

The Analysis of Implementing Augmented Reality within Remote Learning

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Abstract

The world has transitioned into an entire cyber world due to the impact that COVID-19 has had on the planet—forcing us to resort to technology for most of our basic needs like shopping, attending school, and communicating. Technology has already proven to be at the forefront of generation, but now it is causing us not as familiar with technology to use it for our everyday needs. For instance, the elderly and children have had to enter the digital world to keep track of daily life.

As a result of this, The education system was also put into a challenging predicament, forcing schools to shut their doors to students and move to complete remote learning. This solution to the COVID-19 pandemic was to limit the virus's spread by leaving lectures, lessons, and seminars to be taught through distant learning. Although this solution proved to be best, the transition has brought upon some unforeseen challenges putting students, parents, school faculty, and staff in difficult positions. The pandemic response has also presented many cybersecurity concerns because, as we all know, cybercriminals target everyone. The transition to remote learning has opened up tons of vulnerabilities within the education system and consequently expanded cybercriminals' reach.

1 Introduction

The coronavirus pandemic has forced schools, students, and professors into remote learning without the proper time to prepare for the transition. All education levels are witnessing a drastic shift in how things used to be and how they are now. The census

bureau has reported that nearly 93% of households with School-Age children participate in some form of distance learning (6). Usually, schools and professors would have adequate time to prepare for things such as this but instead were forced to put remote knowledge into place overnight practically. Many schools and institutions have been using online learning applications such as zoom, blackboard, and canvas to provide students with online learning capabilities. Although remote learning was a necessary step for mitigating the pandemic, it has revealed that it also comes with many vulnerabilities and sensitivities that the world may not have been aware of just yet.

These challenges range from distracting environments to poor online content students face no control over issues. This research paper will address some of those challenges and analyze solutions to lessen them by implementing Augmented Reality within the remote education spectrum.

2 Methodology

This study will use a combination of literature review, expert interviews, and analysis of current augmented reality technologies that are related to education. Each of the phases of research is described below:

A. Literature Review

We will discuss the challenges that the education system faces due to the widespread transition to remote learning by referencing scholarly journals and research reports of researchers and experts who have been following the effects of

COVID 19 and education. Analyzing these reports will provide us with the foundation to build our research and support our other means of data collection.

B. *Expert Interviews*

Information will be collected on the topic by interviewing a few individuals who are experts in Augmented Reality. Our interview process will involve two experts. We will share their knowledge and expertise working with augmented reality and their opinion of AR being implemented into the Remote Learning Education curriculum during the interviews. The intended targets of research are Gheric Speiginer and Ulrich Neuman.

C. *Analysis of Current in AR technologies in the Education Realm*

We will analyze the current usage of Augmented reality capabilities within education. We will do this by downloading approximately five education AR apps and assess their capabilities and potential security hardships. The intended apps are MERGE cube, Elements 4D, Blippar, CoSpaces Edu, and Mondly.

3 Challenges with remote learning

3.1 *Distracting Environments*

A classroom setting tailored to a child's success is entirely different from trying to learn in the living room, yet this is the harsh reality for a large portion of Americans dealing with the effects of remote learning. At home, distractions are plentiful, so students are having trouble staying focused while attending online lectures.

Along with distractions, learning from home does not offer the same camaraderie as the classroom's buzz, and many students are struggling to stay motivated in these undesirable environments. Students sacrifice the opportunity to do group work, have class discussions and collaborative activities, so it is no surprise that they are less motivated and engaged with remote learning. According to eLearning Industry, 55% of students find the lack of social interaction troubling, and 64% of students expressed concern about staying motivated and maintaining focus because they are easily distracted, making remote learning not an ideal situation [14].

3.2 *Scheduling conflicts*

Remote learning has posed complex scheduling concerns for students but more significantly for parents. Parents were forced to figure out solutions to support these unforeseen circumstances that led to remote learning with the initial transition. This was a challenge for many families who work full-time jobs and do not have the luxury of working from home.

3.3 *Poor Online Training Content*

What works best in instructor-led curriculums may not be best in remote learning environments. Teaching professionals who were not specifically trained to teach online content could have trouble translating courses to the point where they are not useful.

3.4 *Technological challenges*

3.4.1 *Technical issues (Know-How)*

The remote learning transition affected all school-age children, even as young as three years old. Researchers have found that many younger children have had trouble with the remote learning environment simply because they are not yet familiar with the technology. Younger school-age children lack the necessary know-how, and transitioning into this environment could bring upon frustrations. This is also crippling for the parents of younger children as they are almost forced to be virtual teacher assistants as many courses require help from them for the lessons to practice [8].

3.4.2 *Increased Cyber Attacks*

There has been a global increase in cyber-attacks due to the widespread transition to remote learning. These schools and colleges were forced to transition almost overnight, making it nearly impossible to implement security precautions simultaneously. Many did not have the time or resources to invest in security protocols leaving remote learning platforms vulnerable to cybercriminals' attacks.

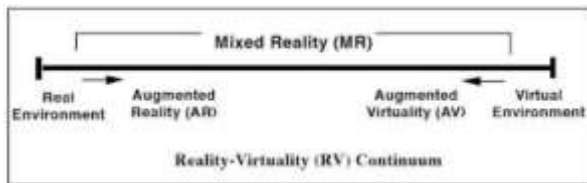
4 Electronic learning (E-learning) and Augmented Reality capabilities in education

Educational psychologists suggest that "in order for students to stay motivated when learning at home, students need to feel competence, relatedness, and autonomy" [9], and what better way to do this by implemented augmented reality in the remote learning spectrum. Technology has brought upon new opportunities to improve the quality and teaching and learning experiences. The pandemic has only

strengthened the need for these technologies as we see first-hand the challenges of remote learning on students. AR offers a unique solution to these challenges by giving students a way to immerse themselves into interactive AR stimulations that are engaging and fun [8].

4.1 History of E-Learning

In the 1840s, Isaac Pitman established the idea of E-Learning before the internet; it started to provide students with education on unique subjects or skills. Pitman used distance learning to teach students



shorthand, a form of symbolic writing created to improve writing speed. Pitman would correspond with students via mail, sending and receiving complete assignments from students. It was not until 1954 when Harvard Professor BF Skinner invented the "teaching machine," which allowed schools to administer programmed instruction to students [13]. In 1960, Programmed Logic for Automated Teaching Operations (PLATO) was the first computer-based training program was introduced to the world. Initially, online learning systems were only intended to deliver information to students, but as the world entered the 70's, there was a push for online learning to become more interactive[13].

As a result of the computer and the internet's introduction in the late 20th century, e-learning tools and delivery expanded. Now that computer was more of a commodity and household item for the wealthy, E-learning and virtual learning opportunities began to thrive. "By the early 90's several schools had been set up that delivering courses only", making education more accessible to those who had geographical or time constraints [13].

4.2 Current Augmented Reality Capabilities

Augmented reality in education can serve multiple purposes. It can help make learning more fun and exciting, but it also helps students acquire, process, and remember information. Ultimately AR is a part of an XR concept, including virtual reality and machine learning capabilities [7]. "AR systems lay

inside Mixed Reality (MR) where most of the information is real, and there are some virtual elements included that supplements it. Azuma (1997) defined three characteristics of AR systems to be an application that:

- Combines real and virtual
- Are interactive in real-time
- Register in 3D

AR is used to enhance real-world environments; in this case, the classroom environment uses text, sound effects, graphics, and multimedia. AR comes in various forms; the hardware ranges from primary handheld devices such as smartphones and tablets to more advanced hardware like AR headsets such as AR glasses. Although in recent years, handheld devices have been mostly popularized in the use of AR in everyday life because they allow a "video see-through metaphor" without the use of Head-Mounted Displays (HMD) and are proven to be more convenient [7].

Figure 2: Milgram's Reality-Virtual Continuum

4.2.1 Handheld Devices

Hand-held AR refers to smart devices that are used to render AR rich multimedia experiences. Handheld devices are increasingly becoming tools of widespread use of machine learning since they now have various sensors, communicative, and processors that allow them to display advanced technologies.

A study was conducted in 2010 by Huang, Lin, and Chen to assess the effectiveness of a Mobile Plant Learning System (MPLS) versus a traditional textbook. The study consisted of 32 children around the average ages of 11. Two groups were formed; those who used the system and those who used the textbook. The results showed that the MPLS students had a more positive attitude toward the learning activity. Although they were some difficulties reported with the user interface, the study concluded that mobile devices and outdoor learning strategies were practical tools in teaching students about plants [9].

4.2.2 Head-Mounted Displays (HMD)

The first versions of HMD's appeared in 2013 introduced a new generation of consumer-priced VR technology that revolutionized the potential for VR/AR capabilities within education. Before this invention, HMD's were extremely expensive. Earlier versions dating back to 2006 were in the range of USD 45,000 compared to more recent models that are

as low as USD 1,300; besides the price factor, the new generation of HMD's offers a better user experience more ideal for educational use cases [9].

In 2007 a study was conducted to test the effectiveness and usability of an HMD project called CONNECT. "The CONNECT concept required students to wear HMD headsets and a related computer-mediated learning platform in order to visualize and physically and intellectually connect with learning environments that deal with instructional materials. The study researched a group of students with disabilities and a group of non-disabled students. Interestingly enough, the study showed that the test results of students with and without disabilities were nearly the same. On the premise, the results showed much potential to improve the educational landscape for students with disabilities [9].

4.3 Benefits of AR in education

There are tons of advantages to implementing augmented reality in education, specifically remote learning. AR would enhance motivation and increase engagement for students who struggle to focus on the at-home environment. It could also lead to a better understanding of complex ideas. Studies have shown that some students perform more poorly with distance learning due to the lack of face-to-face instruction. AR could enable better visualization. The ability for concepts to be repeated allows students to learn at their own pace, resulting in better memory retention of the subject being taught [15].

5 Expert Interviews

5.1 Gheric Speiginer

Generic Speiginer is Hampton Alumni, graduating with a bachelor's in Computer Science. He is currently pursuing his Ph.D. in Human-Centered Computing At the Georgia Institute of Technology.

Could you speak a little about your experience with Augmented Reality or any research you may have conducted related to it?

Developing software architecture enabled immersive applications to adapt to different kinds of hardware configurations and adapt those applications to different physical environments. The second part of the research is developing the tools and abstractions

that designers need to create content tailored explicitly towards user interface elements displayed in an immersive presentation.

Do you think implementing augmented reality technologies will lesson challenges with Remote learning, such as lack of engagement?

There is much potential in making remote learning feel more natural. There is much value in adding AR or VR to the classroom learning environment, but I am not sure if the technology is there yet where it is as convenient for the remote environment. Take VR; for instance, the headsets are still bulky and heavy to be wearing for long periods. Although the prices have dropped dramatically, they still are pricey. Most students will still require computers or tablets for work have to do so the additional cost to have these headsets to have a more social experience would probably be a bit much. With AR, it would probably be more convenient, but the price factor would be way more. I think that augmented would be a better fit in the long run because you could still be working on your laptop, and other people or a representation of other people could still be in the same space. Nevertheless, want to create a classroom environment where you can look and be inspired by others' work, almost more of like an art studio environment would probably be ideal.

Which do you think would be more useful for Remote learning? AR or VR?

I think that augmented would be a better fit in the long run because you could still be working on your laptop, and other people or a representation of other people could still be in the same space. Nevertheless, want to be able to create a classroom environment where you can look and be inspired by the work of others, almost more of like an art studio environment would probably be an idea.

Due to your expertise with the subject, can you think of any unique ways to implement AR within a remote learning curriculum?

It's interesting because you do not want things to be distracting on one end, but you still want students to be able to interact casually when allowed. It's difficult to imagine what the right solution would look like. This is a similar thing to conferences, one

of the values of going to a conference is that you will run into people in the hallway, for instance. However, when you do remote conferences, there is no virtual hallway to bump into people, so you lose that advantage. There is probably something similar that happens in classrooms as well. So, the biggest challenge is finding a solution that allows this coincidental casual conversation and making it useful enough on its own so that students will be comfortable wearing AR/VR headsets. You almost want students to be passively connected while doing their work where you could have the ability to like to stand up and run into someone. However, something like that would require the hardware to be convenient, almost like a regular pair of glasses.

Do you foresee any security challenges that implemented AR technologies would bring forth?

Yes tons, Security is a huge deal when it comes to augmented reality, mainly just because of how it works. It gathers much information about the world around you but even more so with AR because it is collecting information you may not be aware of. It is a broader problem because companies like Facebook and Google are always collecting information on us and can predict our actions from moment to moment and often know us better than we know ourselves. AR makes that more accessible because there is more information being gathered from our environment. So yeah, tons of privacy and security concerns there.

5.2 Ulrich Neuman

Ulrich Neumann is a Professor at the University of Southern California. He teaches Electrical and computer engineering. He has expertise in the subjects of interactive media, technology tracking for augmented reality, face modeling and animation and immersive environments.

Could you speak a little about your experience with Augmented Reality or any research you may have conducted related to it?

I first was exposed to AR in the late '80s when I entered the Ph.D. program at Chapel Hill, NC. The graphics group there was run by Prof. Henry Fuchs. It was all around the lab, so I picked up all sorts of info and ideas. My first project in AR was

related to tracking for video-based AR. It got me "hooked" on the topic.

When I started at USC ('94) I pitched ideas to my students. AR soon became a core topic of my lab group. We worked on AR topics and published lots of papers over the next 20 yrs. I was fortunate to find a collaborator in Dr. Anthony Majoros at The Boeing Company in Long Beach (near USC). With his help and contacts, we could explore AR for guiding manufacturing and maintenance workers in the aircraft industry and in general. We later worked with Airbus and Korean Air. Having a specific problem to solve with AR is essential. Others in Europe have done similar work for auto workers. Chapel Hill has chosen to work with surgeons as their problem domain. Without a problem to solve, there is no meaningful measure of success.

Do you think implemented augmented reality technologies will lesson challenges with Remote learning such as lack of engagement, etc.?

It's hard to say much about any AR application until you have a prototype running. AR is an "experience," so talking about it or imagining it is rarely predictive of the real thing. At a minimum, you would need to produce a mockup video that simulates the system working. Getting actual numeric measures of effectiveness is really hard. You need to be able to show metrics and improvement if you expect people to pay for something. In our cases, we were never able to show enough to "launch" the technology and make it commercial.

Due to your familiarity with the subject, Can you think of any unique ways to implement AR within a remote learning curriculum?

No really. I now do zoom classes myself, and I can't see how AR would impact what I do, but to be fair, I don't have someone handing me an AR system that's ready to go like zoom is. It is a chicken and egg problem. I can't use an AR system until there's a good one available, and there's no one working on a polished professional system without the customer base to support its development. This happens all the time with new technologies.

Do you foresee any security challenges that implementing AR technologies would bring forth?
 No - Security does not seem to be a significant factor currently.

6 Current Augmented Reality apps on the market related to education



Figure 3: Image portraying MERGE cube AR experience

6.1 *Merge Cube*

This is a mobile tool, an AR multi-platform tool that enables students to hold a hologram in their hands. Depending on the MERGE's applications that you download, it can become many different things. With Merge Cube, teachers can create STEM lessons and activities or experience science or history. Students can also develop the content, make applications, and see their creative products come to life in AR. This is a great way to get students to see the results of what they create, a very first step to motivate future developers [10]. The instructions to use Merge Cube are pretty straight forward. All students would have to do is download and launch the MERGE cube app on their smartphone or tablet and then point the device in the direction of the cube and watch the cube transform into a virtual object as they hold it [10].

6.2 *Elements 4D*

Like MERGE cube, Elements 4D is a mobile AR tool that provides students with a unique opportunity to see chemistry in action. Teachers and professors can print out and assemble blocks to understand complex concepts better; these blocks become trigger images for an AR experience. They also offer lesson plans for DAQRI'S website, the app developer, so students at all levels can enjoy this fun and immersive experience [5].

6.3 *Blippar*

Blippar is an AR tool that can be integrated into a multitude of educational experiences. They offer a range of products from "Kellogg's," which teaches kids essential skills through play, to a "brain space magazine" that allows individuals to scan book pages to connect to more interactive content. The main feature of Blippar is that it can bring two-dimensional presentations to life, completely transforming a child's reading experience for the better [10].

6.4 *CoSpaces Edu*

This is a design tool that allows students with coding experience to create virtual 3D worlds. They can also create infographics and tell stories through virtual exhibits and tours. With CoSpaces Edu, the teachers create a class and post assignments. Images and 360-degree photos can be uploaded, and a companion application is available[10].

6.5 *Mondly*

Mondly is by far the most immersive app discussed thus far; it is a language-learning mobile AR app that uses a smartphone as a lense to display a virtual teacher to help users practice skills in their real-life environment. Mondly also offers a Chabot experience with the virtual teacher that allows student



to get real-time feedback [2].

Figure 4: Image displaying Mondly's Virtual Teacher [2]

7 *Conclusion*

Although AR can be used as an effective tool to aid in making remote learning more engaging for students, it has its own set of disadvantages that must be considered before implemented such technologies. The use of AR in any given field presents itself with a major security concerns mainly centered around privacy. Smart systems such as AR and VR require a

lot of information gathering, and as a result, more and more data is generated of an individual's physical environment. This may be a challenge for the future of AR within the education spectrum.

Teaching professionals must also consider that using these AR-led instructions courses may distract students even more from the lesson. They must caution themselves not to overuse these tools so that they remain an effective tool in improving education remotely.

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