Augmented Reality in Education: A Primer

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Abstract: Augmented reality is a significant emerging trend that is digitally enhancing our world. It superimposes sounds, videos, and graphics onto an existing environment. It is an interactive experience that brings digital content to the real world. The AR technology is useful in numerous fields including education because it enables an interactive experience with the real world. Augmented reality offers various benefits in education. It is gradually becoming the future of education. This paper provides various applications of AR technology in education.

Keywords: augmented reality, education, applications.

INTRODUCTION

The education industry is constantly being disrupted by technology. Traditional education methods are disappearing and are becoming increasingly digitized. Today, school and university students prefer incorporating the power of technology into their classrooms. Adapting technological solutions to education is becoming increasingly popular. You can find chatbots, gamification, and virtual and augmented reality in the curricula of both elementary schools and universities.

Augmented reality is one of the cloud technologies that bridge the gap between what you see and what you imagine. It allows the students to see 3D objects in the classroom. Digital natives perceive AR technology as more of a part of routine rather than an exception [1]. They do not know a world without technology. Schools should do their best to integrate technological tools into the classroom setting so that digital natives can learn well.

There are four types of digital realities [2,3]:

- **Augmented reality** (AR)— designed to add digital elements over real-world views with limited interaction.

- **Virtual reality** (VR)— immersive experiences helping to isolate users from the real world, usually via a headset device and headphones designed for such activities.

- **Mixed reality** (MR)— combining AR and VR elements so that digital objects can interact with the real world, means businesses can design elements anchored within a real environment.

- **Extended reality** (XR)— covering all types of technologies that enhance our senses, including the three types previously mentioned.
AR effectively “augments” or “enhances” our experience of the world around us.

**CONCEPT OF AUGMENTED REALITY**

The term “augmented reality” was coined in 1990 by Tom Caudell, a former Boeing researcher. Since then the technology has vastly improved. The rise in AR use stems from four main developments [4]: (1) the pervasiveness of low-cost visual sensors, such as phone cameras, (2) progress in environmental perception algorithms, such as visual simultaneous localization and mapping, (3) advances in optics, and (4) the maturity of multimedia techniques.

Augmented reality (AR) is a technology which combines real-world environments with computer-generated generated information such as images, text, videos, animations, and sound. It has the ability to record and analyze the environment in real time. The technology is accessible for the ordinary user. It is becoming more attractive as a mainstream technology due to the proliferation of modern mobile computing devices like smartphones and tablet computers with location-based services. For example, AR allows consumers to visualize a product in more detail before they purchase it. This enhances consumer’s interaction and helps them never to buy the wrong thing again.

The key objective of AR is to bring computer generated objects into the real world and allows the user only to see it. In other words, we use AR to track the position and orientation of the users head in order to enhance/augment his or her perception of the world. Projected images are overlaid on top of a pair of goggles or glasses, which allow the images and interactive virtual objects to lay on top of the user’s view of the real world. Thus, augmented/enhanced reality involves extending the real-time environment with a digital overlay, in which real life is enhanced by computer-generated images and sound. The digital overlay scene appears on the actual scene the user is experiencing.

Augmented reality falls into two categories: 2D information overlays and 3D presentations, like those used with games. It combines multiple technologies allowing users to interact with virtual entities in real time. Various technologies used for augmented reality include a processor, monitors, handheld devices, display systems, sensors, and input devices. Modern mobile computing devices like smartphones and tablet computers contain these elements also, making them suitable AR platforms.

To obtain a sufficiently accurate representation of reality, AR needs the following five components [5]:

- **Sensors:** AR needs suitable sensors in the environment and possibly on a user including fine-grained geolocation and image recognition. These are activating elements that trigger the display of virtual information.
- **Image augmentation:** This requires techniques such as image processing and face recognition.
- **Head-mounted Display:** HMDs are used to view the augmented world where the virtual computer-generated information is properly aligned with the real world. Display technologies are of two types: video display and optical see-through display.
- **User Interface:** This includes technologies for input modalities that include gaze tracking, touch, and gesture. AR is a user interface technology in which a camera-recorded view of the real world is augmented with computer-generated content such as graphics, animations, and 2D or 3D models.
- **Information infrastructure:** AR requires significant computing and communications infrastructure undergirding all these technologies. The infrastructure determines what real-world components to augment, with what, and when.

The AR systems, based on these technologies, should be more accurate, smaller, lighter, faster, simpler, cheaper, and convenient for the users. Google Glass was the first AR platform to get wide public exposure. Figure 1 shows the evolution of AR [6].
AR technology has been used in many fields such as education, healthcare, military, business, engineering, architecture, robotics, manufacturing, entertainment, space industry, maintenance, coding, consumer design; psychology, etc. When incorporating AR in the classroom, it is important to keep the following best practices in mind to ensure a smooth and effective integration [7].

- Setting clear goals and objectives for using AR;
- Creating a plan for how AR will be used in the classroom;
- Providing training for educators and students on how to use AR tools;
- Incorporating AR into existing curriculum and lesson plans;
- Assessing and evaluating the effectiveness of AR in achieving educational goals.

APPLICATIONS OF AR IN EDUCATION

Most AR applications run on smartphones or tablets needing no special equipment since young people use smartphones for almost anything. Modern AR apps are used for various purposes, from entertainment to enterprise applications to military training. One can get an AR app for almost any subject, including chemistry, geometry, zoology, grammar, healthcare, military, and programming. Augmented Reality is revolutionizing education. It is applied in many areas such as the following:

- **Classroom**: The most popular application for augmented reality in education is the use of AR apps directly in the classroom. Augmented reality is becoming popular in schools around the world because it make learning fun and interactive. It turns classrooms into learning environments, where students can enter unknown worlds. Using AR in the classroom can turn an ordinary class into an engaging experience. AR technology provides virtual examples and adds gaming elements to support textbook materials. As a result, classes become more interactive. AR helps students better remember the information they learn. It is replacing traditional methods and introducing creative ways to learn. It is helping students to deepen their knowledge in various areas such as reading, content creation, playing, and spatial concepts.

- **Elementary Education**: Although children’s needs have not changed, the world around them has. Augmented reality for elementary education focuses on helping children familiarize and associate themselves with real-life situations. AR puts children in the driver’s seat as the creators, while technology is just an enabler.

- **Higher Education**: The academic community has not been shy about experimenting with emerging technologies such as VR and AR to increase efficacy and outcomes. Drastic cost reduction has led to broader use of AR systems in education. AR allows students virtually visit locations that they cannot visit physically. Many students learn more effectively by doing rather than just seeing or hearing. As the famous Chinese proverb says: “Tell me and I forget. Show me and I remember. Involve me and I understand.” Examples of learning by doing are engineering labs and architectural designs.

- **Healthcare Education**: Healthcare professions require a high level of proficiency and accuracy since any possible mistakes can be costly. AR application can be used for studying the human body and observing the functioning of the internal organs. From patient education and physician training to surgical visualization and disease prevention simulations, AR’s benefits for healthcare are many. In anatomy lessons, students no longer need to dissect real animals; this can be accurately simulated using AR. Human Anatomy Atlas is an app that lets students explore the human body to understand how it works. An example of how AR can assist surgeons is displayed in Figure 2 [8].
Chemistry: AR-based apps allow students to study the chemical reactions, properties, atomic weight, and other relevant information. AR technology allows conducting experiments with no harm to students and university property. Elements 4D uses AR to make chemistry more fun, exciting, and engaging. Augmented reality gives students the ability to see a molecule from all its angles, visualize how atoms are arranged in an element. A typical use of AR in chemistry is shown in Figure 3 [9].

Military Training: Nothing can substitute for the intense and grueling physical aspects of training soldiers for combat. Soldiers often need to relocate to a particular setting for military training, which may involve time and expenses. AR is used to create a virtual environment required to better train the soldiers, enhance their skills, and let them train more often.

Space Education: This can get outstanding development using AR. The space industry has been exploring the use of augmented reality. Technologies like AR and MR can help astronauts with tasks like maintaining a space station. Using goggles, workers can receive visual work instructions without turning to manuals. Lockheed Martin engineers use AR headsets to assemble the NASA space capsule faster. An example of using AR in space is shown in Figure 4 [10].

Manufacturing Workforce Education: Workforce education in manufacturing has traditionally been very low-tech, one-on-one apprenticeship, and written manuals. With increasing advancement in technology, some manufacturers are now turning to AR to teach their workers new skills. An example of the use of AR in manufacturing workforce is shown in Figure 5 [11].

Other applications of AR in education include museums, mathematics, biology, history, coding, and earning languages.

BENEFITS

Augmented reality in the education offers many benefits that make learning more interesting, interactive, and practical. With a mobile device, educators and students can use AR apps to access projection-based or location-based experiences so that objects or media appear to be in the classroom. AR technology can be integrated into the classroom in all grades. Unlike traditional classrooms, augmented reality does not have any boundaries of time. AR can improve student engagement and motivation. Other benefits include the following [12]:

Accessibility: The learning materials are accessible anytime, anywhere. Augmented reality has the potential to replace paper textbooks and offer portable and less expensive learning materials. In an AR application, you can download the latest data and display it in an interactive format. Mobile technologies can promote access to materials from anywhere. With AR, you can access endless number of resources, all at the click of a button.

Interactivity: AR is an interactive technology that overlays digital features onto the real world. It is increasingly used to enhance the learning experience for today’s audience that craves interactivity. It makes learning an interactive and immersive experience. Interactivity gives a higher degree of autonomy to students. With AR, teachers can recreate 3D models of almost any object and students can manipulate the 3D models as if they were real.

Faster learning: Many students find it hard to perceive theoretical information without any visuals or relatable examples. AR can change the way in which children apprehend learning material. A new way of presenting information reduces the overall learning time. Learning apps based on augmented reality are finding ways into schools and universities. AR-based learning makes the learning experience much richer, more engaging, fun, and inviting.
Retention of Information: Human memory does not forget visuals easily. AR can enhance the retention of information. By using AR to supplement traditional teaching methods, students can better remember the information long-term.

Professional Training: AR can help in professional training. Industries like aerospace, aviation, hospitality, military, and others have to invest a huge amount of money and equipment in training. With AR, the expenses can be reduced drastically and can make training interactive and enjoyable. Companies can now hire employees and train them on-the-go using AR instructions. AR can play a vital role in training for warehouse, factory, and manufacturing workers. For example, police departments are now using VR to train officers to deal with riots or arrest people in specific situations.

Collaboration: Collaboration is one of the most important AR applications. AR has the potential to enable collaboration. The collaboration element of AR technology stems from the online games and chats. In collaborating, you may need to implement strong security controls to protect data.

Cost Efficiency: Integrating AR in education allows cheaper and easier creation than traditional approach. AR-enabled content and all its visuals can be viewed on a reader’s device itself allowing BYOD scenario.

Seven of these and other benefits of AR in education are displayed in Figure 6 [13].

CHALLENGES
Implementing augmented reality in the classroom can initially seem daunting. There is no consistent and standardized curriculum for educators to follow. A major challenge to implementing AR in education is the lack of teacher comfort and familiarity with the technology. An AR application cannot be installed on old phones that do not support immersion.

CONCLUSION
The education system is evolving, and technology is at the forefront of this evolution. AR technology can bring about a wealth of benefits for students, educators, and academic institutions. It pretty cool and amazing how much educators can add to their experience of the world with the modern technology such as AR. With such giants as Apple and Google pushing AR technologies forward, this may be the best time to join the trend.

Using AR in the classroom is relatively new and educators are still finding new ways to use it effectively. By using AR to create interactive and engaging learning experiences, students are more likely to work together and share ideas. AR can help improve their problem-solving and critical thinking skills that are essential for success in today’s job market. More information about AR in education can be found in the books in [14-18].

REFERENCES


ABOUT THE AUTHORS

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Figure 1 The evolution of AR [6].

Figure 2 AR can assist surgeons [8].

Figure 3 A typical use of AR in chemistry [9].
Figure 4 Use of augmented reality in space [10].

Figure 5 An example of the use of AR in manufacturing workforce [11].
Figure 6 Some benefits of AR in education [13].