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An Exploratory Research Examining Knowledge Retention using Virtual Reality and 3D printing in Education

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Abstract: ***The revolution of education has changed drastically from chalk – duster mode to 3D methods featuring Hologram projection in online education and distance learning, virtual and augmented reality in 3D way of live streaming, haptics for 3D sensing i.e. used in game simulation etc. The main area focused on this research is educating people in the world along with conceptual learning with more practical examples for recreating the essence of practical knowledge in educational world. The purpose of the research study is to achieve the factors required for interactive education by using 3D printing and Virtual modules. A Virtual Reality specimen is taken into consideration as an experiment to feel the virtual environment in education.***
Keywords: 3D-printing, Virtual-Reality, Virtual-haptic system, HoloLens, Simulation, Google Cardboard, Augmented Reality.

I. INTRODUCTION

Growing fame and acquisition of smartphones, had viewed subsequent rise in Virtual Reality (VR) applications that leverages smartphone technology. The main aim of virtual reality is imitating the sight i.e. the perception of being present as in real world. Low cost consumer VR headsets such as the Samsung Gear VR, Google Cardboard and Google Daydream had established digital environment which is more accessible than before. Moreover, VR transformed the educational possibilities. Empirical research depicts that the technology promotes students by challenging the barriers in education and creating blissful moment in different contexts and across various subjects. Similarly, 3D printing technology (alias "Additive Manufacturing") is seen to have made a deep impact in the field of education. It is the most advanced manufacturing technique that has changed the era of additive manufacturing industry. It refers to the layer-based additive technique building 3D models using digital data provided by various (Computer Aided Design) CAD software portrayed in meshed phase as Stereolithography (STL) format and then converted into sliced layers in the form of G-code to instruct the 3D printer. Three-dimensional printing is especially useful for numerable topics and even subjects at different levels of education. E.g.: Teachers can print out historical artifacts viz. monuments, coins, etc., biology students can print out organs and cells, geography teachers can get print out a mountain range etc. laying the path of invention & innovation in education field. Implementing 3D automation to the classroom unlocks the barriers to find how students think and incorporate information into useful subjects. Digital 3D domain come to life with 3D printers, which can encourage teamwork, planning, design, and thinking through complex ideas. At present stage, the technology is used in varied dimensions as the limitations like time consumption, less availability and cost have been solved up to an extent due to computational intelligence called artificial intelligence. Combination of both the above technologies will promote professor to encompass students on an intense environment where they can perform multi tasks i.e. visualizing and creating new artifacts or 3D models at the same time to understand the concept in an enjoyable and creative format.

II. OBJECTIVES

A. To find out if theoretical studies is more adaptable to teachers and students when compared to 3D visualization
B. To understand the concepts through VR
C. To analyze different methods that can be used in teaching-learning process

These objectives will be attained by checking through survey analysis based on the following hypotheses as under: -

1) *H1:* "Individuals experiencing a VR environment by means of digital content report - a) High levels of attention to the mediated environment, b) Presence and c) Creative thinking."
2) *H2:* "3D printing technology boosts fields of education that promotes students to pursue challenging courses because it could build school solidarity also upgrade the intellect in divergent areas."

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III. LITERATURE REVIEW

The article explaining the aspects of Haptic technology was introduced by L. Liu et al. [6]. The article explained the basic concepts of haptic technology, how it functions in different levels and sectors of education, applications, and features of the same. The author aimed at step-by-step approach in detailing the Virtual Haptic System. They stated certain problems viewed by their experimental analysis viz. Selective learning content, Improvised learning methodology etc. which could be neglected to some extent considering the changing environment and boost of technology in education. The main objective validated was that the Virtual Haptic System could become a beneficial interaction technology which can intensify the potential of human in educational world. Survey based analysis on Holographic learning proposed by Leonard et al. [4] traced the pilot study of educational design research project using Microsoft HoloLens in a secondary school. The concept of HoloLens Mixed Reality was initially understood by the teachers, students. This study gathered 73 responses from 7-12 sections of the school which was analyzed using PCA analysis through SPSS software. The design approach stated in this study embodies the challenging environment explored and positive impact gained by the students through this system which could be used to revolutionize the education environment. Literature study on 5G technology reinventing Virtual and Augmented realities in education proposed by Baratè, A. et al. [5] focused more on the 5G technology and its applications in developing the VR & AR in education environment. For this, the author had specified the stream (i.e. fine arts) to show insights of the topic. Also, study discussed the failure of performance, connectivity of 4G, 3G technologies in online education and how it can be rectified by 5G. The main objective of the research study was to derive the feasibility of AR and VR in education clubbing it with the high performance rendered by 5G technology. The article [2] by Pates. D focused on the gap that is faced in the online education and generalized the ways to eradicate the problem by defining each part in detail through various examples. The author paved the way for the educator and learner to experience interactive learning in online education through holographic systems.

IV. METHODOLOGY

A. Participants

This study used a survey analysis through Google Forms to test the proposed hypotheses which verified certain parameters in pre-test and post-test with participants containing both teachers and students. A total of 60 participants (14 teachers and 46 students) recruited from Indian Cultural English High School between 5^{th}-9^{th} standard. The participants were randomly selected without any bias. The survey was conducted within the city limits of Kalyan.

B. Materials

As per the above hypothesis stated to prove it a Vivo Y51L smartphone and a DIY (Do It Yourself) VR headset was used to display a content named “The Exoplanets”. The video portrayed had three-dimensional representation of our Milky Way Galaxy and some exoplanets with key details of them and having audio-visual information about the same. The device that was prepared was comfortably used by all the participants.

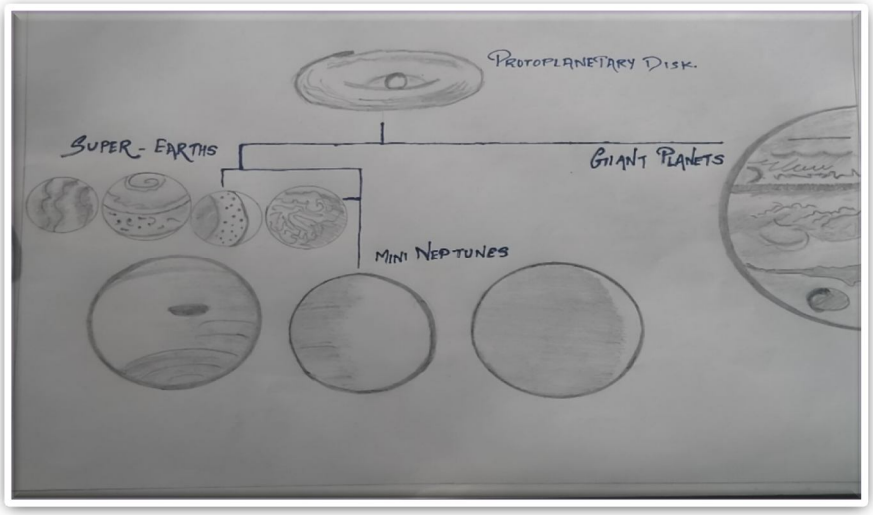


Fig. 1 Hierarchical diagram of Protoplanetary Disk (Pre-test)

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Fig. 2 Screenshot of Exoplanet in Virtual Reality (Post-test)

Even if they require it for personal use it can be built in low cost and eco-friendly way which is easily available. A 360-degree vison was projected by the VR headset to sense the environment. The space provided for the eyes and nose was as per their convenience. The audio data played automatically upon the startup of the experience did not require any specific action from the participants.



Fig. 3 Demonstration of how to use VR headset to view digital content

C. Procedure

As per the current scenario teacher used the method of e-learning where a platform was set for discussion on exoplanets between students and teacher in the form of diagrams and models as in physical classrooms. The teacher was asked to check the parameters like comfort (in understanding concepts), interaction, immersion into the topic and teaching-learning process (theoretical mode with few diagrams to display as done in physical classrooms).For this certain multiple-choice questions were proposed for pre-test and post-test aiming to understand the knowledge of participants. The score was assigned as the feedback of pre-test conducted for each parameter listed above in scores viz. 1 (Bad), 2 (Average), 3(Good), 4(Very Good), 5(Excellent). The same procedure was repeated for the posttest using VR headset by following all the safety measures and the practical test was organized. Presentation of using the VR headset was demonstrated and rules to be followed while using VR headset were stated. Again, a feedback was taken in scores as in pretest on each parameter.

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V. EXPERIMENT

The test scores of paired samples were calculated at the confidence level of 95 percent using t-test. The score of survey parameters were summed and averaged to create overall variable scores. The teacher presented multiple choice questions to test the parameters in pre-test (e.g. Which exoplanet is 880 light years apart? Which planets are considered as exoplanets?) and post-test (e.g. What is one-way exoplanets are indirectly detected?). Each test contained 5 different multiple-choice questions to compare the knowledge of participants regarding the topic. The statistical t-values of parameters at p-value of 0.05 are comfort (-7.18), interaction with virtual world (-5.96), immersion in virtual environment (-7.96), teaching-learning process (-7.23). The fig.4 and fig.5 display the scores of participants in pretest and posttest.

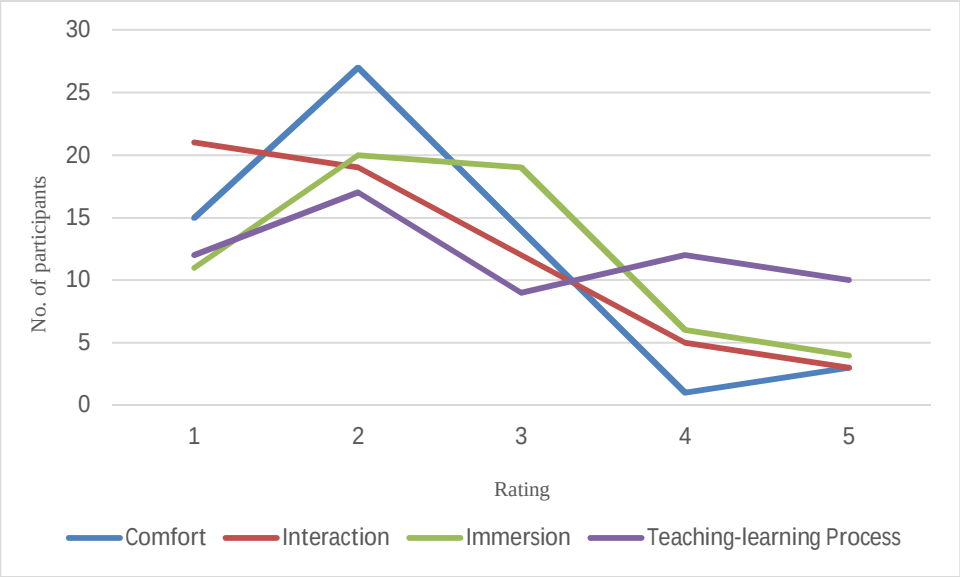


Fig. 4 Pre-test Parameter Rating

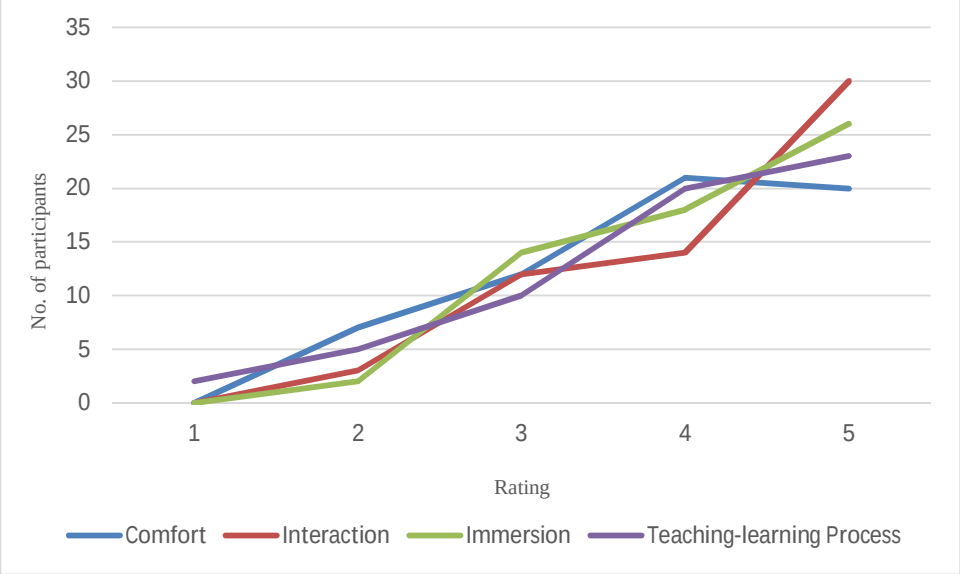


Fig. 5 Post-test Parameter Rating

VI. RESULT

The test scores of paired samples rendered through survey analysis (pretest and posttest) calculated using the t-test resulted in stating that the participants were able to understand the concept more precisely through VR mode than normal mode. The results also rendered that there was a significant difference in scores of parameters checked in VR mode(mean=3.96) and normal teaching executed in pretest (mean=2.16). Therefore, the hypothesis “H1” is accepted.

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The survey included few outcomes to support the second hypothesis i.e. "H2". The participants were asked few questions in the posttest which focused mainly on the technologies used in changing the educational environment. Here, majority of participants supported 3D printing and stated advantages and disadvantages of using it in education. Therefore, the hypothesis "H2" is partially accepted which will be validated in the future research study.

VII. DISCUSSION

This study characterized the impacts of VR and laid the insights into various technologies stated by the participants in revolutionizing the educational environment. Participants in VR mode allocated more attention to the topic, discerned more presence and enjoyment than in normal teaching process. Furthermore, those intellectual and thoughtful responses to the media helped them to gain more knowledge that was visually projected in mobile based platform.

This study has certain theoretically implications for literature to Virtual Reality and 3D printing because both have varied cognitive demands depending on the user. The VR can assist the educators in exploring different realities and alternate experiences. Students of any age will always find this technology quite interesting as it creates amazing experiences which can never be lived-in real-world scenario also it improvises the quality of education in different sectors without having language as a barrier. But there are few flaws which must be noted i.e. VR declines the human behaviour of communication because in VR-based education user can only interact with software and nothing else which can deteriorate interactive culture. Also, it cannot provide flexibility to students in exploring new ideas, ask questions as using specific software you will not be able to do anything else except what you are supposed to do. With the rising technology these flaws can be rooted out and stabilized to the education environment.

On other hand, 3D Printing also called "Additive Manufacturing" has transformed the education due to creation of experiential learning opportunities in students, teachers etc. The biggest advantage for education with 3D printing revolves around its hands-on approach to manufacturing that empower students to design, collaborate, and create amazing artifacts with ideas, projects, and activities in a classroom environment. This area looks more like a workshop than a classroom and is consistent with innovations portraying that hands-on projects and activities displays deeper understanding of concept when compared with traditional textbooks and test-based teaching [23]. This technology could be used by teachers, universities as it provides them all the training tools and simplifies complex concepts in simple manner. Financial perspective of 3D printing is more diverse as students can indulge their creativity in making amazing artifacts which can be traded to gain income and understand how the processes in business organization are operated.

VIII. LIMITATIONS and FUTURE SCOPE

This research study utilized less sample of student participants for validating the hypothesis. The study only included prescribed content on which various parameters were rated to establish the credibility of the teaching-learning process. Also, the study did not specify the use of 3D Printing in detail. The future researchers should expand the scope and population by generalizing the diversification in educational levels (primary, secondary etc.) and educational sectors with validating the parameters stated in this research study on varied subjects. The researchers should verify the consistency of audio-visual information (viz. relevant or irrelevant) or audio-types (earphones, speaker of the phone etc.) optimizes the output of teaching-learning process. The future research will incorporate demonstration of a project on 3D Printing technology using IOT (Internet of Things) by printing robotic artifacts that will be analyzed on large population aiming at its applications and scope.

IX. CONCLUSION

Cost-effective VR technologies provided by smartphone or certain mobile applications and varied technologies like 3D Printing, Haptics, Hologram can pave way for interactive and immersive education. This study has proved that concepts portrayed in practical manner would increase the potential and understanding ability in students as well as it would revolutionize the teaching-learning process. In the end, both the technologies viz. Virtual Reality and 3D Printing provide students with exciting and adventurous educational environment. However, all the technologies discussed have their own set of strength and weakness that should be considered while integrating these in education.

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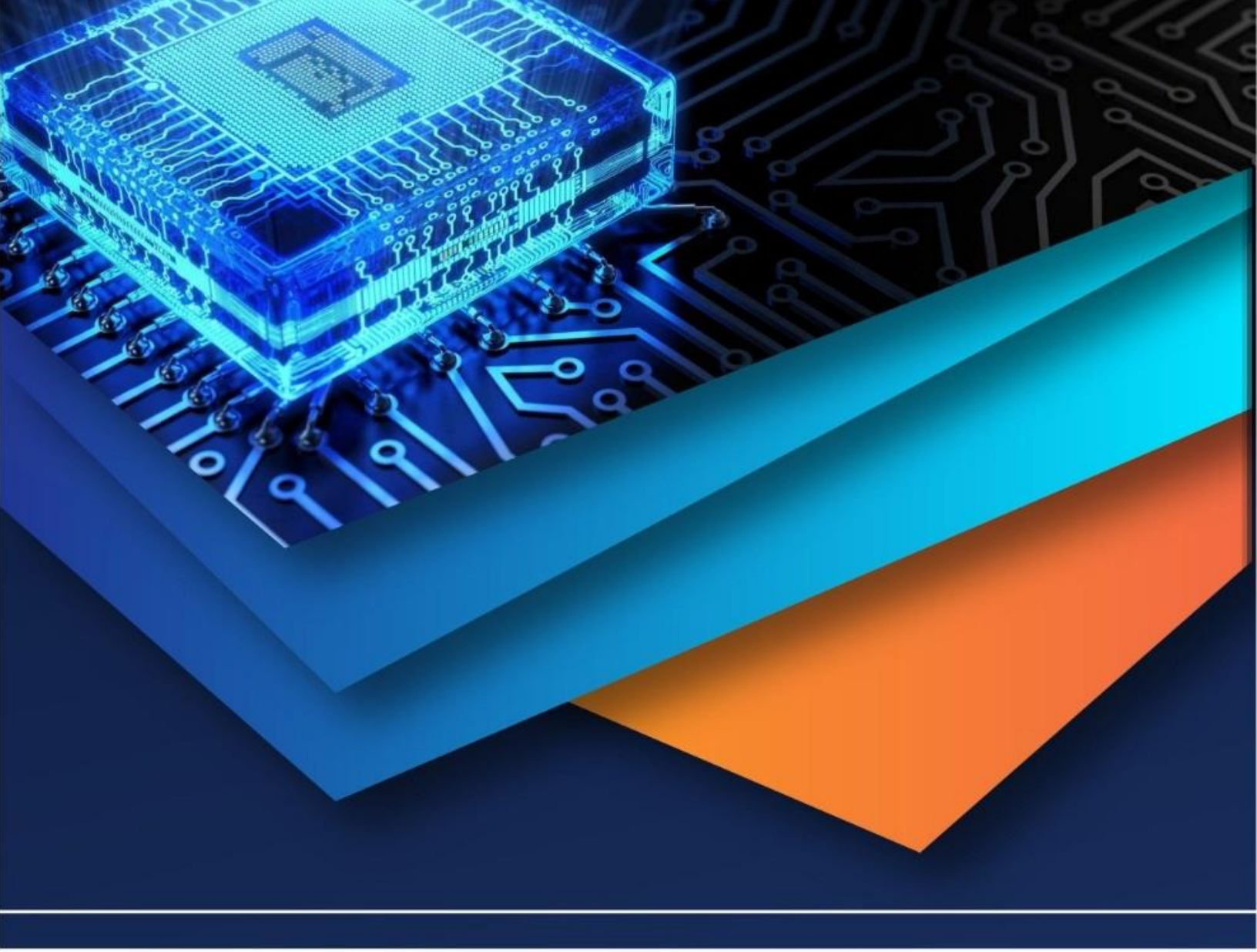
XI. GLOSSARY

1) *5G:* Fifth generation mobile technology which provides broadband access
2) *Haptics:* sense of touch for interacting with digital devices
3) *Microsoft HoloLens:* A mixed/augmented reality head-mounted display manufactured and devised by Microsoft
4) *T-test:* Inferential statistic used to determine if there is a significant difference between the mean of two groups which may be related to certain features
5) *Exoplanets:* Planets outside the solar system

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