Journal of Namibian Studies, 32 (2022): 1218-1232 ISSN: 2197-5523 (online)

Enhancing Critical Care Competency: The Power Of VR Training For Nurses

Abdulsalam Abdulaziz Alzahrani , Bander Saqer Alanazi , Abdulaziz M. Almubrek , Saad M. Alzaml , Mohammaed Ayad Alharbi , Abdullah Hamad M Alyousef Abdullah Mutlag Dhaifullah Al Otaibi , Rabah Raja Alharbi , Alwaleed Mosaed Ahamed Almalky , Abdullah Mutlag Dhaifullah Al Otaibi , Rabah Raja Alharbi , Alwaleed Mosaed Ahamed Almalky , Ali Mohammed Moudhi Alqarni , Abdulaziz Obaid Saad Al Doseri , Mubarak Nasser Mansour Aldosari , Bdoor Badi Alosaimi

Abstract:

Nursing education emphasizes the translation of theoretical knowledge into practical skills to ensure patient safety. Clinical experiences, however, often present challenges for students, such as medication errors, decision-making in unforeseen situations, and communication difficulties with patients and healthcare teams. These challenges can potentially compromise patient safety. Upholding the ethical principle of "primum non nocere" (first, do no harm) is paramount for nurses, and fostering a culture of patient safety is crucial during nursing education. Traditionally, clinical environments utilize mannequins and simulated labs to provide students with practical experience. However, virtual reality (VR) simulations offer a compelling alternative by creating realistic clinical scenarios with potential risks and complications. This immersive technology allows students to develop essential skills, build confidence, and prepare for real-world clinical practice. This study investigates the impact of VR exercises in nursing education on the acquisition of clinical skills and its potential contribution to enhanced patient safety.

Keywords: Simulation, Virtual reality, Medical devices, Critical care, Nurse competency, Nursing education.

1. Introduction:

Despite the incorporation of therapeutic breakthroughs, the complexity of the patient's condition, and the total attention that patients and their families need, intensive care unit (ICU) nursing care for critical disease patients requires specialist training. Before their clinical rotations, students must comprehend the complex situations that face critically sick patients in intensive care units (ICUs) to plan, prioritize, and coordinate treatment (1-3). Teachers struggle to persuade students without previous experience in such settings to understand the situation and perform an effective nursing evaluation to identify patients' needs and offer appropriate care. Students' nervousness and tension before ICU clinicals exacerbates the problem. Due of the criticality of the patients they will be accountable for, their inadequate technical knowledge, and the unpredictability of a new situation (4,5).

High-fidelity therapeutic modeling lets students experience dynamic, controlled, and safe medical scenarios. These strategies also reduce anxiety and boost self-confidence before clinical assignments. Financial and administrative tools are needed to create superior simulation-based scenarios (6-8). Saab et al. (9) suggest VR as an alternative to clinical simulations, which are resource-intensive. VR is more cost-effective, resource-efficient, and location- and time-independent, yet it still offers anxiety-free and low-risk acquisition.

Virtual reality allows nursing and medical students to learn a wide range of skills in different locations and clinical circumstances of variable complexity. Simulations of wound care, disasters, and crises provide learner-centered training (12-15). A comprehensive review by Plotzky et al. (10) describes many nursing education VR simulation approaches. The evaluation finds little research on immersive VR situations using HMDs alone. Several researches have used VR for technical teaching in life-threatening patient care, including cardiac resuscitation, but few have developed integrated and complete scenarios. In this context, Horwitz (16) suggests that this strategy might improve critical care practitioner education at both the university and postgraduate levels. VR is

typically used as a complement to traditional teaching techniques, although other research (12,17,18) claim it has a greater impact on student learning.

Although cheaper than simulation, the instrument's financial investment is still more than traditional teaching. While some experts argue that higher VR realism does not improve student learning, this does not justify the cost expenditure. Usability of hardware input codes, recognition errors, lack of feedback, unrealistic attributes, and poor software usability are also recorded. Motion perception may cause physiological issues (11).

2. Types of Simulations and Virtual Reality

Simulations are a valuable tool in nursing education, as they allow students to engage in tasks that simulate real or prospective situations, enhancing their problem-solving and decision-making abilities before entering real-world clinical environments. Nursing education employs two types of models: low-fidelity and high-fidelity. Low-fidelity models include three-dimensional organ designs, human corpse models of mammals, and virtual and standard patients. These models teach students about cardiac activities, peripheral IV catheter insertion, anesthesia for spinal surgery, emergency care for harm, and breast examination (19-23).

High-fidelity models include virtual reality (VR), haptic systems, and image-based, feasible, and participatory patient models. Image-based simulations help learners develop critical thinking and decision-making abilities, while real and functional simulations mimic body parts. Interactive simulations consist of computerized virtual patients that simulate human anatomy and physiology, while haptic systems and virtual reality are realistic three-dimensional simulations that interact with users via computers (23,24). Virtual reality (VR) is a three-dimensional simulation generated by a computer that provides the user with an extensive array of sensory data, enabling them to communicate with objects within the virtual environment and create the sensation of being physically present. This can be used to assist nursing students in developing skills within virtual hospital environments (24-27).

Interactivity is crucial in virtual reality, as it allows learners to

implement interventions on models to address challenges they might encounter in actual clinic settings. One application of VR is in teaching tracheostomy care and urinary catheterization to nursing students, allowing them to hone their nursing abilities on simulated patients and execute interventions with ease and assurance in actual clinics, all while ensuring no actual patients are harmed. Non-immersive and immersive VR systems are the two types of VR systems. Immersive VR offers experiences where the user loses all sense of reality in a space no larger than a room while donning a headgear and motion-sensing mitts. Non-immersive VR is a computer-generated, non-fully interactive three-dimensional environment that the user navigates and controls using a joystick, keyboard, mouse, and haptic display (28-30).

Visual reality has been implemented in various fields, including education, culture, arts, tourism, online shopping, manufacturing, military and airline industries, construction, and production. It increases students' motivation to access and apply information, promotes collaboration skills, and encourages lifelong learning (31-35).

3. Virtual Reality Simulations In Nursing Education

Virtual reality in medical education refers to computer-generated three-dimensional simulations that accurately replicate clinical surroundings. This technology allows users to practice and improve their skills without putting actual patients at risk. Virtual reality is used in medical and nursing education as well as physical therapy. Students are allowed to participate in unlimited practice and detect their mistakes in safe laboratory settings. Consequently, actively participating in these simulations improves the participants' ability to remember what they have learned and helps them analyze problems in an engaging manner (36-39). Virtual reality enables the fusion of theoretical knowledge and practical application in the field of nursing education. Virtual reality enhances active participation and fun learning via feedback. Additionally, it supports the acquisition of skills and information among nursing students, while also increasing their confidence and motivation (40-44).

According to Nehring and Lashley (46), Phillips (45) is recognized as the trailblazer of virtual reality (VR) in the field of

nursing. Merril and Barker (47) developed an initial iteration of intravenous (IV) catheterization, while Skiba (48) introduced interactive virtual settings that could be accessed over the Internet. Research indicates that CathSim ITS effectively lowers intervention-related discomfort, minimizes the occurrence of hematoma formation, and decreases the number of required treatments. Additionally, it enhances participant motivation and confidence. Students who possess advanced skills and minimal anxiousness are more inclined to carry out efforts promptly and securely. The execution of many interventions increases the likelihood of risks and undermines the safety of patients (49,50).

4. Challenges of Using Virtual Reality:

Virtual reality simulations not only boost students' enthusiasm, engagement, attentiveness, and creativity, but also allow them to apply theoretical information and advance at their own pace. Moreover, it enables individuals to participate in practice sessions whenever they find it convenient, and without any restrictions, in safe and genuine environments. This eliminates any concerns about making mistakes that may possibly harm patients. Due to their experiential learning approach, students who engage in virtual reality activities are more inclined to experience a sense of comfort, confidence, and accomplishment in real-life clinical environments. Moreover, they are able to replicate intricate, costly, and risky operations that are seldom seen in real-life healthcare environments. Virtual reality simulations, however, need collaboration across many disciplines, financial resources, and time for creating scenarios and training instructors. In addition, prolonged usage of virtual reality (VR) is linked to headaches, eye pain, and vertigo (51,52).

5. Impact Of VR Simulations On Patient Safety

Patient safety is crucial in ensuring the safety of patients and is a key focus of nursing education. Virtual reality (VR) and simulations can enhance the quality of nursing education by allowing students to apply theoretical knowledge while developing practical skills and positive dispositions. Students who have acquired foundational nursing competencies in online environments are more likely to experience ease and self-assurance, as well as mitigate potential negative consequences of interventions in

actual clinical settings (53-56).

Verification of the patient's identity is a prerequisite for all essential nursing interventions, and studies have shown that a virtual reality (VR) scenario involving tracheostomy care can help students accurately identify patients and prevent participants from progressing to the subsequent phase. Character verification of the patient is also an important aspect of nursing skills, as it helps students focus on the same stage in the clinic (57-60).

Communication abilities are essential for healthcare professionals to safeguard patients, as inadequate, nonexistent, or miscommunicated information can lead to incorrect diagnoses and inappropriate care. High-fidelity simulations can enhance communication abilities for healthcare professionals, enabling them to make precise and timely clinical judgments. Engaging in conversations with virtual patients can enhance students' communication proficiencies, allowing them to learn how to obtain patient histories, interact with other healthcare professionals, greet patients, and carry out patient discharge protocols (61,62).

Nurses administer medications according to the six rights: the correct medication, the correct patient, the correct dose, the correct route, the correct time, and the correct documentation. Virtual reality simulations provide students with feedback and facilitate interactive learning, demonstrating how to safely administer medications. Studies have found that VR simulations have improved students' understanding of medication management, infection, catheterization of the urinary tract, and medication management (63-67).

Visual reality simulations have also enhanced IV drug infusion skills and taught students how to recognize potential complications following drug administration. For example, Vidal et al. found that nursing students who participated in VR simulations executed IV interventions more effectively with fewer errors, caused less pain, and experienced a decreased risk of hematoma formation. This indicates that nursing students who engage in VR simulations adhere to the six principles of prescribing drugs and management procedures, leading to increased patient compliance and a reduced duration of hospitalization (68-70).

Infections are the leading cause of clinical mortality in hospitals, and preventing them can be achieved through the use of virtual reality (VR) simulations. Hand hygiene is the most efficient way to prevent infection transmission, and simulation scenarios have been shown to increase understanding of hand hygiene and decrease catheter-associated infections. VR simulations also enhance students' knowledge and proficiency in various medical procedures, such as nasogastric (NG) tube insertion, disinfection, urinary, intravenous, line catheter injectable, tracheostomy aspiration, and care (71-73).

Studies have shown that VR simulations can improve students' decontamination abilities, leading to measures to mitigate the spread of infections. For instance, a study involving 20 nursing students and a computer-based VR application found that urinary catheter skills improved, while haptic VR applications improved urinary catheterization skills. Additionally, VR applications have been used to improve the understanding of port catheter injection among 77 nurses and the tracheostomy aspiration abilities of 35 nursing pupils (74-77).

Ensuring patient safety is a critical responsibility for nurses, and VR simulations can be employed as instructional tools. Studies have shown that VR simulations can help students learn fall prevention measures, leading to a reduction in patient falls in clinics where nurses conducted their duties using virtual scenarios. Collaboration has also been shown to be effective in preventing patient mishaps. DeBourg et al. (78) found that simulation studies were efficacious in fostering a culture of patient safety among 285 students and in the prevention of accidents. Students can continue to hone their accident prevention skills within VR simulations, preparing them to respond appropriately in actual clinical settings. To ensure the safety of actual patients, students should expose virtual patients to danger during VR simulations, as the initial learners can tolerate the risk while the latter cannot. Overall, VR simulations can significantly enhance the quality of care and reduce the occurrence of illnesses and consequences in healthcare settings.

6. Conclusion

Nursing education is a practical kind of education. Therefore,

students must fulfill the obligation of completing both laboratory and clinical practice. Nevertheless, as a result of their limited expertise, students may compromise the well-being of patients. Nurses have the duty to safeguard and promote a secure environment for patients. Nursing students must participate in laboratory interventions and activities that enhance their understanding of patient safety. Nursing students who are unable to participate in laboratory activities due to physical limitations may access virtual reality simulations.

Research indicates that virtual reality (VR) simulations assist students in absorbing information, developing critical thinking and teamwork skills, recognizing rare clinical settings, and effectively engaging with patients. Nursing students has the skills to provide safe patient care, administer drugs with precision, and identify physiological changes in their patients. Students who participate in virtual reality (VR) simulations have the ability to guarantee patient safety in real clinical settings.

References:

1. Viana PP, Andrea R, Torre CM. Enfermería en cuidados intensivos. Practicas integradoras. Sociedad Argentina de terapia intensiva. Asociación de medicina intensiva Brasileira. Editorial Panamericana. 2019.
2. González-Alcantud B. Barriers to the application of the nursing methodology in the Intensive Care Unit. Enfermería Intensiva (English ed.). 2022 Jul 1;33(3):151-62.
3. González EK, Loján CV, Ordóñez HE, Mora GD. El plan de cuidados, como garantía de calidad asistencial de Enfermería. Pro Sciences: Revista de Producción, Ciencias e Investigación. 2022 Aug 31;6(44 (esp)):99-107.
4. Ortega RH, Pascual JL, Araque AM. Estrés y ansiedad al comienzo de las prácticas clínicas en estudiantes de Enfermería. Metas de enfermería. 2020;23(6):50-8.
5. Pulido-Martos M, Augusto-Landa JM, Lopez-Zafra E. Sources of stress in nursing students: a systematic review of quantitative studies. International Nursing Review. 2012 Mar;59(1):15-25.
6. Harrington DW, Simon LV. Designing a simulation scenario.
7. Labrague LJ, McEnroe-Petitte DM, Bowling AM, Nwafor CE, Tsaras K. High-fidelity simulation and nursing students' anxiety and self-confidence: A systematic review. InNursing forum

2019 Jul (Vol. 54, No. 3, pp. 358-368).

8. García-Pazo P, Pol-Castañeda S, Moreno-Mulet C, Pomar-Forteza A, Carrero-Planells A. Virtual reality and critical care education in nursing: A cross-sectional study. Nurse education today. 2023 Dec 1;131:105971.
9. Saab MM, Hegarty J, Murphy D, Landers M. Incorporating virtual reality in nurse education: a qualitative study of nursing students' perspectives. Nurse Education Today. 2021 Oct 1;105:105045.
10. Plotzky C, Lindwedel U, Sorber M, Loessl B, König P, Kunze C, Kugler C, Meng M. Virtual reality simulations in nurse education: a systematic mapping review. Nurse education today. 2021 Jun 1;101:104868.
11. Kavanagh S, Luxton-Reilly A, Wuensche B, Plimmer B. A systematic review of virtual reality in education. Themes in science and technology education. 2017 Dec 27;10(2):85-119.
12. Chen FQ, Leng YF, Ge JF, Wang DW, Li C, Chen B, Sun ZL. Effectiveness of virtual reality in nursing education: Meta-analysis. Journal of medical Internet research. 2020 Sep 15;22(9):e18290.
13. Pottle J. Virtual reality and the transformation of medical education. Future healthcare journal. 2019 Oct;6(3):181.
14. Mendez KJ, Piasecki RJ, Hudson K, Renda S, Mollenkopf N, Nettles BS, Han HR. Virtual and augmented reality: Implications for the future of nursing education. Nurse Education Today. 2020 Oct 1;93:104531.
15. Jung Y. Virtual reality simulation for disaster preparedness training in hospitals: integrated review. Journal of Medical Internet Research. 2022 Jan 28;24(1):e30600.
16. Horwitz S. Virtual reality as a tool for education and training in intensive care. InSystems, Software and Services Process Improvement: 28th European Conference, EuroSPI 2021, Krems, Austria, September 1–3, 2021, Proceedings 28 2021 (pp. 730-740). Springer International Publishing.
17. Radianti J, Majchrzak TA, Fromm J, Wohlgenannt I. A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Computers & education. 2020 Apr 1;147:103778.
18. Weiss S, Bongartz H, Boll S, Heuten W. Applications of immersive VR in nursing education. InConference:

Clusterkonferenz Zukunft der Pflege—Innovative Technologien für die Praxis 2018.

19. Tan Ş. Öğretim Ilke ve Yöntemleri. 13rd ed. Ankara: Pegem Akademi; 2016. pp. 2-307 (in Turkish)17.
20. Butt AL, Kardong-Edgren S, Ellertson A. Using game-based virtual reality with haptics for skill acquisition. Clinical Simulation Nursing. 2018;16:25-32. DOI: 10.1016/j.ecns.2017.09.010
21. Şendir M, Doğan P. Hemşirelik eğitiminde simülasyonun kullanımı: Sistematik inceleme. Florence Nightingale Nursing Journal. 2015;23(1):49-56 (in Turkish)
22. Ziv A, Small SD, Wolpe PR. Patient safety and simulation-based medical education. Medical Teacher. 2000;22(5):489-495. DOI: 10.1080/01421590050110777
23. Lane JL, Slavin S, Ziv A. Simulation in medical education: A review. Simulation & Gaming. 2001;32(3):297-314. DOI: 10.1177/104687810103200302
24. Mıdık Ö, Kartal M. Simulation-based medical education. Marmara Medical Journal. 2010;23(3):389-399 http://hdl.handle.net/11424/1925
25. Bayraktar E, Kaleli F. Virtual reality on commercial applications Akademik Bilişim 2007. 1-6.
26. Çoban S. Uzaktan ve teknoloji destekli eğitimin gelişimi. 2012. Available from: http://inet-tr.org.tr/inetconf17/bildiri/26.pdf. [Accessed: 2020-06-30]
27. Bulu ST, İşler V. Second life ODTÜ kampüsü. Akademik Bilişim Kongresi'nde sunulan bildiri. İnönü Üniversitesi, Malatya: Kasım, 15, 2011.
28. Aydın ED. Üç boyutlu sanal gerçeklik ortamında mimari mekan temsilinin geliştirilmesi: temel anlam ve yan anlam yaratma, [thesis]. Fen Bilimleri Enstitüsü, İstanbul: Yıldız Teknik Üniversitesi; 2012
29. Kaufman D, Sauve L. Educational gameplay and simulation environments: case studies and lessons learned: Case studies and lessons learned. New York: Information Science Reference; 2010. pp. 231-250p
30. Sherman WR, Craig AB. Understanding virtual reality: Interface, application, and design. USA: Elsevier. 2003. 24-37p.
31. Biyik Bayram S, Caliskan N. Effect of a game-based virtual reality phone application on tracheostomy care education for

nursing students: a randomised controlled trial. Nurse Education Today. 2019;79:25-31. DOI: 10.1016/j.nedt.2019.05.010

32. Tepe T, Kaleci D, Tüzün H. Eğitim teknolojilerinde yeni eğilimler: sanal gerçeklik uygulamaları. Paper presented at the 10th International Computer and Instructional Technologies Symposium. 2016. Rize, Türkiye.

33. Lee EAL, Wong KW. A review of using virtual reality for learning. Heidelberg: Springer; 2008

34. Erbaş Ç, Demirer V. Eğitimde sanal ve artırılmış gerçeklik uygulamaları. Online Books: Eğitim Teknolojileri Okumaları; 2015. pp. 131-148p

35. Lupton D. Health promotion in the digital era: a critical commentary. Health promotion international. 2014;30(1):174-183. DOI: 10.1093/heapro/dau091.

36. Tsai WW, Fung CP, Tsai SL, Jeng MC, Doong JL. The assessment of stability and reliability of a virtual reality-based intravenous injection simulator. Computers Informatics Nursing. 2008;26(4):221-226. DOI: 10.1097/01.NCN.0000304804.46369.5a

37. Tsai SL, Chai SK, Hsieh LF, Lin S, Taur FM, Sung WH, et al. The use of virtual reality computer simulation in learning Port-A cath injection. Advances in Health Sciences Education. 2008;13(1):71-87. DOI: 10.1007/s10459-006-9025-3

38. Loukas C, Nikiteas N, Kanakis M, Moutsatsos A, Leandros E, Georgiou E. A virtual reality simulation curriculum for intravenous cannulation training. Academic Emergency Medicine. 2010;17(10):1142-1145. DOI: 10.1111/j.1553-2712.2010.00876.x

39. Shin JH, Park SB, Jang SH. Effects of game-based virtual reality on health-related quality of life in chronic stroke patients: A randomized, controlled study. Computers in Biology and Medicine. 2015;63:92-98. DOI: 10.1016/j.compbiomed.2015.03.011

40. Boz Yüksekdağ B. Hemşirelik eğitiminde bilgisayar teknolojisinin kullanımı. Açıköğretim Uygulamaları ve Araştırmaları Dergisi. 2015;1(1):103-118 (in Turkish)

41. Huang HM, Rauch U, Liaw SS. Investigating learners'attitudes toward virtual reality learning environments: Based on a constructivist approach. Computers & Education. 2010;55(3):1171-1182. DOI: 10.1016/j.compedu.2010.05.014

42. Simpson RL. The virtual reality revolution: Technology changes nursing education. Nursing Management. 2002;33(9):14-15 http://www.nursingmanagement.com

43. Chia P. Using a virtual game to enhance simulation based learning in nursing education. Singapore Nursing Journal. 2013;40(3):21-26

44. Lancaster RJ. Serious game simulation as a teaching strategy in pharmacology. Clinical Simulation in Nursing. 2014;10(3):129-137. DOI: 10.1016/j.ecns.2013.10.005

45. Phillips JR. Virtual reality: A new vista for nurse researchers? Nursing Science Quarterly. 1993;6(1):5-7

46. Nehring WM, Lashley FR. Nursing simulation: A review of the past 40 years. Simulation & Gaming. 2009;40(4):528-552. DOI: 10.1177/1046878109332282

47. Merril GL, Barker VL. Virtual reality debuts in the teaching laboratory in nursing. Nurse Educator? 1996;19:182-187

48. Skiba D. Nursing education 2.0: Second life. Nursing Education Perspectives. 2007;28:156-157

49. Vidal VL, Ohaeri BM, John P, Helen D. Virtual reality and the traditional method for phlebotomy training among college of nursing students in Kuwait: implications for nursing education and practice. Journal of Infusion Nursing. 2013;36(5):349-355. DOI: 10.1097/NAN.0b013e318243172f

50. Chiang VCL, Choi TKS, Ching SSY, Leung, KLK. Evaluation of a virtual reality based interactive simulator with haptic feedback for learning NGT placement. Journal of Problem-Based Learning. 2017; 4(1), 25-34. DOI: 10.24313/jpbl.2017.4.1.25

51. Çavaş B, Çavaş PH, Can BT. Eğitimde sanal gerçeklik. TOJET: The Turkish Online Journal of Educational Technology. 2004;3(4):110-116

52. Aslan R. Uluslararası rekabette yeni imkanlar: sanal gerçeklik, artırılmış gerçeklik ve hologram. Ayrıntı Dergisi. 2017;5(49):21-26

53. National Patient Safety Foundation. Patient safety. 2016. Available from: http://www.npsf.org/?page=dictionarynz [Accessed: 2020-06-30]

54. Fay-Hillier TM, Regan RV, Gallagher GM. Communication and patient safety in simulation for mental health nursing education. Issues in mental health nursing. 2012;33(11):718-726. DOI: 10.3109/01612840.2012.709585

55. Guinea S, Andersen P, Reid-Searl K, Levett-Jones T, Dwyer T, Heaton L, et al. Simulation-based learning for patient safety: The development of the Tag Team Patient Safety Simulation methodology for nursing education. Collegian. 2019;26(3):392-398. DOI: 10.1016/j.colegn.2018.09.008

56. Joint Commission International. Available from: https://www.jointcommissioninternational.org/standards/international-patient-safety-goals/ [Accessed: 2020-07-28]

57. National Patient Safety Foundation. Patient safety. 2016. Available from: http://www.npsf.org/?page=dictionarynz, [Accessed: 2020-07-28]

58. Henneman EA, Roche JP, Fisher DL, Cunningham H, Reilly CA, Nathanson BH, et al. Error identification and recovery by student nurses using human patient simulation: Opportunity to improve patient safety. Applied Nursing Research. 2010;23(1):11-21

59. Bayram ŞB, Çalışkan N. Using a game-based virtual reality application in psychomotor skills acquisition: An experience sharing Oyun tabanlı sanal gerçeklik uygulamasının psikomotor beceri öğretiminde kullanımı: Bir deneyim paylaşımı. Journal of Human Sciences. 2019; 16(1), 155-163. DOI: 10.14687/jhs.v16i1.5508

60. Biyik Bayram S. Effect of game based virtual reality application on tracheostomy care learning of nursing students, phd. thesis, Gazi University Institute of Health Sciences, december 2017

61. Shibuy H, Eto C, Suzuki M, Imai R, Yamashita A, Nakano R, et al. Exploring the Possibility of Virtual Reality in Nursing Skills Education: A Preliminary Study Using a First-Person Video. Open Journal of Nursing. 2019;9(02):163. DOI: 10.4236/ojn.2019.92015

62. Koivisto JM, Niemi H, Multisilta J, Eriksson E. Nursing students' experiential learning processes using an online 3D simulation game. Education and Information Technologies. 2015:1-16. DOI: 10.1007/s10639-015-9453-x

63. Rice MM. Teams and teamwork in emergency medicine. Croskerry P, Cosby KS, Schenkel SM, Wears RL, editors. In: Patient safety in emergency medicine. 1st Ed., Philadelphia. Lippincott Williams & Wilkins, 2009;174-187p.

64. Green J, Wyllie A, Jackson D. Virtual worlds: A new frontier for nurse education? Collegian. 2014;21(2):135-141. DOI: 10.1016/j.colegn.2013.11.004

65. Uslusoy EÇ, Duran ET, Korkmaz M. safe injection practices. Hacettepe UniversitY Nursing Faculty Journal. 2016;3(2):50-57

66. Dubovi I, Levy ST, Dagan E. Now I know how! The learning process of medication administration among nursing students with non-immersive desktop virtual reality simulation. Computers & Education. 2017;113(16-27):16-27. DOI: 10.1016/j.compedu.2017.05.009

67. Gu Y, Zou Z, Chen X. The effects of Vsim for nursing™ as a teaching strategy on fundamentals of nursing education in undergraduates. Clinical Simulation in Nursing. 2017;13(4):194-197. DOI: 10.1016/j.ecns.2017.01.005

68. Luctkar-Flude M, Pulling C, Larocque M. Ending infusion confusion: evaluating a virtual intravenous pump educational module. Clinical Simulation in Nursing. 2012;8(2):39-48. DOI: 10.1016/j.ecns.2010.06.001

69. Potter PA, Perry AG. Fundamentals of nursing. (8th ed). St. Lous Missouri: Mosby Inc. 2013. 821-882p.

70. Nakamura I, Fujita H, Tsukimori A, Kobayashi T, Sato A, Fukushima S, et al. Scenario-based simulation health care education for performance of hand hygiene. American journal of infection control. 2019;47(2):144-148. DOI: 10.1016/j.ajic.2018.07.024

71. Smith PC, Hamilton BK. The effects of virtual reality simulation as a teaching strategy for skills preparation ın nursing students. Clinical Simulation in Nursing. 2015;1(11):52-58. DOI: 10.1016/j.ecns.2014.10.001

72. Kardong-Edgren S, Breitkreuz K, Werb M, Foreman S, Ellertson A. Evaluating the usability of a second-generation virtual reality game for refreshing sterile urinary catheterization skills. Nurse educator. 2019;44(3):137-141. DOI: 10.1097/NNE.0000000000000570

73. Farra SL, Smith S, Gillespie GL, Nicely S, Ulrich DL, Hodgson E, et al. Decontamination training: With and without virtual reality simulation. Advanced Emergency Nursing Journal. 2015;37(2):125-133. DOI: 10.1097/TME.0000000000000059

74. Jung EY, Park DK, Lee YH, Jo HS, Lim YS, Park RW. Evaluation of practical exercises using an intravenous simulator incorporating virtual reality and haptics device technologies. Nurse Education Today. 2012;32(4):458-463. DOI: 10.1016/j.nedt.2011.05.012

75. Noyudom AN, Ketpichainarong W. Ruenwongsa, P.

Development of a computer-based simulation unit on tracheal suctioning to enhance nursing students' knowledge and practical skills. The Thai Simulation 2011-TS'11-3rd Annual International Conference. 2011. Thailand.

76. Choi KS, He X, Chiang VCL, Deng Z. A virtual reality based simulator for learning nasogastric tube placement. Computers in Biology and Medicine. 2015;57:103-115. DOI: 10.1016/j.compbiomed.2014.12.006

77. Bursiek AA, Hopkin MR, Breitkopf DM, Grubbs PL, Joswiak ME, Klipfel JM, et al. Use of high-fidelity simulation to enhance interdisciplinary collaboration and reduce patient falls. Journal of patient safety. 2020;16(3):245-250 www.journalpatientsafety.com

78. DeBourgh GA, Prion SK. Using simulation to teach prelicensure nursing students to minimize patient risk and harm. Clinical Simulation in Nursing. 2011;7(2):47-56. DOI: 10.1016/j.ecns.2009.12.009