



A Survey on Imparting Education Using Augmented Reality

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A Survey on Imparting Education using Augmented Reality

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Abstract –

In today's modern times, augmented reality is one of the most evolving fields of technology which has its expanse spread in myriad domains, one of the most significant being the education sector. Integrating augmented reality into the educational fields has many benefits as it propagates the idea of creative learning having capabilities to enhance the logical and social skills of students. The profundity of the abilities of augmented reality lies in the fact that it can be efficiently utilized to aid the learning speed of specially-abled students along with any normal individual. An analysis of a survey of teachers and parents showed that when using an AR application, the interest and self-efficacy of children in learning letters and numbers significantly increased. Moreover, obstacles to implementing augmented reality in online learning may include details and cognitive overload, a lack of prior experience with the technology, teacher opposition, complex and expensive technology, and technical problems with connectivity.

Keywords: augmented reality, vuforia, education, e-learning, unity

I. INTRODUCTION

Augmented reality (AR) is the real-time blending of digital information with the user's surroundings. Users of augmented reality (AR) encounter a real-world environment with perceptual information superimposed on top of it, as opposed to virtual reality (VR), which produces a completely artificial environment[30]. Using augmented reality, users can receive more information or have natural landscapes aesthetically altered in some way. The prime benefit of augmented reality is that it successfully combines digital and three-dimensional elements with people's perception of the real world. Augmented Reality has various applications, from entertainment to aiding in decision-making [17].

Writing a survey article on augmented reality (AR) has strong motivations since it serves as a crucial instrument for knowledge diffusion and consolidation, gathering and condensing the fast-growing body of AR research into a thorough resource. Such articles offer a comprehensive overview of the field's complex terrain while clarifying essential ideas, technology, and applications [1]. As a result, a large audience, including experienced practitioners and researchers as well as beginners, may better comprehend and access AR. Beyond providing historical context, these survey papers act as dynamic tools for tracking new trends and advancements in AR. By keeping readers informed of the most recent developments, readers are better able to make wise decisions and advance the field [3].

II. LITERATURE SURVEY

The field of augmented reality (AR) has emerged as one of the most promising ones in computer graphics during the past ten years. Numerous ground-breaking applications have been made possible throughout this time, elevating the importance of augmented reality in everyday life. The application of augmented reality technologies is widespread in both business and academics. The aerospace sector was the first to adopt augmented reality (AR) technology as a training aid. Augmented reality enables seamless interaction between virtual and real-world objects. This technique combines virtual or computer-generated elements with the physical world.

A. Augmented Reality Technologies in Education

The traditional classroom framework has undergone a significant transformation due to advancements in digital technologies, ushering in a new era of educational content. Educational institutions worldwide, grappling with the profound impact of the COVID-19 pandemic, are increasingly reliant on innovation and digital resources to navigate these challenges. Augmented Reality (AR) technology emerges as a valuable tool, offering both instructors and students access to specialized materials that transcend the limitations of time and space [2]. Recent data from UNESCO reveals that, as of December 1, 2020, a staggering 18.2% of enrolled learners across various education levels, from pre-primary to tertiary, faced barriers preventing them from physically attending school or university. Moreover, the exact number of COVID-19 infections at the time of writing remained uncertain, adding to the complexity of the situation. This review's objective was to investigate the literature on the use of augmented reality applications in educational settings. In order to determine the knowledge that currently exists on AR technology utilized in education, qualitative research has been conducted through a methodical literature study in this work. According to Pettigrew and Roberts (2006), a systematic literature review must "completely identify, evaluate, and synthesize all relevant studies on a given topic." It can also be described as "a synthesis of published materials that provide an examination of recent or current literature, which may include research findings." A quality assessment and in-depth searching may or may not be included [12].

B. Mobile Augmented Reality in Education

The transformative potential of technology in education extends to reshaping students' learning experiences, serving as a potent motivator and igniting the process of acquiring knowledge. This article delves into the realm of mobile augmented reality technology within the educational context. Mobile Augmented Reality (MAR) proves to be a particularly effective tool in delivering a positive, efficient, and captivating learning journey for students. The researcher conducted an exhaustive search for articles on Google Scholar and Scopus, spanning the years 2015 to 2020. This cutting-edge technology enables individuals to

engage their senses and immerse themselves in applications, effectively piquing learners' interests through natural interactions. Scholars have been dedicated to exploring avenues to integrate augmented environments into education, facilitating students' engagement with real-world scenarios.

The study encompasses various related topics, including historical systematic reviews, augmented reality in education, the development of Mobile Augmented Reality software kits, Augmented Reality technology itself, user interfaces in the Mobile Augmented Reality sphere, and the forthcoming trajectory of Augmented Reality's role in education. The surge of interest in mobile augmented reality in both academic and industrial circles underscores its capacity to harmonize real-world surroundings with virtual information, thus unlocking fresh educational possibilities. Research findings affirm that augmented reality harbours diverse potentials and merits that can enrich the field of education. One of the key advantages of MAR in education is its ability to promote active learning. Students can manipulate virtual objects, explore 3D models, and even conduct virtual experiments, all within the confines of their classroom or home. This hands-on approach fosters a deeper understanding of the subject matter and encourages critical thinking [13].

Moreover, MAR has proven to be a valuable tool for personalized learning. Educators can tailor content to individual students' needs, offering targeted support and resources based on their progress and preferences. This adaptability ensures that students receive a customized and engaging educational experience. MAR also has the potential to bridge geographical gaps in education. Through virtual field trips and collaborative projects, students from different parts of the world can come together to explore and learn. This global perspective enriches their learning journey and fosters cultural understanding [14].

C. Augmented Reality in Education: Advantages and Applications

Students' engagement in learning can be influenced and motivated by technology in the classroom, resulting in an efficient learning process. If the technology being utilized does not encourage critical thinking, meaning-making, or metacognition, there is a risk that it will turn learning into a passive activity. Since its inception, augmented reality has demonstrated that it may significantly improve learning by making it more engaging, efficient, and meaningful. This is so that users can interact with virtual and real-time applications and have experiences that are more like those in the real world. Additionally, because it enables students to be immersed in authentic experiences, the integration of AR with education has recently received study attention. Their view describes the application of AR in a number of fields of learning including Medicine, Chemistry, Mathematics, Physics, Geography, Biology, Astronomy, and History. Also, the advantages of AR compared to traditional technology (such as e-learning and courseware) and traditional teaching methods are discussed [18][25].

Reviewing the research's findings reveals that, overall, AR technologies have promise and benefits that can be applied in education. The paper also highlights AR's shortcomings, which could be investigated in other studies. Governments have carried out programs recently to enhance the caliber and efficiency of the teaching and learning process. In order to realize this ambition, a philosophy known as "Falsafah Pendidikan Kebangsaan" is being developed. Furthermore, Malaysia is developing and requires a community that is intelligent, forward-

thinking, creative, and capable of making contributions to science and technology.

D. Effectiveness of Augmented Reality on Students with Special Disability in Higher Education

Students are obliged to utilize their own devices in higher education settings to keep track of their attendance and participate in classes using online learning management systems and other teaching and learning resources including schedules and virtual learning environments. a genuine chance to utilize digital technology like augmented reality. Utilising AR technology has revealed a variety of benefits in a number of fields [24]. To precisely grasp how AR improves kids' learning, however, more investigation is required. Augmented reality (AR) has been used in higher education for a few years now to help students with special needs develop their physical, cognitive, personal, and social skills. Literature indicated a gap in studies concerning an intensive review of the AR factors in the educational field and context and considering this fact, the present study conducted a systematic literature review to unearth the current status of AR in higher education settings among individuals with disabilities. The present study also took categories of analysis of the current status and tendencies of AR, like its uses in the educational context, advantages, limitations, effectiveness, and the availability of adaptation and personalization in its applications, particularly those addressing students who have special needs. Analyzing various categories enables the highlight of emerging trends, challenges, and opportunities and extended research and vision towards future outcomes and goals [15].

E. Effectiveness of Augmented Reality Environments on Individuals with Special Education Needs

The design, development, and efficacy of augmented reality (AR) settings aimed at serving people with special education requirements are the determined goals of this study. This study is centred on the creation, development, and assessment of Augmented Reality (AR) environments with the aim of catering to individuals with special education needs. The primary objective behind the development of these AR teaching materials is to empower children with special education needs to acquire essential life skills autonomously, reducing their dependence on others for support. To conduct this research, a design-based research methodology was employed. The study group consisted of four educators and six students. Data collection was carried out through the utilization of Design Observation Forms, Student Attention Observation Forms, and Criterion-Referenced Assessment Tools.

The outcomes of the study underline the appropriateness and effectiveness of AR teaching materials in enhancing the overall development of children with special education needs by providing them with real-life experiences. Moreover, a noticeable increase in students' engagement and enthusiasm for the lessons was observed during the implementation of the AR materials. These students demonstrated heightened readiness for the lessons, exhibited a greater interest in the subjects, and displayed increased activity levels along with a higher likelihood of responding correctly to questions. Based on these encouraging results, it can be inferred that the adoption of the developed AR environment holds significant promise for promoting the growth and development of children with special education needs. This innovative approach not only fosters self-sufficiency but also positively impacts students' overall engagement and learning

outcomes, aligning with the evolving landscape of inclusive education practices [16].

III. METHODOLOGY

This review's objective is to identify the possible applications of augmented reality in many areas of education. AR enhances the user's perception of the physical world by adding digital content, allowing for an interactive and immersive experience that blends the virtual and real worlds[23]. The keyword used in the search of the literature was the phrase “Augmented Reality”. There were 463 hits from the keyword search, of which nine were selected after taking into account certain criteria. Firstly, only studies conducted in 2007 were selected. This is because the AR technologies began to emerge in 2007 [20]. Secondly, the studies must represent different fields in order to give examples of how AR has been used in a range of areas. Lastly, the studies must highlight the purpose and the features of the AR technology that had been used. The search of the literature was conducted using EdITLib which is the digital library for Education and Information Technology [3].

A thorough search was conducted to locate all literature on the advantages and benefits of adopting augmented reality in education, especially in e-learning environments. A quick scoping study and appraisal of major studies on AR in different fields were done to help direct this research. This allowed for the identification of common terms and the implementation of a more thorough search. Additionally, with the demand for AR in education and other industries growing over the past ten years, now is a crucial time to assess the advantages of the technology as well as the difficulties that those who have adopted and implemented it at various levels of education have faced.

There aren't many studies that have looked into AR usage in educational settings because it is a research area that has just lately gained attention and appeal. The articles under consideration were found and chosen based on journals, research methodologies, research questions, data analysis, conclusions, and limits as well as the benefits and drawbacks of AR [9]. To determine the educational AR studies trends, a thorough and comprehensive systematic review was undertaken, which required the analysis of papers from numerous databases, including ERIC, EBSCOhost, dissertation, ScienceDirect, Scopus, Elsevier, and ISI databases. 'Augmented reality' was the keyword most frequently used to search for research in the databases, giving users access to a larger selection of studies in a variety of subjects and levels.

The parameters and scope for the scholarly publications that were included in the final review were determined by the inclusion and exclusion criteria for this study. After the research topic and objectives were chosen and refined, these criteria were established [21]. The eligibility criteria were developed considering a few variables to assure the inclusion of just recent papers, strengthen the study's focus, and define a reasonable scope of analysis. First, the researcher only incorporated studies that addressed AR in formal academic settings (education), where results could be tracked. In order to restrict the analysis and narrow the review's scope, other related technologies, such as VR and MR, that address comparable benefits, limitations, and issues in academic contexts, were excluded [30].

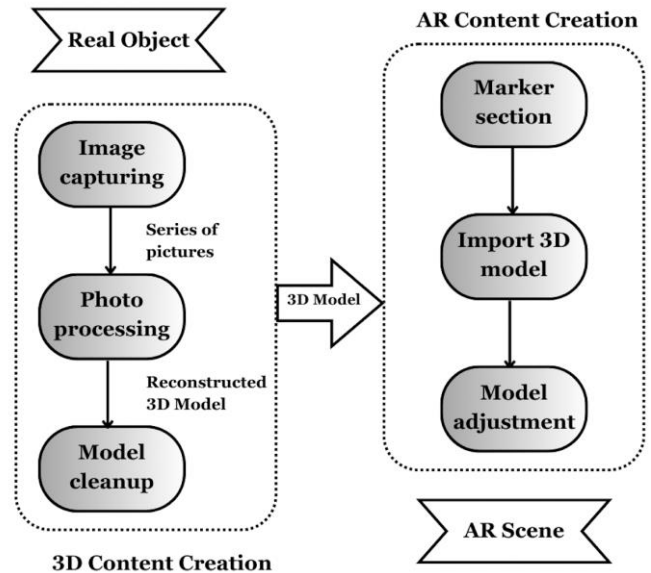


Fig. 1. Augmented Reality Content – Proposed Methodology

Fig. 1 indicates methodology involved in the development of an augmented reality model. The methodology briefly involves two sections – 3D content creation and AR content creation.

IV. APPLICATION OF AUGMENTED REALITY IN EDUCATION SECTOR

The field of education can benefit greatly from the use of augmented reality (AR), which transforms conventional teaching techniques and produces engaging, immersive learning environments. Such initiatives have the potential to raise educational quality, accessibility, and engagement [19].

AR makes static textbooks and educational resources into lively, interactive resources. Students can access a plethora of supplemental knowledge by scanning photographs or chapters in their textbooks using AR-capable devices. Students can utilize augmented reality to examine 3D models of cells, creatures, or chemical reactions in a biology textbook, for instance, to better understand difficult ideas [11]. Using virtual laboratories, augmented reality has a chance to transform science education. In a secure, regulated digital environment, students can run simulations and experiments. As it eliminates the need for pricey lab equipment and reduces safety issues, this is especially useful for schools with low budgets[26][27].

With unmatched immersion, AR can transfer pupils to cultural and historical settings. Students can study historic civilizations or events by superimposing historical artifacts or reconstructions onto actual surroundings. For instance, students can see the ruins of ancient Rome or watch important documents be signed [7]. By providing immediate translation and pronunciation assistance, AR helps language learners. The AR app can offer translations, pronunciations, and even instances of contextual usage when a student points their AR-enabled device at an object or text in a foreign language, improving understanding and fluency[8].

AR deepens education in astronomy and geography. Students can utilize augmented reality to examine constellations in the night sky or visualize geographical facts on a globe. Abstract concepts become more concrete and memorable through these

interactive interactions. In maths and science, AR can offer detailed instructions and help. Through interactive AR overlays, complicated mathematical formulae or scientific experiments may be deconstructed and explained, making these topics more approachable and less daunting[22] [10].

Students have the chance to travel to far-off places, other ecosystems, or different historical periods thanks to AR-powered virtual field trips. For instance, students can travel virtually to historical civilizations to study their cultures and accomplishments or the ocean floor to study marine life. AR can be tailored to meet the particular requirements of students with

disabilities. It creates a more welcoming learning environment and enables teachers to modify interactions and content to accommodate different learning preferences and skills [5].

AR can be applied to professional development and teacher training. To improve their teaching methods, classroom management abilities, and use of technology for instruction, it provides real-time feedback during classroom simulations. By allowing students to collaborate on projects or experiments in a common augmented reality space, AR promotes collaborative learning. No matter where you are physically, this promotes creativity, problem-solving abilities, and teamwork.

TABLE 1: A SUMMARY OF RESEARCH REVIEWED IN SECTION II (LITERATURE SURVEY)

Sr. No.	Title of the Paper	Work	Description	Limitations
01	Augmented Reality for Learning Mathematics	Ahmad, N.I.N., Junaini, S.N [2]	<ul style="list-style-type: none"> • Conducts a systematic analysis of research trends • Identifying 19 journal articles from the Scopus database 	<ul style="list-style-type: none"> • Potential lack of representativeness • Possibility of publication bias
02	Comparative study of augmented reality SDK'	Amin, D., Govilkar, S.: Comparative study of augmented reality Sdk's. Int. J. Comput. Sci. Appl. 5(1), 11–26 (2015) [3]	<ul style="list-style-type: none"> • Presents a comparative study of augmented reality software development kits • Explores the distinctions between AR and VR 	<ul style="list-style-type: none"> • Lacks specific methodology • Insufficient study of AR software development kits
03	The usability analysis of using augmented reality for linux students	Awang, K., Shamsuddin, S.N.W., Ismail, I., Rawi, N.A., Amin, M.M.: The usability analysis of using augmented reality for linux students. Indones. J. Electr. Eng. Comput. Sci. 13(1), 58–64 (2019) [4]	<ul style="list-style-type: none"> • Evaluates the usability and potential of Augmented Reality in mobile applications • Teaching LINUS students, basic mathematics 	<ul style="list-style-type: none"> • Small sample size (32 LINUS students from three schools) • Lack of detail about the specific usability test constructs
04	A Survey of Augmented Reality	Azuma, R.T.: A survey of augmented reality. Presence: Teleoperators Virtual Environ. 6(4), 355–385 (1997) [5]	<ul style="list-style-type: none"> • Offers a comprehensive survey of AR, highlighting its applications • Discusses system characteristics and addressing various challenges 	<ul style="list-style-type: none"> • Does not offer an in-depth analysis of recent trends • Insufficient data collection
05	Augmented Reality and programming education: A systematic review	Dass, N., Kim, J., Ford, S., Agarwal, S., Chau, D.H., Polo, E.: Augmenting coding, pp. 156–159 (2018) [6]	<ul style="list-style-type: none"> • Examines the use of Augmented Reality (AR) in Computer Science Education • Highlights its potential benefits for enhancing Computational Thinking 	<ul style="list-style-type: none"> • Lacks information on the specific search criteria • Inefficient methodology used for analysing studies
06	Sustainability of Educational Technologies: An Approach to Augmented Reality Research	Abad-Segura, E., Gonzalez-Zamar, M., Rosa, A., & Cevallos, M. Sustainability of educational technologies: An approach to augmented reality research. Sustainability, 12, 4091 (2020) [7]	<ul style="list-style-type: none"> • Explores the growing interest and evolving research landscape of AR • Highlights its relevance in addressing sustainability challenges 	<ul style="list-style-type: none"> • Lack of information about the specific bibliometric analysis • Does not provide insight into the quality of examined articles

07	The value of using ICT in the education of school students with learning difficulties	Adam, T., & Tatnall, A. The value of using ICT in the education of school students with learning difficulties. <i>Education and Information Technologies</i> , 22(6), 2711-2726 (2017) [8]	<ul style="list-style-type: none"> • Gives perspective of the 2015 OECD report on ICT's value in education • demonstrates that using ICT significantly enhances the learning experience 	<ul style="list-style-type: none"> • Does not provide specific details about the research methodology employed • Insufficient details about the techniques used
08	Advantages and challenges associated with augmented reality for education: A systematic review of the literature	Akçayir, M., & Akçayir, G. Advantages and challenges associated with augmented reality for education: A systematic review of the literature. <i>Educational Research Review</i> , 20(1), 1-11 (2017) [9]	<ul style="list-style-type: none"> • Conducts a systematic review of 68 research articles on AR in educational settings • Reveals an increasing trend in AR research with reported advantages 	<ul style="list-style-type: none"> • Does not detail the specific criteria for article selection • Affects comprehensiveness
09	Scoping studies: towards a methodological framework	Arksey, H., & O'Malley, L. Scoping studies: towards a methodological framework. <i>International Journal of Social Research Methodology</i> , 8(1), 19-32 (2005) [10]	<ul style="list-style-type: none"> • Introduces the concept of scoping studies • Distinguishes them from systematic reviews for emphasizing the benefits of including consultation exercises 	<ul style="list-style-type: none"> • Difficult to assess the rigor of the approach • Insufficient extent of consultation exercises
10	Instructional Strategies for Enhancing Learning Disabled Students' Reading Comprehension and Comprehension Test Performance	Awada, G. Instructional strategies for enhancing learning disabled students reading comprehension test performance. <i>Universitat Rovira Virgil</i> (2014) [11]	<ul style="list-style-type: none"> • An experimental study investigated the impact of combined strategy instruction • Improves reading comprehension in dyslexic learners across different age groups 	<ul style="list-style-type: none"> • Difficult to evaluate the research design • Potential lack of representativeness
11	A Review of Research on Augmented Reality in Education: Advantages and Applications	Nor Farhah Saidin, Noor Dayana Abd Halim & Noraffandy Yahaya, A Review of Research on Augmented Reality in Education: Advantages and Applications, 2015 [12]	<ul style="list-style-type: none"> • Explores how AR technology enhances meaningful learning experiences • Discusses its advantages over traditional technology and teaching methods 	<ul style="list-style-type: none"> • Does not provide specific details regarding the research • Challenging to assess the rigor of the review
12	Augmented reality applications for mathematical creativity: a systematic review	Flavia Aurelia Hidajat, Augmented reality applications for mathematical creativity: a systematic review [18]	<ul style="list-style-type: none"> • Provides a comprehensive analysis of the research trends in using AR for mathematical creativity • Highlights its positive impact on student learning and creative thinking 	<ul style="list-style-type: none"> • Insufficient methodological details • Potential lack of representativeness
13	An Overview of Twenty-Five Years of Augmented Reality in Education	Juan Garzon, An Overview of Twenty-Five Years of Augmented Reality in Education [19]	<ul style="list-style-type: none"> • Reviews the evolution of augmented reality (AR) technology in education • Categorizes it into three generations, addressing challenges, and proposing improvements 	<ul style="list-style-type: none"> • Lack of analysis of evolution of AR • Potential lack of representativeness
14	Research on the Effectiveness of Augmented Reality on Students with Special Disability in Higher Education	Malek Turki Jdaitawi Imam Abdulrahman, A Decade of Research on the Effectiveness of Augmented Reality on Students with Special Disability in Higher Education [15]	<ul style="list-style-type: none"> • Examines the usage and effectiveness of AR in higher education • Highlights its positive impact on enhancing social skills and engagement 	<ul style="list-style-type: none"> • Insufficient study of articles that affect comprehensiveness of review
15	The effectiveness of augmented reality environments on individuals with	Recep Cakir and Ozgen Korkmaz, Effectiveness of augmented reality environments on	<ul style="list-style-type: none"> • Focuses on designing and developing AR environments to aid individuals with special education needs 	<ul style="list-style-type: none"> • Study does not discuss potential limitations related to the design-based research design

	special education needs	individuals with special education needs, 2018 [16]	<ul style="list-style-type: none"> • Demonstrates the effectiveness of AR teaching materials 	<ul style="list-style-type: none"> • Limitations in the data collection tools
16	Exploiting Augmented Reality Technology in Special Education	Andrianthi Kapetanak, Akriki Krouska, Christos Troussas, Cleo Sgouropoulou: Exploiting Augmented Reality Technology in Special Education: A Systematic Review [20]	<ul style="list-style-type: none"> • Examines the utilization of augmented reality (AR) in special education • Highlights its potential advantages and limitations across 14 selected studies 	<ul style="list-style-type: none"> • Does not provide details about criteria used for analyzing the 14 studies used
17	Augmented Reality in Educational Inclusion	Jairo Quintero, Silvia Baldiris, Rainer Rubira, Jhoni Cerón and Gloria Velez: Augmented Reality in Educational Inclusion. A Systematic Review on the Last Decade [21]	<ul style="list-style-type: none"> • Explores the utilization of AR in promoting inclusive education • Analyzes its advantages, limitations and impact on students with diverse needs, based on 50 studies conducted 	<ul style="list-style-type: none"> • Lack of analysis of studies used
18	On mobile augmented reality and user experience: A reflection and future research agenda	Ana Paula Faria, Célia Pinto, Emanuel Sousa: On mobile augmented reality and user experience: A reflection and future research agenda [22]	<ul style="list-style-type: none"> • Examines the design and user experience aspects of Mobile Augmented Reality (MAR) applications • Provides insights, research gaps, and guidelines for creating improved MAR experiences 	<ul style="list-style-type: none"> • Advancements in the field are not represented fully
19	Enhancing Education through Mobile Augmented Reality	Robert Joan: Enhancing Education through Mobile Augmented Reality [23]	<ul style="list-style-type: none"> • Discusses the potential of Mobile Augmented Reality to enhance education by utilizing mobile networks • Improves learning through mobile functions 	<ul style="list-style-type: none"> • Potential lack of representativeness
20	The Advent of Augmented-Learning: A Combination of Augmented Reality and Cloud Computing	Hsu, J.-L., & Huang, Y.-H. (2011). The Advent of Augmented-Learning: A Combination of Augmented Reality and Cloud Computing [24]	<ul style="list-style-type: none"> • Explores learners' preference for printing digital materials • Examines the feasibility of displaying digital information on physical materials 	<ul style="list-style-type: none"> • Lacks details about participant demographics • Inefficient data collection methods
21	Augmented Reality Applications for Learning Geography in Primary Education	C. Volioti, E. Keramopoulos, Theodosios Sapounidis, Konstantinos Melisidis, Georgios Christoforos Kazlaris, George Rizikianos, Christos Kitras: Augmented Reality Applications for Learning Geography in Primary Education [25]	<ul style="list-style-type: none"> • Explores the use of Augmented Reality applications for teaching Geography • Reports a positive usability evaluation and acceptance of the technology among computer science students 	<ul style="list-style-type: none"> • Insufficient details about the usability evaluation • Criteria, instruments, or procedures employed lack details
22	Development of Mobile Augmented Reality of Series Circuits for Science Learning in Primary School Students	Paweena Kusonyang, Phattaraporn Pondee, Wacharaporn Khaokhajorn: Development of Mobile Augmented Reality of Series Circuits for Science Learning in Primary School Students [26]	<ul style="list-style-type: none"> • Focuses on using augmented reality (AR) to enhance science education, particularly teaching series circuits to sixth-grade students in Thailand • Focuses on addressing common misconceptions. 	<ul style="list-style-type: none"> • Lacks details about assessment of students' attitudes and acceptance
23	Mobile Augmented Reality Learning Media with Metaverse to Improve Student	A. Marini, Syifa Nafisah, Rossi Iskandar: Mobile Augmented Reality Learning Media with Metaverse to Improve	<ul style="list-style-type: none"> • Investigates the impact of using a mobile augmented reality metaverse app on the learning outcomes 	<ul style="list-style-type: none"> • Insufficient data collection • Inefficient design of the Metaverse app

	Learning Outcomes in Science Class	Student Learning Outcomes in Science Class [27]	<ul style="list-style-type: none"> Engagement of students for learning science courses 	
24	Augmented Reality for Learning Mathematics: A Systematic Literature Review	Nur Izza Nabila Ahmad, Syahrul N. Junaini: Augmented Reality for Learning Mathematics [28]	<ul style="list-style-type: none"> Conducts a systematic analysis of research trends in the implementation of Augmented Reality (AR) for learning mathematics between 2015 and 2019 Identifying key themes and areas of focus 	<ul style="list-style-type: none"> Does not provide details about selection criteria of study articles
25	Mathematics learning instrument using augmented reality for learning 3D geometry	R N Auliya and M Munasiah: Mathematics learning instrument using augmented reality for learning 3D geometry [29]	<ul style="list-style-type: none"> Focuses on the development of mathematics learning instruments using AR Helps to aid secondary students in visualizing three-dimensional geometrical objects, demonstrating its effectiveness and validity 	<ul style="list-style-type: none"> Lacks details about procedures for expert assessments and student responses
26	Analyzing augmented reality (AR) and virtual reality (VR) recent development in education	Abdullah M. Al-Ansi, Mohammed Jabooob, Askar Garad, Ahmed Al-Ansi: Analyzing augmented reality (AR) and virtual reality (VR) recent development in education [30]	<ul style="list-style-type: none"> Explores the development and adoption of Augmented Reality (AR) and Virtual Reality (VR) technologies in education Highlights the growth, applications, advantages, and challenges 	<ul style="list-style-type: none"> Lack of information about text mining and topic analysis methodology employed Insufficient hypothesis formulation

V. SUMMARY

The above table gives us an idea about the technique known as augmented reality (AR) which combines virtual or computer-generated elements with the physical world. Marker-based, marker less, projection-based, and superimposition-based AR are its four main subtypes. Numerous industries, such as medical, education, manufacturing, robotics, and entertainment, find wide applications for augmented reality. It falls under the category of mixed reality and differs from Virtual Reality (VR) in that it incorporates digital content into the physical environment. This essay examines the history of augmented reality, as well as its various forms, uses, benefits, and drawbacks, as well as foreseeable difficulties and improvements. Additionally, it contrasts AR and VR and looks at how Augmented Reality affects daily life.

Augmented reality (AR) enables seamless interaction between virtual and real-world objects. As a once-impractical concept, augmented reality has attracted a lot of interest and developed into a workable technology. Future mainstream acceptance of AR technology, like that of smartphones and laptops, is still being researched and developed. This study provides a thorough investigation of augmented reality, covering its functioning, applications, current issues, and potential future uses. In essence, this study is a compendium of how augmented reality is now used in society.

VI. CONCLUSION

The design of learning and teaching environments in the education sector with the digitalization process is addressed in this research along with a thorough investigation of the augmented reality settings and applications that are often employed. According to the overall findings of the study,

different tools and materials are now being employed in teaching methods as a result of the entrance of technologies into educational settings. In this context, it is clear that integrating mobile devices and applications into learning environments has recently gained popularity. With the rapid advancement of mobile technology, new media environments with higher levels of interactivity provide users with an expanding range of services [4].

The use of augmented reality technologies in education is one of the most significant fields. Applications for augmented reality assist students in learning and teaching abstract concepts, and they offer settings in which groups of students can exchange information. Additionally, research in the literature has proven that these settings considerably improve students' learning [29]. Additionally, it was emphasized that augmented reality plays a role in transferring the knowledge and skills acquired in the virtual environment to actual environments as well as increasing the interests, motivations, and experiences of students in the field of education [9].

The most significant recommendations of this research are to employ augmented reality applications and learning environments more frequently in different levels and course contents where its efficacy in education has been established to this extent [3][28]. Augmented reality (AR) holds enormous promise and possibility for the future of education. AR is positioned to play a bigger and bigger part in the educational scene as technology develops. The potential for augmented reality (AR) in education to increase immersion and engagement is one of its most exciting features. As augmented reality applications advance over the next few years, learning will become a far more engaging and dynamic process [14]. Students will probably find themselves fluidly interacting with digital

content as AR hardware and software advance, generating a sense of immersion that makes learning feel like a true experience.

Another crucial aspect of AR in the future of education is accessibility. It is projected that more kids will have access to AR technology as it develops. To guarantee that education reaches all students, especially those with impairments or those living in rural or underdeveloped areas, inclusion is crucial. The future of AR in education will likewise emphasize personalization [6]. AR apps will probably get better at adapting instructional content to different learning preferences, needs, and styles. This implies that each student can get a unique educational experience that fully utilizes their abilities. Additionally, AR has the potential to promote international collaborative learning. In the future, students from various countries might collaborate on projects, sort out issues, and gain cultural insights through a common educational experience in shared AR settings. As augmented reality develops further, it might transform conventional classrooms. Physical locations could be changed into adaptable, technologically advanced settings where augmented reality (AR) plays a crucial role in providing instructional information and promoting creativity. Overall, the potential for augmented reality to be used to deliver education is really exciting. It is an area where educators and technology will collaborate to design highly personalized, inclusive, and engaging learning experiences for students from all backgrounds and abilities.

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