplies and daily life products, were made to match the actual size of the program. The UI elements of this study were appropriately placed within the user's field of vision to help learners easily recognize the necessary information in the VR environment, and enhanced the sense of presence and immersion emphasized in the simulation guidelines[27]. Presence and immersion act as facilitating factors that lead to judgments about real situations[27], and the visual feedback of this program is thought to have contributed to allowing learners to experience nursing practice that enhances their visiting nursing capabilities, such as knowledge and clinical performance, in an environment similar to an actual visiting health care situation.

The ABC Nur-sim VR developed in this study showed an expert agreement of over 80% in the expert usability evaluation. According to a previous study [28], items with over 78% consensus among 3 to 5 experts are considered were valid, confirming the reliability of these results. Therefore, this research program was developed as a specific situation-based virtual reality simulation practical education program targeting chronic disease patients by applying digital technology, and it has practical significance in that it supports community nurses and nursing students to effectively learn and apply clinical performance capabilities and skills required in actual visiting health care. In addition, this research program has educational significance in that it provides a customized learning experience by developing a function that dynamically changes content according to

user actions and selections, and increases learning accessibility. It is believed that this will be used as important basic data for developing a high-fidelity educational program similar to actual clinical situations by incorporating digital technology in future nursing practice education.

The usability evaluation results of this program showed the following limitations. First, the screen resolution within the HMD field of view is limited. This program is designed to enable learners to observe patients and their surroundings in virtual reality using an HMD-type VR device and to determine risk factors that can be experienced during actual home visiting healthcare practice. HMD-type VR devices have the advantage of allowing users to utilize 3D spatial information for realistic spatial perception by allowing a wide field of view and free viewpoint change[29]. However, this program was found to have limitations due to the screen resolution within the HMD field of view, which may act as a limitation in conveying detailed information of the VR environment to learners [30]. Therefore, future research on sophisticated graphic processing to simulate complex clinical situations is needed. Second, since the evaluation of this study was limited to a few experts, we suggest an experimental study to evaluate the usability and effectiveness of this program targeting community nurses, and nursing students in the future.

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