

A Preview of Augmented Reality as Pioneering Method in Education

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Abstract—In Today's fast paced world, constant changes occur in everything around us especially technologies and this triggers the education sector to embrace the advancements. One such major distinctive approach is 3D Augmented Reality (AR). AR strengthens & supplements what can be seen, heard, smelled and sensed and allows the users to interact with the real & virtual worlds simultaneously. This paper reviews on how AR has been used in various genres in the field of education. Also, the benefits, the barriers faced and tests results over how effective is AR in acquiring knowledge is discussed. Amongst the varied published papers, the documents picked in this survey are from prominent journals, special issue articles and conferences that have implied 'Marker based augmented reality'. The paper will give an overview about the prevalent methodology used in developing the AR based applications. Adding to the aforesaid data, the paper also gives information on, how in pandemic situation, AR has brought a new dimension to online classes and has become the head-turner.

Keywords: 3D, Augmented Reality, Engineering-course, Lab, Teachers, Education, Unity, Vuforia.

I. INTRODUCTION

In the modern era, revolution in technologies is transforming the planet into a digital world. Our reality is beckoning these innovations to change the lives for better. Additional enhancements are required to make life more intriguing and contentment is sought in renovated reality (digitally). One such greatest innovation from 1990 is Augmented Reality. Though in existence since long, AR technology is available in every field (Medicine, Retail, Education, Defense, etc.) these days and is also accessible with ease due to the commercialization of smart phones and tablets. The devices used for AR, stratum digital items on the top of elements that we see in real world.

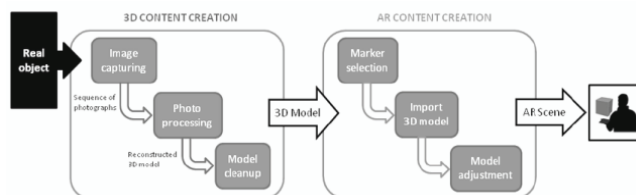


Fig. 1: Creating AR Content

Amongst the four types of Augmented Reality (Fig. 2), the paper has focused on Marker based AR, in which a

smart phone scans a steady 2D image and a 3D model or an audio or video or a combination of these pops out.

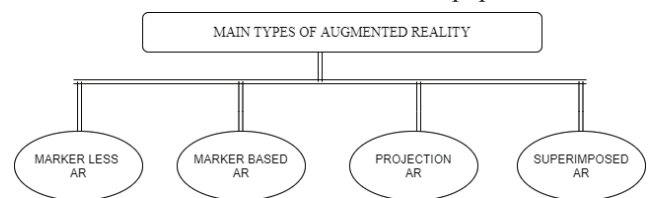


Fig. 2: Types of Augmented Reality

Implementing Augmented Reality in education takes a divergent trajectory approach from the traditional method of teaching and learning and still tries to channel the gap. Studies have recognized that AR based learning improves the spatial skills, stimulates the thinking process and motivates the students to perform well in academics.

Section 2 of this article, gives a deeper survey about how Augmented Reality applications have been used in primary, higher and college education. The predominant software packages that are used to build the AR apps have also been analyzed [1][3][5][11] followed by the pitfalls upon inculcating this practice in education[18]. Strategies for testing the renewed learning method varying from "NASA: TLX" to 'Wilcoxon Test' or traditional approaches or TAM model, [3] [4] [15] have been surveyed. In section 3, the future scope of AR is highlighted.

II. LITERATURE SURVEY

Procedure to design/develop an AR application using the 3D modelling software is to some degree to be aware about [1]. Augmented Reality being the centre of lure amongst users of smart phones, possession of basic knowledge on how it is made and how it works is essential. The two giant names associated with AR are Unity and Vuforia. Unity3D is a gaming tool used to layer the virtual content in three dimensions over the objects in the real world making a possibility for interaction between system and human. The detection of the target images/markers and a lot more 3D add ups happens here. On the other side, Vuforia is a kit for software development that makes use of computer vision and is the backbone for object detection from camera.

Svitlana I. Pochtoviuk et al [2] realized the commendable impact of Augmented Reality and have performed a detailed study on feasibilities of integrating AR in various educational fields such as Chemistry, Anatomy, Physics, Maths, architecture, etc.. A Diligent comparison of national and international AR applications has been included as a part of the study. With foreign projects focusing on interactive and innovative AR applications for children, domestic proposals focusing on interiors, astronomy, medicine and other fields have been reported. With suitable and apt applications for specific fields, implementing them in further educational levels is recommended for future research.

A. Augmented Reality Implemented in Several Fields Associated with Education

TABLE 1: SURVEYED IMPLEMENTATION OF AR IN VARIOUS SECTORS

| S. No | Category | Reference |
|-------|--|---------------------|
| 1. | Primary Schools | [3] |
| 2. | Study of Arts (Museum) | [4] |
| 3. | Engineering-Courses (Theory) | [5] [6] [7] [8] [9] |
| 4. | Engineering-Courses (Practical/Laboratory) | [10] [11] [12] |
| 5. | Storybook for kids | [13] |
| 6. | Landscape Architecture | [14] |
| 7. | History of a country via game | [15] |

B. Primary School Level

Veronica Rossano et al [3] came up with an application in Augmented Reality named as Geo+, owing to the advancement in technological tools employed in education. The suggested application which was developed using Unity & Vuforia is interactive in nature and mainly targets the primary-schoolers to understand geometry in a better way. Having tested the application with around 96 school students and validating them over NASA TLX and UES questionnaires, the app proved to be very effective since it has been developed more like a game to increase the student's interest. The authors have suggested enhancing the multimedia portions in geometrical figures and a mode for self-assessment within it.

C. Museum Art Works

Assessing from the university point of view; the bundle of factors generated from Augmented Reality while training the impending teachers has been detailed out [4]. Roughly about 87 teachers, who were trainees, were taken in consideration for the study and were tested by Wilcoxon test method. Sketch up application was used to have a 3D view of museum artworks. The study found that without proper planning and equipping the teachers with necessary technical knowledge, the AR based education would merely be considered as time consuming and distraction filled method. So, the results highlight the fact that - to witness the benefits of augmented reality, a prior training is mandatory.

D. Engineering Courses (Theory)

Realizing the struggle of engineering students in studying Embedded Systems [5] has given the possibility for a special article about the same. As this course comprises of not just electrical and electronic objects but also includes programming and mathematics, the typical teaching method wouldn't be effective for the present generation. Considering this fact, the authors have proposed an education learning method coupled with animation or three dimensions with tangible features for the students to have a deeper insight of the subject. The developed model was tested with 20 staff members and the summarized score was 79.5% in terms of being suitable to use. The system was designed using Unity 3D, Vuforia and 3D Maya software and various hardware components. In future, this new gen learning culture can be introduced amongst students for experimental studying. Fig. 3 illustrates an approximate estimate of how AR based teaching helps in consuming less time.

Implementation of augmented reality is contributing towards saving time in lecturing

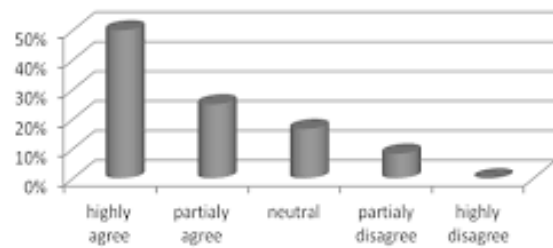


Fig. 3: Implementation of AR in Saving Lecture Time

Oguz Colak and Lokman Yunlu [6] have shared their research on the application of both AR & VR in engineering prospectus. In 21st century, the engineering students are expected to have great skills of communication, ability to innovate and have practical expertise. The market has lot of multimedia tools (smart-phones, smart-watches, tablets, podcasts and screencasts) to support them. Though every subject within engineering will be intriguing when viewed in 3D, subjects like Engineering Graphics, Fluid Dynamics, Mechatronics, etc will help the aspiring engineers to get a deeper perception of what they see or what they study. The paper has also spoken about virtual reality in welding section. The conclusion by authors is to improve the theory and lab materials towards e-learning since both VR and AR can be deployed at ease in engineering training.

Apprehending the fact that students especially those who hail from non-technical background struggle to learn mechanical subjects due to more of complex designs and models involved in it and following the instructions that are written or printed while using the machines can lead to slipups. AR has not been explored much in mechanical

field, so the AR scenario was applied on this [7], which can be accessed by tablet as well as the ‘HoloLens’ glasses. Experiments were piloted in 2 sets with 1st and 2nd Year College students, one with AR and other with usual CAD tool over an ‘electric actuator’. The results were in favour of those who used AR learning method. Augmented reality supported learning, eases the spatial visions which is much helpful not only education wise but also in industries. With this kind of effective learning, students can get more of practical knowledge rather than theory.

Implementing AR in engineering curriculum is not an easy task and similar to this saying, Mehmet Simsek et al [8] have presented their trials & tests about the same while implementing AR in the stream of Computer Science. Amongst the varied subjects within CSE, the focus is on Discrete Maths (DM) as it acts as the base for many concepts within the curriculum. The main factor to be considered in “Target mapping AR” is the detection of key-points on the image (Fig. 4) and it has been tested with test scripts of “Python” and “OpenCV”. The authors have concluded with various real time issues in using AR application and have suggested testing the e-learning technique in one of the semesters.

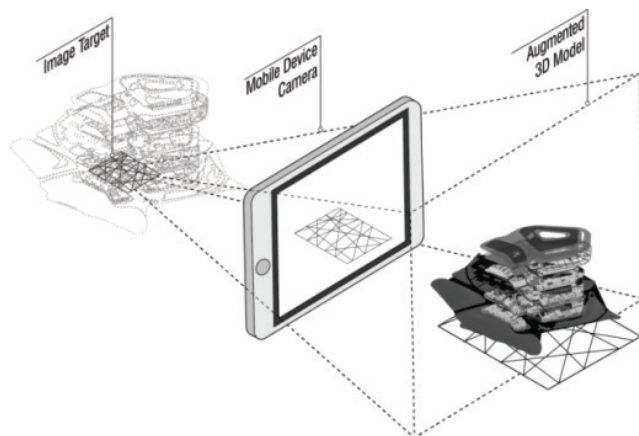


Fig. 4: Marker based AR Layout

Insights on the absence of appropriate research and study materials in the fields of Engineering Graphics and Descriptive Geometry have been reported [9]. The usage of AR in certain educational courses, the way in which the concepts are being taught and in what way the learning has created an impression on both the learners and the teachers is the prime motive behind this study. The methods used to measure the parameters were a) Theoretical b) Empirical and c) Experimental. Identifying the articles related to AR in education sector from the Database like “ERIC and ProQuest” is yet to be done. Laboratories with at least minimal AR facility to have professional hands on experience for the graduates are a future vision.

E. Engineering Courses (Practical/Lab)

Augmented Reality to be incorporated to train the engineering students during their practical periods in

their respective universities has been researched [10]. The augmented reality application used here is HP Reveal that demonstrates the working of the equipment in physics lab via video for improvised understanding which otherwise were studied by them only from books. A National University conducted an experiment with their 1st year batch from Software Engineering Department and valued the efficiency parameter of implementing AR by splitting the batch into Control Group and Experiment group. The 40% and 16% of additional impact on the experimental group summarized that application of AR for engineering students are efficient.

Learning the lab exercises in a distinctive way is enthralling. True to this, Ankita Sarode et al [12] and Saba Baloch et al [11] have come up with proposals that help the students in engineering institutes to have a unique way of learning their lab exercises unlike the usual learning from handbooks and kits. While the former proposes an innovative approach of interactive guidebook for lab, the latter focuses on applications on Augmented Reality in practical classes and their advantages.

A university’s entire lab course of ‘Analog and digital communication’ was made interactive with AR using Vuforia, Unity 5.5.0 along with video playing facility. While, the other paper details the development of android AR app that displays the 3D models of Kits with audio developed using Blender and Unity software. The common scripting language used in both the cases is C#.

Drawbacks stated in the first paper is that, handling a device while working with the equipment might be burdensome so suggestion for compact head fitting devices in future. Saba Baloch and the co-authors have reported that apart from labs in colleges and schools, the presence of lab in any sector can apply AR.

F. Storybook with AR

The concept of visualization can be seen from a commercial aspect too [13]. The AR application developed is about a story book for the children with audio, visuals and feel. The app named as Goon AR has been developed for android phones to enhance the interest in learning amongst the children in an enjoyable manner. GoonAR was developed using Unity, Vuforia, Blender, Adobe Photoshop and Visual Studio which is brought to reality through a Pseudo book of around 15 pages. The book supports 2 languages (English and Filipino). Here when the app scans the markers in the Pseudo book (Fig. 4.), the characters in the story appear in three dimensions with audio. The search for the publisher of this book in large scale is under consideration.

G. Landscape Architecture (Practical/Lab)

When visualization is to be considered as the main criteria then the work by Jeremy Kerr and Gillian Lawson [14] should be considered. An AR app called “Master of

Time” was created exclusively for designs of Landscapes to be of help for the 1st years and learners from non-design background. The authors have mentioned stringent rules and ways in which AR can be learnt across disciplines. Abbreviated as m-education, this proposal came into picture due to the nonexistence of landscape architecture amongst the acknowledged apps.

The study in this discipline involves field-trips to indoor and outdoor locations which are seen as a challenge these days. A combined effort of literature and design teams lead to this app creation. The application is made livelier with the story telling feature while unlocking levels in the game. A reference to a botanical garden is pictured here to have a linking to the nature. The authors conclude on the point that besides being an educational tool in institutes, these apps can help the public while visiting the sightseeing locations.

H. Learning History of a Country Via Game

As history is a subject to be known by everyone, teaching it in an impressive manner right from early age at school would be the most efficient approach. Hence, the authors [15] came up with idea of inducing fun with learning and achieved it by developing an AR application more like a game named as ‘HistoriAR’ built using Vuforia and Unity software. The application is found to be lively due to the feature of interaction with the ancient characters within the game. The implemented app was tested using the model, “Technology Acceptance” and the results were impressive. In spite of the app being perceived well, there is a suggestion to make use of better measures to evaluate the perseverance & fun factor of the users while using these applications.

I. Advantages & Shortcomings over Applications of Augmented Reality

TABLE 2: MERITS & DEMERITS OF AR

| Authors | Issue Addressed | Methodologies & Findings | Conclusion |
|---|--|--|---|
| Nor Farhah Saidin, Noor Dayana Abd Halim and Noraffandy Yahaya | [16] The intention to improve the way in which students are taught, need a back-ground check of the existing problem in the traditional method. The brighter side of AR enactment in education has been researched | Surveyed over various verdicts, it is affirmed that, with AR, students can acquire great wisdom since they learn through animations and interact with the non-real items and it can be learnt away from class too. | Since the demerits of using AR are technical related; with exploration of the capabilities of AR, these shortcomings can be overcome. |
| Mona Alkhatabi | [17] Hurdles in accepting and using the AR based learning from the teacher's point of view especially those in the primary school level. | “Likert scale” was used to measure statistical data. Analysis using SPSS. The hurdles faced are absence of enlightenment about the advanced technology usage and shortage of the necessary infrastructure. | Future scope is recommended to expand AR to varied subjects and innovative tutoring methodologies. |

| | | | |
|---|--|---|--|
| Julio Barroso-Osuna, Juan Jesus Gutierrez-Castillo, Madel Carmen Llorente-Cejudo and Rubicelia Valencia Ortiz | [18] Hurdles/ Obstacles that would be faced by the educational organizations in integrating AR into their system. | A special instrument named “CORA” which was more like an Opinion poll was designed to record the difficulties faced. “Delphi Technique” was used to validate the questionnaire. Few noticeable barriers were: (a) Teachers are not updated enough about the technique and they are not given proper training (b) Undersupply of contribution from the institutions (c) Lack of research (d) Less presence of experienced handlers (e) Theoretical Base needs to be stronger. | To train the teaching staff, the education union should come up with centres to train them and implement context oriented, constructive and game centred approaches. |
|---|--|---|--|

J. Study of AR in the Market over a Decade

Almaas A. Ali, Georgios A. Dafoulas et al [19] have reported their discoveries from a study that was conducted over the literatures from the past 10 years on the education system that has adapted mixed reality i.e. a combination of Virtual reality and Augmented Reality. This research was carried out due to the growing attention to mixed reality and introduction of the new trendy devices like Oculus Rift, HTC Vive, etc. The underlined content of the results was that, the Mixed Reality field was deficient in research on the whole; with “Virtuality in augmentation” topping it all. The major factor of concern was the technical skills required by the staff to educate the students. Though the study has mentioned the downsides, the recent development in technologies has paved way to possibly experience mixed reality in a better way.

A statistical analysis of multiple articles, papers and documents collected from all over the world for over a period of 10 years (2001 to 2019) investigating the ways in which Augmented Reality applications have developed has been researched [20]. Around 1008 documents were selected by means of resolute sampling and thirteen varied criterion were chosen for scrutinizing. The research has emphasized a report that predicted, AR in combo with smart phones would be revolutionizing after the year 2010 and there would be a steady rise in the usage of AR in schoolrooms. Highlights of several definitions of AR by researchers are presented. The list of countries that have researched in AR along with the year of publication has been mentioned. The authors have insisted upon the use of AR in special-education area too. With the thought of; researchers to shoulder the responsibility of confiscating the pitfalls from the AR applications, the article has been concluded.

K. Augmented Reality: The New-Fangled Headlines

The recent impactful use of AR can be seen in the article from ‘The Hindu’ [21] dated July 2020 by Abdul Latheef Naha and from ‘The Economic Times’ [22] dated March 2020. Due to the pandemic state, schools had to gear up for online classes and creating interest amidst the primary school children to listen to virtual classes was a challenging task. At the right moment, a social science teacher from Kerala succeeded in implementing Augmented Reality with other supplementary apps to create a super interesting virtual class room. In the meantime [22], the tech companies that provide AR/VR/MR solutions have reported increase in their business requirements during the lockdown period and the services were provided remotely. Experiments with other innovative techniques are on the run.

III. CONCLUSION

Productive usage of Augmented Reality in education would make the learning process a huge accomplishment. From the documents examined, Augmented Reality supportive learning has had advantages on the raise. Many schools and universities have shown eagerness for AR based curriculum. Owing to the current pandemic state, the virtual classes have to be made attention-grabbing for the students and AR would be the friendliest option since the only tool required would be a smart phone or tablet for marker based AR learning. The prevalent software used to develop AR found over this survey are:

TABLE 3: SOFTWARE USED FOR AR DEVELOPMENT

| S. No | Software Used |
|-------|-----------------|
| 1. | Unity 3D |
| 2. | Vuforia |
| 3. | Blender |
| 4. | Sketch up |
| 5. | Adobe Photoshop |
| 6. | Visual Studio |

The reviewed papers have implemented different models which has its own efficient quotient to execute the research over how effective was AR in learning. The various models/techniques found to be used are:

TABLE 4: EVALUATION TECHNIQUES USED

| S. No | Strategies/Methodologies Used |
|-------|--|
| 1. | ‘NASA TLX’ |
| 2. | ‘UES Questionnaire’ |
| 3. | ‘Wilcoxon Test’ |
| 4. | ‘Likert Scale’ |
| 5. | SPSS (“The Statistical Package for the Social Sciences”) |
| 6. | Theoretical / Experimental / Empirical |
| 7. | ‘TAM model’ |
| 8. | ‘CORA model’ |
| 9. | ‘Delphi Technique’ |

In future, there might be betterment of experiences in the immersive nature of mobile based Augmented Reality, provided that a deeper research in this field is focused upon. Being a multi-disciplinary concept, there is a bright scope in this technology (AR).

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