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Technology in nursing education: Augmented reality

Hemşirelik eğitiminde teknoloji: Artırılmış gerçeklik

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Abstract

The augmented reality technology, in which virtual images are combined with real world objects in real time, has begun to take part in the education of "Generation Z", 21st century youth. Today, augmented reality applications that contribute to the learning process are also utilized in the field of nursing education. When database research is conducted with the combinations of "nursing education" and "augmented reality" keywords, it is seen that various augmented reality applications are used for improving English proficiency, anatomy knowledge and some of the nursing practices of nursing students. Research results show that students' learning experiences are improved with the use of augmented reality method thus learning becomes interesting and useful. This review includes the definition of augmented reality technology which increases the reality of environment and improves learning by embodying abstract concepts, its importance and place in nursing education, and the results of various studies on this subject.

Keywords: Augmented reality, Nursing, Nursing education.

Öz

Sanal görüntülerin gerçek zamanlı olarak, gerçek dünya nesneleri ile birleştirildiği artırılmış gerçeklik teknolojisi, 21. yüzyıl "Z kuşağı" gençlerinin eğitiminde yer almaya başlamıştır. Günümüzde öğrenme sürecine katkı sağlayan artırılmış gerçeklik uygulamaları, hemşirelik eğitimi alanına da aktarılmaktadır. Veri tabanlarında "hemşirelik eğitimi", "arttırılmış gerçeklik" ve "nursing education", "augmented reality" anahtar kelimeleri kombinasyonları ile tarama yapıldığında, hemşirelik öğrencilerinin İngilizce yeterliliklerini geliştirmeye, anatomi bilgilerini artırmaya ve bazı hemşirelik girişimlerinin öğretimine yönelik çeşitli artırılmış gerçeklik uygulamalarına rastlanmaktadır. Araştırma sonuçları öğrencilerin artırılmış gerçeklik yöntemi ile öğrenme deneyimlerini geliştirdiklerini ve bu şekilde öğrenmenin ilgi çekici ve kullanışlı hale geldiğini göstermektedir. Bu derlemede, ortamının gerçekliğini arttıran ve soyut kavramları somutlaştırarak öğrenmeye katkı sağlayan artırılmış gerçeklik teknolojisinin tanımı, hemşirelik eğitimindeki yeri, önemi ve bu konuda yapılan araştırma sonuçları yer almaktadır.

Anahtar kelimeler: Artırılmış gerçeklik, Hemşirelik, Hemşirelik eğitimi.

1 Introduction

Today, technological changes and advances affect and change teaching strategies, materials and environments in which education takes place. The use of digital education technologies has become widespread in the field of health education in recent years in line with the demands of our age to meet the needs of the "Generation Z", the young people of this century. The term "Generation Z" defines the generation that was born after 2000, which is intertwined with technology. This generation is also known as "net generation", "i-generation" and "digital natives" [1]-[3]. Another name given to this generation is "instant online generation" [1].

The children of the digital age, Generation Z, has many characteristics including the ability to multitask, creativity, high motor skill adaptation, learning whenever they want and under the conditions they set, and learning by discovering [3],[4]. Their memories are actived with animation via games, storytelling and dreaming [4]. This generation, who use technology much better than other generations, have made wearable and portable technology products a part of their daily life [4]. In line with these characteristics, educational environments should be designed with attention-grabbing elements and interactive activities to increase the motivation of this generation [5]. It is thought that technological resources energise teaching and develop skills and knowledge that can activate problem solving actions [6]. Using the constructivist learning approach with technological innovations in education will create an effective learning environment through active participation and interaction [7]. It is considered that this environment may facilitate nursing students' learning of problem-solving skills to use in the real-life clinical practice [7]. As these features are taken into consideration, nursing education has also begun to keep up with the times and take advantage of technological innovations that will improve the critical thinking skills of its students, increase learning motivation and reinforce learning [6].

In recent years, simulation mannequins, virtual environment simulators, videos, educational games and mobile applications have been used for comprehensive skill training which is difficult to learn in nursing education [6]-[8]. These educational materials are suitable for the characteristics of the 21st-century youth [9].

Being one of the technological innovations of the century, AR technology has also begun to take its place among the new generations of technological innovations. It contributes to experience-based learning and have become widespread in the field of education with its feature of bringing together the real

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and virtual worlds [10]. It is observed that AR technology applications have become widespread in the education and training of the nursing professionals, which is one of the building blocks of the health care system [11],[12].

AR practices, reflections of which we see in daily life, will contribute to the future of the nursing profession and education. Learning what AR is, knowing its usage, knowing its advantages will take the nursing profession and nursing education further in line with technological advances. The aim of this article is to emphasize the AR concept and its importance for education in addition to present examples of its use in cognitive and psychomotor fields in nursing education. From this perspective, examination of the concept of AR, its historical development, usage areas and position in nursing within this review will contribute to the literature.

2 Concept of augmented reality

AR consists of applications that enable "real" and "virtual" to come together, interact in real time and exist in the same frame [13]. The term “reality technology” can be divided into two as “virtual reality-VR” and “augmented reality-AR” [14]. When considered conceptually, it is seen that the concepts of AR and VR are confused with each other [15]. VR is the projection of three-dimensional images animated on the computer to the users like a "real world" [8]. In the VR environment, there is an environment where the user's relationship with the world completely disappears [14]. On the other hand, in the AR environment, the connection of the user with the real world continues. In this environment, virtual data and images can be added to real world images and both real and virtual objects can be perceived together in the same environment [14]. According to Azuma [16], AR has three basic features: blending real and virtual in real environments, real time interaction and positioning these elements in three dimensional environments. Milgram and Kishino [17] define AR as all situations where the viewing of a real environment is increased through virtual objects. Figure 1 shows the continuity of the virtuality and reality defined by Milgram and Kishino:

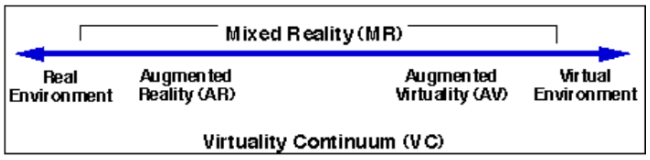

Figure 1. Milgram's reality-virtuality continuum (17).

Many definitions exist for AR. One of them is by Alan B. Craig, one of the prominent names in the field of AR. According to Craig, AR is not just a technology, it is an environment with an artistic and philosophical value that includes senses such as touch, smell and taste, as well as visual and audio experiences [18]. According to Erbaş, AR is defined as environments where real environments are enriched with artificial images by using various imaging or projection tools [19].

In virtual reality environments, the real world is completely replaced by a computer-generated virtual environment, while in AR environment, three-dimensional images are placed on the real world [20]. In the three-dimensional space, the information layer enables the transition of computer use from the desktop to mobile devices. Thus, access to information and new learning methods are enriched [21]. AR enables us to see the real world we live in with virtual objects created by computer at the same field in real time [22]. Many AR products exist in different capacities. In line with the studies conducted, it is thought that the AR is still in its infancy and that there are endless possible future implementations [21].

AR is the technology for the detection of virtual objects that coexist with the real world simultaneously. Reality is being created with the addition of virtual multimedia objects such as three-dimensional objects, sounds, videos, animations or simulations on the image of the real world environment. The creation of AR on mobile devices with the advances in mobile technologies are called “Mobile Augmented Reality” practices [22]. Mobile AR practices are mobile applications that enable the creation of AR through a mobile device by using a location, image or marker icon [19]. Technological components such as monitoring, recording and interaction, operational structure, wireless network and data storage are needed in order to create mobile AR applications [22]. Mobile AR applications are used in smartphones, tablet computers or smart glasses [23].

AR technologies have been changing and AR began to take quite different forms through the acceleration of the internet, the proliferation of mobile devices and related applications and spreading of wearable technologies in different areas [24].

3 History of augmented reality technology

According to Altunpulluk's study on paradigm shifts in AR applications, the first thoughts about AR surfaced in the 1900s [24]. Glasses named "Character Marker" in L. Frank Baum's book "The Master Key" published in 1901 is considered as one of the first ideas about the use of AR. According to this book, the person who wears the glasses can understand the character of a person with an image, initial letter, marked upon the forehead of that person indicating his or her character [24],[25]. In the 1950s, the first studies about AR technology began to emerge. In 1955, a cinematographer called Morton Heilig brought up important ideas for the future of the cinema industry in his article "The Future of Cinema". By making a simulator named “Sensorama” in 1957, Heilig achieved the increased perception of reality of the environment by using three-dimensional visuals with the addition of aroma odors, wind effects and vibrations. In 1962, he obtained the patent right for his machine [24],[26]. In 1968, Ivan Sutherland of Harvard University took a crucial step in the development of AR by designing the first head-mounted display (HMD) which he called the "Sword of Damocles". Sutherland created the first imager that looks like the ones used today. This viewer which works with head and eye movements hangs on the laboratory ceiling due to the fact that it is too large to be carried in the head [24],[26]-[30]. Towards the end of the 1900s, Myron Krueger established a room called “Videoplace” in 1975, which enabled users to interact with virtual objects for the first time [26],[27]. Steve Mann is known as the inventor of the term "First Cyborg", "Father of Wearable Computers" and "Mediated Reality" for developing digital glasses he has been working on since the 1980s [24],[30]. In 1999, Mann develeoped digital glasses called "EyeTap", which was seen as the ancestor of Google Glass [24]. Thomas Caudell and David Mizell began developing a head-mounted digital imager for Boeing in the early 1990s and coined the term "Augmented Reality" for the first time in 1992 [24],[26],[28],[31]. Another event that has an important place in the history of AR is the development of the mobile augmented reality system (MARS) designed by Feiner, MacIntyre, Höllerer, and Webster (1997) as a mobile guide on campus [32].

The use of AR applications on mobile devices has started to accelerate with the advancement of technology since the 2000s [19], [24]. The mobile AR game, ARQuake, developed by Bruce Thomas in 2000, was one of the first mobile applications towards AR [33]. With the BatPortal application in 2001, AR became available for portable devices [19],[24],[34]. Project

Glass, the first AR glasses developed by Google, was introduced in 2012 [19],[24],[34]. Although Project Glass is able to perform many functions of a phone such as taking pictures or recording videos via voice commands, its sale has stopped due to some problems in terms of health, ethics, privacy and security [24],[35]. The application called MARTA (Mobile Augmented Reality Technical Assistance) which was developed in 2013 by the automobile manufacturer Volkswagen to assist employees in automobile production is one of the important developments in the field of AR [35],[36]. The development of the first holographic computer, HoloLens, by Microsoft in 2015 is a very important step in the advancement of AR. HoloLens, which can be commanded by voice, works integrated with Windows 10 operating system [35],[37]. A new generation of mixed reality experience, Hololens 2, was introduced by Microsoft in early 2019 [38]. AR applications will be a part of our lives considering all these historical developments and the rapid advancements in technology. In his book on AR, Brett King suggests that the generation in the 2030s should be named "Augmented Age of Intelligence" or "Augmented Age" [39]. Today, research and development of virtual retina imagers, bionic contact lenses, holograms, mobile applications and smart glasses continue and studies are carried out for the use of these technologies in various fields [24].

4 Components used for augmented reality

AR applications consist of software and hardware components [40]. In his book "Understanding Augmented Reality: Concepts and Applications", Alan B. Craig emphasizes that the software is the component that tells the system "what to do" and the hardware is the component that "does" it [18]. The hardware infrastructure is very important for the software created for the AR technology to work effectively [14]. Software technologies act as a bridge and provide interaction between virtual and real world [35].

4.1 Hardware contents of augmented reality applications

Kipper and Rampolla have listed hardware structures as computers or mobile devices, monitors or video displays, cameras, monitoring and detection systems, network infrastructure and pointers [40]. In Alan B. Craig's book, the hardware structures are gathered under three titles as sensors, processors and viewers [18]. Information collected from the real world through sensor systems are sent into AR application in order to be processed [18],[35]. All types of objects that collect data at physical environment such as wireless devices, GPS, compass, accelerometer, navigation and camera are defined as sensors in AR [35],[15]. Processors are the main structure that forms the center of the AR system [18]. After the information created with the sensors is interpreted by the processors, they are delivered to the users through the viewers [38]. There are three types of viewers used in AR systems: Head Mounted Displays (HMD), Handheld Displays and Spatial Displays [26]. HMDs are display devices that allow real and virtual images to be displayed simultaneously via head-mounted helmets or optical viewers [26]. Small computing devices with a screen that the user can hold are used as handheld screens [26]. Nowadays, we experience smart phones with the ability to present AR content as a hand-held display [26],[35]. With Spatial Displays, the user does not need to wear or carry the screen. With this system, the appearances of real objects are enhanced with virtually produced materials. With Spatial Displays AR system, it is possible to see a car with different colors and patterns without actually painting it [35]. Viewers (Screens) are components such as computer, tablet or mobile device screens [15],[18]. Visual, auditory, tactile, stereoscopic / steriophonic and other sensory screens are also defined as viewers [18]. AR applications are currently implemented with wearable technologies such as smart goggles, smart watches, headphones, helmet-connected displays and t-shirts along with mobile devices such as tablets and smartphones [11],[41].

4.2 Software contents of augmented reality applications

The main elements of software in the creation of an AR system are web services, content server and a locally running application or program [35],[40].

There is a need for an AR software interface to interpret the virtual and real environment together. The software types offered are modeling tools, marker production tools, performance enhancing engine tools, mobile application tools and web interface tools [42]. Three-dimensional modeling of a real-life object is provided on computer in the modeling tool which is the most important component of AR technology [14]. The most common modeling tools are Unity3D, SketchUp, Blender, Cinema 4D, 3ds Max and Sweet Home 3D [14]. Performance enhancing engine tools help the operation of three-dimensional objects made with the modeling tool. Commonly used engine software types are Papervision3D, Away3D and Sandy3D, WebGL and Unity3D [15]. Markers are AR tools that are used to combine virtual and real environment and to ensure the interaction between them [15],[40]. These tools are visualized with white and black patterns in a black background surrounded by a white border for better perception by the camera [15]. With the current technological advances, it is possible to use a real-world object (a real building, a human face, a picture on a wall) as a pointer [15].

There are marker-based, non-marker-based and location-based image identification techniques in AR applications [43]. In marker-based applications, visual marker codes or physical objects detected by the AR system are used. AR software enables the virtual content to be displayed on this defined marker with the data it receives from the marker. Thus, users perceive this image as if it were real. In location-based applications, computer generated information is overlaid using location data determined by GPS or Wi-Fi positioning systems [21].

AR is created in two ways, optics-based and video-based technologies. In both, the real world and the virtual world are seen on the same platform. In the use of optics-based technology, the virtual world integrates with the real world with the help of devices in the form of goggles placed on the user's head. In video-based systems, real world and virtual world are integrated on the computer screen by using video cameras [16].

5 Usage areas of augmented reality applications

AR applications are being used in many areas, even in our daily lives with the active, interesting and visual richness of AR. Its use is expanding in many fields such as military, advertisement, art, marketing, engineering, architecture, commerce, GPS, geotagging, entertainment, games, health, museology and tourism [14],[44],[45].

Military fields are the leading areas where AR technology was first used. The Battlefield Augmented Reality System (BARS) has been developed to be used in military training of fighter pilots [46]. We see that AR applications are used in many sectors for marketing and advertising purposes with the advancement of technology. An example of the use of AR in advertisement is trying on a clothing item with the Doll Up application developed by Smartis with "virtual dressing" experience prior to be purchase [35],[47]. Similarly, there are

AR applications in architecture and home decoration. IKEA aims to reduce the possible risks and difficulties of the furniture purchasing process with the mobile application called "IKEA Place" developed in 2012 [48]. AR applications are also used in maintenance and repair services [35]. When we examined the development of AR throughout the history, we have seen that AR has been developed in order to assist personnel in automobile production. Apart from that, we see that nowadays AR technology is used in many important areas, not only in the automobile sector but also in the assembly and design of spacecraft [35]. Looking at the AR applications used for travel, we have seen that Vlahakis and his colleagues have developed an AR-based application called "ArcheoGuide", which offers personalized guidance of archaeological sites [49]. As in many fields, AR use is used in engineering [50],[51]. In Parmar's study, we see that an AR book which includes a mobile compatible AR application has been developed to improve the technical graphic skills of engineering students [51]. Apart from the given examples, there are AR applications in many other fields such as manufacturing, natural disasters, art and security [15].

With the use of AR, education which at times cannot be reached or materialized due to various impossibilities in the real world is also enriched [13]. Therefore, the education sector has become an area where AR technologies are frequently preferred. Students have the opportunity to access the content in real time wherever they are outside of the physical learning environments with digital education technologies including AR applications [52]. The use of AR in the field of education provides many benefits for students to learn. Using AR systems to facilitate training not only increase the success of students but also contributes to knowledge acquisition with increasing their attention. Learning is facilitated by concretization and visualization of abstract concepts [45],[53]. Apart from these, we see many advantages of the use of AR applications in education such as increasing academic success, facilitating learning, increasing student motivation, attention, concentration and satisfaction, increasing observational skills, ensuring that dangerous experiments are carried out in safe environments, increasing permanence in learning, reducing cognitive load and increasing interest in the lesson [22],[23], [27],[45],[54]-[60].

Apart from these benefits and positive features of AR and its contribution to education, there are various problems and disadvantages associated with its use [61]-[64]. A study by Rochlen et al. that examines the use AR technology in demonstration of anatomical structures during central venous catheter placement process states some of these problems [63]. The participants of this study reported both positive and negative features regarding the use of AR. Most of their negative comments were related to the comfort and convenience of the glasses and their relatively higher cost for students. In addition, the difficulty in keeping the head immobile in a certain position with the equipment used during AR study was reported [63]. Furthermore, several various technical problems such as slow loading rates, incompatible smartphones and interruptions on the internet connection were expressed by participants in the other study conducted by Garrett et al [64] which aimed to support clinical skills laboratory training with AR technology. Carrying out more studies that involve the difficulties and obstacles encountered using AR technology in education will contribute to the field and the solution of these problems.

The use of AR is observed in every stage of education, from pre-school to higher education [65]. Preschool children learn with fun educational virtual toys such as story animations, 3D objects and flash animations [58],[66]. Teaching with AR in higher education institutions will facilitate easier understanding of abstract and complex information such as astronomy, chemistry, physics and biology [44],[54],[65],[67]. Tools such as educational cards, textbooks, story books, comics, handbooks and brochures are used for educational games, educational trips and exercises in pieces of training with AR [54],[68].

It is seen that mostly mobile AR technology is used in the field of education both in Turkey and worldwide according to the studies conducted [54],[65],[67]. AR as a learning tool provides new digital areas that can improve teaching and learning while improving a student's perception of and interaction with the real world [69]. Digital mobile devices that are portable and usable anytime and anywhere ease the learning process [70].

AR technologies can be used safely in health education where human life is of great importance [54],[71]. The use of AR technology in medical and health education is very important to prevent possible human errors [38].

Research results about AR practices in health education show that students can accept AR as a learning technology. According to those results, AR facilitates the understanding of medical concepts and increases the permanence of learning, thus the effect of learning. Students are offered a more personal and exploratory learning experience by addressing their learning styles with AR technology. In addition, errors that can be encountered during skills training with AR technology do not pose a risk for patient safety [10],[12].

Studies in which AR applications are used in the field of health education are seen with the advancement of computer technologies [10]. These applications are included in various medical fields, mostly in endotracheal intubation, clinical breast examination, laparoscopic surgery and life support training [12]. Recently, AR is used mostly in anatomy education and cardiopulmonary resuscitation training during health education. In a study conducted by Küçük, anatomy education of medical students was carried out using mobile AR. The study revealed that the students in the experimental group were more successful and their cognitive load was lower than the students in the control group. The opinions of students towards learning with mobile AR were positive [27]. AR training was received positively by most participants in a study that examined the effect of cardiopulmonary resuscitation training with AR on health workers by Balian et al. [72]. The participants of that study perceived the experience realistic and almost all of them stated that the visualizations were beneficial for their education. In the field of vocational medical education, we also see AR applications developed for laparoscopic surgery education, neurosurgery education and echocardiography education [73]. In addition, there are AR applications developed for emergency medical education [74]. Wilson et al. conducted a pilot study on the use of AR glasses as a clinical support tool to reduce preventable causes of death on the battlefield [75]. As a result of this study, it has been reported that medical students using AR glasses were able to treat pneumothorax cases in human cadaver models more accurately compared to the students in the control group. This study also states that AR technology can be used in real-time during the treatment of war injuries as it is able to provide quickly accessible information to inexperienced combat health officials while treating pneumothorax cases at combat environments [75]. Apart from these, we also see various studies in the health field where a new telemedicine platform was created by using AR system to facilitate and develop remote medical education [74],[76].

AR applications are used for other health practices besides education in the field of health. In a study by Correa et al., an AR music software technology (GenVirtual) was developed to help

people with physical and cognitive disabilities for rehabilitation purposes [77]. Great contributions have been made to the motor and cognitive rehabilitation of children and adults with the GenVirtual application [77]. According to Sünger's article, an AR application has been developed by Dr. Itaru Endo and his team to reduce the risks associated with liver surgery [35]. This application aims to demonstrate the complicated vascular system with AR technology during surgery. In addition, possible risks can be demonstrated simultaneously [35]. Sielhorst's team developed an AR application to show patient data such as heartbeat and pulse information [78]. There are also AR studies in the field of mental health [79],[80]. Also, there are many examples of the use of AR technology in surgery. An imaging method has been developed that provides helpful information to the surgeon during the operation by enhancing the AR navigation system in the fields of endoscopic surgery [81]. Choi et al. have also developed AR systems for bone tumor surgery [82]. Brown and Hua stated that three-dimensional images of tissues and organs can be displayed via AR technology with the device named "Magic Lens" they have developed for use in medical education [35],[83].

In parallel with changing and developing technology, the nursing profession and nursing education has to keep pace with these changes considering the young generation of our age. Thus, with the use of technology, interventions that are difficult to teach to students and can harm patients can be implemented repeatedly and permanence in skill teaching can be achieved.

6 Studies about augmented reality in nursing profession and nursing education

Nursing education consists of a combination of theory and practice and includes cognitive, sensory and psychomotor fields of learning [84]. Nursing discipline extensively uses psychomotor skills as a part of professional practice. Students learn these skills that they encounter for the first time by practising them on life-size models and sometimes on each other in a laboratory environment before going to the clinical environment. In addition, the implementation of certain applications that violate the integrity of the body directly on the patient poses a great risk in terms of patient safety and privacy. Therefore, certain skill applications are taught in the reliable and controlled laboratory setting without student anxiety about harming the patient [85].

Demonstration or role-play activities and simulation techniques are traditionally used with tools such as mannequins and models in the laboratory environment for the permanent tracked behaviour changes that the students must acquire [85].

The use of simulation method in the training of healthcare professionals has become increasingly widespread since the twentieth century with the increase of variables that complicate the learning conditions in the hospital environment and the impact of developments in technology [85],[86]. Various reasons such as the increase in the number of students, difficulties in the arrangement of appropriate clinical practice areas and decrease in the number of educators in nursing education have made it necessary to integrate the simulation method into the nursing education. Nursing education is very important in providing and maintaining effective and safe care for individuals who are given health care. It is reported that professional knowledge, skills and attitudes that need to be acquired by nursing students can be gained through simulation practices. For this reason, different types of simulation techniques are included in nursing education day by day [87]. One of these simulation methods is information technologies. The US National League for Nursing (NLN) recommends the use of information technologies to facilitate learning and support the learning process [87]. Information technologies that can be used for this purpose include computer aided simulations.

Screen-based computer simulations used in this context are designed to model human physiology, specific tasks or environments from various aspects. These simulations allow the trainee to make clinical decisions about the situation and to observe the results of the actions through various computer software. Computer aided simulations cost less than other options and can be used individually or in groups. These types of simulations allow students to access the simulation anytime and anywhere, reuse the simulation many times or repeat it as necessary [87]. These simulations reduce the cost of using high-reality simulations and eliminate the distance between the student and learning environment as they do not oblige students to enroll in a campus [88].

Virtual reality and AR tools are among the computer - integrated simulations that have high fidelity audio and haptic tools in addition to real materials used to learn complex functions within the scope of computer-aided simulations [88]. According to Rochlen's article, a report of the National League of Nursing defines AR as one of the six new technologies expected to significantly affect learning, teaching and research in the near future [63]. In addition, in the recent years, a greater importance is given to the constructivist approach to learning within contemporary health education where students take an active role in developing new knowledge and skills related to their existing knowledge [89]. The constructivist learning approach increases students' confidence levels and improve their abilities towards planning, critical thinking and entrepreneurship [7],[90],[91]. AR studies offer a constructivist approach to encourage and improve active learning [89].

As mentioned above, the use of AR technology in health education not only makes education significant by energising it, but also teaches by ensuring patient safety without causing harm. In consideration with the learning features of Generation Z, AR technology has become increasingly important for nursing students to obtain knowledge at school and develop skills in a clinical setting without harming patients.

When literature review is conducted about the use of AR technology in the field of nursing, studies can be organized under two headings; clinical nursing settings and nursing education. When studies related with AR technology for clinical nursing environments are examined, various studies are found in many different subjects like wound care evaluation, remote patient follow-up, visualization of the elderly patients' vessels and medical device management used in the operating room [11],[92]-[97]. The number of studies in the field of nursing education is low but it has started to increase gradually in recent years.

Aldaz and his team enabled wound care nurses to perform wound evaluation in their pilot study using hands-free wearable technology by developing an application called SnapCap. Patient data can also be recorded quickly with this system that is integrated with glasses [92]. SnapCap application provides hands-free digital image capture, labeling, the addition of image descriptions to text without speech and transfer of data to electronic medical records. The camera of Google Glass and internal various sensors guide clinicians in taking wound images and adding comments. [92]. The SnapCap system includes both a Google Glass app and an Android smartphone app designed for chronic wound photography for use by nurses. Today, in the light of technological advances, we also see examples of AR for disease prevention and patient health protection. In a study by Gonzalez et al. [94], a system was developed for remote measurement and monitoring of

patients' body temperature and heart rate via wireless sensor network and mobile AR. With this application, the nurse will have the opportunity to monitor body temperature and heart rate remotely at any time. Thus, the time required to monitor the patient will decrease as the rate of intervention to the patient will increase. In addition to these studies, one of the studies in the nursing clinic field is a new application that uses AR imaging to facilitate visualization of veins and access to a vein in elderly patients in critical condition. As a result of this pilot study, lower hematoma incidences were reported in addition to decreased anxiety and depressive symptom indications as patients suffered less pain associated with the venous intervention [95].

Apart from these, there are other applications of AR that direct medical device use in the form of giving instructions to users [97]. In the study by Nilsson and Johansson, instructions for the use of a medical device in the surgical field were defined for the hospital workers with the HMD. Although users stated that it was easy to understand the instructions with this application, there were participants who said that the device made them dizzy and nauseous. The results of this pilot study will form the basis for further research aimed at confirming the advantages of AR applications and identifying the fields most likely to benefit from it.

The aim of this study is to define the basic concepts of AR technology, its place and importance in nursing education and to compile information obtained from studies on this subject.

7 Method

In this review; the research articles, the last one of which was carried out in May 2020, on AR use in the field of nursing education were examined. The research papers, which were found on Google Scholar, Pubmed, Science Direct and Ulakbim databases with the combination of "nursing education" and "augmented reality" keywords in Turkish and English languages, and of which the full text were available online are discussed. In addition, the studies that were not accessible online, published as a summary, compilation articles and thesis studies were excluded from the review. Although there are few studies using AR technology in nursing education in the literature, we see that the number of studies has started to increase in recent years. When the studies are reviewed, it is seen that these studies are mostly conducted using mixed designs.

8 Literature review

Both the effectiveness of the AR in the teaching material and the kind of effect it has on the students are discussed in the studies reviewed. In our study, the characteristics of the studies reviewed and included in the research limits were described one by one and important points were summarized in a table in order to contribute to the literature.

9 Discussion and results

Review of studies on the effect of AR technology on nursing education are presented in Table 1.

In the study by Aebersold et al. [98] was conducted with 69 nursing students. The students' ability to place a nasogastric tube was performed with an enhanced virtual simulation training model revised by iPad technology. Considering the results of this training that allows the student to see the anatomical regions during the nasogastric catheter insertion, it is seen that the rate of students that place the nasogastric catheter according to all of the checklist items is significantly better in the experimental group compared to the control group. The participants stated that they considered the AR application as a realistic, easy to use, enjoyable and useful tool for skills training. In addition, nursing students reported that the AR program provides a superior education method compared to standard education methods. With this practice, the student feels comfortable, remembers all steps and can perform the operation effectively and safely. In another related study conducted by Tilghman et al. [99] using simulation and AR, intravenous drug administration and female bladder catheterization practice skills levels of 25 first-year nursing students were examined. The data was provided with Juxtopia® CAMMRAD Medic prototype goggles. Regarding the completion times of the practices, the control group completed the necessary procedures faster than the experiment group. The students in the experimental group reported that they felt confident in understanding the material and practising the skill. The researchers stated that the use of technology is a valuable aid in providing patient care and developing clinical skills in addition to lectures, laboratory practices and clinical experiences which compose the basis of nursing education. The information presented with AR significantly affects student learning.

Similarly, 12 nursing students participated in a pilot study conducted by Vaughn et al. [100] in another nursing school in the United States in 2015. An innovative hybrid simulation called "Augmented Reality Headset (ARH)" has been created by combining a high accuracy simulation mannequin with AR technology to increase the perception of realism. Google Glass was used as the ARH device and a video was uploaded containing a scenario of a patient experiencing acute respiratory distress. Students were asked to evaluate this patient. At the end of the study, students evaluated ARH as a useful and effective teaching resource and a motivational tool that contributes to independent problem solving. Problems that are difficult to convey on the model make it feel like they are interacting with a real-life patient using AR. When students were asked about the barriers related to ARH, they reported that lack of experience can be a problem, and only one student found this practice distracting.

The study conducted by Pugoyl et al. [101] shows that research on AR in the field of nursing education is not only towards clinical skills. Pugoyl et al. developed a prototype of learning material in the form of comics consisting of a clinical scenario to help nurses improve their English proficiency with 17 participants. This application allows the user to both read and hear their voice, while bringing the mobile device over the comic strip. Thus, it ensures that words are pronounced and expressions are understood correctly. Most of the participants agreed that the material developed with AR is better than printed-only material and improves learning experiences [101]. In another study about AR practice in anatomy training, Rahn et al. [102] have developed an application that allows visualization of the lung anatomy using AR technology on iPad with the participation of 14 first-year nursing students in a nursing school in Denmark. Following the application students who participated in the research found this new training method and technology helpful and promising. In addition, some of the students stated that the lung anatomy visualized using AR application provides a much more realistic image than a textbook.

Ball and Hussey [103] examined the effect of using “AR 360 ° photosphere” technology developed with AR technology on the anxiety levels of nursing students in their first clinical experience. Although there was a decrease in the anxiety levels of nursing students who tried “AR 360 ° photosphere” technology, there was no statistically significant difference between students using this new technology and students who did not [103].

Table 1. Features of studies in nursing that use augmented reality technology.

Author and year of the Research	Study Name	Study Type	Sample Group	Technological Approach	Results
Aebersold et al. (2018)	Interactive anatomy-augmented virtual simulation training	Qualitative and quantitative mixed pattern study	Nursing students (n=69)	Tablets (iPad)	According to all of the checklist items, correct placement rate of students who performed nasogastric probe insertion skill training with augmented reality method was found to be statistically significant compared to the control group.
Tilghman et al. (2018)	Innovative utilization of augmented reality and simulation to promote nursing practice	Qualitative study	Freshman nursing students (n=25)	Juxtopia® CAMMRAD Medic prototype goggles	Students who practiced with Juxtopia® CAMMRAD Medic prototype goggles felt more confident in understanding the material compared to the control group and gained confidence about the skill.
Vaughn et al. (2016)	Piloting augmented reality technology to enhance realism in clinical simulation	Pilot study, mixed pattern study	Nursing students (n=12)	Augmented reality headset (ARH)	With the augmented reality application implemented using Google Glass, students felt as if they interacted with a real-life patient and they felt confident.
Pugoyl et al. (2016)	Augmented reality in nursing education: addressing the limitations of developing a learning material for nurses in the Philippines and Thailand	Pilot study	Nursing students (n=17)	Mobile device	Learning English with the comic book prototype created using augmented reality technology provides a better learning material compared to printed materials.
Rahn et al. (2014)	Augmented reality as a visualizing facilitator in nursing education	Mixed pattern study	Freshman nursing students (n=14)	Tablets (iPad)	With the use of augmented reality, learning experience has become easier and the level of understanding has increased.
Garrett et al. (2015)	Using Mobile Augmented Reality to Enhance Health Professional Practice Education	Pilot study, mixed pattern study	Freshman and senior students (n=72)	Smartphones and Tablets (iPad)	Access to augmented reality resources at the bedside supports learning, but the technical problems experienced during augmented reality application negatively affect the learning experience.
Ball and Hussey (2020)	The Effects of Augmented Reality on Prelicensure Nursing Students' Anxiety Levels	Pretest/posttest, semi-experimental study	Nursing students (n=47)	AR application (360° photosphere)	An effect of using "AR 360 ° photosphere" technology on the level of anxiety was not detected in the first clinical experience.

In addition to these studies, it is seen that AR-based teaching have positive effects on student learning, as well as negative results in connection with the technology used. A total of 72 first and fourth year undergraduate students participated in a pilot study conducted by Garrett et al. [64] to support clinical skills laboratory training. Various materials and protocols that nursing students use in the clinical skills laboratory were labeled using visual markers and QR codes. Web-based videos

were presented to students showing how clinical hand washing and respiratory auscultation is performed and how to select the appropriate oxygenation equipment after respiratory evaluation. At the end of the study, in addition to positive feedback about how access to AR resources at the bedside supports learning, technical problems such as slow loading, incompatible smartphones and internet connection failures have been reported which affect the learning experience negatively. Furthermore, it has been determined that teachers need to receive pedagogical training on AR. Apart from the positive contributions of AR to nursing education, technical difficulties include negative features.

In this review, we also reviewed studies that contribute to nursing education that are still being conducted. Şendir and Kızıl [104] introduced the NAZO-AR Program which aims to increase nasogastric tube placement skill of students by keeping the feeling of reality using haptic controlled AR technology in their study [103]. In addition, the article of Taçgın and Taçgın [105] explains the interface, features and smart system structure of the AR application that they developed. In this study, a smart multi-model AR application was developed to teach pre-operative procedures to nurses and nursing students who have just started nursing profession and to provide structured feedback. With this application, students can receive individual feedback regarding the suitability of their sequence after performing the preoperative preparation steps [105].

In conclusion, nursing education should be re-structured in line with the increasing technological opportunities of the globalizing world and the changing profile of nursing students, taking into account the needs and conditions. In this context, AR applications used in the education of 21st century "Generation Z" youngsters make the content more concrete and more understandable by facilitating meaningful and effective learning by visualizing the invisible abstract structures in three dimensions [40],[71]. Most of the research results on the use of AR in nursing education show that this method has positive effects on students' learning, supports learning and increases their skill performance.

10 Contribution to the literature

AR technology will contribute positively to the knowledge and clinical skills of nursing students with respect to learning difficult theoretical content included in the undergraduate curriculum as well as abstract psychomotor skills with limited application areas which are difficult to learn on models. We also think that by integrating this technological development into mobile devices more students will be reached, learning process will be enhanced and students will gain self-confidence regarding practices.

11 Author contribution statements

In the scope of this study, Emine PINAR MARTLI and Nigar UNLUSOY DİNCER, in the formation of the idea, the writing and editting, the design and the literature review, the assessment of obtained results, examining the results and the spelling and checking the article in terms of content were contributed.

12 Ethics committee approval and conflict of interest statement

There is no need to obtain permission from the ethics committee for the article prepared and there is no conflict of interest with any person / institution in the article prepared.

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