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Challenges Analysis for Using Augmented Reality in Education: A Review

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Abstract: ***This paper is a systematic review of literature on augmented reality (AR) used in education from 2014 to 2019. Emphasis was placed on AR technology used in pre-university levels. We discussed, the challenges facing the educational process using this technology. Four types of databases (IEEE, Web of Science, Science Direct and Scopus) were used for data collection, and the final search yielded 84 articles which were analysed in detail. Results indicate a relatively low increase in the number of studies using AR technology to enhance education. The features found in all the relevant articles in the literature confirm that AR enhances knowledge and education by improving and expanding the perception of knowledge space. The challenges in using AR technology are in terms of technical problems, material costs, knowledge and experience, among others. Other challenges and advantages of using AR were discussed in detail.***

Keywords: augmented reality; advantage; effect; educational

1. Introduction

Augmented reality or AR is an upgraded version that extends the actual environment through VR. The main difference between VR and AR is the reality. VR separates a user completely from the real world, whereas AR keeps the user in the real and virtual worlds at the same time through smooth interface, tools and applications such as head set, interactive glasses, tablets and 3D objects. AR consists of three main aspects: (1) integration of real and virtual objects, (2) interaction of these objects at the same time and (3) participation of real and virtual objects for the same task [1][2]. Although the literature mentions numerous definitions, many scholars agreed that AR technology simultaneously combines virtual reality with actual reality [1, 3-5][6].A few scholars defined AR as computer-generated images that provide a composite vision to be seen by a user in the real world [7, 8]. Others stated that AR are devices that allowed virtual objects to be visualised in a real environment [9]. AR is also defined as a direct or indirect presentation of a real environment, complemented by virtual elements created by a computer [10]. Since the advent of this technology, researchers have used it in most fields (medical, military, industry, tourism, entertainment, advertising, psychology, marketing, engineering and the arts). AR has also wielded an effective and strong influence in education. This technology has incited considerable interest among students, stimulating their active participation, high concentration and deep understanding of the subject taught [1]. Education researchers have recognised AR's remarkable potential and substantial impact on cognitive and emotional learning outcomes [5]. This technique helps students connect what they observe in the real world with their previous knowledge and handle goals and tasks [11][12]because of the following benefits. AR provides effective learning environments and new opportunities to enhance the learning process [9]. For experiments, AR combines the digital environment with the real sensory experience, allowing real and virtual coexistence that in turn leads to engaging user interaction [13-15]. AR provides not only knowledge but also guidance on how to process acquired information[16]. In addition, this technology is an easy and natural method of teaching because it creates large areas for exploration [3]. AR is a mature area of psycho-physical studies as well for those who suffer from a physical disability [6]. The advantages of introducing AR technology in educational reliability include increased student experience in real-world environments and raised awareness of the environmental context through interface with digital components [17]. Reality is enhanced with additional virtual information [18]. AR also increases the sensory perception of users [19]. Given the learning experience it provides, AR is a good interface for the next generation that enables different means of handling information by designing better educational environments [20]. Designing an educational environment with electronic and scientific training activities can be achieved [21]. The results showed particularly significant benefits of using AR in primary and secondary schools (pre-university education), where the technology is a highly accessible medium. Previous research demonstrates that AR can improve education [22], but this technology has major determinants that must be considered to be acceptable in the field of learning, such as providing low-cost devices and applications based on AR technology [19]. One of the ways to improve the learning process is by enhancing the quality of the educational system with AR, given its ease of use for applications and their benefits, including immersion and enjoyment for learners [23].

a) Challenges

This section describes the common challenges found in AR used in education studies across different domains. The challenges discussed in this section are elaborated because they come from different domains. They are only shared based on their general importance (Figure 1).

1) Challenges related to individuals

This challenge is meant to discuss some of the common issues associated with individuals in the literature. Three challenges are reported in individuals, namely, teachers, students, and developers.

b) Related To Teachers

The first is for teachers; many challenges have been associated or faced by teachers, such as the inability to teach in a sensory manner [3], followed by limited class time [24] [25, 26], limited knowledge of AR [25, 27], fear of failure in using technology [28], lack of equipment and high cost [3]and insufficient training for dealing with technology [13, 25]. Moreover, teachers may have misconceptions of using AR tools [8] and cannot improve student performance due to a lack of reliance on AR [12]. Teachers are insufficiently familiar with the AR technology [14]. Teachers cannot afford these ad-hoc developments [29]. Teachers are unaware of how to increase students' learning motivation with AR [14]. Studies that attempted to engage the teacher to assess educational gains using different measures are lacking; furthermore, most studies did not include the teacher as an instructional designer [30].

c) Related To Students

This section aims to review the challenges faced by students during and after the use of AR in education as collected through literature. Among the most important challenges facing students while using AR technology are students' difficulties related to their abilities, being the pioneers in AR-enabled subjects [8, 31, 32] difficulties in connecting and observing while also using AR technology [33]. Other issues include imaginative abilities [4], the inability of students to keep up with the lessons [8], and a lack of student sensory perception for AR-related experiments[8]. Additional issues are limited background knowledge [34], student difficulties in developing learning awareness [34], lacking spatial concepts [8, 35], lacking cognitive load and learning motivations [4, 36, 37]and the inability of participate and interact [38].

Challenges and issues that students may face during the experiment are a lack of equipment and tools [3, 13, 39][40], lack of appropriate instructional scaffolds in AR applications [41], cognitive overload when learning in an AR environment [17], no content for practice in the AR system [11], insufficient time for the experiment [11], lack of proper guidance [3]and unfamiliarity with the equipment and the environment [3] and learning content [11]. Students cannot participate and interact; furthermore, samples of students living in rural areas were not used to measure the effect of improved technology on education in rural areas. Given the great difference between students in urban areas and rural areas in terms of sufficient technological knowledge, students in urban areas are often more in contact with technology [38, 42]. Students have difficulty focusing on the learning objectives [40], a lack of opportunity for practical observation [34]and a lack of effective strategies to focus on what needs to be observed in the field. [12]. Furthermore, students are unable to apply what they have learned in class in the form of observation [36]due to weather [8]. Students remain passive viewers, following at the instructor's pace, as is also the case in the traditional lecture-based format [38]. Spatial ability, technology self-efficacy, mathematical prediction and problem-solving are lacking [43], as are provisions of effective strategies to help students focus [12]. Student injury is also possible during experiments [28].

1) Challenges Related To Equipment and Tools

In this section, we explain the most important challenges related to the equipment and tools that are used in AR technology in terms of factors such as cost of equipment, difficulty in use, and inappropriate operation. The main challenge for users of the AR technology is expensive equipment [3, 9, 15, 44-46], expensive educational systems [39] financial restraints AR technology [47]. Insufficient equipment [3, 13]. All of the above challenges led to limited access to labs [39]. In addition, technical challenges arise in the equipment, such as complex instruments [46]; difficulties arise in preparing devices [9]and specialised instruments are needed [46]. Other challenges are lack of relevant teaching facilities and creative design equipment [27], like tools [40]. Using equipment is also difficult. [48]. Insufficient learning outcomes of tools [49] and a lack of effective learning strategy tools [40] are other challenges.

2) Challenges related to teaching using AR

This section reviews the challenges of teaching with the use of AR technology in terms of factors such as technical, scientific, and educational efficiency. These challenges include lack of teaching experience [3], lack of experience in using AR in education [50], lack of teaching assistance [17], lack of teaching facilities [27] and lack of various appropriate instructional AR applications [31, 41]. Further challenges are lack of effective teaching materials [8], unknown learning effectiveness[38], the inability to provide interactive learning in outdoor learning environments[9], the inability to provide observational learning and its mechanisms [51]and difficulties connecting to actual instances of the observed phenomenon. [33]. Time is an important challenges, that is, time is insufficient for teaching [25]. Studies are lacking that compare the effectiveness of AR technology and other technologies on student learning [36]. In terms of teaching languages, AR contributes less for students who need verbal assistance by removing the necessity for spoken language [52].

3) Challenges Related To AR System and Development

This section reviews the challenges of the system used in AR technology, such as limited capability [53], financial restrictions [39]and system instability [3]. Other challenges are the need to develop applications to help motivate students, especially in STEM applications [54], inadequate system design [17], lack of practical system content [11] and excessive work needed to create content[15, 55]. Incorporating AR in courses is difficult [27], and the cost of development of AR-related content is not always affordable for educational institutions [29]. Creating AR system experiments is challenging [10]as is lack of virtual ongoing professional development [2]. The development of an educational AR system is time consuming [36].

4) Challenges Related To Usages of AR

This section illustrates the challenges related to the use of AR technology collected from the literature. For example, no proper guidelines exist for applying AR for education [20] [3], unfamiliarity with the environment [3], long-term involvement [8], occasional instability[3, 25]and cognitive overload [17]. Furthermore, users are sometimes not accustomed to using AR [9]. In terms of training, challenges include no content available for practice [11], a lack of

opportunities for practical observation [34], limited knowledge to use AR [11, 34], few experiences of using AR in education [28, 50], limited and unnatural experience [3]and lack of AR use in education [66]. Some of the challenges are in technological knowledge such as difficulties in use, [34, 56] and a lack of using AR and game-based learning in educational settings[57]. Furthermore, computer skills are required [45], and academic staff must be involved actively when designing virtual learning scenarios to obtain maximum learning benefits [15]. Simulations for real scientific data are lacking [2]. Developmental difficulties arise [26]. Sufficient information about the educational usefulness of AR is lacking [22].

5) Challenges related to environment

In this section, the challenges are related to AR environments found in the literature are provided. These challenges include the difficulties of learning in an outdoor environment is challenging [8, 58] and learning overload [17]. Real environments are different from virtual environments [27]. The objects in the real and virtual worlds must be properly aligned with respect to each other, or the illusion that the two worlds coexist will be compromised [6]. Situational contexts for the environment are lacking [2].

6) Challenges related to studies on AR

This section illustrates the challenges collected from the literature on the quality and quantity of studies conducted on AR. These challenges include the few studies that have been conducted in educational observation and academic collection [57, 59]. AR scaffold environments must be provided to support deep learning [60]. Furthermore, few studies have been conducted on AR cognitive learning [5]and on using AR in language [47]. Comparative studies between the effectiveness of AR technology and other technologies on student learning are lacking [36]. Comparative studies between AR teaching and traditional teaching method are lacking [22]. Literature on using AR technologies in science teaching is lacking [61]. Disadvantages of tools and content in analysis and discovery of data exist [62]. Studies are lacking in acceptance of AR as a learning tool and the perception of users in education [7]. Studies the in elementary or secondary school context are lacking [28]. Effects of AR technology in learning have not been comprehensively investigated [40]. Studies on AR in education are lacking [43,56, 63]. Few studies have explored how to use AR technology effectively for science education. [35]. No studies have been conducted on AR technology that involve taste and smell [64].

2. Conclusion

Researchers have attempted to use this technology in several areas, including education. However, the number of studies using AR in education has been relatively low. This technology is supposed to be used in the future because it is useful in education, as previous studies have shown, and it is likely to spread considerably in the near future. Many researchers have focused on AR in education with different ideas, different samples and different cultures. We conclude from this literature review that AR strongly supports the educational process. However, after comparing the research studies, we note that the effect of AR in education is not different from that of traditional methods. Another study suggests that AR causes a higher cognitive load. Another study suggests that AR reduces cognitive load. We believe that the information that has been raised in literature is absolutely correct and unquestionable, but the greatest challenge is in the way to choose the applications of AR for each purpose and method of use. Lack of experience, technical problems, application user interface, fear of failure by teachers, and the time (lecture time is limited or insufficient). Additional factors are other costs (prices of smartphones and tablets), the Internet and technical problems. We believe that if these challenges are addressed, AR will be an extremely appropriate tool in education.

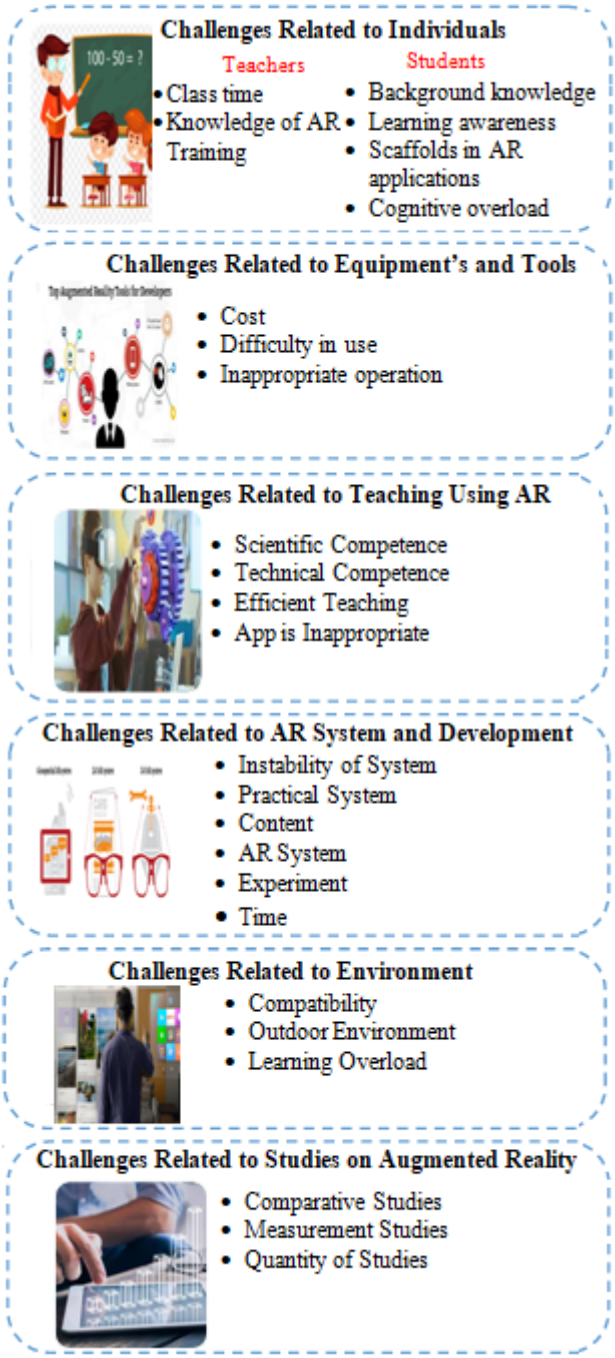

Figure 1: Challenges Overview

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