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Research Article

The Impact Of Augmented Reality On Teaching And Learning In The Educational Context: Exploring Its Pedagogical Implications

Dr. Ashish Samuel Huri[1*], Dr. Avis Chintamani[2], Dr. Kirti Cutting[3]

[1*]Assistant Professor, Department of Teacher Education, Ewing Christian College, Prayagraj-211003, Email: ashishhuri007@gmail.com
[2]Assistant Professor, Allahabad School of Education, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj-211007
[3]Assistant Professor, Allahabad School of Education, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj-211007

***Corresponding Author:** Dr. Ashish Samuel Huri
*Assistant Professor, Department of Teacher Education, Ewing Christian College, Prayagraj-211003, Email: ashishhuri007@gmail.com

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ABSTRACT

Augmented reality (AR) is a new technology that combines digital content with the real world and enhances our perception of reality. The most important quality of augmented reality is that it overlays digital content on top of the real world. AR has a significant impact on school teaching in different subjects and school levels. AR has the potential to transform traditional learning methods and pedagogical practices by providing an immersive and interactive experience that engages students in dynamic ways and fosters deeper understanding, creativity and collaboration. AR offers several advantages in educational settings, and vignettes and anecdotes are suitable research tools. The Impact of AR Technology on Teaching and Learning in Educational Contexts: Exploring its Pedagogical Implications.

Keywords: Augmented Reality, Superimposition, spatial, Moatboat etc.

Introduction

Today our life is surrounded by technology. We cannot think about our life in the absence of this technology. Weather it may be education, health & hospitality, banking or industrial sector technology has spread its wings all over the world. *"Augmented reality is a new term which was invented in 1968, with Ivan Sutherland's development of the first head-mounted display system. However, the term 'augmented reality' wasn't coined until 1990 by Boeing researcher Tim Caudell.(Bridget Poetker 2023)"* Augmented Reality (AR) is a new technology that seamlessly merges the digital content with the real world, which helps to enriching our perception of reality. Virtual reality (VR), which engage users in entirely new digital environments but AR enhances the real world environment by overlaying the virtual elements like images, videos, or 3D models onto the user's view of the environment. This blend of the virtual and real can be made possible through devices such as smartphones, tablets, AR glasses, or specialized headsets which is equipped with sensors, cameras, and processors which detects and interpret the user's surroundings. *"Augmented reality is a technology that overlays digital information on objects or places in the real world to enhance user experience, and is used in various areas like medicine, marketing, and museums. (Donna R. Berryman et al. 2012)"*
AR works in real-time it integrates dynamically the digital information with the user's environment. AR helps the learners for interactive experiences where virtual objects can blend and interact with real-world elements, the users can manipulate digital content as if it were physically present in front of them. For examples, in AR gaming, players can see the virtual characters or objects which were overlaid onto their original surroundings, engaging in immersive gameplay experiences which helps to bridge the gap between fiction and reality.*"Augmented Reality (AR) is an emerging technology that supports significant and ubiquitous learning, with a strong relationship between student motivation and academic performance improvement. (Julio Cabero-Almenara et al. 2019)"* In the sector of education, Augmented Reality offers an immersive learning experiences by blending educational content onto real-world objects. It also enables the students to explore complex concepts in a tangible and interactive way. In the sector of Healthcare, the professionals utilize

it during surgeries in which where vital information such as patient's data or the 3D anatomical models which can be projected directly into the surgeon's field of view leads to enhance precision and efficiency.

Types of Augmented Reality (AR)

Augmented Reality (AR) can be differentiated into several types on the basis of its category of blending and presentation of digital content onto the real world and the level of immersion it provides. There are some common types of AR discussed below:

1. **Marker-based AR:** The Marker-based Augmented Reality (AR) use specific markers such as QR codes or images to point virtual content in the real world. A camera-equipped device use to detects these markers, it blends the digital elements such as 3D models or videos onto the reality. AR helps to creates interactive and immersive experience in which the users can engage themselves with augmented content directly through their devices. *"Marker-based AR systems use predefined markers to construct content, with virtual markers providing user-defined information. (Xiang Zhang et al.2002)"*
2. **Markerless AR**: The Markerless Augmented Reality (AR) doesn't based on specific markers but instead it uses GPS, sensors, and computer vision to blend digital content onto the real world. "*Markerless AR is a type of AR that does not require markers for displaying information, as it combines the real world with virtual objects. (Jack C. P. Cheng et al. 2017)"* It detects the user's location through GPS and orientation and use to seamlessly integrate virtual elements into their surroundings. Markerless AR provides more freedom of movement and flexibility compared to marker-based AR, it allows the user for dynamic experiences without the need for predefined triggers.
3. **Projection-based AR**: Projection-based Augmented Reality (AR) projects the digital content onto physical surfaces by creating interactive experiences without any devices. Projectors were used to display virtual elements onto any surface such as walls, floors, objects, blending them seamlessly onto the real world. "*Projection-based AR systems accurately project high quality virtual information at a user-specified area using a projector. (Jihyun Oh et al.2007)"* Projection-based AR helps the users in immersive interactions in public spaces, exhibitions, and events and engaging audiences without the need for specialized equipment. It helps to motivate the users for collaborative experiences and enhances their engagement by transforming ordinary surfaces into interactive displays. It helps to present creative opportunities for storytelling, education, and entertainment by enriching environments with dynamic and visually captivating content which hides the line between the physical and digital realms.
4. **Superimposition-based AR**: Superimposition-based Augmented Reality (AR) covers and blend digital content directly onto the user's real-world viewpoint through transparent displays like AR glasses or headphones. It integrates virtual elements into the user's surroundings which helps the user to enhance the perception of reality. *"Superimposition-based AR involves superposing AR contents on detected wall contours and human shapes in a museum environment to enhance visitor experiences. (J. Rodrigues et al.2019)"*
5. **Recognition-based AR:** Recognition-based Augmented Reality (AR) use the object recognition algorithms to identify and augment specific objects or scenes in the real world. By using Recognition based AR it helps in recognizing the objects through cameras or sensors, it blends relevant digital information or enhancements onto them. *"Recognition-based AR involves using face-ARG matching to recognize faces robust to facial expression changes, illumination conditions, and occlusion. (Bo-Gun Park et al.2005)"* It also enhances user experiences by providing them contextual information and interactive overlays prepared to the recognized objects. Recognition-based AR can be applied in the sectors like education, advertising, retail, navigation and also offering personalized and engaging interactions with the environment.
6. **Spatial AR:** Spatial Augmented Reality (AR) use to combine computer vision, depth sensing, and spatial mapping to connect with the user's physical environment accurately perfectly. It helps to enables virtual objects to interact realistically with real-world surfaces and objects by providing more immersive and interesting experiences. It used to enhance the navigation, gaming, design, and training application by providing precise spatial interactions and contextual information by the user. Spatial AR helps to generate a dynamic and engaging experience which seamlessly blend the virtual and physical worlds. "*Spatial AR is a technology that combines two-dimensional or three-dimensional virtual objects into a real environment and projects these virtual objects in real-time, attracting the interest of elementary school students.(Lina Anggita Ahsani et al 2022)"*
7. **Web-based AR:** Web-based Augmented Reality (AR) makes the users to access AR experiences directly from their web browsers, delimiting the need for dedicated apps. The technologies like WebXR and WebGL, users can use to interact with AR content using smartphones or other internet-connected devices. Web-based AR provides seamless access to augmented experiences it also helps to make it convenient for the users to engage with AR content without installing any additional software. It enables the users to a wide range of applications, including marketing, education, and entertainment, accessible from any web-enabled device. *"Web-based augmented reality offers a pervasive, lightweight, and cross-platform experience for mobile augmented reality, with potential for enhanced communication efficiency on 5G networks. (Xiuquan Qiao et al.2019)"*

AR and School Learning & Pedagogical Implications

Augmented Reality (AR) is building a breakthrough in education system by transforming traditional learning approaches and pedagogical practices . This innovative technology provides a new framework for immersive and interactive experiences which makes the students to engage in dynamic ways and foster deeper understanding uplifting creativity, and collaboration. The main quality of augmented reality is that it overlays the digital content onto the real world, AR has significant implications for school learning across various subjects and school levels. *"Augmented Reality (AR) technology in mathematics courses can help students with higher self-efficacy focus on higher level conceptions and apply more advanced strategies when learning mathematics. (Su Cai et al.2018)"* The main advantage of AR in the field of education is its ability to enhance the student's engagement in the content. Many a times this happens that in our traditional classroom traditional lectures and textbooks can fail to capture students' attention which leads their disengagement and passive learning. AR focuses on this challenge by providing immersive experiences which uses to stimulate curiosity and active participation of the students in the class. For example, in a history class, students can use AR to explore ancient civilizations by showing virtual reconstructions onto historical sites, bringing history to life in a way that textbooks cannot. Augmented reality offers experiential learning by allowing students to interact with the virtual objects and environments. "*Augmented reality (AR) in vocational education and training can enhance learner control, collaboration, and decision-making, while also supporting localized decision-making in industry. (S. Lester et al.2020)"* Instead of merely reading about scientific concepts or historical events, students can also experience them and take the first-hand view through AR simulations and virtual reconstructions. This approach helps the students to deepens understanding and retention of knowledge by engaging multiple senses and providing tangible experiences to them. For instance, in a biology class, students can use AR to dissect virtual organisms, gaining a better understanding of anatomy and physiology. *"Augmented Reality (AR) enriched notes on mobile devices strongly correlate with increased student motivation and improved academic performance in the subject where it is used.(Julio Cabero-Almenara et al.2019)"* This Augmented reality also promotes personalized learning experiences which is prepared to individual students' needs and preferences as per their requirements. Educators can also create AR content as per to each student's pace, interests, and learning styles, providing targeted support and feedback. In a language learning program, AR can allow the teachers to dynamically adjust the difficulty level of vocabulary exercises based on students' proficiency levels and ensuring that they are appropriately challenged and supported. *"Augmented reality (AR) technology positively impacts primary and secondary students' learning effectiveness, with a higher impact on affective levels than cognitive levels. (Qianqian Shen et al.2022)"*

AR can have a profound impact on Collaborative learning. Augmented reality creates an environment which encourages students to work together to solve problems, complete tasks, and explore virtual worlds. Collaborative AR projects helps to motivate communication, critical thinking, and teamwork skills, preparing students for success in the digital age. For instance, in a science class, students can use AR to conduct any virtual experiments, which allows them to disseminate ideas, hypotheses, and observations in real-time. *"Learning as an educational experience has implications for pedagogical practice and teaching in the modern age, with vignettes and anecdotes being suitable research instruments. (Evelyn Eckart et al.2016)"*AR contextualizes learning by blending educational content onto real-world objects and environments. Contextualization makes learning more meaningful by makes the user understand the abstract concepts to concrete examples. For example, in a geography class, students can use AR to explore geographical features, landmarks, rivers, sea and cultural sites in their local area, deepening their understanding of the world around them. Multisensory learning experiences are also provided through Augmented reality which engages multiple senses, enhancing comprehension and retention of information. By adding visual, auditory, and tactile stimuli, AR motivates to different learning modalities and accommodates diverse learning needs of the students. For instance, in an art class, students can use AR to create interactive artworks that respond to touch, sound, and motion, allowing them to express their creativity in new and innovative ways. Augmented Reality has the potential to transform school learning and pedagogy by providing immersive, interactive, and personalized learning experiences provided by the equipped teachers. By enhancing student engagement in AR which facilitates experiential learning, promoting collaboration, contextualizing learning, and providing multisensory experiences, AR generates new opportunities for educators to engage and inspire students in meaningful ways.

AR Tools for learning

Some of the AR tools for school learning has been discussed below:

1. **3DBear :** 3DBear AR is a design application that combines augmented reality (AR), 3D design and 3D printing by integrating Maker Bot and Thingiverse. The YouTube tutorials available in the program are a useful starting point for users. Teachers create and assign lessons or challenges to students through the teacher dashboard, and children use the app on their smartphone or tablet to create scenes using the object library, images from the devices or downloadable files. Students can share completed models, scenes and videos via the cloud feature to view on the teacher's dashboard. From there, teachers can discuss and draft plans with student groups.

2. CoSpaces Edu
CoSpaces Edu is an innovative platform that enables students and teachers to create immersive 3D experiences. Using intuitive tools and models, users design virtual worlds, games and simulations that enhance the learning of various subjects. CoSpaces Edu promotes creativity, collaboration and digital literacy by empowering students to create and explore interactive environments that encourage hands-on experimentation and problem solving. The platform supports a variety of educational goals, from storytelling and STEM education to project-based learning and virtual field trips. With its user-friendly interface and extensive library, CoSpaces Edu is revolutionizing the classroom, preparing students for the digital age with engaging and experiential learning opportunities.

3. Froggipedia
Froggipedia is an educational program that provides a virtual dissection experience that allows users to explore the anatomy and life cycle of a frog in a 3D environment. Available for iPad and Apple Pencil, Froggipedia enables interactive learning and provides detailed views of organs, tissues and biological processes. Users can dissect virtual frogs, manipulate structures and observe physiological functions, improving understanding of biological concepts without the need for physical specimens. Froggipedia is an invaluable tool in biology education at all levels, promoting hands-on research, fostering curiosity and providing a safe and ethical alternative to traditional dissection methods.

4. JigSpace
JigSpace is an educational program that provides interactive 3D explanations of complex concepts. Users explore augmented reality (AR) and virtual reality (VR) models that visually break down complex topics into easy-to-understand parts. Covering a wide range of subjects from science and technology to art and engineering, JigSpace's library offers engaging learning experiences for students and hobbyists alike. By allowing users to interact with digital models, manipulate parts and see step-by-step explanations, JigSpace fosters deeper understanding and knowledge retention. Its intuitive interface and extensive visual features make it a valuable tool for interactive and easy-to-use exploration and mastery of complex concepts.

5. MERGE Cube
The MERGE Cube is an innovative learning tool that connects the physical and digital worlds. This cube-shaped object features Augmented Reality (AR) technology that allows users to view holographic content on a smartphone or tablet. By holding the cube, users can explore 3D models, play interactive games, and experience immersive experiences on a variety of topics. The MERGE Cube provides hands-on learning opportunities, promoting creativity, problem solving and spatial awareness. Its versatility and portability make it a valuable resource for classrooms, homeschooling, and STEM education. It awakens curiosity and fosters a deeper understanding of complex concepts through interactive exploration.

6. Moatboat
Moatboat is an immersive storytelling platform that combines augmented reality (AR) technology with a story-driven experience. Through the Moatboat app, users can go on interactive adventures where they play a key role in shaping the outcome of the story. By scanning physical objects or locations, Moatboat brings characters and scenes to life, allowing users to interact with virtual elements in their real-world environment. Focused on interactive storytelling and user engagement, Moatboat offers a unique and immersive way to experience stories, fostering creativity, imagination and exploration in an immersive digital environment.

7. World Brush
"World Brush is an indoor location-based Augmented Reality (AR) experience that allows users to paint, create and leave artwork wherever they are, helping to hide the bad things and show the good things to others. The World Brush was born out of a desire to connect the physical and digital worlds in a way that everyone could use friendly Connected to the real world enables a vast array of possibilities that cross language barriers and fit into the context of each person's unique daily experience. Art teachers may assign students to create virtual drawings anchored to real objects and locations on their school campus.

Benefits of using AR in educational setting
Augmented Reality (AR) offers numerous benefits in educational settings:

1. **Engagement:** AR helps to enhance the student engagement by providing them interactive and immersive learning experiences which captures the attention of the students' and motivates them to explore and interact with educational content. *"AR-enriched notes positively influence academic performance and increase student motivation in the classroom. (Julio Cabero-Almenara et al.2019)"*
2. **Experiential Learning:** AR facilitates experiential learning by allowing students to interact with virtual objects and environments and provide hands-on experiences that deepen understanding and knowledge retention.

3. **Personalized Learning:** AR enable the students for personalized learning experiences prepared to cater the need of the individual students' needs and learning styles, providing targeted support and feedback based on their progress and performance.
4. **Visualization:** AR helps students visualize abstract concepts by overlaying digital content with real objects and environments, making complex ideas more tangible and understandable.
5. **Collaboration:** AR promotes collaboration and teamwork among students as they work together to solve problems or complete tasks in blended environments, promoting communication, critical thinking and peer learning.
6. **Contextual Learning:** AR contextualizes learning by providing relevant information and interactive overlays based on the user's environment, making learning more meaningful and relevant.
7. **Multisensory Learning:** AR provides multi-sensory learning experiences that activate multiple senses and improve comprehension and retention of information by appealing to different learning styles. *"AR as a learning material gives positive results in the education of individuals with special needs, supporting effective teaching strategies. (H. Köse et al.2020)"*
8. **Accessibility:** AR accommodates diverse learning needs by providing alternative ways for students with disabilities to access the educational content and participate in learning activities, ensuring equitable opportunities for all learners.
9. **Real-World Applications:** AR connects learning with real-world applications, allowing students to explore and interact with virtual content in an authentic context, preparing them for future careers and life experiences.
10. **Creativity and Innovation:** AR fosters creativity and innovation by empowering students to create their own augmented experiences and encouraging them to experiment, design and solve problems in a digital environment. *"AR simulations in educational settings present unique technological, managerial, and cognitive challenges to teaching and learning. (M. Dunleavy et al.2009)"*

Limitations of using AR in Educational Setting

While Augmented Reality (AR) offers numerous benefits in educational settings, it also has some limitations:

1. **Cost:** Implementing AR technology in education can be too costly as it requires investment in hardware, software, and training for educators. This may pose a challenge for schools with limited budgets or resources.
2. **Technical Requirements:** AR applications often require some specified hardware, such as smartphones, tablets, or AR glasses, as well as a proper internet connections and compatible devices. Ensuring access to these technical requirements for all students can be a difficult task. "*Challenges of using AR in educational settings include usability issues and frequent technical problems.(Murat Akçay et al.2017)"*
3. **Learning Curve:** Integrating AR into the curriculum may require educators to acquire new skills and knowledge about AR technology and its educational applications. The learning curve for both teachers and students may impact adoption and effectiveness. *"AR solutions in educational settings can enhance learners' outcomes in natural sciences, but limitations exist in their impact on social behavior.(Crispino Tosto et al.2022)"*
4. **Content Development:** Creating high-quality AR content as per the need of the students to educational objectives can be time-consuming and resource-intensive. Developing engaging and relevant AR experiences in the real situation requires expertise in both educational content and AR development.
5. **Access and Equity:** Access to AR technology may not be equal for all students, especially for the students who belongs to a economically weaker section, disadvantaged backgrounds or underserved communities. Unequal access to devices, internet connectivity, and technical support can exacerbate existing disparities in education.
6. **Distraction:** Excessive use of AR technology in the classroom may lead to distraction and reduced focus on learning objectives and the teaching of the content may be compromised. Balancing the use of AR with other instructional methods is a very difficult and important task along with maintaining student's attention and participation.
7. **Technical Issues:** Like other applications and software's AR applications may also encounter technical issues such as glitches, compatibility issues, or software bugs, which can disrupt the learning experience and frustrate users at the time of its use.
8. **Ethical Considerations:** Ethical concerns related to privacy, data security, and digital citizenship is a big concern for them who are using it. Educators must address these issues and ensure responsible use of AR technology in educational settings.
9. **Pedagogical Integration:** Integrating AR into the curriculum requires careful planning and alignment with educational goals and pedagogical approaches. Without thoughtful integration, AR experiences may not improve learning outcomes as desired.
10. **Assessment Challenges:** Assessing student learning and progress in AR-enhanced activities can be difficult because traditional assessment methods may not capture all of the skills and competencies developed through AR experiences.

Conclusion:

In conclusion, Augmented Reality (AR) is a technology that perfectly combines digital content with the real world and improves our perception of reality. It has various applications in education, healthcare, marketing and other fields and provides an immersive and interactive experience. AR can transform the way we learn, participate and collaborate by providing personalized and contextual learning experiences.

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