

# A Review of the Impact of Developing Augmented Reality Applications in Education

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**Abstract:-** Inventory and collection of previous studies in this field, which reached 22 studies from 2012 to 2023 and dealt with the topic of the study from a perspective that was more one-sided than others, and after seeing these studies, The study found great importance in the researchers' consensus using the development of augmented reality applications at different stages of the educational process. This study's goal is to draw attention to the significance of the influence that the creation of augmented reality has had and to show how it has changed the world.

**Keywords:-** Augmented Reality, Applications, development, educational.

## I. INTRODUCTION AND OVERVIEW

The end of the twentieth century witnessed three revolutions in information technology science, the first revolution was the emergence of the personal computer, as its emergence was a turning point in human history, and the second revolution was represented by the emergence of the Internet, which had and still has a great impact on all aspects of science and life, and the third revolution was represented in the huge information media revolution, (K. Lee, 2012) which made a new qualitative leap in human life, and the scientific and technical progress we are witnessing in our world led to the comprehensive transformation of all Aspects of life, including educational technologies, as it is necessary to keep pace with technical developments in educational institutions to provide the learner with knowledge and skills up-to-date, and all of this helps in organizing information and the ability to prepare generations capable of absorbing the technical flow and its development, education has been able to keep pace with these developments and revolutions that have occurred in information technology science, E-learning has transformed the traditional vision of education, in which the student sits passively while the instructor explains material and the learner takes notes, into an interactive model of education that is predicated on collaboration between all of the components of the learning process(Masalimova et al., 2023). Among the contemporary uses of e-learning is the technology of augmented reality, which has just started to become more extensively employed in educational settings.

The advent of the technology known as augmented reality can be traced back to the late 1960s; however, the word "augmented reality" wasn't created until 1990, at a time when many businesses were using this technology to both represent their data and teach their personnel. The interactive technology known as augmented reality (AR) has seen widespread adoption and use as a learning tool in a variety of educational settings(Fidan & Tuncel, 2018). The fact that

augmented reality applications may run on a variety of platforms, including personal computers, mobile devices (including smartphones and tablets), and laptops, is one of the most significant factors contributing to their widespread adoption. Researchers described augmented reality in their investigations as follows: According to (Fidan & Tuncel, 2018) definition of augmented reality, it is "an expansion of real reality by adding layers of computer-generated information to the real environment."

These layers of information may take the form of text, images, video, audio, GPS, and so on. It can be concluded that augmented reality is an appealing interactive technology, whether it is text, graphics, videos, or sounds, or a composite combination of all of them in a three-dimensional form with a digital dimension added. This technology was designed and developed by the computer to perform many purposes in the fields of education, such as medicine, engineering, computers, technology, etc. Additionally, augmented reality may play a useful function in the dissemination of information in a manner that is both engaging and straightforward. Research has demonstrated that incorporating augmented reality into educational settings not only helps students learn more but also boosts their capacity for creativity in the context of their studies and future careers. According to the findings of research that was conducted in 2014 by (Bacca Acosta et al., 2014) the use of reality .

The use of augmented reality in education has several benefits, including the enhancement of education, the motivation of learners (and the development of their motivation), the interaction and collaboration amongst students, and the retention of knowledge. According to the findings of research(Yuliono & Rintayati, 2018), the use of augmented reality in educational settings has a beneficial impact, and it also provides an efficient, fascinating, and exciting technique for encouraging students to learn and assisting them in doing so. One of their suggestions was that there should be more emphasis placed on the use of educational software programmers for professional development, training, and teaching. The applications of technology that enable augmented reality to have seen significant advancements in recent years. Personal computers, mobile phones, and other tiny digital devices may all be used by its users to interact with and benefit from this technology to enhance the learning process. Because technology is now more readily accessible, working with it has gotten less difficult, and the challenges associated with its use and high prices have been more manageable.

## II. LITERATURE REVIEW

The development of modern technology known as augmented reality (AR) is contributing to the transformation of the educational system. The incorporation of digital content into the actual environment, such as pictures, text, and videos, is the core concept of augmented reality.

This makes the process of learning more interactive. Here are some suggestions on how augmented reality may be used in the classroom. Augmented reality is used in the classroom to provide concrete examples of abstract ideas, which makes them simpler to comprehend and remember. Augmented reality allows teachers to better explain difficult concepts to their students, such as the composition of a molecule or the workings of a machine, by using tools such as 3D models, animations, and simulations. Students have an easier time grasping complex ideas when they are taught using a style of instruction that is both visual and participatory (Yuliono & Rintayati, 2018). The use of Augmented Reality technology is beneficial for expedition field excursions. When students utilize devices that are outfitted with augmented reality (AR), they can investigate historical landmarks, museums, and other places of interest in a manner that is more participatory and interesting. Students can better learn on their own at their own pace with the help of augmented reality (Bower et al., 2014).

Teachers are able to provide more individualized lessons to their pupils when they use gadgets with augmented reality capabilities. (Roopa et al., 2021) Students may, for instance, have access to interactive videos, quizzes, and simulations that are geared specifically towards their learning methods based on their individual requirements. Students' ability to work together on projects and improve their communication may be facilitated by augmented reality. Students may utilize cellphones equipped with augmented reality software to work together on group projects, find solutions to challenges, and finish their tasks. Students who choose an approach to education that emphasizes collaborative learning are better able to work together effectively.

In the classroom, the use of augmented reality encourages inclusiveness as well as diversity. Augmented reality may allow students with impairments, such as hearing or vision issues, to fully engage in the learning process. It does this by giving teachers numerous ways to instruct students—for instance, students can obtain translations and audio explanations in several languages—and by providing students with access to a variety of teaching methods.

### A. Contextual considerations for the many applications of augmented reality

A technology known as augmented reality (AR) projects digital material onto the physical environment around the user according to the researcher (Crandall et al., 2015). There are several variations of augmented reality, and each variation has a unique set of features and qualities (Duan et al., 2022). The following is a list of the primary kinds of augmented reality:

## III. MARKER-BASED AR

It is connected to a particular physical picture pattern marker in a real-world environment, which enables a virtual 3D object, text, or animation to be overlaid on top of the real-world item (Boonbrahm et al., 2020). The cameras do a continuous scan of the input and place a mark there for picture pattern recognition so that the geometry may be generated. When the camera is not correctly focused on a certain location, the representation of the virtual 3D object will not be accurate. You are familiar with marker-based augmented reality (AR) because of the filters on Instagram, Facebook, and Snapchat, as well as games like Pokemon Go. (Andrea et al., 2019) It is slowly making its way into our day-to-day lives via many enjoyable and sociable activities. A camera, picture capture, image processing, rendering, and marker tracking are some of the components that make up an augmented reality (AR) image recognition system that relies on markers. Implementing the filters by means of a specialized app that uses the video feed to recognize certain patterns is not difficult and does not require a large financial investment.

### A. Markerless AR

It is an application for computers that does not need the usage of a camera to set a mark for the purpose of picture pattern recognition. Augmented reality without markers integrates three-dimensional models of real-world settings and objects. via an analysis of the characteristics held by the real-time data. It is necessary for the hardware of any smartphone, such as the camera, GPS, digital compass, and accelerometer, for the augmented reality software to be able to do its tasks in an effective manner. Because of the advancements that have been made in cameras, sensors, and AI algorithms, an object tracking system is no longer necessary (Huang et al., 2011). The output of digital data is combined with the input of real-time data that is captured in an actual place. Image analysis using markerless augmented reality makes use of a technique called Simultaneous Localization and Mapping (SLAM), which examines the surrounding area and generates relevant maps in order to position virtual 3D items. During their time spent using Augmented Reality, users have the ability to expand their normal range of motion. It is possible to divide markerless augmented reality into four distinct categories, which are location-based, projection-based, superimposition-based, and marker-based. and Outlining AR It is connected to a particular physical image pattern marker located in a real-world setting.

This connection is made so that a virtual 3D object, text, or animation may be overlaid on top of the real-world one. The cameras do a continuous scan of the input and place a mark there for picture pattern recognition so that the geometry may be generated. When the camera is not correctly focused on a certain location, the representation of the virtual 3D object will not be accurate. You are familiar with marker-based augmented reality (AR) because of the filters on Instagram, Facebook, and Snapchat, as well as games like Pokemon Go. (Teichrieb et al., 2007) It is slowly making its way into our day-to-day lives via many enjoyable and sociable activities.

A camera, picture capture, image processing, rendering, and marker tracking are some of the components that make up an augmented reality (AR) image recognition system that relies on markers. Implementing the filters by means of a specialised app that uses the video feed to recognise certain patterns is not difficult and does not need a large financial investment.

#### *B. Projection-based AR*

It is a means of displaying digital data in a static setting that is based on projection and is meant to concentrate augmented reality on projecting three-dimensional virtual objects into or onto the physical space of the user. The user is free to walk about the area as they like within the confines of a designated zone that has a stationary projector and a camera for tracking purposes (Mine et al., 2012). By projecting artificial light onto actual flat surfaces, it is used to generate illusions regarding the depth, location, and orientation of an item.

These illusions may be created with this technique. It is possible to use projection-based augmented reality (AR) to provide suitable assistance in order to ease difficult manual activities in firms or industries. It dispenses with the need of having computers and displays (J. Lee et al., 2015). It is provided so that instructions may be placed in the appropriate job area. The use of projection-based augmented reality allows for the enhancement of feedback processes as well as the creation of unique digital IDs for construction cycles.

#### *C. Superimposition-based AR*

It is used to replace the initial partial or total replacement of an item with an updated condensed portrayal of that object that is shown to the human eye. (Al-Taai et al., 2021) Superimposition augmented reality offers several perspectives of the target item, with the opportunity to display additional information that is pertinent to that object.

#### *D. Outlining AR*

For the purpose of performing outlining of specified objects, such as borders, limits, and lines, special cameras tailored for human eyes have been developed. (Manuri & Sanna, 2016) In addition, Outlining AR has included object recognition in order to get a deeper comprehension of the surroundings in particular circumstances when it might be of use. In-car navigation systems are equipped with this feature to ensure drivers' safety after the sun has set.

#### *E. Projection-based AR*

It is a technique for providing computerized digital data in a static environment utilizing projection-based augmented reality that focuses on displaying virtual 3D items inside or on a user's physical space. This may be done by placing the virtual objects within or on the user's physical area. (Sekhvat & Namani, 2018) The user is free to walk about the area as they like within the confines of a designated zone that has a stationary projector and a camera for tracking purposes. By projecting artificial light onto actual flat surfaces, it is used to generate illusions regarding the depth, location, and orientation of an item.

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## IV. METHODS

Articles having the phrase "augmented reality" anywhere in the title that were published in journals that fall within the purview of the SSCI between the years 2012 and 2023 make up the sample. Education and Technology of the Information Age Before choosing the journals whose articles would be analysed, the journal indexes were researched and examined. Journals that fall within the purview of the SSCI and are related to education are identified and graded in accordance with their impact criteria.

After that, articles were chosen by utilizing the option to conduct an advanced search inside journals that have a broad domain for articles and publications that contain the phrase "augmented reality" solely in the titles of their respective articles. I looked for papers in the databases of Web of Science, PubMed, Scopus, and Cochrane, as well as ERIC and CINAHL plus. We collected the following information from each of the papers in order to investigate the effects of implementing augmented reality in the classroom: the authors, the year of publication, the type of study (whether comparative or not), the number of participants, the score level according to the Kirkpatrick hierarchy, the acceptability of augmented reality, the effect on test performance, and the ability of the students to use the technology. To encourage pupils to study and to make it easier for people to grasp how the spatial organization of buildings works.

## V. SAMPLE METHODS AND RESULTS

Table 1: The sample for this research comprised of all previous research and studies (a total of 22 of them) that had been conducted on the topic of using augmented reality in educational settings from a variety of perspectives between the years 2012 and 2023.

Researcher	Title	Country	Summary
(Yuliono & Rintayati, 2018)	The Promising Roles of Augmented Reality in Educational Setting: A Review of the Literature	INDONESIA	This study looked at articles about augmented reality in educational settings that were published in ScienceDirect, Emerald, and ProQuest journals. Since this is what has lately transpired with augmented reality in education, research papers on AR creation and testing have emerged as the most popular type of publication. Because they are generally interested in technology and are easy to contact for university academics, university students were the selected participant type. This review revealed that AR improves educational methods and student interactions, allowing students to learn more effectively.
(Wu et al., 2013)	Current status, opportunities and challenges of augmented reality in education	TAIWAN	In recent years, there has been a substantial increase in research interest in augmented reality (AR), with varied meanings of the term. Educators, academics, and designers might benefit from understanding AR as a concept rather than a technology. Specific features and affordances of AR systems and applications can be found in different technical systems or learning environments. Aligning technological design, instructional approach, and learning experiences is part of educational strategies. However, because of the large amount of information and complicated activities, AR offers new issues for educators, such as cognitive overload. Future study should look into themes and difficulties, as well as potential solutions to these problems.
(Kesim & Ozarslan, 2012)	Augmented reality in education: current technologies and the	TURKEY	AR technology merges the actual and virtual worlds, providing novel affordances and user control. It improves the effectiveness of teaching and learning in real-world circumstances. Combining augmented reality with educational information improves the effectiveness of teaching and learning. In the framework of education, key technologies and methodologies are discussed.
(K. Lee, 2012)	Augmented Reality in Education and Training	NORTHERN COLORADO U.S.A	Methods of education and training differ according to an individual's access to technology and infrastructure. By altering location and timing, Augmented Reality (AR) technology can have a huge impact on education and training. It has a tremendous potential impact on the future of education since it enables individuals to apply information efficiently and effectively in a variety of situations.
(Molnár et al., 2018)	Use of Augmented Reality in Learning	HUNGARY	AR programs such as Pokémon Go 3D, Quiver, and HP Reveal can improve education by allowing teachers and students to create personalized curriculum using photographs or videos. This study covers augmented reality (AR) and its application, Pokémon Go, as well as a survey of Hungarian higher education students.
(Phon et al., 2014)	Collaborative Augmented Reality in Education: A Review	MALAYSIA	Globalization and technological innovation have resulted in extensive usage of technology in education, particularly Augmented Reality (AR). AR allows computer-generated virtual information to be overlaid in real-time, providing new approaches for constructing engaging learning environments. Collaborative learning, which involves students and educational information, can result in greater comprehension and motivation. However, collaborative AR research is still in its infancy, and this paper evaluates literature on its application and potential in education.
(Garzón, 2021)	An Overview of Twenty-Five Years of Augmented Reality in Education	COLOMBIA	Augmented reality (AR) has transformed educational environments by allowing students to interact with real-world items and computer-generated perceptual information. The paper analyses difficulties and offers recommendations to improve the benefits of AR in education using three generations of AR in use.



(Bower et al., 2014)	Augmented Reality in education – cases, places and potentials	AUSTRALIA	Augmented Reality is poised to transform education by superimposing rich material on web-enabled devices, providing students with personalized scaffolding, and facilitating learning in a variety of ways. This study examines its application in mainstream culture and education, emphasizing technology's instructional potential. Students can create Augmented Reality experiences to help them improve higher-order thinking skills, which will lead to more autonomous thinking, creativity, and critical thinking. The article finishes with a forecast for Augmented Reality and a research agenda for future study.
(Chytas et al., 2020)	The role of augmented reality in Anatomical education: An overview	GREECE	A review of the literature examined the consequences of using augmented reality (AR) in anatomy instruction. Five comparative studies and two non-comparative studies were examined. AR was found to be a highly acceptable and engaging anatomy teaching technique, assisting students in understanding three-dimensional structure organization and achieving satisfying exam scores. Although there has been little research on AR deployment, encouraging results imply that it could motivate anatomy educators to include it in their teaching techniques. To assess whether AR can replace or enhance other anatomical pedagogy approaches, randomized controlled trials are required.
(Bacca Acosta et al., 2014)	Augmented Reality Trends in Education: A Systematic Review of Research and Applications	SPAIN	This study examines 32 studies on augmented reality in educational contexts, emphasizing its applications, benefits, limitations, efficacy, problems, and features. It analyses trends, future vision, and future research potential in supporting inclusive learning via AR.
(Korucu et al., 2016)	Using Augmented Reality in Education: A Content Analysis of the Studies in 2007–2016 Period	TURKEY	This study examines 33 academic works on Augmented Reality concepts in Turkey published between 2007 and 2016. It investigates the journal, the year, the purpose, the sector, the sample, the research method, and the data gathering tool.
(Saltan & Arslan, 2016)	The Use of Augmented Reality in Formal Education: A Scoping Review	TURKEY	Augmented Reality (AR) is an important educational technology in both higher education and K-12 education. It is predicted to be widely embraced in higher education in two to three years and in K-12 education in four to five years. The purpose of this scoping review is to give a complete overview of studies on the advent of AR, its linkages to pedagogy, and educational results in formal education. The review follows the five-stage approach developed by Arksey and O'Malley, which includes developing research questions, exploring the ERIC database, choosing studies, charting selected papers, and reporting conclusions. The findings suggest that using AR applications in educational settings improves academic achievement, student involvement, motivation, and satisfaction.
(Dey et al., 2016)	A Systematic Review of Usability Studies in Augmented Reality between 2005 and 2014	AUSTRALIA	This research examines 291 AR publications published between 2005 and 2014, with an emphasis on user studies. It depicts the landscape of user-based AR research, indicates locations with insufficient user studies, and highlights future research prospects. The poster describes the review's methodology and categories.
(Guntur et al., 2020)	Assessing the Potential of Augmented Reality in Education	INDONESIA	Augmented Reality (AR) is a technology that blends 3D virtual items into a real-world environment to aid in teaching and student comprehension. Through a scope review process, AR has been shown in school to improve spatial ability, problem-solving, and student motivation.
(Arulanand et al., 2020)	Enriched Learning Experience using Augmented Reality Framework in	INDIA	This study provides a paradigm for integrating Augmented Reality in mobile phones to alter the teaching-learning process in engineering education. M-Learning is possible using mobile devices, allowing students to focus on their creativity and motivation. In addition, the study provides an experimental setup for converting a topic into an

	Engineering Education		Android app, thereby making AR technology an excellent tool for teaching and learning in engineering education.
(Matcha & Rambli, 2013)	Exploratory study on collaborative interaction through the use of Augmented Reality in science learning	MALAYSIA	The purpose of this study is to investigate the application of Augmented Reality (AR) in group learning environments, with an emphasis on the interaction and communication process. The study employed an electricity science experiment with eight groups of two pupils. The findings revealed natural interactions, both verbal and nonverbal, with physical items serving as the primary interacting medium. The study emphasizes the relevance of using tangible objects in AR-based systems, emphasizing AR's potential as an effective tool for group learning.
(Roopa et al., 2021)	Revolutionizing education system with interactive augmented reality for quality education	INDIA	By changing research sites, scheduling, and methodologies, augmented reality is likely to revolutionize the modern learning cycle in education. Because our brains are powerful 3D computer technology, this technology will make classes more interactive and informed. Augmented Reality technology will give learners a 360-degree picture of real-world entities, allowing for improved understanding and shorter learning curves. Smartphones have broadened the scope of Augmented Reality applications, changing conventional classes into exciting experiences. Based on the learning theory of mobile Augmented Reality, the goal is to increase situational learning, experimental learning, and transformative learning.
(Chang et al., 2022)	Ten years of augmented reality in education: A meta-analysis of (quasi-) experimental studies to investigate the impact	TAIWAN	From 2012 to 2021, 134 quasi-experimental research on augmented reality (AR) in education were examined. The findings revealed that AR technology improved all three learning outcomes, with a bigger mean effect size on performance. The duration of treatment was discovered to be a crucial element influencing AR's impact. AR in language or social studies relates to higher levels of positive learner responses, such as motivation or attitude. The meta regression results show that 3-D visualization in AR should be carefully designed and evaluated. The consequences of employing AR in education are examined, as well as AR learning environments and future research objectives.
(Han et al., 2022)	Augmented Reality in Professional Training: A Review of the Literature from 2001 to 2020	CHINE	This study examines 49 papers on the use of augmented reality in professional training from 2001 to 2020, analyzing important research findings. It identifies trends, research methodologies, and technological affordances, as well as contextual distinctions in AR pedagogies and functions. A meta-analysis of AR application effectiveness discovered a tiny effect size and nine significant moderating factors. The research has implications for providing and researching AR-supported professional training.
(Masalimova et al., 2023)	Bibliometric analysis of augmented reality in education and social science	RUSSIA	Augmented reality (AR) superimposes virtual components on real-time visuals, resulting in benefits such as engagement, motivation, and learning outcomes. It does, however, encounter problems such as technological tools, application, and educational challenges. This study looked at 3,823 pieces of AR literature released after 2015, with an average annual citation rate of 2.49. China has the most citations, followed by the United States and Macedonia. The strategy map highlights crucial concerns such as student learning, augmented reality applications, and augmented reality technologies. For bibliometric study of AR, researchers should concentrate on theme-based learning studies and use multiple databases.
(Bacca Acosta et al., 2014)	Augmented Reality Trends in Education: A Systematic Review of Research and Applications	SPAIN	This research examines 32 studies on augmented reality in educational contexts published between 2003 and 2013, concentrating on its applications, benefits, limits, efficacy, problems, and characteristics. The paper addresses trends, future vision, and prospects for additional study in augmented reality for educational contexts, as well as the present state of AR research in education.
(Fidan & Tuncel, 2018)	Augmented reality in education	TURKEY	From 2012 to 2017, 83 papers on augmented reality (AR) in education journals were examined. Between 2014 and 2017, there

	research (2012–2017): A content analysis		was a surge in AR studies, mainly in science education. The main studied factors were accomplishment and attitude, with marker-based methods chosen. Taiwanese scientists mostly performed AR experiments at universities, with a sample size of 0-50 from universities and 50-100 from elementary schools..
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## VI. LIMITATIONS AND RECOMMENDATIONS

Even though AR-related papers may be found in a great number of journals that have been scanned into various indexes, an analysis of articles published in 22 journals that are indexed in the SSCI database revealed that additional journals that have been scanned into various indexes can be included in further searches. apps that are based on location, gestures, or movement may be built, and studies can be done depending on how effective they are in educational domains. In addition, studies can be reviewed because marker-based apps have been employed mostly in educational research. Importantly, when the dearth of research on the creation of data collecting tools connected to AR is taken into consideration, scale development studies may be conducted to assess emotional factors like self-efficacy and attitude towards AR. When doing research in the future, sample levels might more often include educational stages other than higher education. Choosing a greater number of samples is another way to investigate the nature of the link that exists between the different variables.

## VII. CONCLUSION

The technology of augmented reality enables users to encounter digital material in the physical environment in a manner that is both novel and engaging. There are several flavors of augmented reality, each with its own set of characteristics and uses for technology. The research and development of augmented reality technology is always expanding, and it is expected that new kinds of AR may appear in the future. There are a lot of perks and upsides that come along with adopting augmented reality apps in the classroom. Enhancing the learning experience, providing hands-on experience, increasing engagement, offering personalized learning, encouraging collaborative learning, and being a cost-effective solution are all things that may be accomplished with this solution. AR technology is expected to continue to advance, and as a result, it is likely to become a more significant component of classroom instruction. This will provide students with an advantage in the marketplace and prepare them for professions in developing technologies. The immersive, engaging, and efficient learning experiences that are being made possible by augmented reality are helping to usher in a new age in education. It is possible to employ augmented reality to facilitate distant learning, improve visual learning, offer personalized learning, enhance interactive learning, boost inclusion and diversity, and more. As the technology behind augmented reality continues to advance, it is probable that it will play an increasingly crucial part in the education system of the future, giving new and inventive methods to study and develop. The use of augmented reality, a cutting-edge technology that is only now becoming widely available, is revolutionizing education. The use of augmented reality makes it possible to improve cooperation, which in turn encourages inclusion and

diversity. It is expected that the technology of augmented reality will continue to advance, and as it does so, it will become an increasingly vital tool in the education sector, bringing new and inventive methods of teaching and learning.

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