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The Potential of Augmented Reality in Education: A Scoping Review

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Abstract

The augmented reality experience is becoming increasingly popular, especially among today's digital-born generation who have technology permeating almost every aspect of their lives. Because of its capacity to augment computer-generated graphics into the natural environment on screen, several research has been conducted to determine the benefits and challenges of this advanced technology in educational settings. This study intended to provide the current state of augmented reality literature in education. Specifically, this study attempts to identify research gaps and suggest future research directions. A total of forty-nine articles that were published in scientific journals between 2017 and 2022 were obtained using Scopus and categorized as Q1 to Q4 journals were analyzed for this study. The findings provide the current trends in the application of augmented reality in education, the impact of this technology on learning processes, and opportunities and challenges for educators and students. Based on the data, augmented reality is maturing in some countries and has successfully taken root in education today.

Keywords: Augmented Reality, Education, Sustainable Tourism, Technology, Student

Introduction

The augmented reality systems augment the real world with virtual (computer-generated) objects that coexist in the same space as the real world. Augmented reality has three technical features, according to Azuma (1997): a combination of the natural and virtual worlds, real-time interaction, and accurate 3D registration of virtual and natural objects. Throughout the years, rapid technological advancement in smartphones and wearable devices has made augmented reality technology more accessible and affordable, causing people, particularly those in today's generation who are so keen on advanced technology, to become more enthusiastic about its use in their daily lives. Tom Caudell pioneered the phrase "augmented reality" in the 1990s, and this technology has seen remarkable progress since then (Garzon et al., 2019). Throughout the years, augmented reality has picked up steam, most likely due to advancements in mobile computing power and functionality, which allowed augmented reality systems to be integrated

into mobile devices, making this technology available to a larger number of users (Bower et al., 2014) and spreading to a wide range of fields of application, most notably medicine, entertainment, tourism, and education (Akcayir and Akcayir, 2017). Most people confuse augmented reality with virtual reality, but while virtual reality immerses the user in a completely virtual environment, augmented reality overlays virtual objects on the real-world environment (Garzon et al., 2019).

Since the earliest augmented reality application development more than twenty years ago, this technology has significantly impacted the education sector (Garzon, 2021). Subsequently, augmented reality applications have been effectively applied at many levels of education environments, and they bring several benefits to learners, educators, and institutions. However, there are still issues highlighted in previous studies that must be resolved before this technology can be used effectively, particularly to enhance education today. According to prior research studies, as an emerging technology, augmented reality faces various concerns, including accessibility (Akcayir et al., 2016), educator reluctance (Akcayir & Akcayir, 2017), and information overload (Turan et al., 2018).

Therefore, this study attempted to dig deeper into augmented reality in educational settings, highlighting the benefits and challenges highlighted in peer-reviewed publications and empirical research papers. For this purpose, answers to the following research questions were sought:

1) What are the benefits identified in augmented reality in education studies?
2) What are the challenges identified in augmented reality in education studies?

These research questions are due to this study's purpose, which is to highlight the potential of augmented reality as an effective teaching and learning tool in the educational setting. As integrating augmented reality into the field of education resulted in effective teaching and learning outcomes, some authors have also emphasized the challenges associated with its adoption and its potential to influence the development for education and moderate students' cognitive outcomes.

Scoping Review Process

As an alternative to qualitative methods, some leading journals and researchers have encouraged the use of scoping review as one of the most common quantitative methods in the social and behavioral sciences (Garzon & Acevedo, 2019). A scoping review was described by Tricco et al (2016) as a “review that used to identify knowledge gaps, set research agendas, and identify implications for future research directions."

This part outlines the method used to retrieve articles related to augmented reality in education from relevant studies. This study utilized the Preferred Reporting items Systematic reviews and Meta-Analysis (PRISMA) from only one database, which is SCOPUS. This method was used to run the scoping reviews, eligibility and exclusion criteria, and review process steps (identification, screening, and eligibility), followed by data abstraction and analysis.

Initial Literature Search

An initial search was conducted in the literature database of SCOPUS (https://www.scopus.com/search/form.uri?display=basic#basic, accessed, 2022) using the search term "augmented reality in education." This search resulted in 5707 studies. One document type parameter was modified to be adjusted to the purpose of the search.

Document type included only articles, proceeding papers, reviews, and book chapters and excluded meeting abstracts, editorial material, corrections, and book reviews. The search was also narrowed to the year of publication between 2018 – 2023 only. It resulted in only 2,961 studies, including 1,427 conference papers, 1,192 articles, 211 reviews, and 131 book chapters.

Manual Screening

At this stage, the first and second authors examined all the articles on the following three criteria: (1) An exclusive focus on educational contexts that covers school and universities – articles in another educational context like professional training or courses provided by companies were removed. (2) Within the scope of augmented reality in education – articles that describe virtual reality or any other type of technologies like 360 videos or those in non-educational fields were removed. (3) Only empirical research with primary data was included, with conceptual, literature review, and meta-analysis papers saved for future reading and reference. Because several works of literature were not available or permitted to be downloaded, only 121 research were downloaded, and their suitability for the present research was examined separately. A review of the suitability of the 121 articles was further screened based on the inclusion and exclusion criteria (Table 1) prepared concerning the previous augmented reality review studies (Akcayir & Akcayir, 2017; Garzon et al., 2019; Ibanez & Delgado-Kloos, 2018). As a result of these evaluations,49 articles were found and decided to be suitable for this study.

Each piece of literature was cross-reference-checked of their rankings on the SCImago site to identify the quartiles of the journal. Each subject category of journals is divided into four quartiles: Q1, Q2, Q3, and Q4. Q index defines the rank of a journal in a specific field for example, Q1 means it occupied the ranking among the top 25% of journals in the same field, Q2 is occupied by journals in the 25% to 50% group; journals occupy Q3 in the 50% to 75% group and Q4 is occupied by journals in the 75% to 100% group (SCImago, n.d).

The trends of augmented reality in the fields of education, as reviewed by Garzon (2021), as he gathered studies that were analyzed by different researchers from 2007 to 2018, discovered that augmented reality applications have been successfully implemented to teach most fields of education, with the most popular broad field being natural sciences, mathematics, statistics, and followed by the fields of arts and humanities and health. It will be intriguing to see if other disciplines of education have begun to suit integrating augmented reality applications into their pedagogy in recent years.

Table 1
Inclusion and exclusion criteria

Inclusion	**Exclusion**
Only articles, proceedings papers, reviews, and book chapters	Meeting abstracts, editorial material, corrections, and book reviews
Published between 2019 and 2023	Before 2019
Articles focusing on augmentedd reality	Articles that focus on environments such as virtual reality and mixed reality, 360 videos, and gamification, although the term augmented reality is used.
Only empirical research with primary data	Conceptual papers, literature reviews, and meta-analysis papers saved for future reading and reference

Data Analysis and Results

The researchers designed a data extraction form to collect the information to address the study objectives. Each paper was read by three researchers, who used the content analysis technique as recommended by Hsu et al (2013) to extract the data. The data form includes the following information: authors, year of publication, the article's title, theory, and variables used, sample size, type of research design, research setting, domain subject, findings, and limitations of the studies. Cohen's Kappa statistic was used to measure inter-coder reliability. This value was found to be 0.85, which corresponds to 'excellent strength of agreement', as stated by Cohen (1968) with occasional disagreements were discussed and resolved by consensus.

Data were then analyzed using the content analysis method. Content analysis is a method that includes text organization, categorization, comparison, and development of theoretical results (Cohen et al., 2005) and the inductive approach, as suggested by Miles and Huberman (1994) was adopted in the data analysis. First, the coding scheme was created by coding the expression that was meaningful in themselves. Later sub-categories were formed by combining the codes, and inductive categories were formed by combining sub-categories.

Table 2

Scoping Review Matrix of Recent Development on Augmented Reality in Education

	AUTHORS/YEAR	***METHOD SAMPLING DATA ANALYSIS***	***RESEARCH SETTING/ COUNTRY***	***FINDINGS***
1	Laura Cercenelli, Alessia De Stefano, Anna Maria Billi, Alessandra Ruggeri, Emanuela Marcelli, Claudio Marchetti, Lucia Manzoli, Stefano Ratti, Giovanni Badiali /2022	Mixed Method 62 medical students SPSS	University of Bologna	Students rated AR to be an enjoyable experience, showing enthusiasm to test it, exciting, and more valuable and engaging compared to textbook study
2	Shalom Adonai Huaraz Morales, Alexi Delgado, Laberiano Andrade-Arenas, Enrique Lee Huamani/2022	Mixed Method 98 nursing students Frequencies	University of Sciences of Lima-Peru	The augmented reality prototype to improve education can interact with users, making it attractive and motivating for the students.
3	Li Xiao, Xu Bo, Teng Yue, Ren Yi-Tian, Hu Zhu-Min/2017	Mixed Method 28 participants Comparative Analysis	China	The classification of system function, the information receiving frequency, and the subjective evaluation of users after using a product concluded that the AR system is superior to the VR system generally.
4	Maria-Blanca Ibanez, Diego Villaran, Angela Di Seriol, Carlos Delgado-Kloos/2017	Mixed Method 122 students Regression Analysis	University of Carlos de Madrid, Spain	Perceived ease of use had a positive effect on perceived enjoyment but not on perceived usefulness. This led to a positive impact on attitude toward using AR technology.
5	Jeongah Kim And Jaekwoun Shim /2022	Mixed Method 88 students SPSS	Korea University, Seoul	The study indicates that AR-based education can sufficiently recognize the interest of non-engineering majors and provide enough immersion and audio-visual stimulation to perform meaningful learning activities.
6	Alberto Ruiz-Ariza, Rafael Antonio Casuso, Sara Suarez-Manzano, Emilio J. Martínez-Lopez / 2018	Quantitative 190 participants SPSS	Spain	Pokemon GO makes it an efficient tool to gamify the teaching-learning process and shows a higher level of selective attention, concentration, and sociability than those who did not play.
7	Cyncia Matsika, Munyaradzi Zhou/2021	Mix Method 220 students Cost-Benefit Analysis	Zimbabwe	The lack of adoption of AVR technology was due to the lack of coordinating policies and lack of enabling infrastructures.

8	Rubina Dutta, Archana Mantri, and Gurjinder Singh / 2022	Mixed Method 90 students SUS & HARUS Analysis	Punjab, India	The SUS and HARUS analysis suggest that MAR application using a keypad matrix has better perceived usability, manipulability, and comprehensibility.
9	Shiwei Shen, Kexin Xu, Marios Sotiriadis, Yuejiao Wang /2022	Quantitative 604 students PLS SEM	Tourism Department Chinese University	Findings indicated that perceived usefulness, hedonic motivation, and price value are important predicting factors for Chinese students' adoption and use of these applications.
10	Sergio Sandoval Pérez, Juan Miguel Gonzalez Lopez, Miguel Angel Villa Barba, Ramon O. Jimenez Betancourt, Jesús Ezequiel Molinar Solís , Juan Luis Rosas Ornelas, Gustavo Israel Riberth García and Fernando Rodriguez Haro/2022	Mixed Method 26 students ANOMA	Technological Institute of Ciudad Guzman, Mexico	The experimental results indicate a positive effect on the students compared to the traditional teaching approach; with better cognitive performance and better retention for the activities carried out, it is feasible to continue designing tools for the entire electronics course.
11	María Graciela Badilla-Quintana, Eileen Sepulveda-Valenzuela, and Margarita Salazar Arias/2020	Quantitative 60 students SPSS	Chile	The result showed significant immediate academic achievement and content retention. Immersive technologies enhance students' learning regardless of their special educational needs (SEN).
12	Murat Akçayır, Go€kçe Akçayır, Hüseyin Miraç Pektas, Mehmet Akif Ocak /2017	Mixed Method 76 students SPSS & Content Analysis	Faculty of Education, Kirikkale University of Turkey	The experimental results obtained following the 5-week application revealed that the AR technology significantly enhanced the university students' laboratory skills development. AR technology improved the students' laboratory skills and helped them build positive attitudes toward physics laboratories.
13	Zeynep Gecu-Parmaksiz and Omer Delialioglu/2019	Mixed Method 72 preschool students SPSS	Public school Istanbul, Turkey	Virtual manipulatives affect preschool children's improvement in understanding geometric shapes, which prove to be an effective tool in supporting the learning process
14	Darren Yi Sean Low, Phaik Long Poh, Siah Ying Tang/2022	Mixed Method 50 students SPSS	Monash University Malaysia	AR technology in education is a more well-rounded learning experience enhances student motivation, improves learning outcomes, and promotes lifelong learning.
15	Gloria Yi-Ming Kao, Cheng-An Ruan/2022	Mixed Method 98 students ANCOVA	elementary school Taiwan	AR-based learning system enhanced students' programming learning achievement more than the control group. Students' feedback showed that AR based programming learning system was valuable and easy to use, gave high motivation and more self-exploration
16	Ting-Chia Hsu/2017	Mixed Method 38 students ANOVA	Elementary school, North Taiwan	The students' learning approaches and styles played a vital role in the flow experience, mental effort, and foreign language learning anxiety. Freedom is one of the features highlighted in the AR learning system.
17	Kun-Hung Cheng/2017	Mixed Method 153 students ANOVA	Taiwan university	Findings show that students did not need much cognitive capacity to process the information in AR books, have a positive attitude towards reading AR book activities and attract their attention with solid motivation.
18	Su-Ju Lu, Yu-Chiao Lin, Kim Hua Tan and Ying-Chieh Liu / 2022	Mixed Method 85 students SPSS	Taiwan	The result showed that the developed AR suite supported its educational goals and motivation in generating interest and providing an immersive experience for the students. The toolset is easy to operate and maintain and shows positive results in learning motivation and achievement.

19	Tasneem Khan, Kevin Johnston, and Jacques Ophoff/2019	Mixed Method 78 students SPSS & Excel	University of Cape Town, South Africa	This research is consistent with previous studies which positively impacted student learning motivation. Students were moderately motivated when using the anatomy notes and slightly more motivated when using the Anatomy 4D mobile application.
20	Hakan Cevahir, Muzaffer Ozdemir, Meltem Huri Baturay / 2022	Mixed Method 94 students SPSS	Dept of Information Technologies Anatolian High School in Turkey	Augmented Reality Animation Work Examples (ARAWE) effectively transfer information to long-term memory, facilitating students' intensive cognitive process and complex problem-solving decreasing anxiety, and improving their attention for learning and achievement.
21	Shao-Chen Chang, Gwo-Jen Hwang/2018	Mix Method 111 students ANCOVA	Taiwan	AR-based flipped learning system has significantly improved students 'learning achievements, motivation, critical thinking, and group self-efficacy.
22	Ángela Di Serio, María Blanca Ibáñez, Carlos Delgado Kloos / 2018	Mix Method 69 students SPSS & Thematic Analysis	Madrid, Spain	The use of AR in learning environments positively affected motivation with clear improvement in attention and satisfaction, further supported by a qualitative study.
23	Mustafa Serkan Abdusselam/ 2017	Qualitative Three teachers Eight students Thematic Analysis	Turkey	For teachers, the technology is insufficient for efficient teaching and learning - students think an AR learning environment has more advantages than standard classes, which affects their thoughts, and affects their academic success positively.
24	Josef Buchner, Martin Hofmann/2022	Mix Method 45 teachers SPSS	Germany	The results show that our developed Tell– Show–Enact–Do (TSED) learning design, fully based on the SQD strategies, is better able to foster teachers' AR/VR-related WST than the Tell–Show–Enact (TSE) learning design.
25	Devon Allcoat, Tim Hatchard, Freeha Azmat, Kim Stansfield, Derrick Watson and Adrian Von Muhlenen/2021	Quantitative 75 participants ANOVA	University of Warwick, England	There is an emotional benefit of learning in AR and VR, which performed significantly better than traditional learning in the measure of engagement.
26	Mohamad M. Saab, Josephine Hegarty, David Murphy, Margaret Landers/2021	Qualitative 26 students Thematic Analysis	Public University in Ireland	Virtual reality technology has the potential to facilitate learning, complement current educational approaches, and provide nurse educators with novel and engaging means of content delivery.
27	Karen Hofmann, Gabby Walters, and Karen Hughes/2021	Quantitative 114 students ANOVA/MANTOVA	University of Queensland Australia / Lady Eliot Island Great Barrier Reef	The persuasive power of VR in environmental messaging to prompt changes in environmental attitudes and behavior. Respondents also felt a sense of connectedness to nature as they went for a virtual snorkel experience.
28	Lis P Tussyadiah, Dan Wang, Timothy Jung, Claudiea tom Dieck/2018	Quantitative 926 participants CB-SEM	Hong Kong / UK	This study hypothesized that the sense of presence during a VR experience with a tourist destination would lead to positive consequences, which include positive VR experience from the enjoyment of VR participation.
29	Gavin Baxter and Thomas Hainey/2019	Mix Method 100 students Mann-Whitney & Kruskal-Wallis Test	University of West Scotland	The predominant findings of the research indicated that most of the students considered the use of VR to have functional pedagogical implications, enhance their learning experience, enhance student self-efficacy.
30	Qiong Liu, Zhongming Cheng, and Min Chen/2019	Quantitative 360 volunteers Regression Analysis	Yangtze University, Hubei, China	The research results show significant correlations between environmental education, environmental ethics, and environmental literacy with the application of VR to environmental education.
31	Dorothee Taut, David Alexis Sprenger, Adrian Schwaninger/ 2021	Mixed Method 95 students ANOVA & PLS SEM	Switzerland	The results show that students enjoyed using the tools because they enriched the lecture. However, students perceived differences regarding the

				impacts on active learning, repetition, and feedback.
32	HengLuoa,TingtingYang,SejungKwon, GegeLi,MingzhangZuo,aIkseonChoi/ 2021	Mixed Method 150 students SPSS	Central China	The result reported moderate effect sizes of debriefing on increasing knowledge tests and performance scores of the VR learners but revealed no significant difference between direct and observed VR learning experiences.
33	Cyncia Matsika, Munyaradzi Zhou/2021	Mix Method 220 students Cost–Benefit Analysis	Africa	The research study found that the main reasons for the lack of adoption of AVR technology were the lack of coordinating policies; lack of enabling infrastructures; perceived complexity of the use of AVR technology.
34	Arun R Srinivasa, Rajesh Jha, Tamil Ozkan, and Zhujiang Wang/2021	Mix Method 118 students Statistical Analysis	Texas USA	The results demonstrate that student self-efficacy, knowledge retention, and engagement improved, and learning gain for female students was generally better than that of male students.
35	Meysam Siyah Mansoory, Mohammad Rasool Khazaei , Seyyed Mohsen Azizi and Elham Niromand/2021	Mixed Method 50 students SPSS	Iran	The results indicated that both modules of the challenging game affected students' learning levels. VRBSG (Virtual Reality-based Serious Games) was more effective and enhanced the quality of medical education.
36	Enda McGovern. Gerardo Moreiraa and Cuauhtemoc Luna-Nevarezb/2021	Mixed Method 71 students T-test	North-eastern University Texas	The results prove that VR can enhance students' ability to acquire broader skills in nurturing their overall educational experience.
37	David M. Markowitz, Rob Laha, Brian P. Perone, Roy D. Pea, and Jeremy N. Bailenson /2018	Quantitative 270 students SPSS & ANOVA	Stanford University, USA	The findings showed a high opportunity to use immersive VR for environmental education and drive information-seeking about critical social issues, especially climate change.
38	Omobolanle R. Ogunseiju, Nihar Gonsalves, Abiola A. Akanmu, Diana Bairaktarova, Doug A. Bowman, Farrokh Jazizadeh/2022	Mixed Method 8 participants Thematic Analysis & SPSS	USA	This study revealed that knowledge scaffolding could improve task performance in a mixed-reality learning environment and address the technological gap between the construction industry and construction engineering education. MR should be embraced as a pedagogical tool in construction education.
39	Nasser Alalwana, Lim Chengb, Hosam Al-Samarraiec, Reem Yousefd, Ahmed Ibrahim Alzahrania, Samer Muthana Sarsame/2020	Qualitative 29 teachers Thematic Content Analysis	Malaysia	A few challenges addressed by teachers affect their willingness to use AR properly. Internet availability and speed are the primary concerns. Limited learning materials and parental support are among the challenges mentioned by students.
40	Marijke van der Linde-van den BorSarah A. Frans-RensenFiona SlondOmayra C.D. LiesdekLinda M. de HeerWillem J.L. SuykerTiny JaarsmaSaskia W.M. Weldam/2022	Qualitative 19 patients Thematic Content Analysis	The Netherlands	Patient perceptions regarding virtual reality and information needs related to hospitalization and surgery improve understanding and reduce concerns and anxieties. However, it should not be a substitute for personal contact with the physician
42	Danica Mast, Michel Bosman, Sylvia Schipper, Sanne de Vries/2017	Mix Method Work on progress	The Netherlands	work on progress
43	Carlos Orus, Sergio Ibanez-Sachez, Carlos Flavian/2021	Mix Method 206 students MANTOVA	Spain	Results show that content with real (360-degree videos) positively influences perceptions of presence, ease of imagination, visual appeal, and booking intentions.
44	Yuan-Jen Chang, Chin-Hsing Chen, Wen-Tzeng Huang Wei-Shiun Huang/2018	Mix Method 111 students Regression Analysis	Taiwan	The results showed that system quality was critical to perceived satisfaction, usefulness, and AR-learning effectiveness. Perceived self-efficacy also affected perceived satisfaction and perceived usefulness.

45	Tegegne Tesfaye Haile, Mincheol Kang/2020	Mix Method 179 participants SEM & AMOS	University of Suwon, South Korea	MAR application's real-time interactivity and entertainment increase cognition and affection, respectively, while irritation with MAR application decreases affection.
46	Hao-Chiang Koong Lin, Yu-Hsuan Lin, Tao-Hua Wang, Lun-Ke Su, and Yueh-Min Huang /2020	Mix Method 52 students ANCOVA	Taiwan	Learning effectiveness, emotion, and flow experience improved and were significantly affected by the integration of AR into the health education board game.
47.	Francesco Strada , Maria Ximena Lopez , Carlo Fabricatore, Alysson Diniz dos Santos , Dimitar Gyaurov, Edoardo Battegazzorre, Andrea Bottino/2023	Mix Mehod 99 participants Wilcoxon Signed Rank Test	Italy	The sustain was effective in changing players' awareness and commitment towards sustainability issues.
48.	Su Cai , Changhao Liu, Tao Wang, Enrui Liu and Jyh-Chong Liang/2021	Mix Method 98 high school Students ANCOVA	Taiwan	AR technology in physics classrooms can significantly enhance students' physic learning self-efficacy, guide students to be more inclined to higher-level conception in learning physic and stimulates students' motivation to learn more.
49.	Shih-Yeh Chen/2022	Mix Method 26 Taiwanese students 26 Japanese students PLS - SEM	Taiwan	Students who had a better self-efficacy in science learning were more likely to engage in conservation actions. Moreover, when students read the contents of AR digital picture books and learn about local cultures and environmental issues, the emotional satisfaction they receive may enhance positive attitudes toward local environment and support related conservation policies and activities in their daily lives.

Data Findings and Discussion

Table 2 provides the example of literature review matrix that was developed from this study. It was found that the mixed method approach (e.g., Haile & Kang, 2020; Orus et al., 2021; Lu et al., 2022) was employed in most studies (75.5%), followed by the quantitative method (16.3%) and the qualitative method (8.7%). In contrast, the study by Ibanez and Delgado-Kloos (2018) discovered that most studies (46.4%) applied quantitative methods, followed by mixed methods (35.7%) and qualitative (17.9%) for augmented reality in education, respectively. Given the vast increase in augmented reality research over the years, it is understandable that mixed method studies were performed to determine the effectiveness of augmented reality in education. Another reason for the prevalence of mixed method studies could be the capabilities known to be provided by the application of the mixed method to move beyond the vague conceptualizations of 'usefulness' and 'ease of use and to increase the understanding of user acceptance of technology in context.

It was discovered that 67.3% (33 studies) of the studies were conducted in university settings, 16.3% (8 studies) in primary/elementary school settings, 14.3% (7 studies) in high school settings, and 1 study (2%) at a school with Special Educational Needs (SEN). Badilla-Quintana et al. (2020) studied the educational benefits of integrating augmented reality into the curriculum and found significant results in immediate academic achievement and content retention. Most of the research were mostly done in western countries, including Europe (14 countries, primarily in Spain and the Netherlands), the United States of America (9 studies), and South America (4 studies, for example, in Peru and Chile). In Asia, 16 studies were conducted, with the majority (9 studies) taking place in Taiwan, followed by China and South Korea. Only two studies were conducted in Malaysia, with the remainder in Iran, South Africa, and Turkey. According to Ibanez and Delgado-Kloos (2018), studies on augmented reality have

indicated a broader adoption in Asian countries compared to before, which only a few Asian countries were included. However, this was to be expected given Asia's recent reputation as a technological force to be reckoned with. According to Woetzel and Seong (2021), the region has accounted for 52% of global growth in technology-based company revenue over the last decade, with 87% of patents related to advanced technology registered. For example, more than 90% of the world's smartphones are manufactured in Asia (Woetzel & Seong, 2021), indicating that the region's consumer markets are rapidly expanding and digitizing, providing ample space for growth and growth innovation in advanced technology.

The two studies in Malaysia were focused on learning motivation among Chemical Engineering students at one of the top private universities (Low et al., 2022), while the study by Alalwan et al (2020) was conducted among primary school teachers on the challenges and benefits of using augmented reality in science subjects. This demonstrated that there is significant room for research opportunities among Malaysian students with the integration of augmented reality into the curriculum as it was also manifested in the Malaysia Higher Education 4.0 paradigm to integrate teaching and learning with the use of digital technologies such as augmented reality, artificial intelligence, and virtual reality. Furthermore, despite Malaysia's Ministry of Higher Education's drive toward Education 4.0, Uygur et al. (2020) found that the technology-based literature on education to meet the learning styles of today's tech-savvy generation is still quite limited.

Benefits

All studies concluded that integrating augmented reality into teaching and learning benefited both students and educators. Improvement (47%), which includes improving students' focus, attention retention, academic accomplishment, and engagement throughout the learning session, is one of the most frequently used words (e.g., Cevahir et al., 2022; Perez et al., 2022). This was followed by the word interest, which hit the second highest (21%) where students and educators find augmented reality interesting and they are eager to use augmented reality as a tool in assessing their performance and self-exploration (e.g., Cercenelli et al., 2022; Lin et al., 2020). An increase in motivation (17%) where students and educators alike highlighted the learning situation with advanced technology has given them a different experience and feel motivated to learn more (e.g., Kao & Ruan., 2022; Low et al., 2022). Approximately 11% of the studies stated that the integration of augmented reality had also benefited their students' academic progress (Badilla-Quintana et al., 2020; Gecu-Parmaksiz & Delialioglu, 2019). The remaining benefits mentioned in the studies include helping with learning anxiety and the development of positive attitudes (Morales et al., 2022), learning freedom and ability to interact socially (Dutta et al., 2022), and immersive enough to compete with other technologies (Kim & Shim, 2022).

Challenges

Despite this, several studies addressing the challenges experienced by students and educators in using or integrating augmented reality into their teaching and learning had emphasized the crucial factors that educators, institutions, and the government should consider. As highlighted by Baxter and Hainey (2020), augmented reality would be a great choice for any learning institution to adapt, particularly those located in districts with limited facilities and budget, because it will still provide similar features and benefits as other advanced technologies such as virtual reality and 360 videos that are available on the market. It was discovered from the reviews that studies with educators (teachers and lecturers) as

respondents would highlight more challenges in integrating augmented reality in their teaching than students' responses and feedback, which will mainly highlight the benefits they gain in learning with the aid of augmented reality.

Among the challenges mentioned are that augmented reality will not be able to replace traditional methods of teaching because it provides less engagement between students and educators, it is insufficient to deliver the intended information to students, there is a lack of enabling infrastructure, that there is a lack of a framework to guide the adoption of augmented reality in class, that there are limited augmented learning materials available, and that there is a regular feeling of irritation owing to unfamiliarity with the features of augmented reality, which leads to a loss in motivation to integrate this technology into their teaching and learning (Allcoat et al., 2021; Alalwana et al., 2020, Haile & Kang, 2020; Matsika & Zhon, 2021).

Conclusion

A notable feature of augmented reality is its support for students learning and increases motivation and interest compared to traditional classroom settings. The challenges that are highlighted generally related to technical problems. It is believed that in the coming years, advances in mobile technologies and facilities in most places may help to overcome these challenges. The resistance among the educators could be another good indicator to conduct future research on how to support these educators and provide professional development on using augmented reality in their teaching. Concerning the gaps highlighted from all the studies in the review, it found a lack of studies done in Asian countries, particularly Malaysia. This strongly indicates that more research into augmented reality in education should be conducted in Malaysia. It also follows Malaysia's Ministry of Higher Education's drive toward Education 4.0, which encourages all learning institutions to adopt advanced technology such as augmented reality, virtual reality, and artificial intelligence into their teaching and learning. Moreover, the studies in universities are mostly tested on students and educators from science and technology majors, with minimal studies on science and society, particularly tourism and business study. It will be an eye-opening for all to investigate students with different study backgrounds on what drives their acceptance of augmented reality and its competitiveness in today’s education system.

The articles reviewed in this research are limited to journals indexed from SCOPUS and grouped among Q1-Q4 quantiles, which excludes several studies that can be found in other databases. Other databases such as ScienceDirect, Springer, and ProQuest can also be used to search for more research articles on broader aspects. More works of literature to be included in a study will provide more in-depth information relating to the research of augmented reality in education, providing better direction, identifying apparent research gaps, and making more suggestions for future research directions.

This study has identified the factors that affect the acceptance level of students and educators in adopting augmented reality technology in education while highlighting the benefits and challenges from previous studies. The results are similar to those of other authors (Garzon et al., 2019; Ibanez & Delgado-Kloos., 2018) who reviewed literatures related to augmented reality in education. This enabled this study to conclude that the measures applied for this study had appropriate levels of reliability concerning the method and analysis that comprised the entire examination. Subsequent work includes establishing a framework with further analysis of how much effort could be focused on driving the introduction and adoption of augmented reality technology initiatives in the higher education sector, as well as other

challenges to augmented reality mentioned in this study that should be taken into consideration for its adoption in the future.

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