Augmented reality in education

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Abstract

Smartphones are more affordable and common than ever. And with it we have witnessed the rise of augmented reality (AR) and virtual reality (VR) too. Both in terms of its usability and affordability. As of now, it has been in major use in the commercial world, with e-commerce stores [1] *and applications like Snapchat with hundreds of millions of daily users* [2]*. But still, we are yet to witness perfect synthesis of smartphones and AR/VR technology in the education sector. There have been innovations but no one has been able to leverage this exciting technology in education to the fullest. We have seen that one of the promising technologies that can transcend level of education is the augmented reality. This work consists of data, research and arguments on why it is time to bring augmented reality into mainstream education.*

I.   Introduction

Snapchat falls in the perfect intersection, where their majority users are students and they use augmented reality technology. People knowingly or unknowingly use AR in their day-to-day life. Thanks to Snapchat, a majority set of smartphone users are already familiar with AR, especially students. Most snapchat users are and will be the first generation born in 21st century. They will be the most technologically infused demographic up to date. They are used to using smart devices naturally and we do not want augmented reality be part of only entertainment part of the picture[i]. Another reason why Snapchat is perfect example because it is a smartphone application. And they have successfully proved that you can gain hundreds of millions of users [2] by using novel technology such as AR. But what exactly is AR and how it is going to help out in revolutionising education. Let's find out.

II.   Detail explanation

1.   What is augmented reality?

Augmented reality or AR is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory. [3] [4] It changes your physical environment, kind of upgrades it, to give you an immersive experience. By combining technology and sensations, it is perceived as natural part of your

environment. The primary value of augmented reality is the manner in which components of the digital world blend into a person's perception of the real world. With the help of AR, your surrounding becomes interactive and digitally manipulative. [5] It gives user autonomy to manipulates their environment with the endless possibilities in the world. Unlike virtual reality (VR), AR is part of the surrounding environment is actually 'real' and it just adds layers of virtual objects to the real environment. Manipulating your environment to the extent, that it could be replaced by textbooks [6] and reading curriculums [7]

2. Education in augmented reality

The augmented reality market was valued at USD 14.7 billion in 2020 and is projected to reach USD 88.4 billion by 2026; it is expected to grow at a CAGR of 31.5% from 2021 to 2026. [8] The augmented and virtual reality in education market is expected to grow from USD 9.3 billion in 2018 to USD 19.6 billion by 2023, at a Compound Annual Growth Rate (CAGR) of 16.2% during the forecast period. [9] And the global online education market will reach around USD 450 billion by 2023 [10], that is less than 5% of global online education. That means that most education currently is happening with the same old teaching methods but just digitally.

There is no as such innovation in the way students were taught about a subject. While VR could be a hassle to improve education with technology, as we will discuss later on, AR is promising technology to bet on. In educational contexts, knowledge is typically learned from visual, auditory, and sometimes tactile representations. Paper-based textbooks carry static visual content, such as text and diagrams. Through augmented reality, content can be presented in a variety of other forms: Static images become animations, 2D representations become 3D objects, text becomes sound, and noninteractive content becomes interactive. All these changes in representation can be educationally effective, as information becomes easier to process and appeals to different learning styles. [11]

While AR learning experiences can take a variety of forms. Smartphone-based AR applications allow learning with users to travel through their environment while looking at their augmented world through a mobile device, hence being cost-effective too. [12]

A study showed that AR and VR can both be used effectively to teach science-based information, specifically with smartphone learning. [13] Just like that, there have been bunch of studies showing the practical learning from AR. Seo et al. [14] tested the effect of AR in a classroom setting. There 9-12 year old students learned about the volcanoes. They compared the effect of teaching with textbooks, teacher-controlled AR, and student-controlled AR. The research shows that students learned significantly better under the AR conditions, but no significant differences were found between the AR groups. Chen [15] showed that students will have a better understanding of chemical structures when they learn individually using AR versus using textbooks. Talking about human anatomy, Nischelwitzer et al. [16] showed that students with an interactive AR system learned better

than using a traditional textbook. It is worth noting that in this research, the AR system did not only provide interactive 3D visualizations, but also administered test questions.

With all these positives of AR, other benefits of using augmented reality includes long term memory retention [17] [18], learning language association [19] [20], improved physical task performance [21] [22], better collaboration [23] and increased motivation [24] [25]. This should not come as a surprise since students are actively learning with the immersive experience of AR. Where the learning feels less like a task and more like a play, a game.

3. Learning with gamification is better than typical learning

Every educational-tech company in the world is right now trying to make learning as fun as possible. They understand that humans learn best when it feels like a play to them. Digital game based learning has been found more effective in promoting students' knowledge of computer memory concepts and more motivational for students than the non-gaming approach [26] Using gaming approaches towards learning can considerably improve both knowledge of the embedded subject matter and student enjoyment, engagement and interest in the learning process. [26] In recent studies, we have found out that even personality traits affect your learning through gaming methods. [27]

Game designer Jane McGonigal [28] characterizes video game players as urgent optimists who are part of a social fabric, engaged in blissful productivity, and on the lookout for epic meaning. If teachers can successfully organize their classrooms and curriculum activities to incorporate the elements of games which facilitate such confidence, purpose and integrated sense of mission, students may become engrossed in learning and collaborating such that they do not want to stop. The dynamic combination of intrinsic and extrinsic motivators is a powerful force [29] which, if educational contexts can adapt from gamification, may increase student motivation, and student learning. Once the motivation comes intrinsically with the slight adjustment in the environment, learning hardest concepts in the world becomes easy.

4. Augmented reality: a means to teach frontier tech

Technology is changing faster than ever. With so many changes in the technology everyday it is nearly impossible for education institutes to keep up with it. While most institutions don't even have means to teach new domains to students because of lack of teachers in the novel fields. Augmented reality could be helpful there to help institution teach frontier tech to students. Because it takes time for every novel field to gain enough awareness that people are willing to teach. Hence creating a shortage of teachers early on, in that particular field. There have been many innovations in the world, from biotechnology to climate change. But majority of students would not even be aware about them. On the other hand, technologies like blockchain, will ultimately help educational institutes improve in terms of

learning, security and much more. [30] But because of lack of teaching resources, we won't be able to leverage frontier technologies completely. Augmented reality curriculum would turn these hard concepts into interactive and fun session. Learning practically helps them use of that information at that moment and retaining more information than before. For example, in blockchain: visually witnessing building blocks on chain and storing information into them would help students better to understand it than typical theoretical learning.

5. Applications of AR in particular education fields

Augmented reality is disrupting every domain in education in unique ways. Let's find out how:

5.1 Healthcare & Fitness

Interestingly, one of the first applications of augmented reality was in healthcare, particularly to support the planning, practice, and training of surgical procedures. Back in 1992, it was used to enhance human performance during surgery. It was the formally stated objective when building the first augmented reality systems at U.S. Air Force laboratories. [31] Afterwards, there have been ever more interesting use cases of AR. Like to enhance viewing a fetus inside a mother's womb [32] or treating cockroach phobia [33].

On 30 April 2015 Microsoft announced the Microsoft HoloLens [34], their first attempt at augmented reality. The HoloLens has advanced through the years and is capable of projecting holograms for near infrared fluorescence-based image guided surgery [35]. Augmented reality can be used to provide crucial information to a doctor or surgeon without having them take their eyes off the patient. Imperical college of London performed 5 reconstructive lower limb surgery with 100% success with the use of Mixed Reality and Microsoft HoloLens. with human patients who ranged from a 41-year-old man who had sustained leg injuries during a car accident, to an 85-year-old woman with a compound fractured ankle. [36]

In fitness, AR hardware and software for use in fitness includes smart glasses made for biking and running, with performance analytics and map navigation projected onto the user's field of vision.

5.2 Architecture

AR helps in visualizing building and other architectural projects. Computer-generated images of a structure can be superimposed onto a real-life local view of a property

before the physical building is constructed there; this was demonstrated publicly by Trimble Navigation [37] in 2004. It is employed within an architect's workspace, rendering animated 3D visualizations of their 2D drawings. Architecture sight-seeing can be enhanced with AR applications, allowing users viewing a building's exterior to virtually see through its walls, viewing its interior objects and layout. [38]

5.3 Science

2015 Virtual, Augmented and Mixed Reality: 7th International Conference mentioned Google Glass as an example of augmented reality that can replace the physical classroom. [39]

In higher education, Construct3D, a Studierstube system, allows students to learn mechanical engineering concepts, math or geometry [40]. Chemistry AR apps allow students to visualize and interact with the spatial structure of a molecule using a marker object held in the hand [41]. Using this technology to learn anatomical structures has been shown to increase the learner knowledge and provide intrinsic benefits, such as increased engagement and learner immersion [42]

5.4 Archaeology

AR has been used to get help in archaeological research too. By augmenting archaeological features onto the modern landscape, AR allows archaeologists to formulate possible site configurations from extant structures. [43] Computer generated models of ruins, buildings, landscapes or even ancient people have been recycled into early archaeological AR applications. [44]

6. Why not virtual reality?

Basic difference between virtual and augmented reality technology is that AR uses your physical space while VR is not limited to it. The possibilities are quite literally endless in virtual reality; because it is world on its own. While it requires nothing but your smartphone to access your augmented reality application. It requires a complete headset and other accessories to access the virtual reality. Your interactions and functionalities are limited to your access to the resources in virtual reality, unlike AR. The equipment used in VR are expensive too. [45] There is little possibility of it to reach the masses. While VR has been found more useful in transmitting visual knowledge and AR has been more helpful in transmitting auditory information. [13] Other benefits of using AR over VR exceeds these limitations. While VR is a technology on which top companies in the world are betting on, its applications are more in the world of gaming. And despite being immersive and interactive, it has not been found helpful in the education.

7. Shortcomings of AR

With all the benefits, we've discussed so far, there are lots of problems with the technology too. As it becomes more adaptable in educational institutions, we're going to learn about it and understand its shortcomings. Most evident one seems limitation of physical space for students. In a classroom setting, it could be not possible for each and every student to use the technology with the instructors' help. And it could possibly decrease the teacher's engagement with the students. As it has been studies that learning is more engaging in a non-AR setting, than an AR one. [46]

While the young people are quickest learners, the learning curve of AR could be steep. It has been observed to be difficult in usability than non-AR alternatives in learning. But in the gaming, it has been found more engaging than non-AR alternatives. [11] Another interesting research found out that, although low and average achiever students showed learning gains through the AR experience, high achieving students did not receive the same benefits. In fact, the high-achieving students showed more learning gains in a traditional classroom where AR was not used. Potentially, the AR-based educational content was too limited in scope and did not contain novel information for the high-achieving students. [47]

AR came to the masses with the game called Pokemon Go [48] and sadly it caused some devastation too. In a paper titled "Death by Pokémon GO", researchers at Purdue University's Krannert School of Management claim the game caused "a disproportionate increase in vehicular crashes and associated vehicular damage, personal injuries, and fatalities in the vicinity of locations, called PokéStops, where users can play the game while driving." [49]

With further privacy concerns in the AR, overload and over-reliance issues are the biggest danger of AR. For the development of new AR-related products, this implies that the user-interface should follow certain guidelines as not to overload the user with information while also preventing the user from over-relying on the AR system such that important cues from the environment are missed. [50] This is called the virtually-augmented key. [50] Once the key is ignored, people might not desire the real world anymore.

III. Conclusion

Augmented reality can be a very promising technology in education. In order to put forward the vision into reality, we have a long way to go. Almost all reputable institutions are hundreds of years old with similar curriculum. There are also several topics that need to be addressed in order to ease the adoption of this technology into school classrooms. First, AR experiences need to be designed with curriculum and pedagogy in mind. Future research must identify curriculum topics that are currently difficult to teach using other media and are worth the investment cost for AR. [11] But for now, to give ignite to the revolution, we

have to mandate the use of AR in some courses. These could be courses like biotech or mechanical engineering, where practical use of the knowledge is performed in the external environment. Once they start adopting the AR tech, we will be able to observe the possible shortcomings and make necessary improvements with future iterations.

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