A PRISMA Review on Methods and Challenges in Learning Computer Maintenance Using Augmented Reality Technology

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Abstract

Augmented reality technology which is currently used in mobile phones is convenient for students and educational institutions because it provides flexibility and real-time learning environments. The use of AR applications in higher education learning has rapidly progressed. In view of this, this study investigates the design aspects of augmented reality in computer maintenance learning. In designing augmented reality-driven mobile applications, there are several gaps discovered in the interface components and relevant design principles. This study addresses the methods and challenges regarding the design of augmented reality mobile applications. A preliminary search and selection process using Preferred Reporting Items for Systematic Reviews and Meta Analysis (PRISMA) has been conducted and identified 782 articles with 57 full texts assessed for the reviewing eligibility. The results may help to develop the visual aspects of augmented reality systems in prototypes more effectively for computer maintenance courses in future.

Keywords: *Augmented Reality, Heuristics Evaluation, Design Principles, Computer Maintenance*

1. Introduction

Integrating augmented reality (AR) into learning activities has a major impact and thus, it is widely used in learning science at primary, secondary and tertiary levels [1]. Using AR for educational purposes is not a new concept and it has extremely wide applications across a whole range of disciplines [2, 3, 4]. Previous research works have described that the use of AR in theories and firsthand laboratory courses has positive impact among end users [5, 6]. These studies have also mentioned that the information can be explained in three-dimension (3D) which helps students to understand a lesson better. Another study has stated that students

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can analyze the 3D object from different perspectives using AR and this can enhance their visual thinking [7]. In addition, unlike learning via conventional textbooks, learning via 3D models in an AR textbook can provide more detailed auditory explanations and interactions that students can choose which make lessons more interactive and meaningful to them. Hence, AR can increase students' motivation [8]. Overall, it can be said that AR can optimize students' mental efforts and cognitive loads while learning.

Generally, computer maintenance is the maintenance of computer systems and their hardware. Learning computer maintenance needs extensive theoretical knowledge and sensible experiences [9]. Computer maintenance students need this knowledge and experience to understand each part of the computer. This is important because they need to identify and understand the issues or problem that might occur so that they can tackle these efficiently [10]. Identifying and understanding any issues can be done more easily and effectively using AR visualization because students can have a 3D view of the components of the computers which are not accessible [11]. A previous study was conducted to overcome the difficulty in accessing the computer hardware using AR application in learning computer maintenance during the pandemic [12]. Other than this study, the findings of other studies have also stated that AR is effectual for students to acquire experiences virtually and realistically in accessing the computer components. Besides, it is also effective in enhancing the understanding of abstract concepts among students [9, 13].

The primary goal of this study is to determine the existing research approaches used to assess AR applications in view of computer maintenance. To achieve this, Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method was adopted [14] to further evaluate methods and challenges in AR driven mobile applications in computer maintenance.

The next section provides the use of the PRISMA method for searching the relevant studies related to Augmented Reality and Computer Maintenance in education context. Each stages of method are discussed according to the guidelines outlined by PRISMA. These activities include the information sources and search strategies, inclusion, and exclusion criteria. The following section presents findings, followed by the discussion of the reviewed articles' summaries which involve methods, challenges and findings of each articles.

2. Material & Method

This study was conducted using the guidelines and principles outlined by PRISMA.

2.1 Information Sources and Search Strategies

The keywords augmented reality, heuristics, educational design, and computer maintenance were used to perform the database search. The queries used for the database search are shown in Table 1. The scientific articles were searched on various keywords and databases like Google, ACM Library, Scopus and ScienceDirect.

Table 1. Queries Used for Database Search

Database	Search Queries
Google	"Augmented Reality" AND "Heuristics" AND "Computer Maintenance" AND "Educational Design" OR "Instructional Design"
Association for Computing Machinery (ACM) Digital Library	
Scopus	"Augmented Reality" AND "Heuristics" AND "Computer Maintenance" AND "Educational Design"
ScienceDirect	

Below are the stages involved in the process of database search:

a. First, the relevant keywords and databases were identified.
b. Second, post determining the keywords and databases, the search queries were run and the results as either BibTeX file or RIS file were downloaded.
c. Finally, the downloaded results were imported to Mendeley and screened according to the inclusion and exclusion criteria.

2.2 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria for this study are presented in Table 2. Four databases were observed for the syntheses. The inclusion condition was that the articles must be published between 2018 and 2023 and had educational context. In identifying the context, abstracts were read. In addition, since this study focused on the application of AR, the words augmented reality must be in the titles of the articles screened.

Table 2. Inclusion and Exclusion Criteria

Database	Inclusion Criteria	Exclusion Criteria
Google Scholar	• Articles between "2018" to "2023". • Articles which are in the educational context. • Articles are focused on education.	• Articles before "2018". • Articles which do not include in the educational context. • Articles focused on others except for education. • Articles not in English Language.
ACM Library		
Scopus		
ScienceDirect		

3. Findings

The findings focus on study selection and study design.

3.1 Study Selection

According to Figure 1, PRISMA Systematic Review guidelines are employed for the selection of the articles. A total of 782 articles (Google Scholar, n=56; ACM Library, n = 568; Scopus, n=109; Science Direct, n=49) were identified via the initial search process. Consequently, 28 articles were removed in Mendeley because they showed up as duplicate articles. The title and abstract of 754 articles were reviewed and 697 were removed as they did not focus either on education or AR or computer maintenance. Only 57 remaining articles were read thoroughly for eligibility. The articles were eliminated due to the context being about learning other subjects (n=20), focusing on young learners' use of AR (n=9), was not written in English (n=1), was not accessible (n = 2) and content was about the use of AR in software and computing (n=18). However, articles which did not focus on mobile applications for learning computer maintenance were also considered.

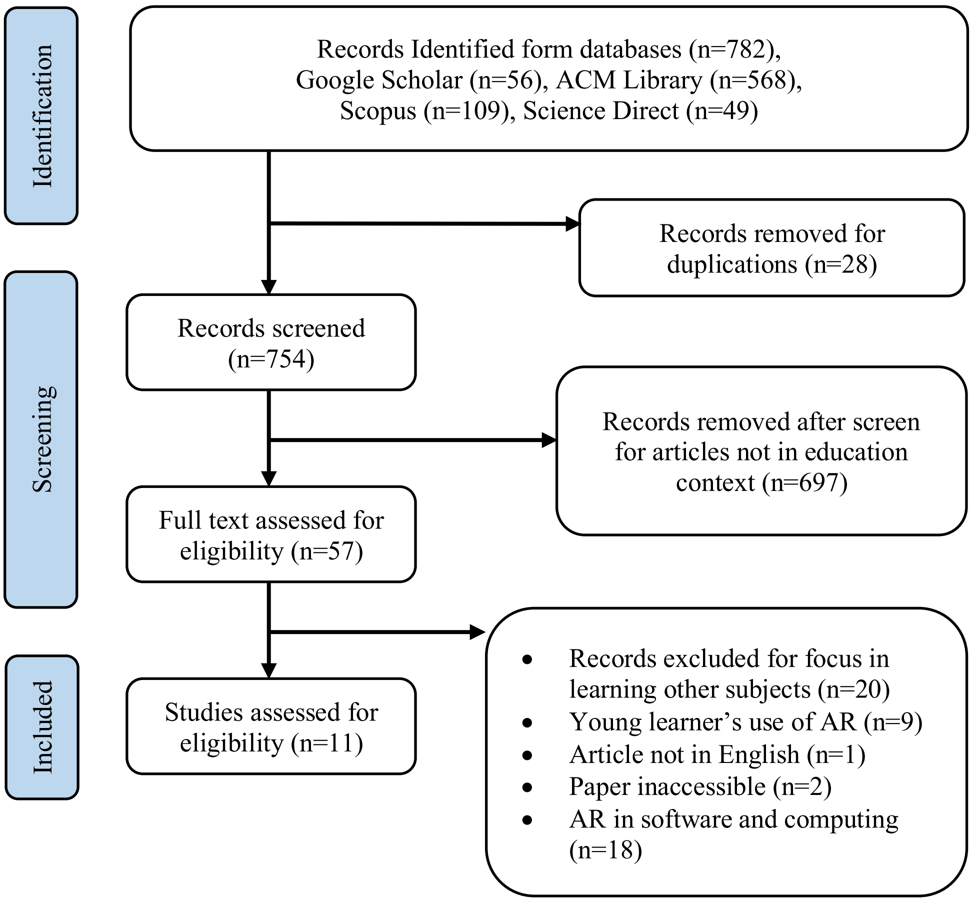

Figure 1. Research flow diagram of manuscripts using the PRISMA

4. Discussion

Augmented Reality has advantages compared to other modern technologies and thus makes it more applicable in various fields. Table 3 presents the summary of reviewed articles on AR in learning and teaching in relation to computer system maintenance.

Table 3. Summary Table of Reviewed Articles

Num	Title	Respondent	Methods	Challenges	Findings
1	Augmented reality in education and training: pedagogical approaches and illustrative case studies [15].	20 respondents: 10 control groups and 10 experimental groups.	Expert observation and questionnaire.	• Lack of technical standards. • Difficulty in generating meaningful content. • Excessive cost in creating 3D video.	The results organized the advantages utilizing AR: i. Learner outcome – academic achievement, motivation, understanding, attitude, and satisfaction. ii. Pedagogical contributions and interactions. iii. Others – suitable for abstract concepts, easy for students and reduce material cost.
2	The Augmented Reality Application for Teaching and Learning Basic PC Maintenance [10].	30 respondents.	Questionnaire - Related to perspective and experience using AR application.	• Need an internet. connection. • Data mobile quota. • Compatible with certain smartphones or table only.	Findings show that AR can be used as one of tool for teaching and learning and it can attract users to use.
3	Video-Annotated Augmented Reality Assembly Tutorials [11].	16 respondents.	End user testing: i. Task completion time. ii. Total errors. iii. Usability – SUS. iv. Mental effort. v. Task load vi. Overall preference.	Should add audio besides video during AR environment.	The findings show the 3D assembly instructions are better compared to the traditional video tutorials.
4	Students as Designers of Augmented Reality: Impact on Learning and Motivation in Computer Science [8].	62 students: First year students (N=25) and Experienced student (N=37)	Field study	Cannot be generalized because study under real classroom settings.	The findings showed that the students who don't have prior experience improved their performance. However, experienced students maintained high motivation and interest.
5	Development of Augmented Reality Application for Learning Computer Network Device [9].	31 respondents	Questionnaire - System Usability Scale (SUS)	Only one university involved.	The application was developed on Android environment to get the full benefits of learning experiences. The application was fully operational, and the results showed the application is acceptable to be used and support lecture activities.
6	Exploring the Potential of Augmented Reality Teaching Aid for Vocational Subject [16].	66 respondents	Questionnaire about perception of the teaching aid.	• Internet connection. • Android user only.	The results showed that the teaching aids are relevant to be used during the lecture as the content was attractive to maximize the student's capability to learn the subject.
7	Augmented Reality towards facilitating abstract concepts learning [13].	36 respondents.	Mixed-method approach	• Tracking loss • Light quality • Delays in the rendering of data • Over-heating of the equipment • Battery consumption	The application has a strong positive influence on learning the periodic table. The designer should consider the age of the design. Ensure to provide the right amount of information to avoid the cognitive workload.

8	VIRKOM as Augmented Reality Application for Visualization of Computer Maintenance Learning Material [12].	2 experts.	ADDIE Framework software development	Need to used markers.	Students can achieve more learning outcome using the application.
9	Augmented Reality in Vocational Training: A Systematic Review of research and applications [23].	Use of AR in Vocational Trainings.	N/A - Literature Review	N/A	The findings show how AR is used and has an impact in various fields including training, maintenance, and assembly. After identifying the benefits, the study explored the impact of AR in vocational training and education.
10	A comprehensive review of augmented reality-based instruction in manual assembly, training, and repair [24].	Use of AR on manual assembly and repair.	N/A - Literature Review	N/A	The findings involve the visual representation of instructions in AR prototypes and the concepts which can be applied for manual assembly, maintenance, and training.
11	Applying Instructional Design Principles on Augmented Reality Cards for Computer Science Education [22].	Instructional Design Principles related to AR.	N/A - Problem-based tasks	N/A	ARcards were created in the PCBuildAR Project and were evaluated in schools. 3C model performed as instructional approach.

There are many advantages in using AR applications in learning and teaching. A study involving 20 respondents via questionnaire and experts' observation was done. It was mentioned in this study that 21st century learning using AR technology was a constructivism learning in which users could construct new knowledge and reduce the cognitive workload [15]. Besides constructivism learning, designers should also consider users' age when designing an application and ensure to provide the right amount of information to avoid cognitive overload among users while interacting with the application [13]. In view of the pedagogy, AR encourages connectivism via real time learning interaction. Moreover, the author stated that AR was suitable for digesting abstract concepts, easy for students to use and reduce material cost which did not use the original component. [10] also found similar findings to [12, 15]. They found that AR could spark students' interest in learning. A study done by [11] showed that the instructions were segmented into stages while illustrating the 3D animations on screen. This allowed users to follow the instructions using 3D to assemble the parts in real time. Simultaneously, using 3D graphics which resembled the real-life components captivate students' interest during the learning process [16].

Measuring satisfaction is important in understanding users' perception. The satisfaction attribute is the most examined construct for predicting post-adoption use [3]. Some of satisfaction instruments that many users use is System Usability Scale or known as SUS [17]. Most researchers like to use SUS because it is suitable for a small number of participants [18, 19, 20]. Several studies involved only 16 respondents [11] and 31 respondents [9] and these studies employed SUS to measure satisfaction. Therefore, even though a small group of respondents were involved, both findings showed positive results that users were satisfied with the application and simultaneously, supported the learning and teaching activities.

Instructional design principles are also important when designing any application related to learning. Constructive alignment should be considered in any activity of learning and teaching. It provides students the opportunity to construct knowledge or skills specified in the desired outcomes [21]. AR application learning environment must be developed systematically, and instructional design principles can be applied to solve the challenges during the development of the application. [22] stated the 3C model which consisted of three components which were content, construction, and communication. The 3C model can be varied based on the learning objectives of the course. However, in another study conducted by [8], it was mentioned that student-centered instructional design allowed students to design the AR artifacts. This was a field study which involved 62 students. It was found that students who did not have prior experience could understand better. Moreover, for the experienced students they maintained high motivation and interest in learning.

Based on Table 3, two articles have been considered as concept articles through literature review. Findings show that AR is suitable for Vocational Education and Training (VET) as 26% [23]. Other studies related to instructional manual assembly, training and repair found that the visual representation of the concept has been suitable for manual assembly, maintenance, and training [24]. Thus, AR is suitable for understanding abstract concepts via firsthand activities.

Even though AR has many benefits, there are several challenges to be considered when designing applications using this technology. These challenges can be in terms of lack of technical standards, difficulty in generating meaningful content, and high cost in creating 3D modeling or video [15]. Suitable polygons are important in developing 3D models to represent realism. Meanwhile, object tracing and stability can precisely track and anchor virtual objects onto real-world surfaces or locations can be difficult to accomplish [25]. Internet connection can also be a challenge. Users must use their mobile data if there is no free internet connection or Wi-Fi. Other challenges can be certain smartphones or tablets only use Android operating system [10, 16]. This is because most developers may consider open-source coding which integrates third-party libraries and tools, wide range resources or community for developers and less restriction guideline from Google Play Store [26]. Tracking loss is also another challenge faced by previous researcher [13]. This happens when the quality of light affects the visibility and clarity of virtual objects. Furthermore, it can strain the eyes or cause discomfort, potentially leading to eye fatigue or headaches. In addition, the equipment will overheat because of the utmost battery consumption. Generally, even though there are many challenges using AR, this technology contributes to a more engaging, realistic, and comfortable users/user experience as well enhances the use of technology among people from various backgrounds or areas of studies.

3. Limitations

In this study, PRISMA methodology was employed and we attempted to identify as many eligible studies as possible. However, the accessibility to some articles was not authorized due to confidentiality and intellect property issues. Thus, these inaccessible articles were left out and other articles were prioritized by broadening the exclusion and inclusion criteria. Moreover, as computer maintenance and AR is an emerging field, the articles which were strictly related to AR and solely computer maintenance courses have been limited. Therefore, we have also included AR articles which did not emphasize learning computer maintenance. Besides, other limitation includes articles on other databases which had restricted downloading option to export as BibTeX file or RIS file.

4. Conclusion

To conclude, this article presents a systematic review of existing methods and challenges of the AR application used in learning computer maintenance. This paper also provides explanations on how these methods and challenges are addressed in developing such applications. Although only a certain number of literatures on AR are chosen for this study, the findings may further assist researchers, software developers and students to better understand the development and evaluation of AR applications in learning computer maintenance subjects or courses.

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