Development of Virtual Reality Head-Mounted Display: Teaching Infection Prevention and Control to Millennial Nursing Students

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ABSTRACT

Aims Teaching infection prevention and control to millennial nursing students is a challenge. This study aimed to develop a virtual reality head-mounted display to teach millennial nursing students about infection prevention and control related to catheter-associated urinary tract infections.

Instrument & Methods This study used the analysis, design, development, implementation, and evaluation (ADDIE) model. Using the User Experience Questionnaire (UEQ), 115 nursing students at the College of Health Sciences at Karsa Husada Garut, West Java Province, Indonesia selected using purposive sampling, were evaluated. The data obtained were analyzed with UEQ Data Analysis Tool version 10.

Findings The designed program showed excellent attractiveness, clarity, efficiency, accuracy, stimulation, and novelty, with mean values of 2.26 (95%CI: 2.162-2.362), 2.30 (95%CI: 2.167-2.425), 1.89 (95%CI: 1.646-2.139), 1.88 (95%CI: 1.536-2.225), 1.72 (95%CI: 1.304-2.127), and 1.61 (95%CI: 1.225-1.990), respectively.

Conclusion The infection prevention and control program on the virtual reality display is excellent in terms of attractiveness, clarity, efficiency, accuracy, stimulation, and novelty, making it suitable for millennial nursing students.

Keywords Teaching; Virtual Reality; Nursing Students; Infections

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[1] The challenge of being a teacher in industrial revolution ... [2] Effective teaching behaviors in the emergency department: A qualitative study with Millennial ... [3] An innovative approach to educating nurses to clinical competence: A randomized ... [4] Effectiveness of peer teaching in health professions education: A systematic ... [5] Nursing Skills Laboratory as Milieu of Clinical Learning ... [6] Catheter-associated urinary tract infection ... [7] To observe the incidence and prevention of catheter associated urinary tract ... [8] To assess the incidence of catheter associated urinary tract infection and evaluate ... [9] Avoiding inappropriate urinary catheter use and catheter-associated urinary ... [10] Prevention of biofilms in catheter-associated ... [11] Comparison of 10% povidone iodine and sterile water as a periuretra ... [12] Creative strategies for teaching millennial ... [13] Nursing students perceptions of using YouTube to ... [14] Technology usage for teaching and learning in nursing ... [15] Benefits and pitfalls of learning anatomy using the ... [16] Gamification and virtual reality for teaching mobile ... [17] Virtual reality simulation in nontechnical skills training for ... [18] User experiences of virtual reality technologies for healthcare in ... [19] The potential for haptic touch technology to supplement ... [20] Pedoman Standar Prosedur Operasional ... [21] Developing a virtual reality simulation system for ... [22] Pharmacy students' perceptions towards ... [23] User experience analysis on mobile application ... [24] Universities and Covid-19 in Argentina ... [25] The use of virtual reality simulations in nursing ... [26] Exploring learning strategies of nursing students ... [27] Advances in virtual and augmented reality-exploring ... [28] P229 improving undergraduate medical student ... [29] Factors associated with virtual reality sickness ... [30] Nursing students' experiential learning processes using an online ... [31] Clinical teaching practices of nurse educators: An integrative ...

Introduction

Teaching millennials born and raised during the fourth industrial revolution and digital technology is a challenge compared to previous generations [1]. Millennial possesses distinct characteristics, such as confidence, innovation, commitment, collaboration, multitasking abilities, and tech-savvy [2]. Lecturers face the challenge of teaching clinical skills of infection prevention and control, specifically catheter-associated urinary tract infections (CAUTIs), to millennial nursing students because the process involves complex steps, strict aseptic technique, patient safety, as well as education to prevent infection and injury [3]. In infection control and prevention, traditional learning methods, such as laboratory demonstrations using manikins are not sufficient for students to practice clinical skills and receive feedback on performance [4]. These methods also require significant human and material resources and are limited in time, thereby preventing the repetition of skills and leading to deficiencies in learning and practical experience in the laboratory, affecting students' knowledge and skills, which increases the incidence of CAUTs, affects students' knowledge and skill development, which will increase the incidence of CAUTIs [5].

CAUTIs are one of the highest nosocomial infections in various hospitals [6], with an incidence rate of 35% in hospitalized patients [7] and approximately 3-7% per day [8]. Furthermore, CAUTIs are urinary tract inflammations acquired during hospitalization due to urinary catheter insertion [9]. Symptoms include fever, bladder pain, dysuria, pyuria, as well as bacteriuria [10] and are associated with increased morbidity, mortality, or cost of patient care [6, 11].

Students are expected to apply their knowledge and skills appropriately to reduce the incidence of CAUTIs [12]. Accessible, interactive, and fun clinical skills learning is needed to help millennials understand laboratory practicum materials more efficiently and effectively [13]. Virtual reality technology is a suitable learning medium for millennial students [14]. This is because virtual reality is a three-dimensional computer platform simulation that provides an interactive and realistic experience [15]. Virtual reality head-mounted display (VR HMD) is a three-dimensional simulation technology that combines haptics, computer simulation, and audio with various information [16]. However, there is limited information on the use of virtual reality based on head-mounted displays to train technical expertise in infection prevention and control and includes guidelines for using sterile and non-sterile equipment, as well as case simulation of infection problems [17]. Previous studies only focused on haptic and computer simulation technology to practice nontechnical skills, such as interpersonal and social, procedural, and anatomy [18]. Although haptic and computer simulation technology offers several advantages, it is not suitable for teaching complex commands and handling complicated devices due to its high sensitivity and need for special care [19]. Traditional learning methods for the prevention of CAUTIs for millennial nursing students have been unsuccessful in enhancing their learning potential. Therefore, there is a need to create technology-based learning media that are cheap, realistic, user-friendly, and customizable to reduce safety, ethical, and health concerns. Therefore, this study aimed to develop a VR HMD for teaching millennial nursing students about infection prevention and control related to CAUTIs.

Instrument and Methods

This study used the analysis, design, development, implementation, and evaluation (ADDIE) model with the following stages:

Analysis

The analysis phase included needs, teaching participants, and technical and content analysis [18]. Functional application needs and problems in the learning process were analyzed in May 2022 using literature review and interview methods. Subsequently, semi-structured interviews were conducted online using Zoom with five students, four lecturers, and nurses at the College of Health Sciences at Karsa Husada Garut, West Java Province, Indonesia. The interviews showed that practicum learning media in the laboratory must be cost-effective, realistic, easy-to-use, and easy-to-configure simulators to reduce safety, ethical, and health concerns. Furthermore, the instructors were not bound by time and location using technology era 4.0. The analysis of teaching participants showed that it was necessary to have innovative and attractive learning to clinical knowledge and skills, specifically in preventing CAUTIs. The formation of learning flows and compiling media content were also consistent with the Standard Principles of Nursing Operational Methods published by the Indonesian National Nurses Association (INNA) in 2021 [20]. The technical analysis proved that up-to-date learning methods are needed and suitable for the 4.0 era in the form of computer software, the Internet, and the character of millennial generation students.

Design

The display design of the application was made by professional developers. The menu concept featured a white patterned box with green patterned writing. Infection treatment tools and materials consisted of three-dimensional images of sterile and non-sterile tools with colors similar to their original shapes. A human-shaped three-dimensional animation was also included, which consisted of a male and female patient sleeping on a bed and wearing a green blanket and blue shirt. The patient also had a penis or vagina that could be used interactively to insert a urinary catheter. The practice and exam plans were

presented in a white menu box display accompanied by instructions and a list of tools written in green.

The design stage required some hardware and software to produce a VR HMD with realistic 3D depictions that respond to the user's perspective and recognize all actions and responses, such as the movement of the head or eyeball [21]. VR HMD hardware consisted of glasses using Oculus Quest 2, 128GB, with operating systems Oculus Mobile and Android 10. Subsequently, software, including Visual Code Editor ver 1.54.3, was used to develop codes for VR HMD application programs. Media 3D creation was made using Unity 2021.3.21 and a lightweight 3D engine.

Development
The developed VR HMD included case simulations, practice, and practical exams. When the infection prevention and control application was turned on, it displayed several menus. The application was made with three-dimensional animation, making it immersive and almost lifelike, depicting the hospital environment, and using the Indonesian language. To access the menu, students were asked to enter their identities, starting with their names, emails, and student identification numbers. The menu entry was separated into simulations of equipment and materials, catheter insertion, a theoretical module for urinary catheter placement, as well as directions for use and application.

The simulation menu provided tools and materials for students to learn about sterile and non-sterile materials used in exams and exercises. In the exercise simulation, there was a variety of sterile equipment, such as gloves, commas, cotton or gauze for perineal hygiene, tweezers, syringes, and clamps. Meanwhile, the non-sterile equipment included a catheter in pure plastic according to dimensions, urine bags, antiseptic, aqua bidest, jelly, plaster, scissors, and garbage bags. These materials should be selected based on the on-screen text instructions and the use of tools must be in line with the name, type, and sequence marked with a bright yellow circle.

The simulation menu also included the installation of urinary catheters for women and men. In this simulation, students can take, store, smear, install, and wash their hands. The process began with the case simulation and patient conversations, followed by the insertion of tools, and washing hands in running water with soap.

Students also performed genital hygiene steps and inserted a urinary catheter. Additionally, when the students were out of order, the sign would still glow and the instructions would not change. In the test session, there were time limits, points, and bright yellow circles that indicated the order of tool use removed during the test phase, and tool selection instructions were not displayed.

Implementation
This study was carried out at the College of Health Sciences at Karsa Husada Garut, West Java Province, Indonesia. Data were collected from September 2022 to March 2023 and the application was tested on 115 nursing students who were selected by purposive sampling. The inclusion criteria were students who were actively studying, attending laboratory practicums, studying conventionally, and no myopia and diplopia eye disorders. Meanwhile, the exclusion criteria were students with leave status and those who left as respondents before the study was completed. Students were given a VR HMD of infection prevention and control for CAUTIs and the simulation of tools as well as materials for the activity lasted for 20 minutes.

Evaluation
A User Experience Questionnaire (UEQ) was used and a consent form was signed. The UEQ had six measurement scales divided into 26 items and the availability of tools to perform data analysis in Excel format made it easier for users to measure attractiveness, clarity, efficiency, accuracy, stimulation, and novelty [22]. Respondents can select a circle closer to their thoughts about a product ranging from 1-7. Data were analyzed by UEQ Data Analysis Tool version 10 [23] and categorized as excellent (>1.60), good (1.00-1.60), and average (<1) [22]. Furthermore, mean values ranging from -3 to +3 were all positive, and other scores were negative. The confidence interval (CI) values >1 showed a good confidence level for the results, while values <1 indicated a bad confidence level. Also, a Cronbach's alpha of >0.7 indicated sufficiently consistent, and <0.7 showed consistent results [24].

The validity of the infection prevention and control program was evaluated by the media and a medical-surgical nursing expert with the twelve-question and ten-question questionnaires, respectively.

Findings

Infection prevention and control application was evaluated by a medical-surgical nursing expert, a media expert, and students who used the UEQ. A total of 115 UEQs were received and the application was considered very valid and suitable for use. Based on the characteristics of the participants in Table 1, 70% of them were 20-24 years old, 60% were female, and 80% had a Bachelor's degree.

Table 1) Characteristics of the participants

Characteristic	Category	No.	%
Age (year)	15-19	35	30
	20-24	80	70
Gender	Male	46	40
	Female	69	60
Education	Bachelor's degree	92	80
	Associate degree	23	20

Table 2 shows that all the mean values were positive and > 1, indicating an excellent result for the application. Furthermore, the CI was good as all mean values had a confidence level greater than one.

Table 2) Mean and confidence interval per scale for the infection prevention and control application

Scale	Mean	Std. Deviation	Confidence	Confidence Interval
Attractiveness	2.26	0.411	0.100	2.162-2.362
Perspicuity	2.30	0.530	0.129	2.167-2.425
Efficiency	1.89	1.014	0.246	1.646-2.139
Dependability	1.88	1.416	0.344	1.536-2.225
Stimulation	1.72	1.692	0.411	1.304-2.127
Novelty	1.61	1.574	0.383	1.225-1.990

The results of the six assessment components of the UEQ Data Analysis Tool in Table 3 revealed that all scales were consistent, as Cronbach's alpha values were >0.7.

Table 3) Scale consistency using the UEQ Data Analysis Tool for the infection prevention and control application

Scale	Cronbach's Alpha
Attractiveness	0.83
Perspicuity	0.80
Efficiency	0.80
Dependability	0.86
Stimulation	0.82
Novelty	0.82

The media expert also assessed the infection prevention and control application and described it as an interactive, innovative, as well as immersive hospital environment that allows students to learn with remote access. The expert suggested that the color of the image was more pleasing to the eye.

According to the assessment of the medical-surgical nursing expert, the application consisted of a simulation menu, exams, and quizzes. The patient case simulations in the application only focused on CAUTIs and did not include other disease complications. Meanwhile, the expert recommended the use of personal protective equipment, such as masks, gowns, and face shields for nurses in the simulation of tools and materials, although gloves were already included.

Discussion

The VR HMD application possessed excellent attractiveness and stimulation, which was also supported by Bayram and Caliskan, (2020). This application provides interactive and realistic experiences in three-dimensional form, which allows users to move, feel the clinic environment, touch, and act on simulated objects, and as a result, provides an immersive and attractive experience. to give [25]. Traditional learning methods in nursing education usually involve lectures, textbooks, as well as hands-on clinical and laboratory experiences, which often result in students' boredom and saturation [26]. However, virtual reality enhances knowledge by providing students with enjoyable experiences in clinical decision-making, collaboration, communication, and problem-solving, including confidence and readiness for practice in hospitals or clinics [27]. The use of VR HMD for infection prevention and control devices, specifically for CAUTIs showed excellent novelty and perspicuity. The results of this study are in line with another study [12] showing that VR HMD can stimulate visual, auditory, and sensory experiences to provide a realistic environment for students to learn through the use of computers with easy use and configuration [12]. Meanwhile, traditional learning methods in nursing education have been limited by physical constraints, such as the availability of simulation rooms, real-life clinical experiences, expensive resources, and materials, as well as supervising, time- and location-bound instructors. To overcome these problems, immersive learning with VR HMD offers a unique experience for students who can learn anywhere, anytime, with unlimited time to practice [28]. However, the use of virtual reality for more than 120 minutes can cause dizziness, headaches, and eye strain [29].

The results showed that the VR HMD application has excellent efficiency and dependability. Similarly, a previous study used VR HMD in high-risk settings in medical education to help trainees acquire skills in a safe environment [21]. The use of virtual reality for simulated patient assessment is more effective and interactive compared to lecture and presentation methods [30]. Traditional clinical teaching approach still plays an important role in nursing education, as it allows direct interaction with instructors and peers, real-world clinical experience, and hands-on practice [31]. However, VR HMD has various simulation procedures that enable students to gain experience without compromising patient safety and students' competence [5].

This study had some limitations. The sample selection did not consider the class level and achievement. Furthermore, VR HMD was based on the Android operating system and should be developed on the IOS application. This study only assessed the user experience and needs by assessing the effectiveness of learning with infection prevention and control applications compared to conventional methods for further study.

Conclusion

This study was validated by medical-surgical nursing and media experts. VR HMD infection prevention and control application is excellent in terms of attractiveness, clarity, efficiency, accuracy, stimulation, and novelty, as confirmed by nursing students. Therefore, this application is suitable for millennial nursing students who become more skilled when practicing in a hospital.

Nursing students and instructors can also use the application for innovative and attractive learning, to improve clinical knowledge and skills. Furthermore, it can be used by nursing students as an alternative to laboratory learning.

Telkom University, STIkes Karsa Husada Garut for data collection, and to all participants.

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