

Systematic Review / Sistematik Derleme

The Effect of Using Virtual Reality in Teaching Basic Nursing Skills on Students' Cognitive, Affective and Psychomotor Skills: A Systematic Review

Hemşirelik Temel Becerilerinin Öğretiminde Sanal Gerçeklik Kullanımının Öğrencilerin Bilgi, Duyusal ve Psikomotor Becerilerine Etkisi: Sistematik Derleme

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ABSTRACT

Today, the use of virtual reality technology in nursing education is becoming widespread and this application has positive effects. To determine the effect of the use of virtual reality in teaching basic nursing skills on students' cognitive, affective and psychomotor skills. In the study, "Cochrane", "EBSCOhost", "PubMed", "Ulakbim", "Medline", "CIHANL", "JBI", "Scopus", "Science Direct" and "Google Scholar" databases were searched. While searching the databases, the keywords "nurse education, virtual reality, virtual reality simulation, basic nursing skills, nursing students, skills training, knowledge level, affective level, psychomotor skill level" were used. The number of studies found as a result of the search was categorized according to the databases and shown in the PRISMA-P flowchart. Quality assessments of the studies were made using the Joanna Briggs Institute checklists. PROSPERO recording number is CRD4202340107. In this study, the literature review was conducted between January 24, 2023-August 4, 2023. In the study, 14 studies that met the inclusion criteria were analyzed. It was found that 10 studies were randomized controlled experimental and four studies were quasi-experimental. Most of the studies were conducted in Turkey, Canada and Taiwan respectively and the total sample size was 970. The quality assessment scores of the studies were found to be at a high level. It was concluded that the use of virtual reality has a positive effect on the cognitive, affective and psychomotor skills of students in nursing education, increases the permanence of knowledge and increases the skill performance of students.

Keywords: Basic Nursing Skills, Nursing Education, Virtual Reality.

ÖZ

Günümüzde sanal gerçeklik teknolojisinin hemşirelik eğitiminde kullanımı yaygınlaşmakta ve bu uygulamanın olumlu etkileri bulunmaktadır. Temel hemşirelik becerilerinin öğretiminde sanal gerçeklik kullanımının öğrencilerin bilişsel, duyuşsal ve psikomotor becerileri üzerine etkisini belirlemektir. Araştırmada "Cochrane", "EBSCOhost", "PubMed", "Ulakbim", "Medline", "CIHANL", "JBI", "Scopus", "Science Direct" ve "Google Scholar" veri tabanları tarandı. Veri tabanları taranırken "hemşire eğitimi, sanal gerçeklik, sanal gerçeklik simülasyonu, temel hemşirelik becerileri, hemşirelik öğrencileri, beceri eğitimi, bilgi düzeyi, duyuşsal düzey, psikomotor beceri düzeyi" anahtar kelimeleri kullanılmıştır. Tarama sonucunda bulunan çalışma sayıları veri tabanlarına göre kategorize edilerek PRISMA-P akış şemasında gösterilmiştir. Çalışmaların kalite değerlendirmeleri Joanna Briggs Enstitüsü kontrol listeleri kullanılarak yapılmıştır. PROSPERO kayıt numarası CRD4202340107'dir. Bu çalışmada, literatür taraması 24 Ocak 2023 ile 4 Ağustos 2023 tarihleri arasında gerçekleştirilmiştir. Çalışmada, dahil edilme kriterlerini karşılayan 14 çalışma analiz edilmiştir. Çalışmaların 10'unun randomize kontrollü deneysel, dördünün ise yarı deneysel olduğu tespit edilmiştir. Çalışmaların çoğu sırasıyla Türkiye, Kanada ve Tayvan'da yapılmıştır ve toplam örneklem büyüklüğü 970'tir. Çalışmaların kalite değerlendirme puanları yüksek

düzyeyde bulunmuştur. Sanal gerçeklik kullanımının öğrencilerin bilişsel, duyuşsal ve psikomotor becerileri üzerinde olumlu bir etkisi olduđu sonucuna varılmıştır.

Anahtar Kelimeler: Hemşirelik Eğitimi, Sanal Gerçeklik, Temel Hemşirelik Becerileri.

1. Introduction

Technological advances are important elements that shape the developing and changing world (1). Technology, which has become an integral part of our daily lives, is a dynamic structure that can improve the quality of life in every field (2). This dynamic structure of technology also enables the advancement of virtual reality (3). Especially the use of virtual reality in education is becoming widespread. Considering the changes in technology, the need for new teaching methods is increasing (4).

Traditional teaching methods cannot respond to the increasing expectations of society and the changing information needs of the age. This change also affects nursing education (5). Nurses, who constitute the basic building block of the health care system, need to receive an effective education in accordance with technological developments. In this context, especially the integration of virtual reality technologies into nursing education systems is one of the promising developments for nursing education (6). The use of virtual reality in nursing education is an innovation for nursing education. This innovation will save time and increase student productivity (7). Virtual reality is defined as the transfer of the physical presence of people or objects to a computer by analogy (8). This transfer consists of software designs that behave like a real world where users can interact with objects through various devices and almost feel them (9). Virtual reality provides interactive experiences of an alternate reality where users are avatars that can move, feel and touch simulated computer graphics, supporting the perception that these objects actually exist (9,10). Virtual reality is designed to support visual and auditory sensory experience so that students can actively explore and practice in a dynamic environment (8). These features underline that virtual reality is an excellent foundation for learning from a constructivist perspective (11). The use of virtual reality technologies in nursing education creates a learning environment where students can experience real life situations more effectively (11,12). Virtual reality has emerged as a safe, effective pedagogical method to teach clinical skills to nursing students and to enable students to reinforce these skills (13).

The aim of nursing education is to provide students with basic knowledge, skills and attitudes in three learning areas: cognitive, affective and psychomotor. According to Bloom's taxonomy in learning, student achievements and goals are classified under three areas (14). The first of these areas, the cognitive area, is defined as the area where mental

abilities are encoded or learning with a predominant mental aspect. Teaching objectives at the knowledge level are recall behaviors such as recognizing the characteristics of an object or phenomenon when one sees it, saying it when asked, or repeating it verbatim from memory (14). The knowledge level of the cognitive domain is not only the basis for comprehension, application, analysis, synthesis and evaluation, but also the prerequisite for affective and psychomotor domains (15). Virtual reality can make learning more effective and participatory by providing students with concrete experiences. Students can be actively exposed to visual and auditory stimuli in interactive 3D environments to better understand abstract concepts and better internalize learned information. The benefits of using virtual reality are seen in increasing the retention of knowledge (16). Virtual reality gives students the opportunity to combine theoretical knowledge with practical applications. This can increase students' ability to apply what they have learned in real-world scenarios. Some studies show that the use of virtual reality can increase students' knowledge recall and retention (17,18,19). Concrete experiences can contribute to the retention of learned information and long-term recall processes.

The affective domain dimension includes factors such as attitude, interest, affection, etc. that students feel towards a certain value, as well as individual characteristics such as personality, temperament or disposition (14). The affective domain includes tendencies such as interest, attitude, demeanor and emotion towards an object, an event or a subject. It is the area where emotional areas such as love, fear, interest and attitude are dominant (20). At this point, it will be seen that learning with virtual reality will affect students' motivation to learn, their desire to learn and their attitudes towards virtual reality. Virtual reality can attract students' attention and help them establish an emotional connection to the learning process. This can make students more motivated and more interested in the subject (11,21).

The psychomotor domain is the domain where skills requiring mind and muscle coordination are dominant. In this domain, physical skills are at the forefront (14). The individual psychomotorly demonstrates some behavior patterns by using his/her muscles, one or more of his/her body organs or all of them. There is a cognitive and affective process in every psychomotor behavior and therefore this field is intertwined with other fields. Nursing skills play an important role in the development of nursing education core competencies. Virtual reality technology allows students to use, reapply or repeat the simulation application from anywhere, anytime and as much as they want. In this way, students practice developing and practicing psychomotor skills; they can reinforce the

practice through supervision and repetition (22,23). It is seen that virtual reality contributes positively to the cognitive learning of nursing students (24,25).

This study was conducted to determine the effect of the current use of virtual reality simulation in nursing education on students' learning in cognitive, affective and psychomotor skill areas. There is no systematic review in the literature that examines the development of all cognitive, affective and psychomotor skills of students in nursing education. Most of the articles published on the role of virtual reality in nursing education (7,26,27). Emphasize the demand for curriculum reforms based on the latest technologies in education. It is thought that virtual reality application methods can make a change in the traditional nursing curriculum in terms of student's search for information, increasing their motivation towards the lessons and developing their psychomotor skills. In this direction, studies on the contributions of virtual reality to nursing education were reviewed in the literature. It is foreseen that the information obtained from this review can guide the national and international literature and future scientific research on this subject.

1.1. Aim

In this systematic review, it was aimed to determine the effect of using virtual reality in teaching basic nursing skills on students' cognitive, affective and psychomotor skills.

1.2. Question of Study

For this purpose, the following questions were answered:

- Does the use of virtual reality in teaching basic nursing skills have an effect on students' cognitive levels?
- Does the use of virtual reality in teaching basic nursing skills have an effect on students' affective levels?
- Does the use of virtual reality in teaching basic nursing skills have an effect on students' psychomotor skill levels?

2. Methods

This study is a systematic review. The "Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols (PRISMA-P)" protocol was used for the protocol of the systematic review and the writing of the article.

2.1. Literature Review

In this study, the searches were conducted between January 24, 2023 and August 4, 2023. The searches were conducted through “Cochrane”, “EBSCOhost”, “PubMed”, “Ulakbim”, “Medline”, “CIHANL”, “JBI”, “Scopus”, “Science Direct” and “Google Scholar” databases. The inclusion criteria were that the studies were published between 2013 and 2023, consisted of randomized controlled experimental or quasi-experimental studies, were in English language, and consisted of studies in which virtual reality simulation was used in teaching basic nursing skills. All studies that met these criteria were included in the study without limiting the sample size. While searching the databases, the keywords “nurse education, virtual reality, virtual reality simulation, basic nursing skills, nursing students, skills training, knowledge level, affective level, psychomotor skill level” specific to the study subject were used. The number of studies reached as a result of the search was categorized according to the databases and shown in the PRISMA-P flowchart (Figure 1).

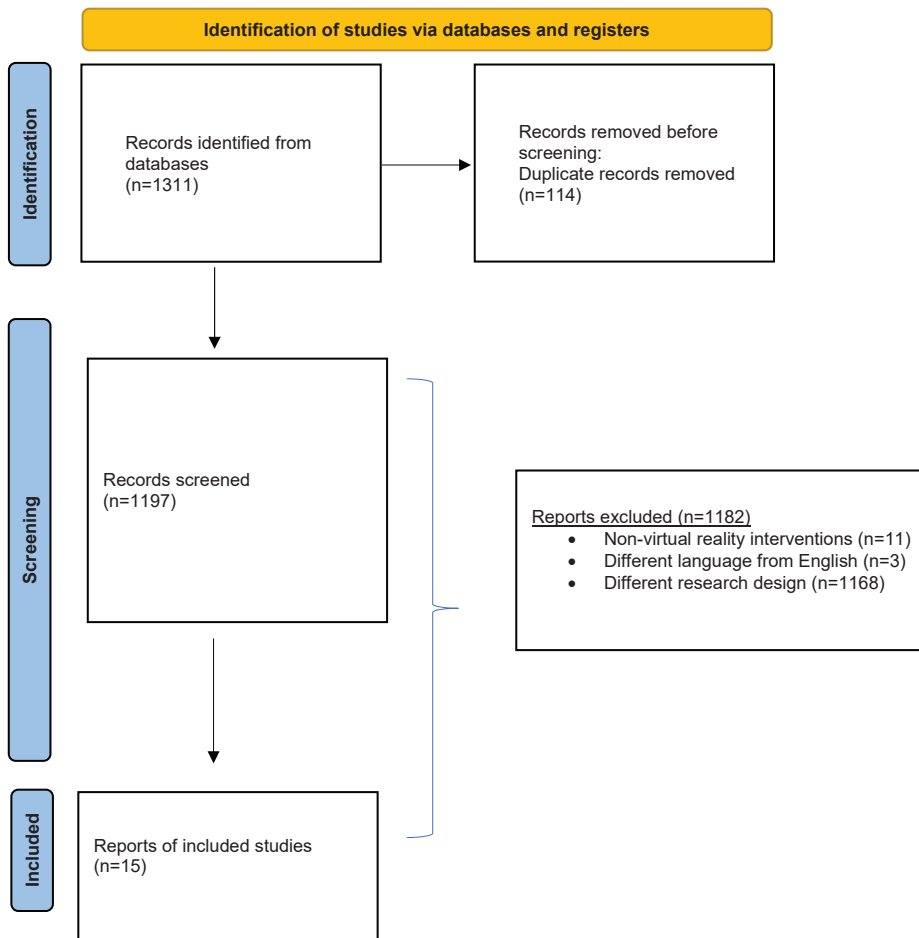


Figure 1. PRISMA-P flow chart

2.2. Sample Selection and Inclusion Criteria

Studies eligible for this systematic review were selected according to the following PICOS (Population, Intervention-Comparison-Outcomes-Study design) inclusion criteria:

P: (Study Group): The sample of the study consisted of studies using virtual reality in the basic skills training of nursing students.

I: (Intervention): Studies in which virtual reality simulation was used in teaching basic nursing skills constitute the intervention dimension.

C: (Comparison): The effects of using virtual reality and other teaching methods on students' cognitive, affective, and psychomotor skills were compared.

O: (Results): The effects of using virtual reality in teaching basic nursing skills on students' cognitive, affective and psychomotor skills were investigated.

S: (Study design): English randomized controlled and quasi-experimental studies published between 2013 and 2023 with full text available were included.

The exclusion criteria were as follows: studies with unclear methodology, studies whose full text could not be accessed, studies not written in English, reviews, qualitative and descriptive studies, studies not published between 2013 and 2023, and studies with a sample group different from nursing students.

In this systematic review, studies using virtual reality simulation in teaching nursing skills were selected. The selection of the studies included in the study according to the eligibility criteria was carried out independently by two researchers. After removing repetitive studies in the scans, the selection was made according to the title, abstract and full text, respectively (Table 1).

Table 1. Included studies and their characteristic.

Study Name and Year	Authors	Design and Country	Sample Size	Data Tools	Results	Conclusion and Recommendation
Effect of Non-Immersive Virtual Reality Simulation on Type 2 Diabetes Education for Nursing Students: A Randomised Controlled Trial ²¹ 2022	Singleton, et al.	Randomized Controlled Study (England)	Total of 171 second year nursing students Control group (n= 88) Experimental group (n=83)	Total of 26-question pre-test survey regarding hypoglycemia, 10-question multiple-choice survey form regarding hypoglycemia prepared together with diabetes specialist nurses.	It was found that the students in the experimental group using VR had significantly higher hypoglycemia knowledge (p = 0.001) than the control group. The experimental group performed better on every question. The experimental group scores were significantly higher than those of the control group (p<.001) at the .05 significance level using the independent sample median test.	VR simulation provides the opportunity to practice clinical skills safely.
Effectiveness of immersive virtual reality training in nasogastric tube feeding education: A randomized controlled trial ¹⁸ 2022	Lo et al.	Randomized controlled trial (Taiwan)	Total of 107 nursing students Control group (n= 53) Experimental group (n=54)	Pre-test and post-test surveys regarding nasogastric tube feeding knowledge, learning motivation, cognitive load and satisfaction surveys.	External goal orientation mean scores were significantly higher in the IVR group than in the control group. Mean pretest scores on nasogastric tube feeding skills were similar between the IVR and control groups. Cognitive load and satisfaction were both rated significantly higher in the IVR group than in the control group.	Both IVR training and traditional 2D video improved nursing students' learning outcomes. Students were more satisfied with IVR than the traditional learning model and indicated that IVR inspired their extrinsic learning motivation and perceived task value.
Virtual reality in nursing education 3D intravenous catheterization E-learning: A randomized controlled trial ³⁸ 2022	Yıldız and Demiray	Randomized controlled trial (Turkey)	Total of 52 nursing students Control group (n= 26) Experimental group (n=26)	Student Information Form, Intravenous Catheterization and Fluidization Skills Checklist, and Bondy Rating Scale	A statistically significant difference was found between the total skill averages of the students in the experimental and control groups (p = 0.001).	Virtual reality technology is effective as a teaching method in improving intravenous catheterization and fluid administration skills.

Study Name and Year	Authors	Design and Country	Sample Size	Data Tools	Results	Conclusion and Recommendation
A pediatric seizure management virtual reality simulator for nursing students: A quasi-experimental design ³⁶ 2022	Wu et al.	Quasi-experimental study (Taiwan)	Total of 105 nursing students Control group (n= 52) Experimental group (n=53)	Seizure Management Knowledge Test, Pediatric Seizure Management Virtual Reality Acceptance Survey and Virtual Reality Usage Survey	The posttest knowledge score in the experimental group was significantly higher than that in the control group.	It was concluded that the use of virtual reality was effective in teaching pediatric seizure management.
Virtual reality simulation for learning wound dressing: Acceptance and usability ¹¹ 2022	Choi	Quasi-experimental study (Chinese)	Total of 30 nursing students Control group (n= 15) Experimental group (n=15)	Knowledge test, user acceptance survey and simulator usability survey	The mean scores of the control and experimental groups for the knowledge test were similar. The user acceptance survey and simulator usability mean scores of the experimental group were higher than the control group.	It was concluded that the use of virtual reality in wound care teaching would be beneficial in terms of students' satisfaction and knowledge acquisition.
Virtual reality teaching in chemotherapy administration: Randomised controlled trial ¹⁷ 2021	Chan et al.	Randomized controlled trial (Taiwan)	Total of 77 nursing students Control group (n= 39) Experimental group (n=38)	Information form about chemotherapy application, Attitude form towards chemotherapy application, Student satisfaction form for chemotherapy application	The knowledge (and attitude posttest scores) in the experimental group were significantly different from those in the control group. The satisfaction of the students in the experimental group with education was significantly higher than the control group.	Virtual reality-based learning is an effective and useful method for students to understand the preparation, administration, and safety of chemotherapy.
The Integration of Virtual Simulation Gaming Into Undergraduate Nursing Resuscitation Education: A Pilot Randomised Controlled Trial ²³ 2021	Keys et al.	Randomized controlled trial (Canada)	Total of 26 nursing students Control group (n=13) Experimental group (n=13)	A 12-item performance checklist was used to evaluate participants. It was developed by the research team using the Heart and Stroke Foundation's (2015) BLS and ACLS testing checklists as a guide.	The overall performance scores of the students in the experimental group were higher than those in the control group.	Students who received resuscitation training with virtual simulation performed better than students who were trained only with traditional pre-simulation preparation.

Study Name and Year	Authors	Design and Country	Sample Size	Data Tools	Results	Conclusion and Recommendation
A Quasi-Experimental Study Comparing Virtual Simulation to Lab-Based Learning of Newborn Assessment Among Nursing Students ³⁰ 2021	Hudder et al.	Quasi-experimental study (Canada)	Total of 36 nursing students Control group (n=11) Experimental group (n=25)	Students' knowledge, skills, satisfaction and self-confidence, as well as clinical judgments, were assessed using four tools: pre- and post-tests, student satisfaction and self-confidence surveys, clinical evaluation and neonatal assessment chart.	Students' knowledge of newborn assessment scores improved from pretest to posttest in both the laboratory and virtual simulation groups, and the mean change score in the virtual simulation was higher than that of other students.	The findings from this study revealed that students' knowledge acquisition regarding neonatal assessment was greater when the content and demonstration were presented by virtual simulation. Students in the experimental group had higher satisfaction and self-confidence with the opportunity to participate in face-to-face laboratory activities.
Clinical Virtual Simulation in Nursing Education: Randomized Controlled Trial ¹⁹ 2019	Padilha et al.	Randomized controlled trial (Portugal)	Total of 42 nursing students Control group (n=21) Experimental group (n=21)	Knowledge and clinical judgment were assessed with a true or false and multiple-choice knowledge test before the intervention, after the intervention, and 2 months later. After the intervention, students' learning satisfaction and self-efficacy levels were evaluated with a Likert scale.	The experimental group made more significant improvements in knowledge immediately after the intervention and two months later, and also showed higher levels of learning satisfaction.	Incorporating clinical virtual simulation into nursing education has the potential to improve knowledge retention and clinical judgment at baseline and over time, and increases satisfaction with the learning experience among nursing students.
Effect of a game-based virtual reality phone application on tracheostomy care education for nursing students: A randomized controlled trial ²⁸ 2019	Bıyık Bayram and Çalışkan	Single-blind randomized controlled trial (Turkey)	Total of 86 nursing students Control group (n=43) Experimental group (n=43)	Descriptive characteristics form, tracheostomy care knowledge test, skills checklists and performance evaluation form	The tracheostomy tube aspiration and peristomal skin care final test mean scores of the students in the experimental group were found to be higher than the mean scores of the students in the control group.	The use of game-based virtual reality phone application to support formal nursing education improves students' knowledge and skills.

Study Name and Year	Authors	Design and Country	Sample Size	Data Tools	Results	Conclusion and Recommendation
Designing and evaluating the effectiveness of a serious game for safe administration of blood transfusion: A randomized controlled trial ³² 2017	Tan et al.	Randomized controlled trial (Singapore)	Total of 103 nursing students Control group (n=46) Experimental group (n=57)	Blood transfusion knowledge evaluation survey, blood transfusion confidence survey, practice-oriented performance evaluation survey, perception scale regarding virtual reality game	After the virtual reality intervention, the posttest knowledge and confidence mean scores of the experimental group were significantly higher than the pretest mean scores and the posttest mean scores of the control group. However, there was no significant difference in post-test performance average scores between the experimental and control groups. Participants evaluated the virtual reality game positively.	The study provided evidence that the use of virtual reality increased nursing students' knowledge and confidence regarding blood transfusion practice.
Comparison of the Effectiveness of a Virtual Simulator With a Plastic Arm Model in Teaching Intravenous Catheter Insertion Skills ³¹ 2017	Ismailođlu and Zaybak	Randomized controlled quasi-experimental study (Turkey)	Total of 65 nursing students Control group (n=32) Experimental group (n=33)	Personal information form, intravenous catheterization knowledge evaluation form, Intravenous Catheterization Skill scale, Self-Confidence and Satisfaction Scale and Fear Symptoms Scale	In the study, the average score for psychomotor skills in the control group was 20.44, 15.62 for clinical psychomotor skills, 31.78 for self-confidence and 21.77 for satisfaction. The mean scores in the experimental group were 45.18 for psychomotor skills, 16.28 for clinical psychomotor skills, 34.18 for self-confidence, and 43.89 for satisfaction.	The results showed that psychomotor skill and satisfaction scores were higher in the experimental group, while clinical psychomotor skill and self-confidence scores were similar in both groups. More students in the control group reported experiencing symptoms such as cold and sweaty hands, significant restlessness, and tense muscles than those in the experimental group.

Study Name and Year	Authors	Design and Country	Sample Size	Data Tools	Results	Conclusion and Recommendation
Virtual versus face-to-face clinical simulation in relation to student knowledge, anxiety, and self-confidence in maternal-newborn nursing: A randomized-controlled trial ²⁹ 2016	Cobbett and Clarke	Randomized controlled trial (Canada)	Total of 56 nursing students Control group (n=28) Experimental group (n=28)	Student anxiety level and perceived self-confidence data, Nursing Anxiety and Self-Confidence Scale with Clinical Decision Making (NASC-CDM), 10 multiple-choice questionnaires for clinical simulation	There was no difference between the post-simulation preeclampsia scores of third-year nursing students who performed F2F or virtual simulation. VCS had a statistically significant effect on the students' anxiety levels. Student anxiety levels were significantly higher for the VCS group compared to F2F.	It is important to consider the application and benefits/risks of the simulation when evaluating the knowledge and confidence levels of undergraduate nursing students when they participate in maternal-neonatal clinical scenarios of face-to-face or virtual clinical simulation.
The Effects of Virtual Reality Simulation as a Teaching Strategy for Skills Preparation in Nursing Students ³³ 2015	Smith and Hamilton	Experimental study (USA)	Total of 20 nursing students Control group (n=10) Experimental group (n=10)	Demographic data collection form for students, Foley catheter insertion skill evaluation form, and visual analog perceived readiness scale	When the skill evaluation form and the visual analogue perceived readiness scale were compared, the score of the experimental group was found to be significantly higher.	Findings from this study support the use of virtual reality simulation as a complementary tool to teach students critical steps in clinical skills, such as insertion of a foley catheter.

2.3. Quality Evaluation

Methodological quality assessment of the studies included in the systematic review was performed independently by the investigators (X, XX). Joanna Briggs Institute (JBI) checklists were used as a methodological evaluation tool. These checklists consist of 13 items for randomized controlled trials and nine items for quasi-experimental studies; each item is evaluated as “Yes, No, Uncertain and Not Applicable”. The detailed evaluation results of the JBI’s evidence quality assessment tools for the quasi-experimental and randomized control studies included in this systematic review are presented in Table 2 and Table 3.

Table 2. Discussion of Joanna Briggs Institute evaluation criteria for Quasi-Experimental Studies (non-randomized experimental studies)

Author(s)	Title of study	Quality Assessment Score
Choi ¹¹ 2022	Virtual reality simulation for learning wound dressing: Acceptance and usability	Yes: 8 No: 1 Uncertain: 0
Wu et al. ³⁶ 2022	A pediatric seizure management virtual reality simulator for nursing students: A quasi-experimental design	Yes: 7 No: 1 Uncertain: 1
Hudder et al. ³⁰ 2021	A Quasi-Experimental Study Comparing Virtual Simulation to Lab-Based Learning of Newborn Assessment Among Nursing Students	Yes: 7 No: 1 Uncertain: 1
Smith and Hamilton ³³ 2015	The Effects of Virtual Reality Simulation as a Teaching Strategy for Skills Preparation in Nursing Students	Yes: 8 No: 0 Uncertain: 1

Table 3. Joanna Briggs Institute Critical Appraisal Checklist for Randomized Controlled Trials

Singleton, et al. ²¹ 2022	Effect of Non-Immersive Virtual Reality Simulation on Type 2 Diabetes Education for Nursing Students: A Randomised Controlled Trial	Yes: 10 No: 0 Uncertain: 1 Not applicable: 1
Yıldız and Demiray ³⁸ 2022	Virtual reality in nursing education 3D intravenous catheterization E-learning: A randomized controlled trial	Yes: 10 No: 1 Uncertain: 2 Not applicable: 0
Lo et al. ¹⁸ 2022	Effectiveness of immersive virtual reality training in nasogastric tube feeding education: A randomized controlled trial	Yes: 11 No: 1 Uncertain: 1 Not applicable: 0

Chan et al. ¹⁷ 2021	Virtual reality teaching in chemotherapy administration: Randomised controlled trial	Yes: 11 No: 1 Uncertain: 1 Not applicable: 0
Keys et al. ²³ 2021	The Integration of Virtual Simulation Gaming Into Undergraduate Nursing Resuscitation Education: A Pilot Randomised Controlled Trial	Yes: 9 No: 2 Uncertain: 2 Not applicable: 0
Padilha et al. ¹⁹ 2019	Clinical Virtual Simulation in Nursing Education: Randomized Controlled Trial	Yes: 11 No: 1 Uncertain: 1 Not applicable: 0
Bıyık Bayram and Çalışkan ²⁸ 2019	Effect of a game-based virtual reality phone application on tracheostomy care education for nursing students: A randomized controlled trial	Yes: 10 No: 1 Uncertain: 2 Not applicable: 0
Tan et al. ³² 2017	Designing and evaluating the effectiveness of a serious game for safe administration of blood transfusion: A randomized controlled trial	Yes: 10 No: 1 Uncertain: 2 Not applicable: 0
İsmailoğlu and Zaybak ³¹ 2017	Comparison of the Effectiveness of a Virtual Simulator With a Plastic Arm Model in Teaching Intravenous Catheter Insertion Skills	Yes: 11 No: 1 Uncertain: 1 Not applicable: 0
Cobbett and Clarke ²⁹ 2016	Virtual versus face-to-face clinical simulation in relation to student knowledge, anxiety, and self-confidence in maternal-newborn nursing: A randomized controlled trial	Yes: 10 No: 1 Uncertain: 2 Not applicable: 0

2.4. Data Extraction Tool

The data extraction tool developed by the researchers was used to obtain the data in the study. With this data extraction tool, the author and publication year of the studies, the country where the study was conducted, the type of research, the characteristics and volume of the sample group, the method used, the intervention applied, the measurement tool used and the findings regarding the results obtained were included. The final data obtained from the compiled studies were combined and presented as a narrative summary using the thematic synthesis approach. These main themes were determined by creating headings for cognitive, affective and psychomotor areas, which are the three sub-objectives of learning for the use of virtual reality in nursing skills education.

2.5. Ethical Aspects of the Research

This study, which is a systematic review, does not require ethics committee approval as it was conducted based on a literature review.

3. Results

3.1. Characteristics of the Studies

In the databases scanned in the systematic review, 1311 studies were reached. After excluding 114 studies that were repeated in accordance with the PRISMA-P protocol and studies that did not meet the inclusion criteria (n=1169), the evaluation was made on the remaining 14 studies.

Within the scope of the research; it was found that a total of 10 studies were randomized controlled and four studies were quasi-experimental. The countries where the studies were conducted include Turkey (n=3), Canada (n=3), Taiwan (n=3), China (n=1), Singapore (n=1), Portugal (n=1), USA (n=1), UK (n=1) and the total sample size (number of students) was 970.

3.2. Main Themes

As a result of the systematic review, the main themes generated and reported were examined in three areas: cognitive, affective and psychomotor in nursing skills training of virtual reality:

- 1) The effect of virtual reality on students' cognitive level;
- 2) The effect of virtual reality on students' affective level;
- 3) The effect of virtual reality on students' psychomotor skill level.

3.3. The Effect of Virtual Reality on Students' Cognitive Levels

The cognitive domain is the domain in which the learner encodes the mental aspects of learned behaviors (14). Virtual reality technology aims to reduce the cognitive load in learning with a three-dimensional learning environment and to help the mind's capacity to conceptualize topics (21). Virtual reality offers rich perceptual cues and multimodal feedback (e.g. visual, auditory, tactile, etc.) to enable simple transfer of virtual reality-based learning within real-world capabilities (1). Virtual reality environments create a strong sense of presence, motivate and thus contribute immensely to the student's cognitive process. In this way, students can access knowledge and skills applied and acquired in everyday situations (6). If students are active in virtual reality learning, they can construct knowledge with the help of events, objects and interaction in the artificial world (24).

In 11 studies examined within the scope of this systematic review, the learning and cognitive performance of the participants were evaluated after the virtual reality intervention by using knowledge tests created by the researchers for the subject studied. In all the

studies reviewed, it was concluded that the use of virtual reality significantly increased cognitive and learning performance (11,18,28,29).

3.4. The Effect of Virtual Reality on Students' Affective Levels

The affective domain includes the student's tendencies such as interest, attitude, demeanor and emotion towards an object, an event or a subject (14). It is the area where emotional areas such as love, fear, interest and attitude are dominant. It is important for students to gain gains in the affective domain during their education (20). Affective teaching methods such as visual imaging, auditory influence, movies or videos, written text narration can be used to mobilize students' affective domain. In this field, the use of virtual reality during teaching has been examined in terms of students' interest in the course, their motivation and how they evaluate their learning experiences with virtual reality. Student satisfaction and self-confidence questionnaires, self-satisfaction and self-efficacy questionnaires, and simulator usability questionnaire were used in the studies analyzed. As a result of the nine studies examined within the scope of this systematic review, it is seen that students gave positive responses to the use of virtual reality, students' motivation for learning with virtual reality increased, and self-efficacy-self-satisfaction scores were higher in the experimental groups (11,21,29,30).

3.5. The Effect of Virtual Reality on Students' Psychomotor Skill Levels

The acquisition of clinical psychomotor skill is an integral part of nursing education. Psychomotor skills traditionally taught in clinical practice or simulated clinical practice involve the transformation of theoretical knowledge into a motor skill in various contexts (27). With the application of theoretical knowledge in clinical practice, which is the ultimate goal of nursing education with virtual reality, the training and simulation room can be effective in transferring students' knowledge to the clinic (25). Repetitive, applied virtual reality is beneficial to improve the psychomotor skills of nursing students. It is important for nursing students to receive training in unreal simulated environments to reinforce their psychomotor skills so that they can transfer their skills to the patients they care for in the real world (5). In the six studies examined in this systematic review, students' psychomotor skills were evaluated using skill checklists. All of the studies suggested that virtual reality intervention improved students' clinical skills in practices such as IV catheter placement, urinary catheter insertion, basic life support, tracheostomy care, blood transfusion (23,28,31).

4. Discussion

In this systematic review, it was aimed to determine the effects of virtual reality use in nursing skills training on students' cognitive, affective and psychomotor skills. The findings of the studies included in the systematic review were examined by grouping them under the titles of the effects of virtual reality use in nursing education on cognitive, affective and psychomotor skill level. The aim of nursing education is to provide students with basic knowledge, skills and attitudes towards three learning domains: cognitive, affective and psychomotor. While the cognitive domain is the domain in which the student codes the mental aspect of the learned behaviors, the domain in which the student codes the learned skill is the psychomotor learning domain (14). Affective domain is a learning domain where individual characteristics such as emotions, attitudes, behaviors, values, motivation, anxiety, self, personality, interest, appreciation and temperament are at the forefront (1,6,7,23). As a result of this systematic review, in general, the educational effect of virtual reality on improving cognitive and learning performance, affective and psychomotor skills in nursing skills training was confirmed. The reviewed studies show that virtual reality increases participation in education, enables constructivist learning and offers authentic experiences. Virtual reality allows students to see new perspectives, develop creativity and visualize complex models or situations (4). Simulated clinical cases of virtual reality are particularly useful for nursing students. Because students can observe or experience basic clinical education in a safe environment without causing physical harm to patients or themselves (27). In this systematic review, 14 studies examining the effectiveness of using virtual reality in teaching basic nursing skills on students' knowledge, sensory and psychomotor skills were included. In line with the results of the studies, it was seen that virtual reality application is an effective way of teaching basic nursing skills.

4.1. The Effectiveness of Virtual Reality on Cognitive Level

The studies obtained from different subgroups in this systematic review supported the effectiveness of virtual reality in improving nursing students' knowledge. The results of the review are consistent with the results of meta-synthesis and similar systematic reviews in the literature (6,12). In another study, it was found that virtual reality was superior to traditional education or other simulated education methods in accessing information for nursing students. On the other hand, virtual reality simulation combines gaming and problem-based learning strategies (34). Self-directed learning provided by virtual reality allows nursing students to better control their teaching-learning programs and gain repeated practice, thus increasing learning efficiency and retention of knowledge

and skills (35). As a result of the randomized controlled study conducted by Padilha et al. (2019) with 42 nursing students to determine the effect of virtual reality use on basic nursing education, it was found that the students in the experimental group had a permanent level of knowledge immediately after the intervention and two months later, and also showed a higher level of learning satisfaction with virtual reality (19). As a result of the quasi-experimental study conducted by Wu et al. (2022) with 105 nursing students to determine the effect of using virtual reality in teaching nursing students to understand and respond to pediatric seizures, the post-test knowledge score in the experimental group was significantly higher than the control group and the use of virtual reality in teaching pediatric seizure management was found to be effective (36). Similarly, as a result of the quasi-experimental study conducted by Choi (2022) with 30 nursing students to determine the effect of using virtual reality in wound care education, the mean scores of the control and experimental groups for the knowledge test were similar, and the mean scores of the experimental group for virtual reality usability were higher than the control group. It was seen that the use of virtual reality in wound care teaching will be beneficial for students' satisfaction and knowledge acquisition (11).

4.2. The Effectiveness of Virtual Reality on Affective Level

High levels of satisfaction strengthen nursing students' desire to learn. Overall, this systematic review strengthened the evidence for the effectiveness of virtual reality in improving nursing students' self-efficacy/confidence compared to other educational strategies. Laboratory simulations, due to their non-responsive nature, give mannequins physical and pathological characteristics similar to those of real patients (37). A virtual reality system provides real-time feedback so that nursing students can have a clear idea of whether their practice is normative or not, and some systems even provide remedies for delayed or incorrect care procedures. Deliberate repetition of nursing practices with virtual reality enabled students to have more confidence in their performance (5). This systematic review showed that virtual reality was favorably adopted by nursing students compared to other educational strategies. The combination of audio and visual representation in virtual reality not only stimulated nursing students' interest in learning, but also facilitated understanding and acceptance of the information taught (19). It also increased nursing students' engagement and satisfaction (18). As a result of the randomized controlled trial conducted by Lo et al. (2022) to determine the effect of using virtual reality in nasogastric catheter nutrition education in nursing students, it was found that the knowledge of nasogastric catheter nutrition of students in the experimental group

improved significantly after the intervention in the experimental and control groups, and the experimental group scored significantly higher than the control group in terms of extrinsic goals, task value and satisfaction (18). As a result of a randomized controlled study conducted with a total of 103 nursing students, it was found that the use of virtual reality was effective in increasing nursing students' knowledge and self-confidence regarding blood transfusion practice (32).

4.3. The Effectiveness of Virtual Reality on Psychomotor Skill Level

The studies included in this systematic review revealed that virtual reality effectively supports nursing students' performance when compared with other educational strategies. In virtual reality simulation, nursing students actively encounter avatars, including doctors, staff and nurses, to accurately understand the patient's condition and identify key elements of care (32). They may also have enough time to choose among the various options offered by the system when caring for patients (33). Yıldız and Demiray (2022) conducted a randomized controlled study to determine the effect of using virtual reality in the training of intravenous catheterization and intravenous fluid therapy in nursing students. In the control group consisting of 27 students, traditional arm model was used, while in the experimental group consisting of 29 students, virtual reality was used for this training. A statistically significant difference was found between the intravenous catheter application and intravenous fluid therapy skills checklist scores of the students in the experimental and control groups. As a result of the study, it was determined that virtual reality application was effective in developing intravenous catheter application and intravenous fluid therapy skills (38). Similarly, as a result of a quasi-experimental study in which İsmailođlu and Zaybak (2017) aimed to compare the effectiveness of the virtual reality application with the intravenous virtual simulator and the plastic arm model in teaching intravenous catheter placement skills to nursing students, the psychomotor skill and satisfaction scores of the students in the experimental group were higher, clinical psychomotor skills and It was observed that self-confidence scores were similar in both groups (31). Similarly, Keys et al. (2021) conducted a randomized controlled study to determine the effectiveness of virtual reality use in cardiac resuscitation learning, it was determined that students who received resuscitation training with virtual simulation performed better than students who were trained only with traditional pre-simulation preparation (23). Overall, this systematic review confirmed the educational effect of using virtual reality in teaching nursing skills on improving students' cognitive and learning performance and psychomotor skills.

5. Conclusion

It is important to ensure that nurses, who constitute the basic building block of the health care system, are proficient in terms of knowledge and skills during their professional training processes so that they can provide the quality care expected from them. In this regard, as an alternative to traditional nursing education methods, virtual reality, which is a product of today's advancing technology, needs to be integrated into nursing education curricula. As a result of this systematic review, it was concluded that the use of virtual reality in nursing education has positive effects on the development of students' knowledge, affective and psychomotor skills. With virtual reality, the permanence of students' theoretical knowledge has increased and their practical skills have been strengthened by repeating an initiative or technique. Additionally, studies have shown that students who learn in a virtual reality environment are more motivated in acquiring knowledge and skills. As a result, it can be said that virtual reality is an effective and useful teaching method in nursing skill training.

Conflict of Interest Statement

The authors declare that they have no known competing financial interests or personal relationships that could affect the study reported in this article.

Research Support

This research has not received any private grants from funding organizations in the public, commercial, or non-profit sectors.

Authors' Contributions

Idea/Concept: A. Dayan, B. Terzi; **Design and Layout:** A. Dayan, B. Terzi; **Supervision/Consulting:** B. Terzi; **Resources:** A. Dayan; **Materials:** A. Dayan; **Data Collection and/or Processing:** A. Dayan, B. Terzi; **Analysis and/or Interpretation:** A. Dayan, B. Terzi; **Literature Review:** A. Dayan; **Writing:** A. Dayan; **Critical Review:** B. Terzi

Note: The abstract of this systematic review was presented as an oral presentation at the International Haliç Multidisciplinary Scientific Research Congress-VII, held on January 23-25, 2025.

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