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The Use of Virtual Reality in Radiology Education: Review Article Year of Publication 2010 - 2022

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Abstract. Background: Advancement in the healthcare sector, the complexity of health problems and healthcare system become an additional burden for healthcare workers who have incompetence along with professional education of healthcare workers, specifically in radiology education. Virtual reality has great potential in educational learning tool development to encounter various challenges in future radiology education.
Objective: To determine the scope of virtual reality and its effectiveness as an educational learning tool in radiology education.
Methods: A literature review was carried out to explore articles related with application of virtual reality in radiology education by adjusting various search terms: "virtual reality", and "radiology"/ "radiography" / "x-ray" / "radiology technologist" / "education". Articles were selected based on the inclusion and exclusion criteria that have been previously assigned. The timeframe for the literature search was restricted from 2010 to 2022. screening process.
Results: Screening process were applied to search across database. Twelve articles were identified related with the application of virtual reality in radiology education. Application of virtual reality had been implemented in several sub-fields of radiology education, consist of three articles from conventional radiography, two articles from general diagnostic radiology, four articles from interventional radiology, two articles from radiological anatomy, and an article from ultrasonography.
Conclusion: The application of virtual reality has been used in several sub-fields of radiology education. Almost all studies showed positive responses on application VR in radiology education. The development of virtual reality as radiology educational learning tools were needed further particularly in several sub-fields that have not been implemented.

Keywords: Virtual reality; radiology education

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INTRODUCTION

Utilization of technology innovation for education contributes to the transition in a higher level of professional knowledge assimilation (Zamyatina, 2020). Virtual reality (VR) is a digital technology that produces three-dimensional interactive situations, and presents objects in a virtual world which has spatial dimension (Kardong *et al.*, 2019). Virtual reality is a digital technology which generate three-dimensional interactive situations and provides objects in virtual worlds with spatial dimensions. Virtual reality are divided into two types, non-immersive and immersive. The non-immersive virtual reality is a computer-based technology that simulates an environment, whereas the immersive virtual reality is a further technology that replicate an environment by providing a real physical perception of the virtual world. Non-immersive VR could be based on standard computers and immersive VR are currently develop as the required devices become more user-friendly and economically accessible. In past few years, there was great difficulty in using equipment such as helmets with goggles, but nowadays recent devices are being developed to make it easier for users. VR have three basic principles: immersive perception, interaction, and user engagement with the environment and narrative. VR offers enormous potential in education by creating encouraging and engaging educational tools. Currently, availability of modern tools that are easily accessible, are become potential opportunities to access immersive VR in many educational situations (Freina, and Ott , 2015).

Virtual reality has been implemented for a long time in the field of education, but its widespread application has underdeveloped due to substantial problems that have to be encountered including technological limitations, financial, limited requiring equipment for wider use (Kavanagh., et.al 2017).

Radiology education has different characteristics compared with other healthcare educations because the involvement of ionizing radiation utilization in their learning activities. Safety conditions are required in clinical practice

activities but also could be able to provide opportunities for students to increase their capability of technology and scientific understanding. Virtual reality is an innovative technology that has potentially developed in radiology education, hence students enable to practice radiography in a virtual environment. Students have to apply their theoretical knowledge to perform radiographic examinations in a radiation-safe virtual environment (O'Connor et.al, 2021). This research aims to determine the scope of virtual reality and its effectiveness as an educational learning tool in radiology education.

METHODS

Literature review were sought to explore the usage of Virtual Reality (VR) in radiology education through Publish-or-Perish Software on Google Scholar. The search term virtual reality", and "radiology" or "radiography" or "x-ray" or "radiology technologist" or "education" were applied to search across the database. The timeframe for the literature search was restricted from 2010 to 2022.

The literature searching applied several stages of screening process based on following criteria:

1. Articles were published from 2010 to 2022
2. Articles were written in Indonesian and English.
3. Articles selection were including the completeness of article's component that contains title, author, publisher, abstract, and accessible fully accessible article and references.
4. The contents of the selected articles discuss about the use of virtual reality in radiology education.

Based on the initial analysis related to the use of VR in radiology education using the vos viewer software, it is shown that this research was carried out from 2015 to 2022. The results of the initial analysis using the VOS viewer software are shown in Figure 1.

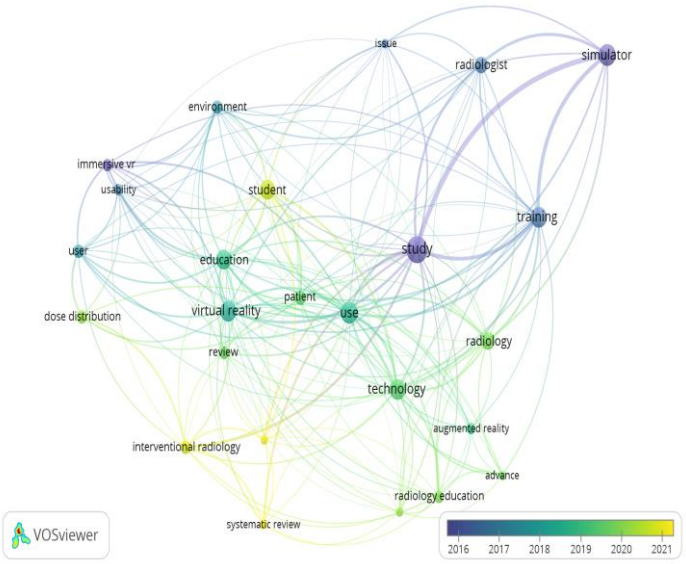

Figure 1. Display of the Vos Viewer software on the use of VR in radiology education from 2015 to 2022

Thelve articles were identified based on following criteria that have been previously assigned. Furthermore, analysis related were apply to look for the use of virtual reality and its effectiveness as an educational learning tool.

RESULT & DISCUSSION

The initial literature searching obtained thirty seven articles, following with screening process to determine the eligible, therefore twelve eligible articles were summarized and synthesised. The identification of the sub-field of radiology that had been implemente virtual reality as their educational learning tools were depicted on Figure 2.

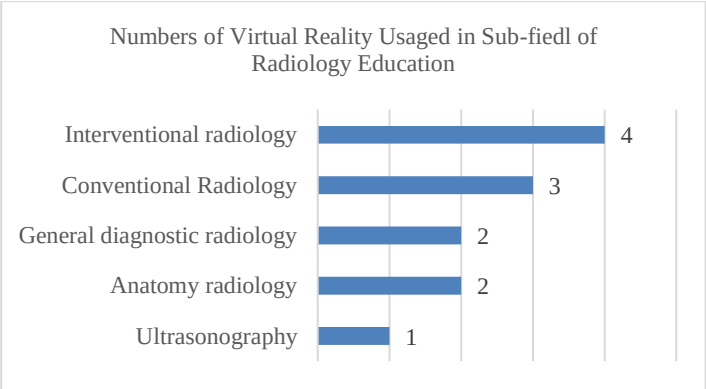

Figure 2. twelve radiology education sub-fiedl articles that have implemented virtual reality as a means of educational learning.

In ultrasonography education, virtual reality were being used to simulate abdominal examinations in fifteen radiologists as respondents. Furthermore, an assessment were carried out by the respondents. The results indicated that virtual reality simulations are suggested by all respondents and considered to provide benefits as an educational learning tool (Østergaard, *et al.* (2019).

In anatomy radiology education, virtual reality (VR) and augmented reality (AR) have capability to contribute to clinical practice and anatomy education, by utilizing AI illustration segmentation techniques for radiology students. VR provides more immersive and intuitive experience for students to interconnect and transform data as the time when they interpret illustraation for diagnosis or for surgical preparation by incorporating AI segmentation technology (Xu, *et al.*, 2020). The review of the use of virtual reality in anatomy education has considered positive feedbacks. Three studies which evaluated the academic performance showed that virtual reality was effective in escalating anatomical knowledge. These results could be stimulate educators to teach radiological anatomy using virtual reality (Barteit et al, 2021).

Radiography education are commonly use virtual reality for several cases. First, virtual reality are being used as educational learning tool by utilization of the C-Arm for radiographers in the operating room. The training tools are created in game-mode that creates C-Arm training become more interesting. Evaluations by respondents indicated that this approach is widely appreciated because it provides an easy-to-use and reasonably realistic training tool with higher educational value for C-Arm imaging in operating rooms (Kavanagh, et.al 2017). VR could be a solution for students participation in learning process who have had obstacles due to working conditions. For example, in certain competencies, students could not directly participate to handle patients because the hazard of radiation. Although VR is not necessarily appropriate to support all competency achievements, its current implementation and successful on increasing students' ability to fullfil quality standards are appropriate for further discussion and argumentation on a transnational basis (Hayre, and Kilgour. 2021). A three-dimentional virtual reality simulation has been generated. Students could implement radiographic examinations on three-dimentional animations of patients to uncover and interpret the imaging results. Simulations were carried out on 105 university students, and it showed that most of the respondents (58%) reported appreciate VR simulations, while some peceived indifferent to them (27%). Ninety-four percent would recommend these tools to other students. The average length of time to establish students to be sensible of Most respondents (58%) wish for VR become more accessible. Students ascribe the elevtaion of confidence in the field of light collimation (75%), placement of anatomical markers (63%), centering of X-ray tubes (64%) and selection of exposure parameters (56%) with VR practice. The difficulties that are encountered in VR simulations were technical defects, inability to palpate the patient and lack of constructive feedback. Students demonstrate that three-dimentional virtual radiography simulation are valuable pedagogical tool in radiography education. 3D immersive VR simulations are perceived by radiography students as a valuable educational learning tool resources. VR needs to be strategically implemented into the curriculum to optimize its benefits (O'Connor et.al, 2021).

Future applications of augmented reality (AR)

and virtual reality (VR) for education include its further integration of previous training levels on anatomy and pathology, also for procedural of general radiodiagnostic examinations simulation. The overall objective of this technology implementation are for rapid concepts and techniques proficiencies. Continuous large-scale assessment of this technology are not only in student satisfaction but also in improving understanding and retention of required material. The AR and VR clinical utilization in patient education and perioperative planning are quite reassuring. Further technical innovations allow to minimize hardware dimensions and escalate comprehensible imaging (Uppot *et al.* 2019). In other study, by creating virtual reality for radiological interpretation room simulations, showed positive responses from respondents (Wirth *et al.* 2018).

The improvement in VR and AR have enabled its current applications in education, training, and patient care in radiology. Investigation of VR effectivities for visualization of complex anatomy and procedural training are currently ongoing in interventional radiology. We believe that further exploration and ind-depth studies are required for greater understanding to figure this technology utilization on optimizing radiology training and improving patient care (Elsayed *et al.* 2020). The investigation for the validation and development of virtual reality as an interventional radiology training tool heva the potential to be transversed in real cases have been implemented. The result shows that the learning skill in VR could be successfully implemented to real cases. Recently, with advances in technology, VR simulators have been developed to enable complicated medical procedures to be practised without being endanger the patient (Johnson *et al.* 2011). Another investigation reported the VR application to indicate radiation distribution in the interventional radiology room. Understanding the proper dose distribution is critical to reduce the risk of radiation dermatitis to patients and staff. Visualization of dose distribution is anticipated to substantially support radiation safety attempts. This VR visualization is looked forward to unfold the latest perspective for dose distribution understanding intuitively, thereby it could assist to avoid radiation injury (Takata *et al.* 2020).

Radiology education has a specific character because the use of radiation could be harmful to students. Virtual reality is one of solution that could be implemented to improve greater understanding and capability of students without increasing radiation hazards risk. The use of virtual reality has arisen in several subfield of radiology education.

A glance of virtual reality prospective, it is required to further develop the implementation of virtual reality in other radiology sub-fields such as radiotherapy, radiography with contrast media, CT Scan, MRI and Nuclear Medicine. Although VR does not always appropriate for all competencies, the implementation of VR could lead students closer to the actual work of radiographers that could not be directly provided by healthcare institutions. Most investigation reports show great responses to the implementation of VR in radiology education. The limitations of virtual reality were identified including technical problems, without having come into contact experience and mutual interaction with the patient during the examination. However, the rapid development of technology in the future, it is highly feasible to minimize its limitation with the invention of latest technologies. This is also become a challenge for further prospective studies related with the implementation of virtual reality in radiology education.

CONCLUSION

The application of virtual reality has been used in several subfields of radiology education and showed a positive response of its application as a learning media. Further studies are needed to develop virtual reality in other sub-fields of radiology education. The limited number of articles obtained is due to the lack of virtual reality research in radiology education.

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