Review Article

Effects of Multimedia E-Books and Augmented Reality on Knowledge and Skills of Health Sciences Students: A Systematic Review

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ABSTRACT

Background: The limited ability of educational institutions to prepare learning materials due to being expensive makes it essential to use other methods such as digital methods or minimize the use of excessive learning materials. Accordingly, the present systematic review aims to find out the effects of multimedia e-books and Augmented Reality (AR) on the knowledge and skills of health sciences students.

Methods: This systematic review was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. Relevant articles were searched in ScienceDirect, ERIC, ProQuest, Pubmed, and Wiley Online Library, with the publication year of 2010-2021. Eligibility criteria were determined based on the PICOS guidelines. Joanna Briggs Institute (JBI) checklists were used for the quality assessment of the included articles. The risk of bias was assessed using the Cochrane Collaboration's risk-of-bias assessment tool. The articles were analyzed thematically after collecting their main findings, design, and applied methods.

Results: The initial search yielded 493 articles. After removing duplicates, articles met exclusion criteria, and those with low quality, 11 eligible articles were selected for the review. Studies showed that multimedia e-books increased the students' knowledge of evidence-based medicine, anatomy, community health nursing, pediatric care, electrocardiogram, and sexual harassment prevention. The use of AR increased the skills of students in performing local anesthesia, dental care, and anatomy.

Conclusion: The use of multimedia e-books and AR has significant effects on the learning process of health sciences students compared to conventional teaching methods.

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Highlights

● The limited ability of educational institutions to prepare learning materials due to being expensive makes it necessary to use other methods such as digital methods or minimize the use of excessive learning materials.

● The use of multimedia e-books and Augmented Reality has significant effects on the learning process of health sciences students compared to conventional teaching methods that use textbooks, whiteboards, or lectures.

Plain Language Summary

Interactive learning encourages independent study through the use of digital technology and electronic materials in the form of text, picture, video, audio, etc. Learning by the use of e-books and augmented reality increase the students' acceptance of the materials. The results of this review showed that the use of multimedia e-books and augmented reality had a significant effect on the learning process of health sciences students compared to conventional teaching methods that use textbooks, whiteboards, or lectures.

1. Introduction

In the 21st century, technology is advancing faster than ever. The younger generation, including college students especially those in medical sciences, are in contact with highly advanced digital equipment, challenging educators to integrate digital technology in education to improve the learning outcomes (O'connor and Andrews, 2015; Risling, 2017). Digital education has become popular for health professions education (Shachar and Neumann, 2003; Choules, 2007; Car et al., 2019). It can be defined as the use of digital technology for teaching and learning. Digital education uses a variety of teaching and learning approaches, including the transformation of simple texts from a paper-based format to a digital format (e.g. portable document format) and the interactive use of sophisticated digital technologies (e.g. video conference, virtual reality) (Car et al., 2019). Most students and healthcare professionals have reported the use of digital technologies in their studies or routine clinical practice (Curran et al., 2017).

Simulation-based medical education in different disciplines (e.g. Medicine, Nursing and Midwifery) has been well recognized and applied for many years. Medical students are required to show an acceptable level of competency. For example, most dental procedures such as cavity preparation, endodontic therapy, and oral surgical interventions are irreversible, and learning these skills only by examining the patient is not an ideal practice. For this reason, simulations of interventions in university laboratories are essential for learning psychomotor skills before going to a real clinic with real patients. In this regard, new technologies can provide tremendous help with the theoretical and practical education of medical students. Among these technologies, multimedia e-books and Augmented Reality (AR) are more common. An e-book is a book available in digital form, consisting of text, images, or both, and can be read on smartphones, tablets, computers or electronic readers. The evidence suggests that students who use e-books also occasionally use traditional printed books. However, there seems to be disagreement about whether the use of e-books is a time-efficient way of learning (Tosun, 2014; Engbrecht, 2018). Some studies have reported that some readers may perceive that e-books take longer to read than printed books (Millar, 2015). A major advantage of e-books is that they have aid to navigation within the text. Navigation is essential in e-books to increase their usage. Having a page with interactive content, links between pages and clear titles improves the user experience (Matraf et al., 2017). E-books ensure that study materials be available for all students, not only for those with the financial ability to purchase a printed book or have access to library books. Access to relevant materials is important for the curriculum in a flipped classroom to ask students to pre-read materials before attending sessions (Eaton, 2017). It has been shown that students support the use of e-books in education for its complementation not for replacing the current practice (Pickering, 2015).

Another technology that has been developed is AR. The AR is the simulation of a three-dimensional environment created using hardware and software that provides users with a realistic experience and the ability to interact. This concept has been developed since the 1960s and has experienced significant improvement since then (Farronato et al., 2019). The key factor in using AR is the development of portable personal computers. The

AR was developed after virtual reality because it requires more complex technological specifications, although it is simpler to realize than virtual reality. The reason is that it improves the existing environment by adding virtual elements rather than replacing it with a completely new environment. However, it faces real-world dynamics that are generally difficult to control and often unpredictable (Bugarić, 2013). Arguably, the AR concept has been widely used in the arts, game industry, architecture, daily life, industrial design, navigation, automotive industry, archeology, and other areas. Great efforts have been made to apply AR technology in biomedical sciences (Wang et al., 2014; Suenaga et al., 2015).

The increasingly rapid improvements in the current digital system have attracted the attention for the development of educational models for medical students using either multimedia e-books, interactive e-books, or web-based AR technology. Accordingly, this systematic review aims to investigate the effectiveness of multimedia e-books and AR in the learning process of health sciences students. The question is "How does the use of multimedia e-books and AR affect the knowledge and skills of health sciences students?"

2. Materials and Methods

Review protocol

This systematic review was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Moher et al., 2009) on relavent articles published from 2010 to 2021.

Literature search

Relevant articles were searched in Sciencedirect, ERIC, ProQuest, PubMed, and Wiley Online Library, with a publication period from 2010 to 2021. The search keywords were based on the MeSH terms for health studies. The used keywords were "Effectiveness" OR "Effect" OR "Impact" OR "Evaluation" AND "Multimedia e-book" OR "e-book" OR "Digital book" OR "Augmented Reality" AND "Education" OR "Simulation" OR "Practice" AND "Medical student" OR "Dentistry" OR "Physiotherapy" OR "Nursing students" OR "Midwifery student" OR "Trainer" OR "Surgery" OR "Public health".

Eligibility criteria

Eligibility criteria for the selection of studies for review were determined based on the PICOS guidelines (Table 1). The population consisted of all students in health sci-

ences, such as dentistry, medicine, nursing & midwifery, public health, and physiotherapy. Two types of educational technologies were identified as interventions to support learning activities: Multimedia e-books and AR. Regarding study design and comparisons, Randomized controlled Trial (RCT), quasy experimental, and qualitative studies indicated the positive and negative effects of the use of educational technologies (multimedia e-books and AR) on student learning, and those published in English were included in the review. Studies that did not examine the use of AR or e-books, those with unavailable full-texts, literature reviews or systemic reviews, books, conference proceedings, reports, thesis, research and development, case studies, or clinical guidelines were excluded from this review.

Risk of bias

The risk of bias was assessed by two authors independently using the Cochrane Collaboration's risk of bias assessment tool (Higgins et al., 2019). Discrepancies were resolved by discussion or reference to the third author. The following domains were assessed: (1) Random sequence generation, (2) Allocation concealment, (3) Blinding of participants and personnel, (4) Blinding of outcome assessment, (5) Incomplete outcome data, (6) Selective outcome reporting, and (7) Other bias (biases due to funding or conflict of interest). Each potential source of bias was graded as low, high, or unclear; only studies with low risk of bias included in the current review. Each judgment was supported by a quote from the relevant study.

Quality assessment

For quality assessments of selected studies, we used Joanna Briggs Institute (JBI) checklist for randomized clinical trials (Tufanaru et al., 2017), the JBI checklist for cohort studies (Moola et al., 2017), the JBI checklist for (non-randomized) experimental studies (Tufanaru et al., 2017), and the JBI checklist for qualitative research (Lockwood et al., 2015). The data were excluded if they did not meet ≥3 criteria. Table 2 shows the quality assessment results for Randomized Clinical Trials (RCTs). For other studies, the results were not included due to the word limit.

Extraction and analysis

Titles and abstracts of studies were screened independently by two authors. Screening for duplicates was carried out using the Mendeley Desktop. Substantive information was extracted from each article and entered into a table in MS Word. Data extraction was carried out care-

Table 1. Inclusion criteria based on PICOS guidelines

Criteria	Inclusion Criteria
Participants	Students in health sciences
Intervention	Multimedia e-books, AR
Comparisons	Single-arm and multi-arm interventions (with a comparison or control group)
Outcomes	Knowledge, skill
Study Design	Experimental studies (eg, randomized controlled trials, quasi-experimental studies, those with a pre-test/post-test design and with control group) and non-experimental studies (observational, qualitative)

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fully. The specifcations of reviwed studies including the author's name, study design, participants, intervention/focus, study method, and main findings are presented in Table 3. Data synthesis was carried out using a synthesis matrix including e-books and AR.

3. Results

The initial search yielded 493 articles. After removing duplicates, 356 remained, of which 271 removed after screening titles and abstracts. The remaining 85 articles were checked for eligibility, which led to the exclusion of 74 articles. Finally, 11 articles met the inclusion criteria. PRISMA flowchart for literature search is shown in Figure 1.

Characteristics of studies

Most of the included studies (n=5) had quasi-experimental designs (Stirling and Birt, 2014; Wu et al., 2018; Liu, Chou and Lee, 2020; Mladenovic et al., 2020; Zafar and Zachar, 2020). Four articles were RCTs (Bogomolova et al., 2020; Moro, Stromberga and Birt, 2020; Chang et al., 2021; Liao et al., 2021), and two articles were qualitative and prospective (Price and Cartledge, 2019; Mladenovic et al., 2020). A total of 616 students and teachers participated in the studies which were published from 2013 to 2021 and conducted in seven different countries, including Australia (n=3), Taiwan (n=3), China (n=1), England (n=1), Netherlands, (n=1), Serbia (n=1), and Brazil (n=1).

Table 2. Quality assessment for RCTs (n=4)

Criteria	Liao et al., 2018	Chang et al., 2021	Moro et al., 2020	Bogomolova et al., 2019
True randomization for assignment of participants to treatment groups	Y	Y	Y	Y
Concealed allocation to treatment groups	Y	Y	Y	U
Similarity of treatment groups at the baseline	Y	Y	Y	Y
Participants' blindness to treatment assignment	Y	Y	Y	Y
Blindness of those delivering treatment to treatment assignment	Y	Y	Y	Y
Blindness of outcomes assessors to treatment assignment	N	Y	N	N
Identical treatment of treatment groups other than the intervention of interest	Y	U	Y	Y
Follow up was complete; if not, differences between groups in terms of their follow up adequately described and analyzed	Y	Y	Y	Y
Participants were analyzed in the randomized groups	Y	Y	Y	Y
Outcomes were measured in the same way for treatment groups	Y	Y	Y	Y
Outcomes were measured in a reliable way	Y	Y	Y	Y
Appropriate statistical analysis was used	Y	Y	Y	Y
The trial design was appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial were reported	Y	Y	Y	Y

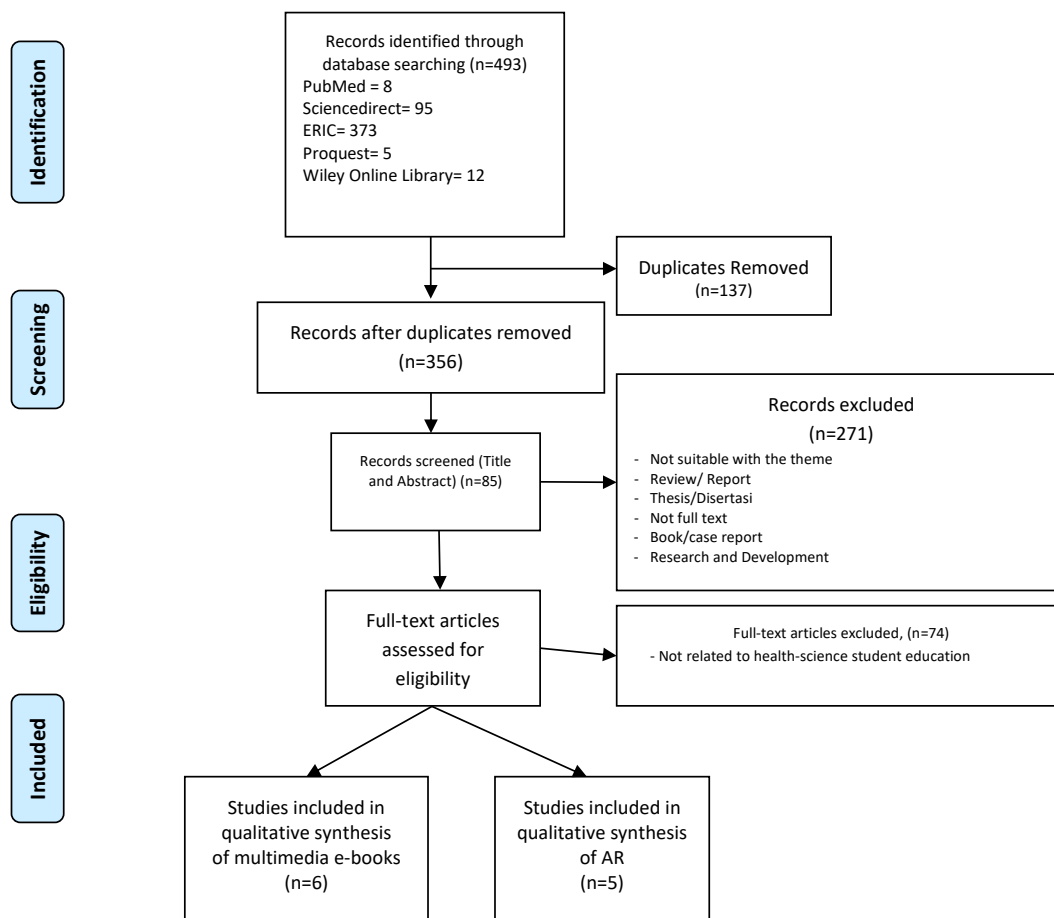N: No; U: Unclear; Y: Yes; NA: Not Applicable.

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Figure 1. PRISMA flowchart for literature search and selection

In general, this review study was conducted on studies assessing the effects of multimedia e-books and AR technology on the learning and teaching process or simulation. The use of e-books in several studies was for improving the ability to teach Evidence-Based Medicine (EBM) (Liao et al., 2021), anatomy (Stirling and Birt, 2014), community health nursing practice (Wu et al., 2018), pediatric acute care (Price and Cartledge, 2019), electrocardiogram (Liu, et al., 2020), and sexual harassment prevention knowledge (Chang et al., 2021). Regarding the AR, several studies used it for simulation of teaching local anesthesia in pediatrics (Mladenovic et al., 2020), local anesthesia of inferior alveolar nerve block (Mladenovic et al., 2020), perception of head and neck anatomy in dentistry (Zafar and Zachar, 2020), medical and health sciences (Moro et al., 2020), and general anatomy (Bogomolova et al., 2020).

Effectiveness of using multimedia e-books in learning

Liao et al. (2021) evaluated the impact of using multimedia e-books by simMAGIC software for teachers as their supporting material for teaching EBM. An evaluation was carried out at the end of each session using the Fresno test. Their results showed the success of online e-books in increasing the effectiveness of teaching EBM, satisfaction, teaching quality, teaching methods, and most importantly, students' interest in learning EBM.

In another study, multimedia e-books showed positive results in learning anatomy. The impact of using this e-book was also seen in students' laboratory exam results, which significantly increased their performance (Stirling and Birt, 2014). A similar increase was also found in another study conducted in Taiwan which used e-books in learning ECG. Students using e-books were more motivated to study because the learning materials were complete and interactive (Liu et al., 2020). The application of e-books in the community health nursing practice, e-books could increase students' attention, motivation, participation, and satisfaction (Wu et al., 2018).

Table 3. Characteristics of the included studies

Main Findings	Evaluation/ Exploration Method	Intervention/Focus	Participants	Purpose	Design	Country	Author, Year, Tittle
The interactive e-book learning improved the effectiveness of teaching in terms of satisfaction, teaching quality, teaching methods, and students' interest in EBM compared to the traditional PowerPoint method	Fresno test	online e-book using SimMAGIC software	80 teachers (40 by e-books, 40 by Power point)	To evaluate the effectiveness of an interactive clinical teaching EBM e-book to improve teacher-related skills, as well as to foster both teachers' and learners' interest in studying EBM.	RCT	China	Liao et al., 2021. A Study on How Using an Interactive Multimedia E-Book Improves Teachers' Ability to Teach Evidence-Based Medicine, Depending on Their Seniority
The traditional practical session did not show a statistically significant improvement; the eBook group showed a statistical improvement	A multiple-choice examination, consisting 15 items to assess knowledge	The Heart Multimedia eBook with content categorized into interactive 3D images, static 2D images, medical imaging, and podcasts.	85 medical students	To compare the use of an enriched multimedia eBook with traditional methods for teaching the gross anatomy of the heart and great vessels	One group, pretest/ posttest	Australia	Stirling & Birt, 2014. An Enriched Multimedia eBook Application to Facilitate Learning of Anatomy
The multimedia content and interactivity of the e-book system held students' attention during the activities, increased their motivation and participation and provided them with a sense of satisfaction	Self-report	Mobile E-Book System Based on Project-Based Learning	64 nursing students	To evaluate an e-book system that integrated project-based learning and authentic learning into a community health nursing practice course	Quasi-experimental	Taiwan	Wu et al., 2018. Application and Analysis of a Mobile E-Book System Based on Project-Based Learning in Community Health Nursing Practice Courses
E-books were very helpful in preparation for the objective structured clinical exams and written exams, and the self-confidence of students increased.	Interview: started with an "ice-breaker" question and then were conducted using pre-planned open-ended questions	E-books	14 fourth-year medical students	To explore students' experiences of using this E-book within a spiral, multi-method teaching package, in order to get an insight into the personal interaction between learners and technology.	Qualitative	England	Price & Cartledge, 2019. Discovering Students' Personalized Uses of a Pediatrics Acute Care E-book

Main Findings	Evaluation/ Exploration Method	Intervention/Focus	Participants	Purpose	Design	Country	Author, Year, Tittle
For EEG 1, learning achievement did not significantly differ between the two groups. For EEG 2, there were no significant differences regarding learning achievement or content retention. The scores were higher in the experimental group than in the comparison group. Study time was significantly lower in the experimental group	Two essay questions to collect students' experiences of using e-books.	E-books about ECG based on the ARCS modela	59 senior nursing students (33 in the comparison group and 26 in the experimental group)	To evaluate the effect of this interactive e-book on nursing students' EEG-related learning achievement when compared to traditional learning materials.	Quasi-experimental	Taiwan	Liu et al., 2020. Effect of an interactive e-book on nursing students' electrocardiogram-related learning achievement
Knowledge in both groups were significantly higher after the intervention, and the posttest score of the e-books group was significantly higher than that of the control group.	Instructional Materials Motivation Survey	Intervention Group: Interactive multimedia eBook Control Group: Video and brochure	64 fourth-year nursing students (33 with learning by e-books and 33 by video and brochure)	To evaluate the effects of a clinical-based sexual harassment prevention e-book on nursing students' knowledge, coping behaviors, and learning motivation.	A randomized, controlled, experimental study.	Taiwan	Chang et al., 2021. Use of an interactive multimedia e-book to improve nursing students' sexual harassment prevention knowledge, prevention strategies, coping behavior, and learning motivation
A statistically significant shorter time to perform infiltrative anaesthesia technique for the anterior superior alveolar nerve was observed in students using the AR technique (28.91±9.06 seconds in the study group and 39.80±9.29 seconds in the control group). The level of cortisol before and after anaesthesia was statistically significant in all subjects (cortisol concentration was 0.53 µg/dL before anaesthesia and 2.44 µg/dL after the procedure); but there was no statistically significant difference between the groups.	Salivary cortisol to all students. The level of cortisol in saliva was measured before and after the anaesthetic procedure as one of the indicators of acute stress. Tests were performed between 2 and 3 pm. Saliva samples were collected by Sarstedt Salivette (Salivette, Sarstedt Inc.). The level of cortisol in saliva was measured using the ELISA method	The mobile simulator on AR-supported device	21 4th- and 5th-year students enrolled in a 5-year dentistry programme	To evaluate the impact of AR simulator on the perception of learning and acute stress level in students administering local anaesthesia to paediatric patients relative to standard teaching methods.	Prospective with control group	Brazil	Mladenovic et al., 2020. Effect of augmented reality simulation on administration of local anaesthesia in paediatric patients
The students who used an AR mobile simulator carried out an anesthetic procedure for IANB in a shorter period of time and had greater success rates in completing the anesthesia than the students who did not use the simulator.	A post-clinical questionnaire evaluating student's knowledge and skills.	The mobile application Dental Simulator	41 students (22 in the experimental group and 19 in the control group)	To evaluate the effectiveness of a mobile AR simulator for local anaesthesia training with dental students who are administering inferior alveolar nerve block IANB for the first time.	Quasi-experimental	Serbia	Mladenovic et al., 2019. Effectiveness of Augmented Reality Mobile Simulator in Teaching Local Anesthesia of Inferior Alveolar Nerve Block

Main Findings	Evaluation/ Exploration Method	Intervention/Focus	Participants	Purpose	Design	Country	Author, Year, Tittle
43.5% of participants agreed that the 3D anatomical structures improved their understanding of anatomy and 36.5% agreed that they felt more confident about their anatomy skills. The results also demonstrated that only 34.1% agreed that it added value in training compared with relying solely on traditional methods. Overall, 75.3% of participants agreed that HoloHuman teaching should not replace traditional cadaver training.	A questionnaire assessing students' experience of HoloLens and conventional cadaver anatomy training	HoloLens	88 second-year dental students	To investigate dental student's perception of the AR head and neck anatomy application and to determine whether the learning environment was beneficial for students compared with traditional cadaver learning.	Quasi-experimental/ pretest/post-test	Australia	Zafar & Zachar, 2020. Evaluation of HoloHuman augmented reality application as a novel educational tool in dentistry
There were no significant differences between test scores from lesson delivery in either the HoloLens or mobile-based AR. However, a significant increase was reported in dizziness when using the HoloLens (25% higher, n=19)	Two questionnaires evaluating the adverse health effects experienced, and participant engagement was assessed with a learning tool	Mobile-based AR, and Microsoft HoloLens	20 students in mobile-based AR, 20 in Microsoft HoloLens group	To assess the effectiveness of learning when an identical lesson was delivered through augmented reality using either the Microsoft HoloLens or a mobile hand-held tablet device.	RCT	Australia	Moro et al., 2021. HoloLens and mobile augmented reality in medical and health science education
The overall posttest scores in the stereoscopic 3D AR group (47.8%) were similar to those in the monoscopic 3D desktop group (38.5%: P = 0.240) and the 2D anatomical atlas group (50.9%; P = 1.00). When stratified by visual-spatial abilities test scores, students with lower Mental Rotation Test MRT scores achieved higher posttest scores in the stereoscopic 3D AR group (49.2%) compared to the monoscopic 3D desktop group (33.4%; P = 0.015) and similar to the scores in the 2D group (46.4%; P=0.99).	A standardized self-report tool	DynamicAnatomy (LUMC, 2019) for HoloLens®, version 1.0 (Microsoft Corp., Redmond, WA)	58 subjects (20 by stereoscopic 3D AR model, 20 by monoscopic 3D desktop model, and 18 by 2D anatomical atlas	To evaluate the learning effect of an anatomical stereoscopic 3D AR model of the lower leg among medical undergraduates when compared to a mono-scopic 3D desktop model and 2D anatomical atlas.	Double-center RCT	Netherlands	Bogomolova et al., 2020. The Effect of Stereoscopic Augmented Reality Visualization on Learning Anatomy and the Modifying Effect of Visual-Spatial Abilities

aA motivational design process including a synthesis of motivational concepts and theories that are clustered into four categories: attention (A), relevance (R), confidence (C), and satisfaction (S).

Effectiveness of AR in learning

Most AR technologies were used in simulating learning processes, such as the administration of local anesthetics in pediatric patients (Mladenovic et al., 2020) and dental care (Zafar and Zachar, 2020). The results of studies regarding the simulation of learning by AR technology showed improved understanding and correct performance of procedures and reduced stress in students. However, the students believed that learning by AR should be combined with traditional cadaver learning. AR was also used in learning anatomy and physiology (Bogomolova et al., 2020; Moro et al., 2020). The results showed that the use of AR in learning anatomy and physiology could significantly improve students' understanding and help them in the next practices.

Comparing multimedia e-books and AR with other methods

Several studies have compared the effects of using e-books and AR with the effects of other methods or technologies. One study compared the impact of e-books with that of videos and brochures. The results showed that e-books were better able to increase student satisfaction in learning and further improve their abilities in independent learning, but there was no significant difference between the two methods (Liu et al., 2020). Another study compared the use of mobile-based AR with Microsoft Hololens, and the results showed no significant difference between them. However, a difference was observed in dizziness when Hololens was used (Moro et al., 2020).

4. Discussion

This systematic review investigated the effects of using multimedia e-books and AR on the knowledge and skills of students in health sciences such as medical, dental, nursing & midwifery, and public health. Among 11 relevant studies, 6 focused on the use of multimedia e-books, and 5 were related to the use of AR. Overall, studies showed that both multimedia e-books and AR could significantly improve the abilities and skills of both teachers and students. The efficacy of multimedia e-books was demonstrated in several studies, whose results showed a reduction in the time required for students to study ECG (Liu et al., 2020). Another study revealed that learning by using e-books had a more lasting effect on long-term memory, and suggested that e-books can be used to increase sexual harassment knowledge and prevention in nursing students (Chang et al., 2021).

Multimedia e-books contain digital information and, compared to traditional books, are much easier to store,

have access to, and disseminate their information (Casselden and Pears, 2020). E-books materials can be searched by keywords, and have navigation aid such as links to other materials and the ability to copy and paste the materials. These technological advances further improved the attitudes towards e-books, and led to their growth. From the library's perspective, e-books provide access to information systems (Ferguson, 2016), support distance and part-time learning modes, can meet the high demand for access to reading lists (Riha and LeMay, 2016), and save space compared to multiple printed copies (Frederick, 2016). One study on the use of e-books in ECG learning found that there was no difference in learning achievement between the group that received e-book materials and the control group (Liu et al., 2020). This may be because both groups had the same level of learning motivation at the beginning of the study. Furthermore, ECG-related education is efficient and helpful for clinical practice; therefore, regardless of the type of learning materials, students themselves need to try to learn as much as possible. The second reason is that learning materials alone do not guarantee the appropriateness of learning achievement; other learning strategies should be included. According to Liberatore (2017), interactive e-books combined with pre-class assignments can improve performance in exams. In Liu et al. (2020)'s study, no preliminary or pre-class assignments were given, and the percentage of students who previewed the ECG-related materials before the class was not monitored. Without the preview of materials, the learning effect of e-books would not be different between experimental and control groups.

The AR is a technology that combines virtual information with the real world. The technical tools it uses include multimedia, 3D modeling, real-time tracking and registration, intelligent interaction, sensing, and more. The principle is to apply computer-generated virtual information, such as text, images, 3D models, music, videos, etc., to the real world after simulation. In this way, the two types of information complement each other and enhance the real world (Chen et al., 2019). The AR can provide broad benefits to education in the health sector. Combining the real world and the digital world that applies the AR provides a valuable experience for students who need continuous skill training in clinical practice with real patients. The limited materials for learning due to the cost of procurement and maintenance is the reason to use AR in the students' learning process (Dutã et al., 2011). Mladenovic et al. (2019) conducted a study on the use of AR for teaching local anesthesia of anterior superior alveolar nerve in dental students. The result showed decreased performance time in students who used the AR simulator compared to controls. In another study, measuring the effect of AR in students performing

local anesthesia, results of Mladenovic et al. showed a reduction in their stress and anxiety levels after the anesthetic procedure compared to pre-procedure results. The authors concluded that, by using AR for teaching local anesthesia, access to anatomical structures in the oral cavity is easy and because of ther user interface, the use of this method provides excellent help in clinical anesthesia (Mladenovic et al., 2020). Another study used AR in studying the structure of human anatomy and physiology. The dynamic exploration of the features of the 3D AR model showed its positive learning effect and created a sense of additional depth in learning (Bogomolova et al., 2020). A study conducted by Moro et al. (2020) showed that AR could act as a useful additional teaching tool. By combining conventional and modern (AR) methods, the learners could feel an increase in their understanding and remembering of the anatomical and physiological structures of the human body.

Several studies indicated the advantages of using multimedia e-books and AR in helping students improve their knowledge. However, a study stated that students did not totally agree with replacing traditional learning methods with e-books as the sole method of learning. Instead, they preferred to use e-books as an adjunct to traditional teaching methods (Stirling & Birt, 2014). In a previous systematic review, students believed that e-books were useful in preparing for the exam and assuring them that they had read everything they needed to know (Folb et al., 2011). In another study, students who used e-books perceived higher learning gains (Price & Cartledge, 2019). A study reported that using e-books for previewing helped to improve understanding of the lecture during class, while with traditional paper handouts and books, it was more difficult to comprehend content, as the only function available was reading the text. In contrast, the students approved the e-book's challenge tests which helped them self-evaluate their levels of knowledge. They mentioned that the "challenge tests allowed me to immediately examine my level of knowledge". Further, the prompt feedback and forced jumpback function helped them to quickly locate the page that contained the relevant content, re-read the content, and find the right answer, and they gained a better understanding of the content' (Liu et al., 2020).

Regarding the variable of knowledge, the results of studies revealed that AR helps students recognize body parts very quickly because the user interface is attractive and can be thoroughly explored. Although the studies did not directly measure the effectiveness of AR on students' knowledge, it can be found from the increase in students' performance and satisfaction with performing procedures or lessons in body anatomy.

According to the studies, both e-books and AR could help students implement practical techniques. Students who received training by the AR simulator were faster at performing anesthetic procedures than those who received training by traditional methods (Mladenovic et al., 2020). The same finding was found in another study that used interactive e-books for learning a practical technique in students. In this study, although students who used the interactive e-books had learning achievement similar to those who received traditional learning materials, they learned more efficiently (Liu et al., 2020).

5. Conclussion

The use of multimedia e-books and AR has more significant effects on the learning process of students in health sciences compared to conventional teaching methods that use textbooks, whiteboards, or lectures. Considering the advantages of these technologies, their inetgration in education, along with traditional methods, can more improve the knowledge and skills of health sciences students. Further research is highly recommended to compare the effectiveness of traditional and digital lerning methods in laboratory practical skills.

Limitations

For conducting a systematic review, all relevant articles need to be collected. We cound not collect all relevant articles due to limited access to other databases that required to sign up to have acces to the full texts of articles. Moreover, we only selected articles published in English. Moroever, we were unable to carry out further analysis (meta-analysis) because the number of articles included in this study did not meet the requirements.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the Health Research Ethics Committee of Health Polytechnic of Jambi, Indonesia (ID: LB.02.06.2.176.2021).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

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