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The applications of virtual reality technology in medical groups teaching

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Abstract

Introduction: Virtual reality is a new method for training different medical groups. Based on this technology, professionals and students of various medical sciences can determine their level of competence for medical treatment before any performance on the patient. Therefore, the aim of this study was to identify the applications of virtual reality technology for training the medical groups.

Methods: This is a scoping review study conducted in 2016. Articles were retrieved through the search of related keywords in databases such as Pub Med, Scopus, Web of Sciences, Springer, and Google scholar. Then, after applying the entry criteria, 21 papers were selected from a total of 1343. Data extraction was done by a data collection form. The collected data were summarized and reported using content analysis technique according to the study purpose.

Results: The findings of the study indicated that 11 cases (48%) have used virtual education technology for laparoscopic surgery training. Using virtual reality has improved learning in 17 (74%) studies. A higher accuracy in medical practice by people trained through VR has been reported in 20 (87%) studies.

Conclusion: The results indicate that the application of virtual reality capabilities plays an important role in improving the performance of different medical groups. According to the results, it can be suggested that virtual reality capabilities should be used to train different medical groups based on their individual and collective needs.

Keywords: Virtual reality, Training, Clinical trials, Technology

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Introduction

Virtual reality is a new technology that has been widely used in the health field in recent years and it is applied in a wide range of diseases. In fact, this technology is the simulation of the peripheral world through a computer as well as communication through a receiver (1). Virtual reality consists of output tools (vision, hearing, tactile and power transmitter), input devices (mouse, chaser, gloves, etc.), a virtual environment's graphical manufacturing system as well as an information software. In a virtual environment, all the features of activity such as duration, severity and type of feedback can be adopted based on the type of treatment and individuals' ability (2,

3). In addition, individuals can see their motor results and correct them if necessary.

One of the most important applications of VR in medical science is in medical education, which has been widely used in the last decade. Many studies have paid attention to various VR applications in medical education (4, 5), including the understanding of fracture anatomy by orthopedic residences (6), improving the knowledge and skills of clinical residences in the MICU and as an adjunct complement for standard clinical education if internal residences in MICU, as well as general objections regarding the patient safety, ethical concerns and financial constraints for education of medical students have led to a widespread application of non-human and inanimate models for training the laparoscopic skills because simulation-oriented syllabus is very effective in transferring skills to the operating room (7-13).

The American Board of Internal Medicine (ABIM) has announced that it is better for residents to be trained by simulation tools before attempting any interventions on patients because it has been effective in performing invasive hemodynamic monitoring, mechanical ventilation, and standardized educational intervention (14).

Stefanidis et al. concluded that suture training using simulator improves the speed and mobility of practitioners in the operation room (15). In the same line, Lin et al. found that given the fact that performing bone cut or bone surgery requires high experience and sensitivity, training the simulation of virtual and tactical surgery with feedback can be a safe, repeatable and cost-effective method compared to traditional methods (16).

Given the importance of medical education using the virtual reality tools and its role in improving the quality of medical education in various medical specialties, many papers examined this field in recent years. Although Walsh et al. instead of using conventional methods systematically reviewed education of endoscopy using virtual reality, but there was no systematic study regarding its applications (17). Therefore, the present study was a systematic review that aimed at identifying the applications of virtual reality in training various medical groups.

Methods

This study is a scoping review which aimed to identify virtual reality applications in training the medical groups in 2016. The research question was identified based on the PCC (Population, Concept and Context) elements. This particular question includes: medical groups that use VR for training (Population); the effect of Virtual Reality in Medicine Groups training (Concept); use of Virtual Reality in medical teaching centers (context).

Consistent with Best Evidence Medical Education (BEME) recommendations, the search was performed on valid databases as well as PubMed, Scopus, ISI Web of Science and Springer. During the search, the restrictions and related keywords were retrieved. To search for related papers, the combination of keywords (Table 1), with the English language and 5-year period restrictions were applied. Also, a search expert helped us to improve the quality of searches.

The inclusion criteria were clinical trial and exclusion criteria were commentary non-randomized trials and non-clinical trials. Erratum Review, Commentary, contact with Editor and available Studies were considered. The process of selection of articles was based on the PRISMA chart (Figure 1), and 24 articles were selected out of 1343 retrieved articles. In accordance with BEME, all stages of the selection and evaluation of the quality of the articles were done by two researchers and in the case of disagreement, a third person was available to help.

Considering BEME, to assess the quality of the studies, we excluded Consortium Assessment Tool 2010 (was used) and 3 papers with undesirable quality from the study. Finally, 21 qualified papers of clinical trials were selected.

Consistent with BEME, the required information of the selected papers was collected using a data collection form (including items of the type of study, the year of the study, the sample number, the country where the

Table 1: The search strategy of the research

Search strategy	
Search Engines and Databases: Pub Med, Springer, ISI Web of Sciences, Scopus, Google Scholar (2012 to 2016)	
Limits: Language (only resources with at least an abstract in English)	
Date: up to 2016,May, 20	
Search strategy: #1 AND #2 AND #3	
#1	"VR" OR "virtual reality" OR "computer simulate" OR "Augmented Reality"
#2	"education" OR "training" OR "learning" OR "teaching"
#3	"medicine" OR "medical" OR "medical students" OR "residents" OR "medical groups"

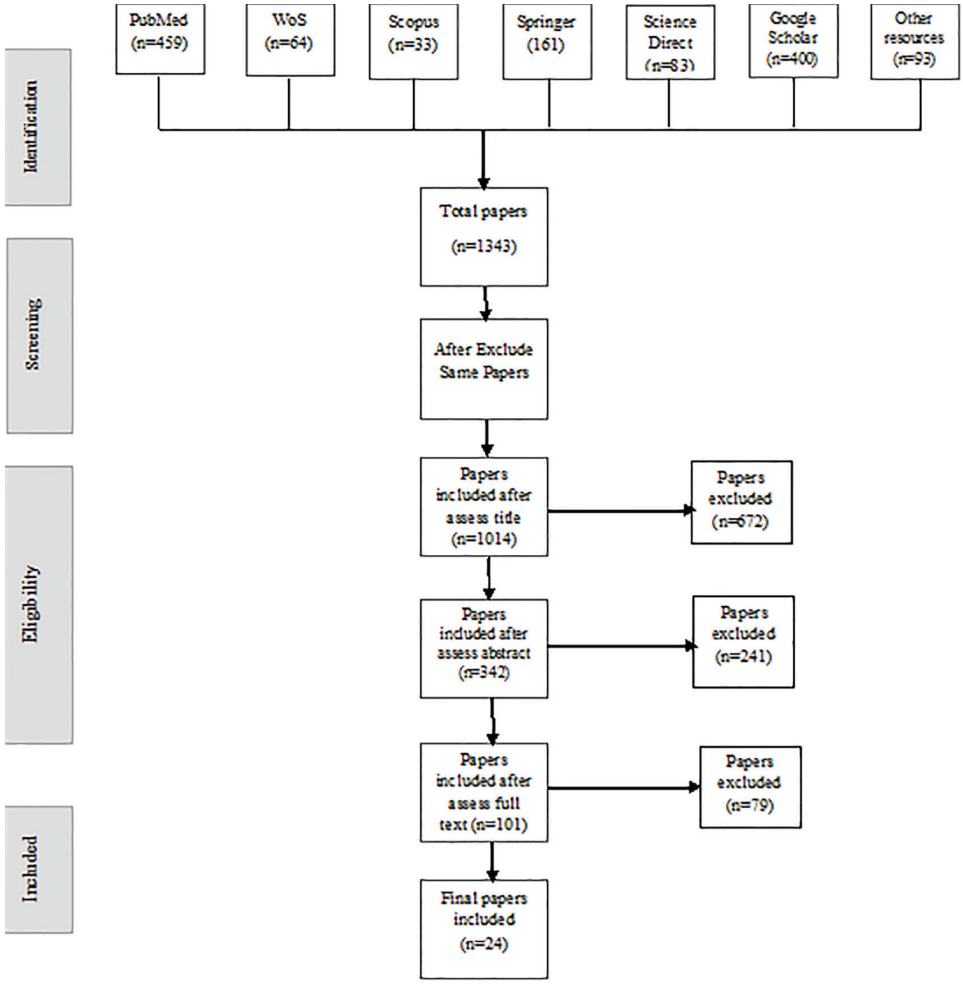

Figure 1: The PRISMA flowchart for the paper selection process

study was conducted, first author, the most important findings, the proposed solutions and the limitations of each study) and the data were summarized and reported in Tables according to the objectives of the study.

Results

All of 21 clinical trials with inclusion criteria were selected for the current study. 2013 had the largest number of studies (9). Studies were conducted in Denmark (4 studies), Canada, the United States and Germany (3 studies for each), England and Australia (2 studies for each), and the Netherlands, Switzerland, Norway, and Austria, (each with 1 study). Using pre-test and post-test was the most common method for data collection.

Based on the other results, the effect of using virtual reality was ranked from 1-4 (very effective, effective, ineffective, and negative); only two studies reported the negative effect on the use of virtual reality in training medical groups. In addition, two studies have reported the ineffectiveness of the use of virtual reality in medical education.

The findings of the present study indicated that the average period of training different medical groups using virtual reality was between six months to one year. In addition, according to the findings of the present study, the application of virtual reality reduced the time required for training medical groups. The secondary results of this study are shown in Table 2 to address the advantages and disadvantages of virtual reality in teaching medical groups.

Other secondary results of the current study include suggestions for improving the application of virtual reality that are presented in Table 3.

Discussion

The results indicated that all studies were conducted in developed countries. 95% of the studies that have been studied emphasize the improvement of the skills of trainees (various medical groups) using virtual reality although a few studies noted the ineffectiveness of virtual reality on medical education. Julie Enne et al. proposed

Table 2: Advantages and disadvantages of training various medical groups using virtual reality

Disadvantages	Advantages
The high cost of the simulators	Decrease in the frequency of training and the ease of training using VR (22-28)
The long nature of some studies in the field of virtual reality	Decrease in the time of surgery in the real environment (23, 29, 30)
The high cost of these studies (high cost of monitors, programming, implementation environment, participants, etc.)	Positive psychological effect on learners (23)
It can never replace the real environment training	Increase in accuracy and accuracy of trainers and reduction of errors (21)
Its implementation requires identification of the effective factors and conditions of that society	Improving the teamwork in the medical team (31)
Additional training using VR without supervision can cause extra stitching, and lead to damages to tissues, and more	Increase in self-confidence in learners using VR compared to other groups (23, 32)
The course of studies is very limited; therefore, further studies and more accurate evaluations are necessary	Decrease of harm to those being treated by people who are trained by VR, decrease in mistakes and more successful surgeries (29, 33-35)
Some studies have also pointed to the increase in training time (18-21)	Increase in skills of learners (18, 21, 24, 28, 36)
	Better learning of anatomical positions (27)
	Better understanding of the exterior and interior space relationships between the organs (27)
	Valuable approach for Standard and unified education of medical groups (28)
	Increase in the skill of surgeon (21)
	Increase in the safety of the physician and patients (21, 33, 34)
	Decrease in the costs and increase in the efficiency (18, 22, 26, 37)
	Overall performance improvement (32, 35, 38)

Table 3: Proposals for the improvement of the application of virtual reality for training various medical groups

No	Proposals
1	The use of virtual reality simulator automatic feedback combined with educational feedback during laparoscopic training in simulated way (17)
2	The divergence between educational concepts of students is decreased. Perhaps significant implications can be stablished for learning using virtual reality technology (20)
3	The presence of an instructor is very influential (guided- education), and in the absence of such a person there may be distortion and in the training process and the performance can be reduced (22, 26)
4	The application of virtual reality equipment for training than traditional medical education (39)
5	Using Portable Learning equipment by virtual reality (23)
6	Application of virtual reality is appropriate for midterm training in medical groups and it is not recommended for long-term education (17, 24)
7	Retraining courses alongside learning using virtual reality (24)
8	The use of VR for the training the medical groups should be considered as an additional training and it cannot replace the main method (25, 29)
9	Understanding the general and specific parameters of the participants in the training will lead to identification of the effective factors in the implementation of more precise laparoscopic surgeries (30)
10	Using feedback during the training using virtual reality (17, 26, 32, 37, 38)

the implementation of virtual reality training courses for the acquisition of hysteroscopic skills for clinical professionals who are interested in learning sterilization techniques (36).

The application of virtual reality in training different medical groups includes different effects. That is, in some specialties virtual reality is very effective, and in several studies and specialties no positive effects are noted regarding the use of virtual reality compared to the control group. A recent study on gynecology and obstetrics reported the impact of VR application on the enhancement of infant and maternal health (35).

A study conducted in 2012 concluded that simulation-based education significantly increased the skills and knowledge of residents in the intensive care unit. It is an invaluable approach for standard medical education (28). However, Brydges et al. indicated that "contrary to expectations of researchers, intervention group did not have more advantages over self-regulated learning (SRL), and in fact they spent more time on doing it" (20). However, most studies reported the positive impact of the application of virtual reality for training the medical groups. Given that a small number of studies reported the lack of effectiveness of the virtual reality application, further studies are required to be conducted in this area.

In addition, Bongers et al. noted that "this study proposed that multitasking could be taught using virtual reality simulator equipment. But the effectiveness of surgery reduced in trainees with multiple trainings and this level of skill requires more research" (18).

The results emphasize a better understanding

of the exterior and interior spatial relationships of the organs and development of the anatomical knowledge of students through the application of VR. Yanping et al. emphasized the improvement of the skills of beginners and experienced bone sawing rescuers because the application of surgical simulations helps the trainees to increase their recognition skill of the anatomical positions (16). Therefore, virtual reality can be used for training the anatomy courses of different medical groups.

Other results showed that virtual reality should be used as a complementary training along with main training and it can never replace the training in the real environment. A study in the field of software development of virtual reality used for education of nursing emphasized guidance in the objectives of simulation training software and its combination with conventional trainings (40). In addition, some studies pointed the effective and positive effects of simulation-oriented syllabus on transferring skills to the operating rooms (8-13).

The results revealed that the presence of an instructor is very influential (guided-training) since his absence may lead to disruption in the learning process and the performance can be reduced (22, 26).

One of the issues of conducting this area is the high cost of these studies, such as the high cost of monitors, programming, implementation environment, participants, and so on. A higher number of student were proposed in a study to cover the high cost of using virtual reality (39).

Given the importance of continuous monitoring of education, the use of feedback during training is recommended (17, 26, 32, 37, 38). Also, the use of virtual reality is suggested for holding retraining courses to increase the quality of the educations.

The results showed that people trained by virtual reality had lower performance errors and higher accuracy compared to those trained by conventional approaches. For example, many studies in the area of education using the simulator indicated that inexperienced residents who learned colonoscopy and endoscopy in the simulator before doing them in real-case (on the patient and in the operating room) did much better and with less errors than other residents who learned it directly in the real environment (41-44).

Conclusion

The application of virtual reality, as a complementary method, plays an important role in improving the performance of different medical groups. Therefore, given the results, it is suggested that it should be used as a complementary educational tool along with main education. Considering that laparoscopic surgery is one of the most important surgical procedures that is taught using virtual reality, individual and general factors affecting its exact implementation should be identified. In addition, given the importance of the issue, it is suggested that more studies should be carried out on the training of medical groups using virtual reality to determine the type and extent of its impact on the performance and efficiency of the students. With respect to the results of the present study, it is suggested that virtual reality should be used in training such skills as laparoscopic surgery, education of orthopedic residents, Gynecology residents, suturing, ultrasound, nursing procedures and paramedical interventions. In addition, it seems necessary to do studies to determine the effectiveness and usefulness of the method and satisfaction of the trainees and patients. Furthermore, considering the needs of trainees, designing virtual reality tools can be an appropriate solution for its effective use for training the medical groups.

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References

1. You SH, Jang SH, Kim YH, Kwon YH, Barrow I, Hallett M. Cortical reorganization induced by virtual reality therapy in a child with hemiparetic cerebral palsy. Dev Med Child Neurol. 2005; 47:628–35.
2. Weiss PL, Bialik P, Kizony K. Virtual reality provides leisure time opportunities for young adults with physical and intellectual disabilities. Cyberpsychol Behav. 2003; 6:335–42.
3. Rizzo A, Kim GJ. A SWOT analysis of the field of virtual reality rehabilitation and therapy. Presence. 2005; 14:119-46.
4. Janse JA, Goedegebuure RS, Veersema S, Broekmans FJ, Schreuder HW. Hysteroscopic sterilization using a virtual reality simulator: assessment of learning curve. Journal of minimally invasive gynecology. 2013;20(6):775-82.
5. Gallagher AG, Seymour NE, Jordan-Black JA, Bunting BP, McGlade K, Satava RM. Prospective, randomized assessment of transfer of training (ToT) and transfer effectiveness ratio (TER) of virtual reality simulation training for laparoscopic skill acquisition. Annals of surgery. 2013;257(6):1025-31.
6. Bongers PJ, Van Hove PD, Stassen LP, Dankelman J, Schreuder HW. A new virtual-reality training module for laparoscopic surgical skills and equipment handling: can multitasking be trained? A randomized controlled

trial. Journal of surgical education. 2015;72(2):184-91.
7. Pahuta MA, Schemitsch EH, Backstein D, Papp S, Gofton W. Virtual Fracture Carving Improves Understanding of a Complex Fracture. J Bone Joint Surg Am. 2012;94(24):e182.
8. Schroedl CJ, Corbridge TC, Cohen ER, Fakhran SS, Schimmel D, McGaghie WC, et al. Use of simulation-based education to improve resident learning and patient care in the medical intensive care unit: a randomized trial. Journal of critical care. 2012;27(2):219.
9. Sachdeva AK. The changing paradigm of residency education in surgery: a perspective from the American College of Surgeons. Am Surg. 2007;73:120–9.
10. Korndorffer JR, Dunne JB, Sierra R, Stefanidis D, Touchard CL, Scott DJ. Simulator training for laparoscopic suturing using performance goals translates to the operating room. J Am Coll Surg. 2005; 201:23–9.
11. Grantcharov TP, Kristiansen VB, Bendix J, Bardram L, Rosenberg J, Funch-Jensen P. Randomized clinical trial of virtual reality simulation for laparoscopic skills training. Br J Surg. 2004; 146: 150-91.
12. Scott DJ, Bergen PC, Rege RV, Laycock R, Tesfay ST, Valentine RJ, et al. Laparoscopic training on bench models: better andmore cost effective than operating room experience? J Am Coll Surg. 2000; 272: 191-283.
13. Seymour NE, Gallagher AG, Roman SA, O'Brien MK, Bansal VK, Andersen DK. Virtual reality training improves operating room performance: results of a randomized, double-blinded study. Ann Surg. 2002; 236:458–63.
14. American Board of Internal Medicine. Procedures required for internal medicine [internet]. USA: ABIM; 2010 [Accessed May 2, 2010]. Available from: http://www.abim.org/certification/policies/imss/im.aspx.
15. Stefanidis D, Yonce TC, Korndorffer JR, Phillips R, Coker A. Does the incorporation of motion metrics into the existing FLS metrics lead to improved skill acquisition on simulators? A single blinded, randomized controlled trial. Annals of surgery. 2013; 258(1):46-52.
16. Lin Y, Wang X, Wu F, Chen X, Wang C, Shen G. Development and validation of a surgical training simulator with haptic feedback for learning bone-sawing skill. Journal of biomedical informatics. 2014; 48:122-9.
17. Walsh C, Sherlock M, Ling S, Carnahan H. Virtual reality simulation training for health professions trainees in gastrointestinal endoscopy. Cochrane Database Syst Rev. 2012;13(6):CD008237.
18. Bjerrum F, Maagaard M, Led Sorensen J, Rifbjerg Larsen C, Ringsted C, Winkel P, et al. Effect of instructor feedback on skills retention after laparoscopic simulator training: follow-up of a randomized trial. J Surg Educ. 2015;72(1):53-60.
19. Bronnimann E, Hoffmann H, Schafer J, Hahnloser D, Rosenthal R. Effect of different warm-up strategies on simulated laparoscopy performance: a randomized controlled trial. J Surg Educ. 2015;72(1):96-103.
20. Brydges R, Peets A, Issenberg SB, Regehr G. Divergence in student and educator conceptual structures during auscultation training. Med Educ. 2013;47(2):198-209.
21. Dehabadi M, Fernando B, Berlingieri P. The use of simulation in the acquisition of laparoscopic suturing skills. International Journal of Surgery. 2014;12:e258-68.
22. Eldred-Evans D, Grange P, Cheang A, Yamamoto H, Ayis S, Mulla M, et al. Using the mind as a simulator: a randomized controlled trial of mental training. J Surg Educ. 2013;70(4):544-51.
23. Johnston TJ, Tang B, Alijani A, Tait I, Steele RJ, Ker J, et al. Laparoscopic surgical skills are significantly improved by the use of a portable laparoscopic simulator: results of a randomized controlled trial. World J Surg. 2013;37(5):957-64.
24. Khan MW, Lin D, Marlow N, Altree M, Babidge W, Field J, et al. Laparoscopic skills maintenance: a randomized trial of virtual reality and box trainer simulators. J Surg Educ. 2014;71(1):79-84.
25. Mulla M, Sharma D, Moghul M, Kailani O, Dockery J, Ayis S, et al. Learning basic laparoscopic skills: a randomized controlled study comparing box trainer, virtual reality simulator, and mental training. J Surg Educ. 2012;69(2):190-5.
26. Oestergaard J, Bjerrum F, Maagaard M, Winkel P, Larsen CR, Ringsted C, et al. Instructor feedback versus no instructor feedback on performance in a laparoscopic virtual reality simulator: a randomized educational trial. BMC Med Educ. 2012;12:7.
27. Pahuta MA, Schemitsch EH, Backstein D, Papp S, Gofton W. Virtual fracture carving improves understanding of a complex fracture: a randomized controlled study. J Bone Joint Surg Am. 2012;94(24):e182.
28. Schroedl CJ, Corbridge TC, Cohen ER, Fakhran SS, Schimmel D, McGaghie WC, et al. Use of simulation-based education to improve resident learning and patient care in the medical intensive care unit: a randomized trial. Journal of critical care. 2012;27(2):219.
29. Nickel F, Brzoska JA, Gondan M, Rangnick HM, Chu J, Kenngott HG, et al. Virtual reality training versus blended learning of laparoscopic cholecystectomy: a randomized controlled trial with laparoscopic novices. Medicine. 2015;94(20):e74.
30. Nickel F, Jede F, Minassian A, Gondan M, Hendrie JD, Gehrig T, et al. One or two trainees per workplace in a structured multimodality training curriculum for laparoscopic surgery? Study protocol for a randomized controlled trial - DRKS00004675. Trials. 2014;15:137.
31. Fernandez R, Pearce M, Grand JA, Rench TA, Jones KA, Chao GT, et al. Evaluation of a computer-based educational intervention to improve medical teamwork and performance during simulated patient resuscitations. Crit Care Med. 2013;41(11):2551-62.
32. DeStephano CC, Chou B, Patel S, Slattery R, Hueppchen N. A randomized controlled trial of birth simulation for medical students. Am J Obstet Gynecol. 2015;213(1):91.
33. Keri Z, Sydor D, Ungi T, Holden MS, McGraw R, Mousavi P, et al. Computerized training system for ultrasound-guided lumbar puncture on abnormal spine models: a randomized controlled trial. Canadian Journal of Anesthesia/Journal canadien d'anesthésie. 2015;62(7):777-84.
34. Luciano CJ, Banerjee PP, Sorenson JM, Foley KT, Ansari SA, Rizzi S, et al. Percutaneous spinal fixation simulation with virtual reality and haptics. Neurosurgery. 2013;72(Suppl 1):89-96.
35. Sørensen JL, Van der Vleuten C, Lindschou J, Gluud C, Østergaard D, LeBlanc V, et al. 'In situ simulation'versus' off site simulation'in obstetric emergencies and their effect on knowledge, safety attitudes, team performance, stress, and motivation: study protocol for a randomized controlled trial. Trials. 2013;14(1):1.
36. Janse JA, Goedegebuure RS, Veersema S, Broekmans FJ, Schreuder HW. Hysteroscopic sterilization using a virtual reality simulator: assessment of learning curve. Journal of minimally invasive gynecology. 2013;20(6):775-82.
37. Paschold M, Huber T, Zeissig SR, Lang H, Kneist W. Tailored instructor feedback leads to more effective virtual-reality laparoscopic training. Surg Endosc.

2014;28(3):967-73.
38. Wijewickrema S, Piromchai P, Zhou Y, Ioannou I, Bailey J, Kennedy G, et al. Developing effective automated feedback in temporal bone surgery simulation. Otolaryngol Head Neck Surg. 2015;152(6):1082-8.
39. Jensen K, Ringsted C, Hansen HJ, Petersen RH, Konge L. Simulation-based training for thoracoscopic lobectomy: a randomized controlled trial. Surgical endoscopy. 2014;28(6):1821-9.
40. Moghaddasi H, Rabiei R, Nazemi E, Bigdeli SH, Ebrahimpour Sadagheyani H. Role of models, approaches and learning theories in the design and production of educational software based on virtual reality techniques and simulation in nursing education: a systematic review. J Urmia Nurs Midwifery Fac. 2016; 14(4):300-12.
41. Eversbusch A, Grantcharov TP. Learning curves and impact of psychomotor training on performance in simulated colonoscopy: A randomized trial using a virtual reality endoscopy trainer. Surg Endosc. 2004; 18:1514-8.
42. Felsher JJ, Olesevich M, Farres H, Rosen M, Fanning A, Dunkin BJ, et al. Validation of a flexible endoscopy simulator. Am J Surg. 2005; 189:497-500.
43. Grantcharov TP, Carstensen L, Schulze S. Objective assessment of gastrointestinal endoscopy skills using a virtual reality simulator. JSLS. 2005;9:130-3.
44. Koch AD, Buzink SN, Heemskerk J, Botden SMBI, Veenendaal R, Jakimowicz JJ, et al. Expert and construct validity of the Simbionix GI Mentor II endoscopy simulator for colonoscopy. Surg Endosc. 2008; 22:158-62.