Virtual Reality & Augmented Reality for K-12 Educational Environment – A Meta-Analysis

Saravanan. S [1], Raja. M [1]

[1] Department of Multimedia, VIT School of Design, Vellore institute of technology, Vellore, India.

Email: [1] saranrulz671@gmail.com, [2] raja.m@vit.ac.in

Abstract

The educational environment tends to adjust and adapt to the technological environment. Virtual Reality and Augmented Reality are a recent technological development in the field of education. A detailed analysis of the impact on AR and VR for Kindergarten to 12th-grade students is analyzed in this article. Analyzed parameters are compared with the traditional methodology and reports proved that VR and AR play a vital role in the field of education. This article also analyzes the implementation on mixed reality & extended reality on education field. Comparative statement on the usage on Augmented Reality, Virtual Reality, Extended Reality and Mixed Reality are evaluated in this article to understand the usage on advanced technologies in education.

Index Terms: Augmented reality, Augmented virtuality, Extended reality, Virtual reality.

1. Introduction

Bringing virtual objects to the existence in the same space as objects in the real world details the method of Augmented reality (AR). It was mainly introduced to use in airline-based applications. Method of AR became widely popular since it doesn't hinge on advanced hardware or high configured computer / equipment such as head mounted display. Application of augmented reality is highly implemented in schooling based upon the budget involved and ease of use. Virtual reality (VR) also attained a major response in educational sector for the past few years. By bringing the presence with immersive characteristics, it found to be a well popular methodology in student learning. Mixed reality (MR) known for its combination of VR and AR that integrates real and virtual content in environment. Bringing virtual elements in a real environment is known as augmented reality and real elements in a virtual environment is said to be as augmented virtuality. XR (Extended reality), which incorporates virtual reality, Augmented reality and Mixed reality technologies more broadly. Any other extended methodology such as IOT, AI in order to blend virtual graphics with real-world elements comes under the umbrella name called extended reality.

For achieving an efficient virtual reality design and development, the cost and time involved is huge to support the K-12 or higher education curriculum [1]. Efforts to train the teachers in order to bring the proper effectiveness on education remains to be a challenging task. Augmented reality attains an advantage to create immersive hybrid learning environments that combine digital and physical objects. Also bring skills like critical thinking, problem solving to students with the ability to concentrate on achieving collaborative exercises [2].

On educational research a wide variety of analysis have been made on analyzing the importance of bringing technical virtuality on education sector. Analyzing the importance of each reality and understanding the compatibility of it to using it in the K-12 education or higher education is still unexplored research. This article analyses the different reality technologies for educational learning methods and process an extensive survey of it with its advantages and disadvantages.

Technology is evolving with a radical change and is being used in a growing number of environments. Educational technology tools are integrated with the instructional methods to attain higher level in teaching and learning process. Virtual laboratories in the higher school grades attains a higher response among students to provide information with material in immersive environment available all the time [3].

Virtual Reality attains a huge impact in the field of education, observation, testing, entertainment, and health. VR technology brings an accessibility of using the same virtual environment for interactive studies. Motivation and improved earnings are achieved through VR based games. Mixed reality allows the user to interact with responsive virtual elements which is integrated with the real environment. Virtual furniture fitting, virtual makeup and snapchat filter are some of the applications of MR.

Low-immersive, semi-immersive, and full-immersive are the three variations of Virtual reality environments. Computers in the school environment may not be a highly configured one to attain the full immersive on VR. A basic personal computer, with a low configuration can be retained to demonstrate on low immersive VR. Computer with stereoscopic monitor can be utilized to work on the creating a semi immersive VR.

On analyzing the low immersive and semi immersive systems, variation on interactivity and a moderate high immersive rate is attained. Fully immersive system comes with a higher configured system with a wearable headset such as HTC vive or Oculus quest. It allows to track the head positions of the user and interact by providing the virtual information. Based on the immersive technology, the taxonomy of the VR system is depicted in the Fig 1.

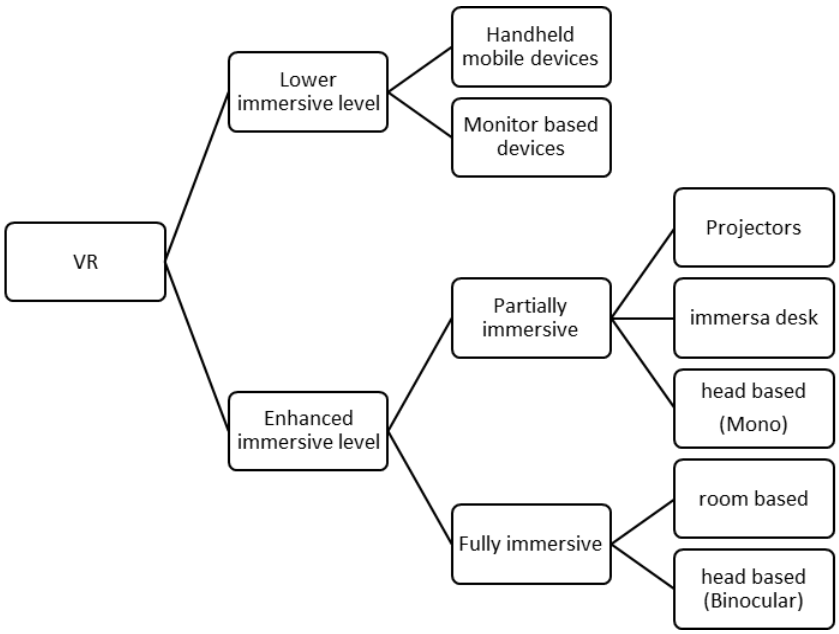

Figure 1. Categories of VR system based on immersive technology

2. Background Works

Technologies have been growing widely in the educational domain such as Virtual reality, Augmented reality which syndicate real world and digital world [4]. From the students output, there has been an effective improvement on critical thinking also a broad change in mind mapping analysis by the students. Gaming platform on a virtual environment brings memory recall sustainability improvement. In article [5], it investigates the brain-rewiring techniques to help the learning disability students and also with various disorders in learning. And the author study reveals that VR attains a productive output in the practice of therapeutic metacognitive techniques. And concludes the article with a statement as virtual learning environment (VLE) can bring change in the student ability in cognitive capacity, to visualize the objects that cannot be seen in reality.

Michael Chau [6] depicts that Three-dimensional virtual environment can simplify students in achieving learning outcomes. This article revolves around using the constructivist learning theory which brings constructive new ideas / concepts on the past and present scenario. Wide variety of possibilities in three dimensional virtual environments, that brings the educational institutions to work on an interactive and immersive learning platform for students. Resulted in benefit of the students to have better learning autonomy, communication and collaboration. Virtual based learning methods brings a game-based education environment since the students are grown up with the digital devices nowadays.

Matt C. Howard et al [7] covers a meta-analysis on the usage on mixed reality in rehabilitation program. Author attains the hypothesis such as MR achieves a good improvement in physical capabilities on the rehabilitation programs. And also found to be the best alternative for improving physical capabilities. Author concludes that understanding cognitive and physical mechanisms achieves a good framework in detailing the MRR programs. Future enhancement on bringing more effectiveness can be attained by considering fidelity and enjoyment in concepts. Effie Lai-Chong Law et al [8] analyzed the issues affecting to usability and UX of AREAs in relevant core concepts. Scaling with low samples for measuring the learning effect, qualitatively or quantitatively retained to bring children's capabilities and system features. From the authors perspective utilizing AR as an adaptable educational brings more promising tool to maximize its potential.

3. Methodology

A brief analysis on variety of technologies used in the educational environment is taken into consideration. Scope and ability of each methodology is considered for comparative analysis. An overview on the usage of VR and AR over K-12 educational environment is analyzed with its limitations. Mixed reality and Extended reality are evaluated based on its domain area in the related works published in journal. Meta-analysis collection on usage of AR over education with VR on different environments is considered to evaluate the best utilizing methodology on educational sector. In this article an overview of all the recent widely popular realities (AR, VR, MR, XR) are equally concentrated and treated its compatibility on the educational environment.

In the Fig. 2 depicts the group framework of individual reality. Though many articles were published based on realities on education. Very few articles described the purpose of each modality with limitations. In article [14], game-based.

Table 1. Systematic reviews of various realities in educational applications

Paper with Author	Year	Aim / Proposal	Findings
[9] Jorge Martín-Gutiérrez et al	2016	To make the virtual technologies for possible breaking the boundaries of formal education	Limitations of using VR/AR in an educational environment is not in technology itself, but in how this technology is used and how students learn.
[10] **Mauricio Hincapie et al**	2021	Aims at Augmented Reality educational applications and content type by using a bibliometric and state of the art analysis	Few of the studies contrasted the influence of the type of content on the quantified variables. And works proposed on the design based on the developers' and researchers' expertise
[11] Maria Fragkaki et al	2020	Aims to facilitate the creation which inspire, motivate, and empower educators to apply innovative, pedagogically informed learning using AR and VR	It empowers teachers to motivate, engage and improve student learning by opening new avenues of student deep understanding, creativity, reflection and production.
[12] **Galya Georgieva-Tsaneva et al**	2020	It presents the results of a survey conducted among trainers and trainees at medical universities in Bulgaria	It shows that students and teachers in the professional field of Health Care assess virtual learning as an important factor in the process of acquiring new competencies
[13] Nurhazarifah che hashim et al	2022	This article framework integrates the multimodal inputs based on the decision tree and develops into a four-phase learning system based on Kolb's experiential learning model.	Model proposed for a mobile learning system based on AR multimodal inputs by processing three types of inputs, namely emotion, image-based marker and speech to learn emotional vocabulary

Education has been taken into consideration and analyzed the perspective of student towards each subject. [15] proposes the method of using virtual reality on education and analyzed the wide scope of methodology. In continuation to that, virtual learning education has been considered to attain a global impact on the usage of such reality in a day to day life.

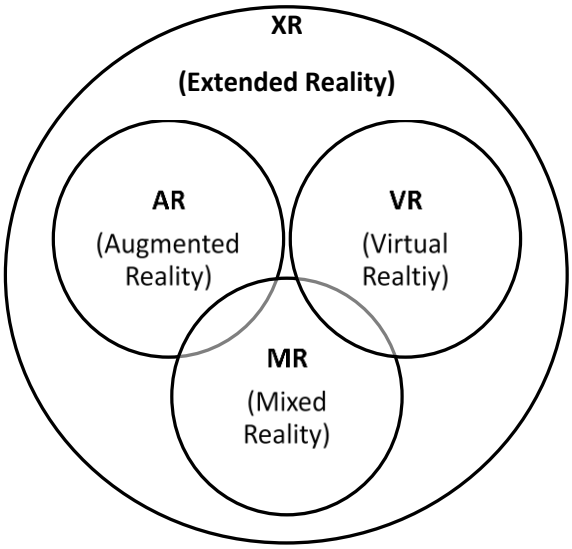

Figure 2. Various Realities in a framework

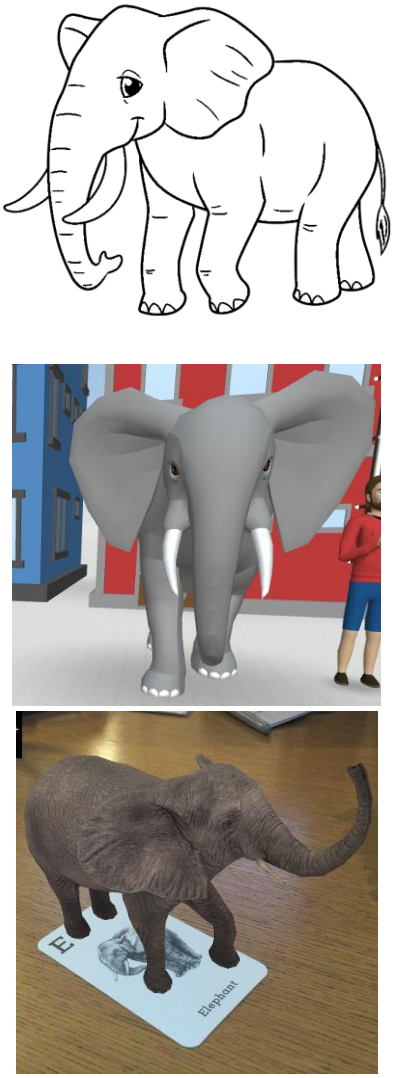

Figure 3. Visual of a 2D, 3D and Augmented look of an elephant

With the new inspiring technology that enriches the real world with 3D makes it more visual appealing and interesting for the students. And it also allows the student to interact with it to understand them better. As shown in Figure 3, a two-dimensional animal character with a 3d one has more changes and features to analyses. As through the augmented view, bringing the character to the real time environment makes it to be a better visual pattern for the kindergarten students to react and understand about the student in a better way.

4. Proposed Work

An analysis of different reality-based exercise was created with a sample of 100 outputs. Students were made to participate with different realities. Feedback of the same is recorded. Concept understanding abilities, Interest towards the realities are analyzed from random 100 samples. Students of kindergarten were made to explore with augmented reality concepts and the interest was analyzed. Virtual reality (HMD's) were analyzed from higher grade student feedback. Sample of the collected data are depicted in table 2 and table 3. XR technology allows for the co-creation of experiences for instance HMDs and goggle-type devices are capable of producing high-quality visuals as well as experiences. Three types of glasses such as HoloLens, Magic Leap, and Google Glass were used for the analysis.

Table 2. Analysis on level of attainment using Augmented reality for K-12 students

Implications	***KG***	***1-6 Grade***	***6-12 Grade***
Attention	93%	90%	86%
Presence	92%	89%	88%
Enjoyment	99%	90%	89%
Science knowledge	91%	89%	85%
Auditory knowledge	90%	88%	82%
Visual Knowledge	97%	91%	89%

From the analysis in table 2 and table 3, the inferences such as attention of the student, Presence of mind with the concept, Enjoyment when learning using device, Science, Auditory & Visual knowledge are considered and the inferences on using AR based method and VR based methods are depicted in the tables.

Table 3. Analysis on level of attainment using Virtual reality for K-12 students

Implications	***KG***	***1-6 Grade***	***6-12 Grade***
Attention	82%	94%	98%
Presence	80%	98%	93%
Enjoyment	86%	95%	93%
Science knowledge	84%	90%	96%
Auditory knowledge	72%	92%	91%
Visual Knowledge	65%	95%	93%

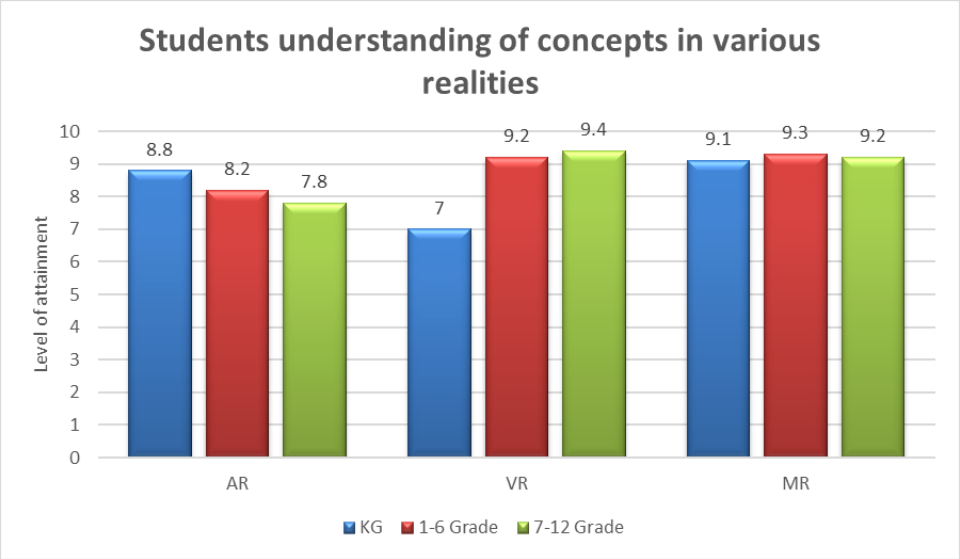

Figure 4. Concept understanding level of students in AR, VR and MR

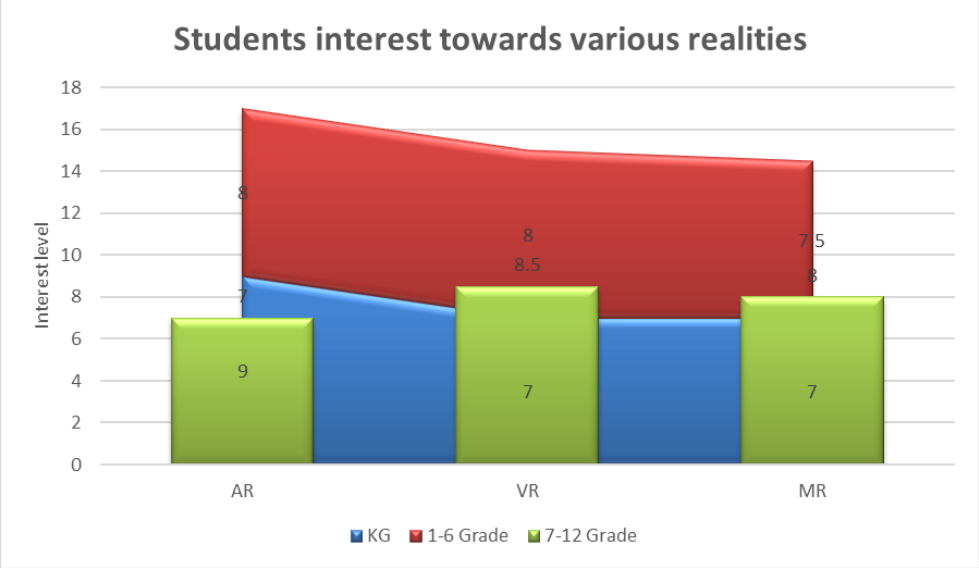

Figure 5. Concept understanding level of students in AR, VR and MR

Fig. 4 depicts that understanding level of each concept using different reality among K-12 students in three groups. As augmented reality found to be more satisfying in the kindergarten level. Compared with the VR and AR, Mixed reality combination achieves a higher level in conveying the concept to the students and brings the interest level on education. Fig 5 states the interest level of students towards AR, VR & MR.

5. Conclusion

As a process of meta-analyzing the K-12 education through various realities such as Augmented reality, Virtual reality & Mixed reality. It has been analyzed that, through utilizing proper methodology for individual sector of students. Students group is categorized into kindergarten students, 1st grade to 6th grade and 7th -12th grade students. From the analysis it has been proved that, AR based concepts are interesting and ease to use by the kindergarten students. VR based concept knowledge on subjects are understandable and bringing interest towards the education for 1st grade to 6th grade students. Combination of VR and MR, that is MR based works are very much beneficial to the 7th grade to 12th grade

students. Even though there were many limitations on the usage of devices knowledge, cost of the product, addictive nature towards game, conveying the education concept method can be brought with these realities in order to meet the technical standards in future education system.

References

[1] Z. Merchant, E. T. Goetz, L. Cifuentes, W. Keeney-Kennicutt, and T. J. Davis, "Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis," *Comput. Educ.*, vol. 70, pp. 29–40, 2014, doi: 10.1016/j.compedu.2013.07.033.

[2] M. Akçayır and G. Akçayır, "Advantages and challenges associated with augmented reality for education: A systematic review of the literature," *Educ. Res. Rev.*, vol. 20, pp. 1–11, 2017, doi: 10.1016/j.edurev.2016.11.002.

[3] Jamah, A. Alnagrat, R. C. Ismail, Z. S. Idrus, R. Mansour, and A. Alfaqi, "A Review of Extended Reality (XR) Technologies in the Future of Human Education : Current Trend and Future Opportunity A Review of Extended Reality (XR) Technologies in the Future of Human Education : Current Trend and Future Opportunity," *J. Hum. Centered Technol.*, vol. 1, no. 2, pp. 81 – 96, 2022, doi: 10.11113/humentech.v1n2.27.

[4] G. Papanastasiou, A. Drigas, C. Skianis, M. Lytras, and E. Papanastasiou, "Virtual and augmented reality effects on K-12, higher and tertiary education students' twenty-first century skills," *Virtual Real.*, vol. 23, no. 4, pp. 425–436, 2019, doi: 10.1007/s10055-018-0363-2.

[5] Drigas and E. Mitsea, "Virtual Reality and Metacognition Training Techniques for Learning sustainability Virtual Reality and Metacognition Training Techniques for Learning Disabilities," no. August, 2022, doi: 10.3390/su141610170.

[6] M. Chau *et al.*, "Using 3D virtual environments to facilitate students in constructivist learning," *Decis. Support Syst.*, vol. 56, no. 1, pp. 115–121, 2013, doi: 10.1016/j.dss.2013.05.009.

[7] M. C. Howard and M. M. Davis, "A meta-analysis and systematic literature review of mixed reality rehabilitation programs: Investigating design characteristics of augmented reality and augmented virtuality," *Comput. Human Behav.*, vol. 130, no. January, p. 107197, 2022, doi: 10.1016/j.chb.2022.107197.

[8] E. L. C. Law and M. Heintz, "Augmented reality applications for K-12 education: A systematic review from the usability and user experience perspective," *Int. J. Child-Computer Interact.*, vol. 30, p. 100321, 2021, doi: 10.1016/j.ijcci.2021.100321.

[9] J. Martín-Gutiérrez, C. E. Mora, B. Añorbe-Díaz, and A. González-Marrero, "Virtual technologies trends in education," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 13, no. 2, pp. 469–486, 2017, doi: 10.12973/eurasia.2017.00626a.

[10] M. Hincapie, C. Diaz, A. Valencia, M. Contero, and D. Güemes-Castorena, "Educational applications of augmented reality: A bibliometric study," *Comput. Electr. Eng.*, vol. 93, no. July, p. 107289, 2021, doi: 10.1016/j.compeleceng.2021.107289.

[11] M. Fragkaki, S. Mystakidis, and G. Filippousis, "Work-in-Progress-Design and Evaluation of an Augmented and Virtual Reality Flipped-Learning Course for K-12 Educators," *Proc. 6th Int. Conf. Immersive Learn. Res. Network, iLRN 2020*, no. iLRN, pp. 275–278, 2020, doi: 10.23919/iLRN47897.2020.9155200.

[12] G. Georgieva-Tsaneva and I. Serbezova, "Virtual Reality and Serious Games Using in Distance Learning in Medicine in Bulgaria," *Int. J. Emerg. Technol. Learn.*, vol. 15, no. 19, pp. 223–230, 2020, doi: 10.3991/ijet.v15i19.15753.

[13] N. C. Hashim *et al.*, "Mobile Augmented Reality Based on Multimodal Inputs for Experiential Learning," *IEEE Access*, vol. 10, no. August, pp. 78953–78969, 2022, doi: 10.1109/ACCESS.2022.3193498.

[14] S. Saravanan and S. D. Juliet, "Education Through Technical Games," *Proc. 2018 2nd Int. Conf. Adv. Electron. Comput. Commun. ICAECC 2018*, 2018, doi: 10.1109/ICAECC.2018.8479425.

[15] S. Saravanan, "Virtual reality game in education: An pragmatic," *Test Eng. Manag.*, vol. 81, no. 4728, pp. 4728–4732, 2019.

Authors Profile

Saravanan. S, Assistant Professor (Senior), Department of Multimedia at VIT school of Design in Vellore Institute of Technology, Vellore, India. He has received his Doctorate in Information technology from Karunya Institute of Technology, Coimbatore, India. He has attended many national and international conferences. He also published more than 15 journal publications. His principal research interests are medical image compression, Virtual reality, Augmented Reality, Healthcare developments.

Raja.M, Assistant Professor (Senior), Department of Multimedia at VIT school of Design in Vellore Institute of Technology, Vellore, India. He is pursuing his Doctorate in Vellore institute of technology, vellore, India.