A SYSTEMATIC REVIEW OF ARTIFICIAL INTELLIGENCE (AI) ENHANCING TEACHING THROUGH AUGMENTED REALITY APPLICATION

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Abstract
This paper explores the development, challenges, and prospects of Augmented Reality Applications (ARA) in education. It examines the transformative potential of AR technology to create immersive and interactive learning experiences, enhancing student engagement and comprehension. The development section highlights the technological advancements and innovative applications that have made ARA a valuable educational tool. Challenges are addressed, including the high costs of ARA devices and content development, the need for technical expertise among educators, accessibility issues, dependence on hardware, and the complex process of ARA development. Despite these hurdles, the paper outlines a promising future for AR in education, driven by ongoing technological advancements, decreasing costs, and increasing collaboration among educators, developers, and researchers. The prospects for AR include more affordable and user-friendly applications, tailored educational experiences, and broader accessibility, positioning AR as a potential catalyst for significant improvements in teaching and learning methodologies. This paper underscores the necessity for continued investment and research to harness the full potential of AR in education.
Keywords: Development; Augmented Reality; Application; Pedagogy.

Introduction

Recent technological developments have completely changed many facets of life, including teaching. Two particularly noteworthy disruptive technologies that have the potential to alter teaching and learning experiences drastically are augmented reality (AR) and artificial intelligence (AI). By enabling individualized and flexible learning environments, AI is transforming education through its incorporation into adaptive learning systems. Since conventional one-size-fits-all methods have not worked, adaptive learning has emerged as a potent remedy (Ashokkumar, 2024). The potential to create immersive, personalized, and interactive learning environments that meet the varied needs of students in the digital age is presented by the convergence of AR and AI. Education has always depended on traditional teaching strategies that frequently fail to successfully engage pupils or take into account their unique learning preferences. However, the advent of augmented reality (AR) technologies has created new opportunities to improve the educational environment through real-time overlaying of digital content in the real world. Techniques for Augmented Reality Applications (ARA) integrate and interact between digital content and the physical world in real-time. These techniques have many applications in intelligent driving, healthcare, entertainment, and education. In light of this, ARA has garnered much interest from academics and the industry (Liu & Zhang, 2019). AI offers tools for gathering and analyzing vast volumes of data, including machine learning techniques, predictive analytics, and natural

language processing. This makes it possible for adaptive learning systems to dynamically modify techniques, content, and feedback to meet the needs of each unique learner. Adaptive learning platforms driven by AI have demonstrated encouraging results in raising student engagement and enhancing learning outcomes (Gligorea *et al.*, 2023; Ashokkumar, 2024).

The fundamental human components needed for leadership development, like fostering relationships and managing change, cannot be replaced by AI, though it can help with some learning and coaching tasks. Thus, rather than replacing human abilities, AI truly benefits them by enhancing them (Gligorea *et al.*, 2023). Teachers are modernising their teaching process by implementing educational trends that prioritize student-teacher interaction, freedom, and responsibility for learning. These days, it is almost impossible to envision both formal and informal education without the use of computers and other modern technology, which provide educators with a wealth of fresh resources and innovative approaches to teaching. Numerous options are provided by information and communications technology (ICT) that can be applied to the teaching and learning process. As a result, it is thought that emerging technologies like augmented reality (AR) have enormous potential for use in education (Redep & Hajdin, 2021). AR applications can enhance the function of educators by utilising AI algorithms to provide content dynamically, tailor learning experiences, and provide instant feedback. This allows learners to engage with educational content in novel ways and explore it. Intelligent interactions between users and digital information are made possible by incorporating AI capabilities into augmented reality apps. These functionalities include machine learning, computer vision, and natural language processing. AI-driven analytics provide teachers with information about learning trajectories, preferences, and student performance. This information helps them make data-driven decisions and create adaptive learning pathways that are suited to each student's needs.

With its immersive and dynamic learning environments, Augmented Reality (AR) has become a potentially useful tool for improving educational practices in recent years. Over the past ten years, educators and instructional designers have become interested in augmented reality as one of the cutting-edge technologies (Erbas, 2021). The majority of AR usage occurs in mobile applications. Unlike VR, AR doesn't require expensive equipment. As per the Pow Research Centre, seventy-three per cent of youngsters possess a smartphone. Consequently, the majority of the intended audience has access to AR. Consequently, there is great potential for applying this technology to printed materials. An AR-enabled textbook, for instance, might feature illustrations that come to life on the user's phone, enabling interaction and close inspection. The Adaptive technologies and VR/AR tools increase student desire for learning, materialize their cognitive interest, and make the educational process more engaging. In this instance, you can engage with both virtual and real-world items and visualize pedagogic content realistically and vividly thanks to VR/AR (Marienko *et al.*, 2020).

Augmented Reality Application (APA) technology has specialised tools that engage students' comprehension and drive them to learn and transfer knowledge more successfully. ARA devices typically consist of cameras, webcams on computers, and eyewear. The animation, audio, and video aspects of three-dimensional objects are incorporated into the presentation method. This feature allows the smartphone to scan the camera towards the focal point of the intended image, even when directed at a flat surface. As a result, the user can perceive the three-dimensional object as if it were real (Sahrim *et al.*, 2023). The capabilities of ARA technology may make classes more engaging and information more accessible, creative and interactive (Singaravelu & Sivakumar, 2020). Through various technology platforms, including smartphones and tablets, ARA combines

digital and physical information in real-time and allows users to interact with virtual pictures superimposed on the actual world. With ARA students may receive more information about their real-time environment. Educational content can be delivered with the use of ARA for the enhancement and effectiveness of teaching and learning environments in real-life situations. ARA is the integration of digital information within the user's environment in real-time.

The precise knowledge, skills, abilities, or attitudes that students are expected to gain or exhibit as a result of their educational experiences are referred to as learning outcomes. The planned accomplishments or quantifiable outputs of the teaching and learning process are represented by these outcomes. Learning outcomes offer a concise description of the knowledge, skills, and abilities that students should possess at the end of a course, module, or educational programme. They provide a roadmap for teachers as they create curricula, instructional techniques, and evaluation procedures that will enhance students' learning and progress. To improve student comprehension of the subject matter, the applied orientation of learning, and the communication skills of both teachers and learners, teaching supports visualization during lectures and practical sessions. A pedagogically sound and appropriate application in the teaching of modern ICT is one method to improve the visualization of abstractions (Kramarenko *et al.,* 2019). ARA technology has a lot of promise for use in education because it already plays a big role in inventive creation.

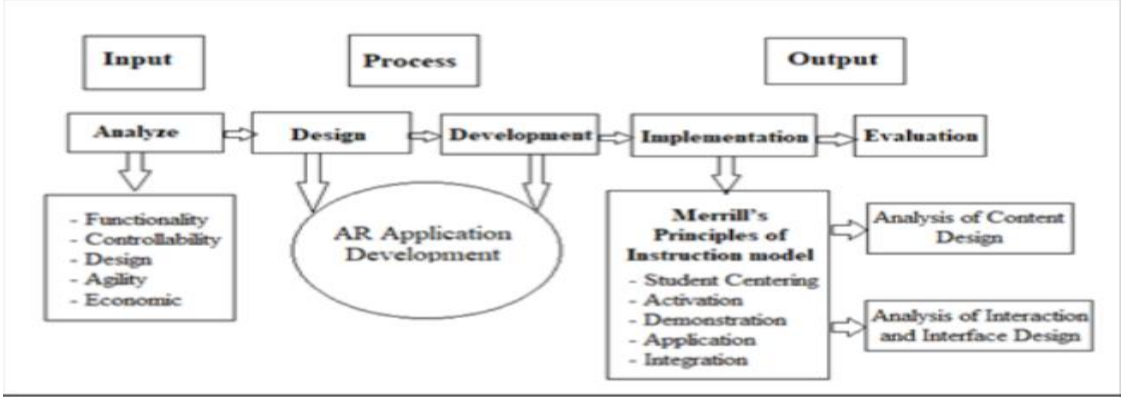
This research endeavours to explore the intersection of AR and AI in education, with a specific focus on how augmented reality applications can be leveraged to enhance teaching practices and improve learning outcomes. By investigating the theoretical foundations, technological innovations, pedagogical implications, and practical considerations of integrating AR with AI in educational settings, this study aims to contribute to the growing body of knowledge and inform the development of effective strategies for leveraging emerging technologies to transform teaching and learning experiences. Through a multidisciplinary approach that draws upon insights from education, computer science, psychology, and human-computer interaction, this research seeks to address critical questions surrounding the design, implementation, and evaluation of AR applications enhanced by AI in educational contexts. By fostering collaboration between educators, researchers, technologists, and policymakers, this study endeavours to shape the future of education by harnessing the transformative potential of augmented reality and artificial intelligence to create engaging, inclusive, and empowering learning environments for all learners. As we embark on this journey of exploration and discovery, we invite stakeholders from across the educational landscape to join us in unlocking the full potential of Augmented Reality Applications (ARA) powered by artificial intelligence to revolutionize teaching and learning in the 21st century. Together, let us embrace the opportunities afforded by emerging technologies to cultivate a future where education is not just transmitted but experienced, understood, and transformed in ways that enrich the lives and minds of learners around the globe.

Augmented Reality Application Development and Learning Environment

Technology-related knowledge application that yields observable, useful outcomes is known as technological development. These outcomes can include brand-new goods, services, or procedures that are always created to enhance society. Examples that stick in your memory the most are usually electronic devices designed to simplify specific tasks. The development is to design an Augmented Reality Application (ARA) tailored to the educational needs and technological context. Virtual and augmented reality are not very novel technological advancements. Daniel

Vickers invented the first virtual reality headgear at the University of Utah in the 1970s. The headset's dual screens allow the user to rotate his head to view the virtual scene being displayed to him. A few years later, the data glove (DataGlove), a novel interface, is created. In 1982 invention detects and relays to the computer the movements of the hand and fingers. The phrase "Augmented Reality" was first used in 1990 to explain how the head-mounted displays that electricians utilized to put together intricate wiring harnesses operated. It was coined by researchers Thomas Caudell and David Mizell. The 1990s saw the end of the previous AR and VR technology frenzy. However, at that time, some barriers kept the general public from really adopting these technologies, like inadequate engineers and experts in the educational sector (Elmqaddem, 2019). The ARA will be designed using Merrill's Principles of Instruction Model as a guide as well. The components of Merrill's Principles of Instruction Model are activation, application, task-centred learning, integration, and demonstration. Students learn when instruction is focused on a real-world task or problem that progresses from simple to complex during the task- or problem-centred phase. In contrast, students learn during the activation phase when they are asked to recall prior knowledge, are given a structure to organize new knowledge, or are reminded of prior knowledge. When new skills and knowledge are presented to students in the context of a real-world problem or task, they can learn them during the demonstration phase. Similarly, when students carry out tasks in the real world, they can learn during the applications phase. Finally, as students incorporate new information into their everyday lives, they learn during the integration phase. The viability of adopting Merrill's ideas for classroom design is stressed, even though they are quite general in describing real practices in classrooms (Suhaizal *et al.,* 2023). Merrill's Principles of Instruction Model, which is integrated into the ADDIE Model for the ARA application's design, is seen in Figure 1.

Figure 1: Merrill's Principles of Instruction Model embedded within the ADDIE Model



Source: Suhaizal *et al.* (2023).

Merrill's Instructional Principles A model is a philosophy of education that considers many theories and models of instruction. It is made up of some related concepts, including activation, integration, task or problem-centeredness, demonstration, and application. These recommendations can help instructional designers create educational resources that enhance the process of teaching and learning. Because it is a task-centred educational philosophy, it is perfect for ARA because it stresses the use of real-world obstacles or tasks in the learning process. Using the ADDIE model instructional design, ARA will be developed through a design and development

process. Users will be given access to instructional design strategies through the ADDIE model, which includes a reiterative process that encompasses all of the stages required to create an effective course. The five essential stages of the ADDIE model approach will serve as a roadmap for the development of ARA: Analysis, Design, Development, implementation and Evaluation.

During the analysis Phase: these should be considered, functionality- the design must fit or meet the content scope and it should have practical usefulness; Controllability- to demonstrate how the ARA system operates, students must handle the items by the instructions provided by the facilitator; Design- the features and operational techniques to be utilized for teaching and learning must be consistent with the development of the augmented reality application; Agility- The choice of materials to be used for the augmented reality application must be considered since it affects how long the product will last and how well it will work; Economic- Although developing an AR application requires a significant investment of time, money, and work, in the end, it is reasonably priced given its usefulness as a teaching and learning aid and may cost N200,000 to N250,000.

Design Phase: The researchers classified the design into three categories: content, interaction (control over the value of a communication service and the level of utilisation and satisfaction), and interface design.

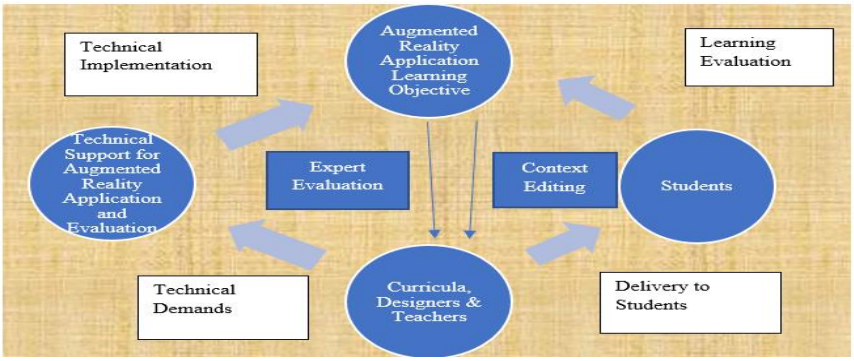
Development Phase: This stage involves the application that was utilized to create the AR application, like syllabus/content, media and technological components.

Implementation Phase: this stage will offer instructional resources that will be applied or utilized in actual settings. students will test the finished AR application to find any bugs during project development. Before giving it all to the user, any errors found will be corrected. This stage will be put into action following the conclusion of the development stage. The act of evaluating the pupils' use of it is part of this step.

Evaluation Phase: this stage is the final, the internet evolution learning topic in the Augmented Reality Application (ARA) is the assessment phase. At this point, a questionnaire will be used to assess the application's usability and get input on how to make the ARA application more beneficial to pre-service teachers.

The application could include interactive modules, simulations, and real-world examples to engage students in learning about the concepts and their practical applications. By supplementing learners' actual surroundings with virtual information in a variety of multimedia forms such as graphics, video, audio, and notes to name a few, ARA is also revolutionizing the learning environment. Students will have a better learning experience since the superimposed information is concealed beneath the cues, which, when scanned with AR-capable devices, bring the static environment to life (Goel *et al.,* 2015). ARA must align with pedagogical principles and curriculum. This alignment helps to enhance the educational experience and meet specific learning objectives. Technical support and system configuration to match the ARA's technological features are part of the Augmented Reality Application's (ARA) design for the learning environment (Radosavljevic *et al.,* 2018).

Figure 2: The Layout of the ARA Learning Environment



Source: Radosavljevic *et al.* (2018).

One cannot initiate or develop a tool without a target, the target here is the objectives. While developing an Augmented Reality Application (ARA) there are needs for the statement of objectives, the target audience (students), and the curriculum activities should be based on the needs and aspirations of the society (designers in this case will decide on the appropriate channels) and teachers will implement it in the classroom situation, this will be necessary with help of technical assistance and evaluation will be done to find out whether the objective have been achieved or otherwise.

Implementation and Challenges of Using ARA in Teaching

A new era in education may be ushered in by the use of technology in the classroom. Ninety-five per cent of youths today own smartphones. The majority of them are frequent users of smartphones, which they use to interact with friends and family, play games, and access social media sites. Meanwhile, a significantly smaller percentage of young adults use their phones for homework, research, and other academic objectives. Though much work needs to be done before the full potential of cell phones and augmented reality for education is realized, it is quite promising. In many respects, augmented reality has the potential to give students access to more digital information on any subject and make complex content easier to understand. In the next two to three years, augmented reality which is quickly gaining traction in higher education will enable the seamless fusion of virtual and physical worlds. It's anticipated that augmented reality textbooks, or "augmented books," will bring it into general usage in education. Although it is practically hard to foresee what technology will deliver next year, it is conceivable to foretell the state of affairs ten years from now. The technology known as augmented reality, which is being developed in several sectors and used in the domains of medicine, architecture, marketing, advertising, the military, archaeology, and leisure, to name a few, will be the most significant transformation in our society. Because of AR technology's adaptability, applications covering a wide range of educational topics, including physics, mathematics, mechanics, and town planning, have been developed (Jorge *et al.*, 2017).

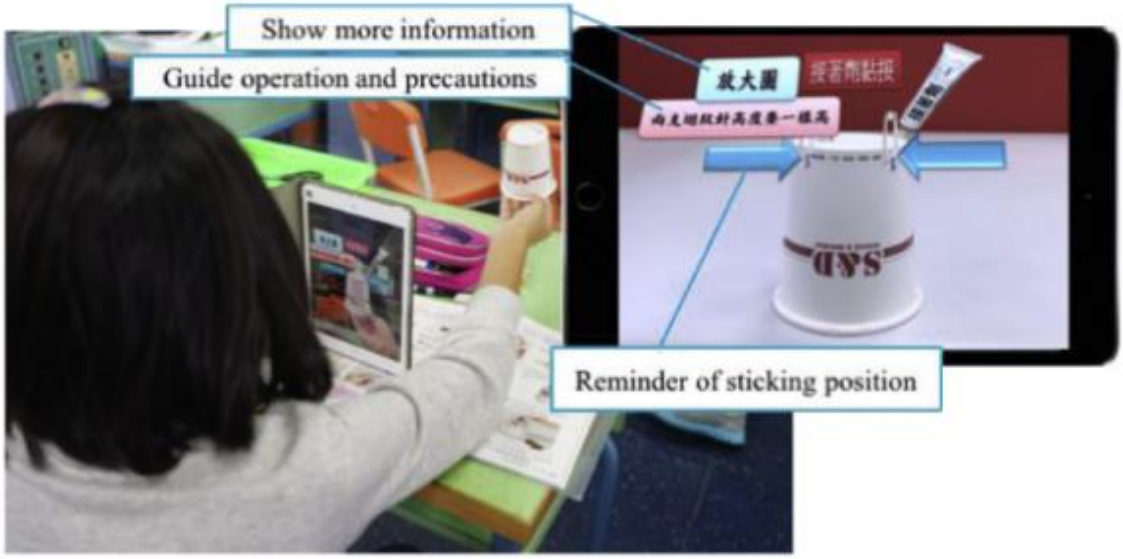
One of the innovative and promising technologies being applied to many facets of education is Augmented Reality Application (ARA). Immersion and interactive learning opportunities in fields

like physics, engineering, foreign languages, and social science can be provided by ARA to improve education. The ARA devices are now more generally accessible and reasonably priced (Liono *et al.*, 2021). The ARA technology, which combines virtual and real-world learning through the use of supplemental resources, has been regarded as a respectable development and useful tool. Applications for augmented reality represent a state-of-the-art innovation in online education that speeds up the learning process for students. Because ARA technology draws students' attention and helps them process information properly, it improves effective teaching and interactive learning. It does this by combining real and virtual pictures with a variety of virtual stimuli. Education experts from the past have agreed that augmented reality (AR) technology is a unique teaching and learning tool that gives teachers the chance to design interactive lessons and student-centred teaching methods. Additionally, it makes scientific and experimental content easier to understand (Mohammad *et al.*, 2023). Visualization is known to be one of the most effective learning strategies. Students find the material more engaging when imagery is used, and it also makes it simpler for them to comprehend the underlying ideas. To create a mixed reality where virtual things and real environments coexist meaningfully and improve learning opportunities, ARA uses virtual objects or data that overlap physical objects or situations. For many industries, ARA is not a novel technology; for instance, augmented reality has long been used by the military, commercial businesses, health organizations, and entertainment industries. Helicopters and military aircraft were the first to use commercial augmented reality systems. These devices, sometimes referred to as Helmet-Mounted Sights (HMS) or Head-Up Displays (HUDs), have been utilized by pilots and other flight crew members (Erbas, 2021). The use of augmented reality in education makes learning more dynamic, efficient, and purposeful by allowing students to immerse themselves in actual experiences. Through the use of multimedia, computer-based simulations, animations, and statistical software, ARA in education and training allows users to interact with virtual and real-time applications that teach and demonstrate topic involvement as well as perception. ARA is a successful addition to traditional teaching and learning methods because it fosters critical thinking and raises student participation and perspective. Researchers have been utilizing augmented reality in a variety of fields, including science education, higher education, game-based learning, and medical education (Shiue *et al.*, 2019). Studies that evaluate the literature have revealed that the majority of studies that use augmented reality in education are focused on science education. With ARA technology, educators may integrate game-based, individualized learning outside of the classroom. Students benefit from gaining new information and abilities. By increasing student engagement and experience, the use of ARA in the education sector enhances the learning environment. ARA can be viewed using various devices, such as a see-through head-mounted display (HMD), a desktop, a laptop computer, or a mobile device with one camera. ARA is characterized by three properties: combining real and virtual objects in a real environment, aligning real and virtual objects with each other, and running interactively and in real-time (Shiue *et al.*, 2019). According to Bower *et al.* (2014), an ARA must have the following basic hardware to function: a video camera for taking live images; a large amount of storage space for virtual objects; a powerful processor for combining real and virtual objects; the ability to display a 3D-simulated environment in real-time; and an interface for the user to interact with both real and virtual objects. While these are the basic prerequisites for operating an ARA, additional technologies could be employed to improve the user experience overall, such as: The use of Global Positioning System (GPS) technology, the system can determine the user's actual location and give contextually appropriate virtual data at meaningful locations; image recognition software allows

virtual data to be anchored in the environment and real-world photos and objects to serve as "triggers" for multimedia and model overlays; Speakers and sound systems: these allow the playing of pertinent noises and audio files; Using Web 2.0 and social media, content may be stored, retrieved, and shared with the use of internet access; Technological advancements in haptic, gyroscope, and touch screen interfaces have made it easier to interact and handle virtual things more intuitively (Bower *et al.*, 2014).

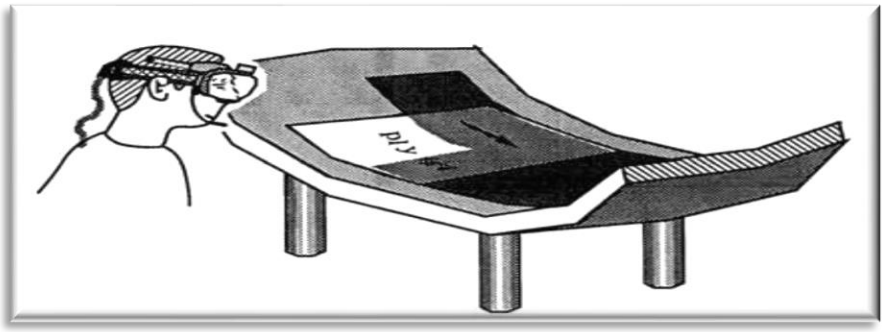
Augmented Reality Application (ARA) helps students retain what they have learned, and augmented reality learning environments are beneficial for active learning. As highlighted by Godoy (2020), blending electronic devices with a real-world setting, ARA offers potential advantages for improving learners' experiences and their comprehension of environmental context awareness and the educational framework. As a developing technology, ARA is rapidly being included in inclusive education, which adjusts learning via exploration and experience by everyone on an equal footing. Therefore, it is expected that ARA will be widely implemented in K–12 for four years and in higher education for three years. The application of Augmented Reality in education and its various opportunities were highlighted by Cabero-Almenara *et al.* (2019): the removal of information that might make it more difficult for students to record important information; the addition or enrichment of real-world information to make it easier for students to understand; the ability to view an object from multiple perspectives, with students choosing the time and perspective; the promotion of ubiquitous learning; the development of secure "artificial" environments for students, like labs or simulators; elevating the printed material for the students with additional information in different formats; turning the students into “pro-consumers” of learning objects in ARA format; can be used in training activities based on the flipped classroom technique; informal education is helped; and can be used in different disciplines and educational levels. Augmented Reality Application (ARA) refers to three primary components of ARA: the simultaneous presentation of interactive information, the integration of virtual and real-world objects, and three dimensions (3-D). It is believed that combining virtual and real environments to have in-time interaction can bring users a sense of engagement and immersion in the scenarios with the smartphone webcam (Chang & Hwang, 2018). Put another way, ARA can give users interaction between the real environment and virtual objects and increase their engagement while using. ARA can be accessed from a user’s smartphone camera to capture the real images and the system adds necessary information about the images to the screen. According to Abraham *et al.* (2022), ARA is the process of combining virtual layers of information of 3-D models with live visuals to create instructional formats for content, images, sound, and videos in educational systems. In today’s digital culture, technology has emerged as a crucial educational resource. ARA is one of the most recent developing technologies. Since ARA can be accessed through smartphones, the learning potential of augmented reality applications is beginning to be widely recognized (Tamam & Duran, 2023).

Figure 3: Smartphone Webcam



Source: Chang & Hwang (2018).
Augmented Reality Application (ARA) is a visual technology that allows users to project images across a real 3D space using their smartphone's webcam.

Figure 4. The head-mounted display was proposed by Caudell and Mizzel in 1992, Kaminska *et al.* (2023).



Source: Kaminska *et al.* (2023).

Augmented Reality Applications (ARA) are facing challenges such as the lack of AR educational applications, the cost of buying and maintaining AR equipment and resources, the lack of teachers' and students' digital skills, classroom management issues, and security and ethical issues (Perifanou *et al.,* 2022).

Challenges of Using Augmented Reality Application (ARA)
There are numerous challenges attached to the use of Augmented Reality Applications (ARA) according to Singaravelu & Sivakumar (2020):

A lack of necessary training: due to their lack of prior training, some teachers may find it difficult to implement this new technology. The use of augmented reality applications in the classroom is still reserved for the most progressive educational establishments and educators.

Dependence on hardware: augmented reality applications in the classroom necessitate a certain level of funding. For instance, not every student has a smartphone that can run apps for augmented reality.

Content portability issues: your augmented reality applications must function flawlessly across all platforms and gadgets. On the other hand, it is nearly hard to deliver augmented reality material of the same calibre across all platforms. Tzima *et al.* (2019) also came up with the following limitation of using Augmented Reality Applications (ARA) in education:

Usability issues: there are usability issues with ARAs since students find them difficult to use and encounter technical difficulties when using them because of things like small screens, slow networks, or low battery life. The disadvantage of employing ARA pupils' distraction and cognitive overload is described in other studies. Solutions for such problems have already been put forth, including a well-thought-out interface, direction, and training for instructors and students on the use of augmented reality technology and controlling experience complexity.

Research and practical restrictions: The challenges and constraints associated with surveying a classroom setting or a natural setting must be taken into consideration. When using physical objects as triggers, for example, every change in lighting and vegetation affects the overlay's launch. However, in an indoor classroom setting, a more involved setup such as placing desks, markers, or Quick Response (QR) codes on each desk is necessary. In an outdoor natural environment, weather conditions and physical characteristics could alter initial plans. Adequate technology, qualified teachers, willing students, cooperation from the school administration, extra lecture time for the efficient use of augmented reality apps, a small research sample, a constrained research period, and using the app as an informational tool rather than an experimental instrument are all common significant factors in both scenarios.

Diffusion of Augment Reality Application (ARA): when it comes to education, ARA is still quite new. While ARA is commonly used in other nations at all educational levels, its usage in education is restricted. The survey also finds that although students are accustomed to using mobile technology in daily life, they are unfamiliar with its application in the educational process. Students "find the AR components more interesting" than the course material, according to another study, and "ARA can be misunderstood by some students and may encourage them not to study outside the class."

The complex process of Augment Reality Applications development: The process of creating an augmented reality experience is intricate and time-consuming, requiring multiple instructors for effective execution, particularly in applications that depend on location. It presents technical difficulties and calls for the assistance of computer experts, knowledgeable educators, and the use of programs for altering images and videos and creating computer graphics.

3D Modelling: teachers perceive the creation of virtual content and 3D models as a complex process that is "unaffordable" and "one of the greatest disadvantages to using ARA." These

elements are essential to applications in the cultural heritage field, and their representation is thought to be the most powerful feature in ARA.

Constant changes in technology and the social requirement for continuous training: Keeping up with the latest developments in software platforms, limited lifespans, and constant and quick changes in technology need to stay current. Additionally, ongoing training may be needed due to unfavourable attitudes or insufficiently prepared instructors, as well as the technical know-how (computer and programming abilities) needed to develop AR applications and the societal requirement for competent workers.

Teachers' and students' involvement in AR application development: To improve learning results, it is suggested that instructors and students actively participate in the development of augmented reality applications. The inclusion of teachers is also suggested because their viewpoints differ from those of designers and because they possess greater educational training than ICT specialists. There are several limitations associated with using augmented reality (AR) technology in education, as noted by Koumpouros (2024): some students' lack of access to smartphones and tablets; technical constraints of digital devices, such as their small screens and quick battery drain; the market for IT devices is changing quickly; the features of older models of mobile devices may not support the newest technologies; the requirement for expertise in safeguarding private information; absence of supervision over pupils' cell phone usage, students being diverted by amusing material; list of augmented reality educational apps, the majority of them are in foreign languages; Not every discipline can have an appropriate augmented reality application, nor can every discipline be studied with the use of such applications; methodological inadequacy of educators in utilizing augmented reality technology in the classroom; lack of experience in working with augmented reality projects for educators and students; the difficulty of developing an application utilizing augmented reality and its high cost; poor model response quality in applications utilizing augmented reality; and other issues related to the limitations of the advancing technology.

Augmented Reality Applications (ARA) have shown promise in enhancing education by providing interactive and immersive experiences. However, it also has several challenges: ARA requires specific hardware such as smartphones, tablets, or AR glasses, which may not be readily available to all students. This can create disparities in access to educational resources. Implementing ARA in education can be expensive, involving costs for hardware, software development, and maintenance. Schools with limited budgets may find it challenging to invest in AR technology. ARA experiences may suffer from technical glitches, such as lagging, calibration errors, or compatibility issues with different devices. These issues can disrupt the learning process and frustrate both students and teachers. Developing high-quality AR educational content requires expertise in both educational pedagogy and AR technology. Poorly designed content may fail to engage students or effectively convey educational concepts. Integrating AR into existing educational curricula can be challenging. Teachers may struggle to align AR experiences with learning objectives and may require additional training to effectively incorporate AR technology into their teaching practices. ARA can enhance engagement; it may also serve as a distraction if not used appropriately. Students may become more focused on the AR elements rather than the educational content, leading to a loss of learning effectiveness. ARA holds promise for

revolutionizing education, but its widespread adoption still faces significant challenges that need to be addressed to realize its full potential.

Prospects of Using ARA in Teaching

Augmented Reality Applications (ARA) have a lot of promise for use in education because they already play a big role in inventive creation. One of the newest visualization technologies being used in educational situations is ARA. Because ARA offers visualization qualities that allow it to embody and demonstrate invisible or abstract content, it has been applied in a variety of industries (Erbas & Demirer, 2019). The use of ARA in conjunction with 3D construction can greatly improve student learning and raise the level of visualisation in education. Furthermore, ARA has the potential to be a tool for improving students' educational technology learning. Development, research, and testing are necessary to use ARA technology in the classroom. As a result, enhancing ARA and existing procedures is crucial. The use of new technologies must raise educational standards. The study of ARA integration concerns in the educational process is the focus of several publications by scientists and software engineers. It focuses specifically on the broad patterns and unique problems associated with the use of ARA in education.

The potential applications of Augmented Reality Applications (ARA) in cloud environments. It is discovered that to keep educators interested in ARA, fresh approaches, didactic materials, and curriculum updates are needed. The key findings and suggestions are as follows: creating a flexible enough environment, paying attention to didactic and teaching issues, modifying the curriculum to master the material, developing research techniques that can be used in training alongside the elements of ARA, creating adaptive materials, and training teachers to incorporate ARA into the classroom are the main tenets of using ARA in the learning process (Kramarenko *et al.,* 2019). In a study conducted by Abu-Ziden *et al.* (2022) titled “Effectiveness of augmented reality (AR) on students’ achievement and motivation in learning science”, 50 participants were used in this study. For the treatment group, the NutricARd applications were used, which had undergone extensive design and development study. There were twenty-five individuals in the control and experimental groups. The Malaysian Ministry of Education's textbooks with AR elements were used by the control group. The results of the investigation showed that the achievement of the treatment and control groups differs significantly. In this study, the research instruments included a semi-structured interview protocol, pre-and post-tests, and interviews. The findings of the paired t-test indicated that there was a noteworthy variation in the motivation of the students as well. The semi-structured interview revealed that AR-NutricARd contains the features and interesting qualities needed to get pupils interested in science. Additionally, the study's conclusions demonstrated a strong correlation between motivation and success. Higher motivation hence suggests higher academic accomplishment.

Similarly, Shiue *et al.* (2019) in their study “Impact of an Augmented Reality System on Students’ Learning Performance for a Health Education Course”, is an empirical study that looked at how middle school students were using augmented reality technology to integrate learning styles with their understanding of human body structure in health education classes. Using pre-and post-test results as a benchmark, a two-way t-test was used to compare the experimental (AR-based) or

control (conventional lecture) groups in health education courses over four weeks. The results showed that compared to the students in the control group, the AR experimental group's students had better learn achievement. Furthermore, there were notable variations in learning achievement among students with distinct learning styles. The study conclusions offered instructors useful guidance on how to use augmented reality (AR) applications to better motivate kids to learn and better understand the variations in their learning styles.

The study "Augmented Reality: The Effect in Students' Achievement, satisfaction and Interest in Science Education" was carried out by Abdullah *et al.*, (2022). The experimental group received AR stimulation, while the control group learned conventionally. A quasi-experimental methodology was employed. Several post-test questions were utilized to collect data on student accomplishment and science process abilities, and a series of questionnaires were employed to learn more about the kids' interests. The t-test and descriptive statistics were used to analyze the data. The results showed that AR significantly improved the experimental group's achievement, interest, and science-process abilities.

A study carries out by Chien *et al.* (2017) in their research "Enhancing students' botanical learning by using augmented reality", improves the learning experience, this study uses augmented reality (AR)-based learning materials to present a variety of perspectives on the plants under investigation. 54 third-grade students were enlisted as participants in a plant observation activity involving a variety of educational resources to confirm the efficacy of this strategy. The degree of learning achievement for each stage was displayed by measuring their learning outcomes using augmented reality by Bloom's cognitive levels. The experimental group's students who observed the plants using augmented reality (AR) had much higher comprehension than the control group's students when it came to conceptual analysis and leaf arrangement recognition. The results imply that AR-based learning materials could considerably improve students' higher-level cognitive capacities in comparison to the conventional plant observation-based learning approach. This would allow them to more successfully scaffold knowledge about target plants in the observational learning activity. The study was done on plants, and efficacy.

In research conducted by Omar *et al.* (2019), "Effects of mobile augmented reality (MAR) towards students' visualization skills when learning Orthographic projection", This study looked at how students' visualization abilities changed in an orthographic projection classroom using mobile augmented reality (MAR) compared to traditional learning methods. This study was carried out at Universiti Teknologi Malaysia with sixty students: Thirty students in the control group learned conventionally, whereas thirty students in the experimental group used MAR. Because it's crucial to make sure students grasp orthographic projection, the Purdue Spatial Visualization Test of Rotation (PSVT: R) was used in this study to test mental rotation skills. The study's findings demonstrated a substantial difference between the two groups of students, with the experimental group's mental rotation skills and visualization abilities being noticeably better than those of the control group. Respondents completed a series of questionnaires after the study to provide input on the application of MAR. Students' enthusiastic comments on MAR demonstrated that it can be a useful tool for spatial visualization. Due to its low production cost, MAR is also a suitable tool

for use in classrooms. The study was based on Orthographic projection and was carried out at Universiti Teknologi Malaysia.

In their study "Augmented Reality for Learning English: achievement, attitude and cognitive load levels of Students," Kucuk *et al.* (2014) investigated whether or not student achievement levels affect their cognitive load and attitudes, and the results showed a correlation between these variables. Both correlational and casual-comparative approaches were applied in the investigation. The study's sample consists of 122 fifth-graders from five different Erzurum secondary schools, 56 of whom are female and 66 of whom are male. In data analysis, descriptive and inferential analysis methods were used. As a result of the study, it was found that secondary school students' achievement level was pleased with learning English with the aid of ARA. They examined learning English: achievement, attitude and cognitive load levels of students with the use of descriptive and inferential analysis methods in secondary schools.

In their study "Developing vocabulary knowledge among low achievers: mobile augmented reality (MAR) practicality," Jalaluddin *et al.* (2020) employed an experimental study design to investigate the efficacy of mobile augmented reality (MAR) applications in vocabulary learning among LINUS students. Using the ADDIE Instructional Design (ID) method as a framework, 45 students participated in this study to investigate the development of MAR in vocabulary learning. The British Picture Vocabulary Scale (BPVS) III was employed as a measurement tool, and the results indicated a statistically significant improvement in the post-test following 6 months of MAR implementation. Despite the positive findings of this study, there was still a deficiency in the ability to write the words that were learned using augmented reality. The study's findings shed light on the viability of employing augmented reality to support learners who are having difficulty picking up and mastering the English language in an ESL setting. The research is based on efficacy.

Augmented Reality Application (ARA) prospects lead us to assume that both technologies could be used to promote exploratory behaviour, perceive usefulness, and develop a positive attitude. This is because of telepresence, immersive experience, a sense of being there, and accommodation of students' learning behaviour. Students could navigate using their favourite avatar and reach objects or act in a good manner that is impossible in the real world. In addition, technology could play a key role in increasing a teacher's perceived usefulness and developing a positive attitude about technology for teaching. ARA potentialities support learners' uses of technology and draw their attention to the lesson while helping teachers teach about different characteristics of the object (Alalwan *et al.,* 2020).

Educational academics are identifying more and more of the new teaching and learning opportunities that ARA offers. In addition to experiencing phenomena that are not possible in the real world and developing critical practices that cannot be developed and implemented in other technology-enhanced learning environments, learners can visualise complex spatial relationships and abstract concepts when virtual objects and real environments coexist. ARA is expected to be one of the most important developing technologies for education in the next five years because of its educational benefits (Mekni & Lemieux, 2014). Exposure to AR applications during teacher

training can improve pre-service teachers' achievement, ability, confidence and competence in integrating technology into their future classrooms (Sánchez *et al.*, 2020).

Augmented Reality Application (ARA) presents promising prospects for enhancing teaching and learning experiences across various educational domains. ARA immerses learners in interactive experiences, increasing engagement and motivation. A study by Akçayır & Akçayır (2017) found that AR positively influenced students' engagement and enjoyment in learning. ARA aids in visualisation and simulation, making abstract concepts to be more tangible and simpler to comprehend. For instance, a study by Dunleavy *et al.* (2009), demonstrated that AR simulations improved students' understanding of complex scientific concepts. ARA allows for personalized learning experiences tailored to individual students' needs and preferences. According to Klopfer *et al.* (2012), AR supports adaptive learning pathways, catering to diverse learning styles and paces. ARA facilitates hands-on learning experiences, fostering skill development and practical knowledge acquisition. Research by Billinghurst *et al.* (2015) highlighted the effectiveness of AR in skill training, such as medical procedures and technical tasks. ARA promotes collaboration and social interaction among students, encouraging teamwork and knowledge sharing. A study by Laine *et al.* (2016) emphasized the collaborative nature of AR-based learning environments, leading to improved learning outcomes. ARA integrates learning into real-world contexts, bridging the gap between theory and practice. Research by Cheng & Tsai (2018) illustrated how AR applications contextualized learning materials within authentic environments, enhancing students' situational understanding. ARA technology has become more pervasive and affordable, it offers greater accessibility to educational resources. With the proliferation of smartphones and tablets, AR applications can reach a wider audience of learners (Bacca *et al.*, 2014). ARA encourages innovative teaching approaches, allowing educators to explore new instructional strategies and methodologies. Studies such as that by Johnson *et al.* (2016) have showcased how ARA transforms traditional teaching practices, fostering creativity and experimentation. These findings collectively demonstrate the promising outlook of integrating ARA into teaching and learning processes, suggesting its potential to revolutionise education in the coming years, by implication in the next decade, ARA will generally be acceptable to learners, teachers, educational administrators, educational managers, curriculum planners and developers, just to mention but a few. However, continued research and development efforts are necessary to address challenges and optimise the implementation of ARA in educational settings.

The provision of immersive and engaging learning experiences, Augmented Reality Applications (ARA) in education improve student engagement, comprehension, and retention. Teachers can work together to develop and distribute AR-based lesson plans that meet curriculum standards and guarantee that the material is both pertinent and easily available in order to successfully adopt ARA. Students gain by utilizing ARA to investigate difficult ideas in a fun, practical method that accommodates various learning preferences and enhances motivation and memory retention. By promoting funding allocations, establishing rules for technology use, and guaranteeing that AR accessibility is equitable among schools, policymakers play a critical role. To help instructors become proficient with ARA tools and maximize their usage in the classroom, technology vendors and educational institutions can also collaborate to provide training and support. ARA can be successfully incorporated into educational systems, improving learning results and promoting a more contemporary approach to education, through cooperation between educators, students, and legislators.

Conclusion

Augmented Reality Applications (ARA) development for teaching has shown significant promise in enhancing educational experiences by providing immersive, interactive, and engaging learning environments. AR technology enables students to visualise complex concepts, interact with virtual objects, and access information in novel and intuitive ways, catering to diverse learning styles and improving retention and comprehension. However, several challenges must be addressed for the full integration of ARA in educational settings. One of the primary obstacles is the high cost of AR devices and development, which can be prohibitive for many educational institutions. Hence, there is a need while creating and implementing ARA to provide content, this requires educators that possess specialised technical skills. Issues related to accessibility and inclusivity also need to be considered, ensuring that AR applications are usable by all students, including those with disabilities. Furthermore, there is a need for empirical research to substantiate the long-term educational benefits of ARA and to develop best practices for its integration into curricula. Looking ahead, the prospects for ARA in education are promising, driven by advancements in technology and decreasing costs. As ARA becomes more affordable and user-friendly, its adoption is likely to increase. Ongoing innovation will lead to the development of more sophisticated and versatile AR applications, enhancing their educational value. Collaborative efforts between educators, developers, and researchers will be crucial in overcoming current challenges and optimizing AR tools to support diverse educational goals. With continued investment and exploration, ARA has the potential to revolutionise the educational landscape, making learning more dynamic, interactive, and effective for future generations.

Recommendations

Based on the exploration of Augmented Reality Applications (ARA) in education as discussed in the paper, several recommendations can be made to effectively harness and expand the potential of AR technology in this field:

1. **Investment in Research and Development**:
    - **Enhanced Funding**: The government should intervene and allocate more resources and funds towards AR research to innovate and develop more sophisticated, cost-effective, and accessible AR educational tools.
    - **Collaborative Research Initiatives**: Foster partnerships between educational institutions, technology developers, and researchers to drive the creation of cutting-edge AR applications.
2. **Cost Reduction Strategies**:
    - **Economies of Scale**: The government should encourage mass production of ARA to reduce costs, making devices more affordable for educational institutions.
    - **Open-Source Development**: The government should promote open-source AR platforms and tools to lower development costs and encourage community-driven enhancements.
3. **Educator Training and Support**:
    - **Comprehensive Training Programs**: Develop extensive training programs to equip educators with the necessary technical skills to effectively integrate AR into their teaching methodologies.

- **Technical Support Networks**: Establish robust technical support systems to assist educators in troubleshooting and maintaining AR tools.

4. **Accessibility Enhancements**:
    - **Inclusive Design**: Design AR applications with accessibility features to ensure all students, including those with disabilities, can benefit from the technology.
    - **Affordable Solutions**: Explore low-cost alternatives and scalable AR solutions that can be deployed in underfunded or rural schools.
5. **Curriculum Integration**:
    - **Curriculum Development**: Integrate AR into the curriculum through collaborative efforts between educators and AR developers to create tailored, subject-specific AR experiences.
    - **Interdisciplinary Approaches**: Encourage the use of AR across various subjects and educational levels to maximize its impact on student engagement and comprehension.
6. **Continuous Improvement and Feedback Loops**:
    - **Pilot Programs**: Implement pilot programs to test and refine AR applications in real classroom settings, gathering feedback from both students and teachers.
    - **Iterative Development**: Use feedback from pilot programs to iteratively improve AR tools, ensuring they meet the evolving needs of educators and students.
7. **Policy and Advocacy**:
    - **Policy Support**: Advocate for policies that support the integration of AR in education, including funding for technology acquisition and professional development.
    - **Standards and Guidelines**: Develop standards and best practice guidelines for the use of AR in education to ensure consistency, quality, and safety.
8. **Community and Industry Engagement**:
    - **Industry Partnerships**: Engage with the tech industry to leverage their expertise in AR development and create more effective educational applications.
    - **Educational Communities**: Build communities of practice where educators can share experiences, resources, and strategies for using AR in teaching.

By addressing these recommendations, stakeholders in the education sector can overcome the current challenges and fully exploit the transformative potential of Augmented Reality Applications to enhance teaching and learning experiences.

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