

## Literature Review about Virtual Reality-Based Education for Healthcare Students

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### Abstract

The purpose of this study was to analyze the current status of the Virtual Reality-based education for healthcare students in Korea. Five databases (KoreaMed, KMBASE, NDSL, KISS, KiSTi) were searched prior to July 2022. A total of 10 articles met the inclusion criteria. Five articles developed VR-based education contents and the other five articles were using vSim already developed as a VR education program and evaluated the effectiveness. As a result of this literature review, VR-based education program was found to be effective in improving the healthcare students' competency. VR-based education program could be considered to improve the healthcare students' clinical practice ability.

**Keywords:** Healthcare Students, Virtual Reality, Education

## 1. INTRODUCTION

Patient safety is the prevention of endangerment of the patient by minimizing the likelihood of medical errors and adverse events as a state of freedom from accident or damage [1]. Patients have the right to get safe treatment in a fundamentally secure environment, that patient safety acts as a factor in assessing the quality of care. Therefore, Patient safety is the duty of every healthcare worker who works in a medical institution. To reinforce patient safety management in hospitals, improvement in the attitude of healthcare workers toward patient safety management, and clinical competence in safety management are essential to reducing the risk of patient safety incidents [2]. Patient safety incidents that happen in the medical field are more important than anything else because of a direct relationship to the patient life. For these reasons, patient safety education for healthcare workers should be a top priority above all. However, the reality is that clinical practice in healthcare is largely based on observation and verbal explanation. While the importance of clinical practice in medical institutions is generally sympathetic, systematic guidance of clinical practice in an actual clinical setting is a difficult situation [3]. In addition, most of the department of emergency medical technicians are poorly trained in patient safety.

From this point of view, systematic and accurate patient safety education in universities must be implemented. While the diverse tasks of the emergency medical technician in clinical fields overload the work, a proactive scheme should be laid out in the first instance, so that the right education in patient safety is properly

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carried out in universities. Simulation-based education that was initiated to overcome the limitation of the teaching method has been reported of contributing to improving the clinical competency of learners through the clinical situation which is going to experience [4]. Since strengthening patient rights and patient safety in a clinical setting is increasingly challenging to clinical practice, student-centered patient safety simulation programs in universities are demanding.

Virtual Reality (VR) is an integration of computer-based technologies that can reactively change graphic images or contents on a computer screen through the user's reaction or movement, and one of the delivery methods that offers users an increased sense of reality and presence [5]. Also, learners are able to experience freely in a virtual space, guiding lots of possibilities for future education. The high-speed evolution in virtual environment technologies can look forward to the educational effects that virtual experience allows to feel in the real world. International research on emergency medical workers has suggested that simulation training is effective in behavioral emergency care [6]. In addition, simulation training for patient safety enables all medical experts to acquire knowledge, skills, and attitudes in safe, educational, and efficient manners [7], and simulation training can improve patient safety behavior [8]. Therefore, this study aimed to provide the basic data for development in VR-based patient safety simulation programs through analysis for study with intervention method in VR-based education for Healthcare students that was conducted recently in Korea to carry out VR-based patient simulation program development and usability evaluation research for paramedic students.

## **2. PURPOSES**

This study was conducted to offer the data to develop the program of VR-based patient safety simulation program through an analysis of the study with intervention methods in Virtual Reality-based education for domestic healthcare students, and the specific objectives are as follows:

- Identify the general characteristics of Virtual Reality-based educational research in Healthcare students
- Identify the validity of the study results
- Identify the measurement variables according to Bloom's classification of educational goals

## **3. METHODS**

This study aimed to identify the research on the education of Virtual Reality-based simulation in Korean healthcare students.

### **3.1 Selection criteria**

In the inclusion criteria of analysis, the participants were healthcare students, the intervention method was conducted by Virtual-Reality-based education or class, and the study aimed to the research that confirmed the intervention effect using the measurement tool. The exclusion criteria of articles is as follows:

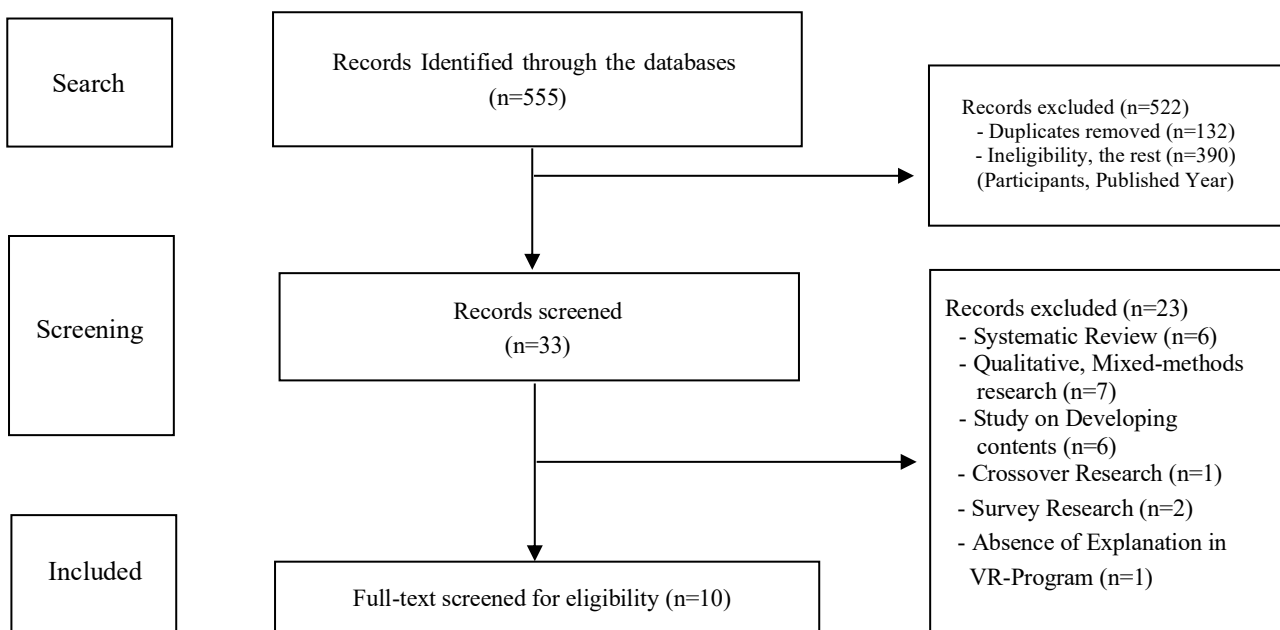
1. The study participated without healthcare students.
2. The study that does not use the intervention method
3. A survey research, a qualitative research, a crossover study, a systematic review and the study published before 2020.

### **3.2 Literature Review**

Four co-authors independently researched articles and decided on exclusion together after discussion. Reviewers searched the electronic bibliographic database inception through KoreaMed, KMBASE, NDSL, KISTi, and KISS on search engine COSI(Core, Standard Ideal) [9] model and keywords included “virtual reality”, and “education,” using OR and AND operators. As a result of searching, we identified a total of 555 articles in the beginning, of which 163 articles were in KISTi, 46 articles in KoreaMed, 56 articles in KMBASE, 38 articles in NDSL, and 252 articles in KISS. In the following procedure, a total of 33 articles were eligible in the first selection while 132 duplicated articles and 390 articles against the participant selection criteria were removed by four researchers who identified the title and abstract. In the second selection, two reviewers screened throughout the full-text articles, and excluded articles were 6 systematic reviews, 7 qualitative or mixed-methods research, 6 study on developing the contents, 2 survey research, 1 crossover study, and 1 study without detailed explanation about the source or utilization of Virtual-Reality program. The number of articles finally retained was a total of 10.

### 3.3 Data Analysis

As shown in Figure 1, We took 3 analytical frameworks to analyze the study. First, summarization with a structured analytical framework was performed to finally selected articles for data analysis by reading in depth. The analytical framework was composed of an author, a published year, a journal, a study design, a number of participant, and measurement variables. Second, the selected articles with sample size calculation and the verification of reliability and validity for used tools was confirmed. Third, measurement variables used in the selected articles were analyzed classifying into cognitive domain, affective domain, and psychomotor domain as an educational objective guided by Bloom(1956) [10].



**Figure 1. Flow and identification of studies to include in review of virtual reality-based education**

## 4. RESULTS

### 4.1 General Characteristics of Analyzed Research

As shown in Table 1, 10 articles were included in the analysis of Virtual Reality-based education in Healthcare. Among 10 articles, Nursing published 9 articles, the highest, and 1 for Radiology. 5 articles (1, 3, 4, 5, 6) developed contents and verified the effectiveness and designed with research of pretest-posttest nonequivalent control group design. And the other five were composed of the off-the-shelf VR educational program and using vSim(virtual Simulation for nursing) that provided by Laerdal Medical and Wolters Kluwer with the research of pretest-posttest single group design.

### 4.2 Validity of Results on Analysis

The validity of 10 results in VR-based educational research analysis for Healthcare students was analyzed. The research presented the basis of calculation in the number of participants was a total of 8(1, 2, 5, 6, 7, 8, 9, 10). The articles presented the source of tools to measure the involved variables, and proposed the reliability and validity of tools. 1 article (4) without homogeneity verification in the pretest-posttest nonequivalent control group design was identified. 3 articles (1, 6, 9) were approved by the IRB institution, and the rest articles proceeded with the consent of the research participants during the progress.

### 4.3 Measurement Variables of Analysis Classified by Bloom

As shown in Table 2, The final 10 articles that were classified in accordance with Bloom(1956) [10] in the study and measurement variables were divided and examined into the cognitive domain, the affective domain, and the psychomotor domain. The variables corresponding to the cognitive domain were categorized into Knowledge, Academic Achievement, Clinical Reasoning Ability, Problem Solving Processes, and Clinical Decision Making Ability. The variables included in the affective domain were Satisfaction, Self-efficacy, Learning Flow, Critical Thinking, Transfer Motivation, and Confidence. And the variables of Therapeutic Communication, Clinical Performance Ability, and Nursing Process Competency were in the psychomotor domain. Self-efficacy(academic Self-efficacy) was the most well-used measurement variable. Satisfaction and Learning Flow were in order.

**Table 1. Summary of Characteristics of Studies**

Author (year)	Journal	Design	IRB	Sample size	Intervention		Measurements variable
					Experimental group	Control group	
1 Kim & Kim, (2021)	Journal of Korean Academy of Fundamentals Nursing	Nonequivalent control group pre-posttest design	+	Nursing student E:69, C:68	VR using 360 degree-view Made by researcher	Traditional method using	knowledge, academic self-efficacy, learning flow, educational satisfaction, and academic achievement
2 Kim & Kim, (2022)	Journal of Digital Convergence	One group Pre-posttest design	-	Nursing Student E:44	vSim for Nursing (Laerdal Medical and Wolter Kluwer)	-	critical thinking disposition, clinical competency, practice satisfaction

3	Kim (2021)	Journal of The Korea Society of Computer and Information	Nonequivalent control group pre-posttest design	-	Nursing Student E:30, C:30	SAM VR	Traditional method using practice	learning flow, learning confidence, learning satisfaction
4	Shim, Kwon (2020)	Journal of Radiological Science and Technology	Nonequivalent control group pre-posttest design	-	Radiology student E:36, C:35	VR using made by Researcher	None application of VR Content	self -direct learning, self -learning efficacy, learning satisfaction
5	Lee & Kim (2021)	Journal of Korean Academy Psychiatric Mental Health Nursing	Nonequivalent control group pre-posttest design	-	Nursing student E:35, C:35	Case-based application of VR program	Receiving materials and self-study	knowledge, learning self-efficacy, Therapeutic communication Communication confidence Learning immersion Problem-solving process
6	Lee & Ryu (2021)	Journal of Korean Academy of Fundamentals Nursing	Nonequivalent control group pre-posttest design	+	Nursing student E:21, C:20	PC based Virtual reality simulation education	PC based prerequisite learning Lecture	clinical decision-making ability confidence in performance, practice flow, class evaluation Simulation design evaluation
7	Lim & Yeom, (2020)	Journal of Convergence for Information Technology	One group pre-posttest	-	Nursing student E:30	vSim for Nursing (Laerdal Medical and Wolter Kluwer)	-	Self-efficacy, Clinical Performance Ability Critical thinking
8	Lim Jung-Hye (2021)	Journal of Digital Convergence	One group pre-posttest	-	Nursing Student E:31	vSim for Nursing (Laerdal Medical and Wolter Kluwer)	-	Nursing process competency, Critical thinking disposition, Self-efficacy,
9	Han & Lee (2021)	Journal of The Korea Convergence Society	One group pre-posttest	+	Nursing student E:41	vSim for Nursing (Laerdal Medical and Wolter Kluwer)	-	Transfer motivation, Learning self-efficacy
10	Kim Sung Hae (2022)	Journal of Healthcare Simulation	One group pre-posttest	-	Nursing student E:15	vSim for Nursing (Laerdal Medical and Wolter Kluwer)	-	Clinical reasoning ability Learning flow

**Table 2. Measurement variables in the analysis literature according to the classification of Bloom**

Category	Measurement Variables	Number of Articles
Cognitive Domain	Knowledge	1, 5
	Academic Achievement	1
	Clinical Reasoning Ability	10
	Problem Solving Processes	5
Affective Domain	Clinical Decision-Making Ability	6
	Satisfaction	1, 2, 3, 4, 9
	Self-efficacy	1, 4, 5, 7, 8, 9
	Learning Flow	3, 5, 6, 10
	Critical Thinking	1, 8
	Transfer Motivation	9
	Confidence	3, 5, 6
Psychomotor Domain	Self-direct Learning	4
	Therapeutic Communication	5
	Clinical Performance Ability	2, 7
	Nursing Process Competency	8

## 5. DISCUSSIONS

This study aimed to research Virtual Reality-based education in Healthcare among the domestic articles till July 2022. The search for the selection of the analysis study was independently conducted by 4 co-authors, and 4 reviewers discussed the inclusion and exclusion and decided on the last 10 articles to be selected as an analysis.

Nine of the analysis documents were related to nursing. As the number of students increases, there are many difficulties in conducting appropriate clinical practice. Like the prevalent Covid-19 difficulties are not only in concerns about infectious diseases and in the direct contact or the various treatment tasks for the safety of patients and practitioners, but also in the limitation of the containable number of clinical practitioners and departments in the medical institution [11]. Therefore, the research in nursing is being actively conducted compared to other healthcare majors because the interest in Virtual-Reality-based education has been amplified as an alternative to clinical learning and VR-based education is getting used in nursing. However, research on VR-based education in other healthcare majors has not yet been conducted enough. Research for Emergency medical technician students and Dental hygiene students were not finally included in this study because the study design of each article was involved in the exclusion criteria. Just like the nursing research, the management in the expansion of VR-based instruction requires lightening a load of clinical practice, setting up education in a safe environment, and increasing the learning effect, simultaneously [12]. 9 articles for nursing students were used in practical courses such as hospital environment, pediatric nursing, scenario-based admission management, case-based psychiatric nursing, respiratory nursing, emergency nursing practice, adult nursing practice, psychiatric nursing practice, fundamental nursing practice, etc. While education using simulators has been carried out in practical training, the visuospatial sense of reality is not apparently present and the cost is still burdensome. However, VR-based education needs students to experience an increased sense of reality and presence [5], and to enable repetitive training in a secure room, not threatening patient safety [11]. In addition, 5 articles were developed by the investigators and verified the effects of the research, all of which were the pretest-posttest nonequivalent control group design, while the remaining 5 articles were all pretest-posttest single group design studies using ‘vSim for nursing,’ provided by Laerdal Medical and

Wolter Kluwer, a virtual simulation-based education program.

All the analysis studies were quantitative research to identify the moderating effect of VR applied education and to classify the measurement variables by the educational goals in Bloom. The cognitive domain is of thinking behavior, which includes knowledge, understanding, application, analysis, synthesis, and evaluation [13]. The cognitive domains composed of Knowledge, Academic Achievement, Clinical Reasoning Ability, Problem Solving Process, and Clinical Decision Making Ability were applied in this research. Knowledge is being measured as an effect variable in VR education [1,14,15]. Also, VR-based education has been confirmed as an educational strategy that improves the knowledge of healthcare students [1,14-18] and has increased Clinical Reasoning Ability and Clinical Decision Making Ability [6,10], while Academic Achievement and Problem Solving Ability were significantly higher in VR-based education than the control group [17,18].

The affective domain corresponds to feelings or attitudes such as behaviors, values, beliefs, etc.[13], and Satisfaction, Self-efficacy, Learning flow, Critical Thinking, Transfer Motivation, Confidence, and Self-direct Learning were used in this study. Of these, Self-efficacy, Satisfaction, Learning Flow, and Critical Thinking were identified as the most used measurement variables in the analysis study. Besides, the measurement variables used for analysis were mainly in the affective domain. The affective domain is often utilized as measurement variables for the identification of learning effects, acting as the variables that bring the change in attitudes toward positive effects on learning. Among the variables, Self-efficacy and Learning Flow showed conflicting results in every study, but in general, Confidence, Satisfaction, and Critical Thinking were consistently high in VR-based education [17-26]. Because the affective domain has characteristics difficult to change through short-term education [27]. No significant change in Self-direct Learning was to be found in the case of virtual reality applications. On the other hand, a significant correlation between academic Self-efficacy and learning Satisfaction was confirmed [22] and a replication study on various factors is demanding to verify the effect of Virtual Reality-based education in the future. It was reported that the transfer motivation is effective only by identifying whether the intention to apply knowledge or skills gained by the new learning method to the practice [28]. Through the analysis study, Transfer Motivation was significantly increased in psychiatric nursing using Virtual Reality-simulation practice education, and a significant correlation was identified between Satisfaction and Self-efficacy [25].

The psychomotor domain is a domain of behavior-like technique through the movement of nerves and muscles, and this study includes Therapeutic Communication, Clinical Performance Ability, and Nursing Process Competency. Therapeutic Communication is an important therapeutic tool that forms therapeutic relationships with subjects. it explores, analyzes, and solves the problem by utilizing verbal and nonverbal communication skills based on empathy and understanding, and should be applied to the practice field regarding knowledge, skills, and behaviors acquired by students [29]. So, the educational effect is expected by practicing adequate communication skills in diverse virtual reality situations. Clinical Performance Ability is an important variable that improves by VR learning [19,23]. Nursing Process Competency is an efficient process of discovering the subject problem and conducting the necessary nursing intervention in the clinical field [30], and it has been identified to be improved sufficiently by VR-based education [24]. The study had limitations, of which VR-based education research for domestic healthcare students was not so sufficient that the systematic review including quality evaluation was not applicable. However, based on the intervention research for recent 3 years, there is a meaning of identifying the effect of Virtual Reality-based education by examining the mainly used variables. And the findings could provide the basic data for planning Virtual Reality-based intervention research in days to come.

## **6. CONCLUSIONS**

Clinical practice is an essential course for healthcare students. But the practice clinical setting in hospital, restricted recently due to patient's safety, infection, and privacy protection. For this reason, the interest in VR-based education is growing rapidly. As a result of the literature review, VR-based education program was found to be effective in improving the healthcare students' competency. However, this study showed that most of these VR-based educations were for nursing students. VR-based education program could be considered to improve other healthcare students' clinical practice ability.

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## APPENDIX

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