Surveying the role of Gamified MOOCs, Augmented and Virtual Reality for Engineering Education

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1 CONTEXT

The developments in the Engineering domain have risen at an unprecedented rate in the past three decades. New technologies emerge every year and find their use case in multiple industries. This also has a direct impact on engineering education as a whole. Educators are pressured with the task to adapt to the advances in their respective field as well as refine their pedagogy, so as to better inculcate the developments into the curriculum. New trends have come to light that aid the engineering education sector. Nowadays, Game based learning, MOOCs, blended learning, Augmented and Virtual Reality based learning are some of the trends that have been successfully used for educational purposes. Specifically, due to widespread of novel coronavirus, there is a sudden shift of regular classrooms towards online teaching-learning, which may benefit from the use of aforementioned technologies. This article looks at the effectiveness of using these technologies as tools for engineering education and focuses on various challenges involved in their implementation and the future prospects. Surveying the literature written in the past decade, it was concluded that the trends and technologies discussed in this paper have been tested and proven to be beneficial in engineering education.

2 IMPLEMENTATION

Educators in engineering domain are striving hard to imbibe the use of technologies such as multimedia learning, immersive techniques, simulation-based solutions and game-based education in addition to traditional teaching, so as to enhance the acquired knowledge amongst their students. Recently, the outbreak of COVID-19 subsequently resulted in the pandemic situation across the world, resulting in the transference of education from regular mode to online. The use of digital platforms for e-learning and use of educational technologies for imparting professional education has been rising since then. This paper discusses the role of techniques like Augmented Reality, Virtual Reality, gamification of MOOCs, and blended learning in the teaching-learning process of engineering education. Augmented reality (AR) is an amalgamation of real world with the graphically generated virtual environment [1]. An AR system facilitates the visualization of hidden phenomenon in engineering processes; for example, in the course of embedded systems, where students may find it difficult to understand the mechanisms inside the devices without being able to see their interactions and functioning [2]. Virtual reality (VR) is achieved through the use of computational technology to create and simulate a virtual environment and placing the user inside that experience [3]. VR system can bring that experience inside the classroom in certain applications in Civil Engineering which require students to study structures of architecture. MOOCs are Massive Open Online Courses constituting the traditional courses with filmed lectures, question statements, readings and summaries, and are available online to the masses [4]. Gamification in education has also acquired a boost in the form of serious games for specific purpose of learning, and providing motivation and more versatile environment for domain specific knowledge [5]. Blended Learning uses the integrated classroom pedagogy where the students learn the course material through online videos in addition to traditional methodology and are engaged in activities during class time. This provides better time utilization and enhances the learning curve in classroom settings [6]. Gamification of MOOCs and game-based Augmented/Virtual Reality set-ups have also been evolved during past few years [7, 8]. By reviewing the related literature, this paper aims to study the effect of these techniques on the learning capability of the students in engineering education with a robust future scope in the field of teaching through techniques other than the conventional classroom teaching methods.

3 RELATED WORK

Massive Open Online Courses (MOOCs) are playing important role in today's time, when regular classroom teaching has come to a halt due to pandemic situation worldwide. MOOCs play an essential role in distance education by offering a platform for individuals to interact, study and share their opinions. In the same way, education through games, and use of augmented and virtual reality for teaching-learning are also rising due to

halt in regular classroom scenarios. Although a vast literature is available mentioning the role of educational technology as an aid for engineering courses, at least two related papers from each of Augmented Reality, Virtual Reality, MOOCs, blended learning and Game-based education were selected from peer reviewed journals and conference proceedings for review in the present study. Pertinent literature was found using online research databases related to education and engineering (Scopus). The summary of selected articles is presented in this section.

Augmented Reality for Computer Engineering [2]: This paper presents an AR software (work in progress) for Computer Engineering laboratory exercises. Students usually face problems with visualization of unseen phenomenon while working with electronics equipment. An AR environment with use of a camera, a tracking system, and a visualisation system can help solve this type of problem. Tracking system analyses the data from the camera, where the augmented information (software based or hardware based) will appear. The main advantages of such method include simultaneous presentation of physical electronic equipment and relevant concepts mentioning the names of electronics parts etc. As the additional information. This method is able to facilitate the comprehension of technical concepts and retention of course related contents for a longer duration. The only drawback to this technology comes from the fact that prototypes are often misunderstood by tests participants during real setting for traditional evaluation sessions.

AR/VR game-based applications to Civil Engineering Education [3]: Virtual and augmented reality use in various fields for learning process has been in use since last decade. In this paper, numerous interfaces involving gaming environments in Engineering Education have been described that can help disseminate Civil engineering as well as other fields to motivate students during their learning process.

MOOCs and Their Role in Engineering Education [4]: The positives and negatives of MOOCs in the educational organizations have been discussed in regard with engineering education. The evolution of MOOC, and the increasing number of courses and universities worldwide since then, have been discussed. According to the author, University of Phoenix launched its online degree in the year 1989. Sebastian Thrun and Peter Norvig in the year 2011, started free online courses which got a very high participation of people. MOOCs hold a bright future full of opportunities in the field of engineering education. It can be used for professional education and undergraduate courses with wide variety of applications in different fields. There are some implementation related issues and few other challenges, but MOOCs are a helping hand in building a secure future by providing cheap education medium from massive online courses to graduation degree.

Evaluation of Blended Learning Approach in Computer Engineering Education [6]: Blended Learning is defined as the amalgamation of traditional methods for teaching-learning with connected learning. It provides a rich content and tools to the students to interact and learn efficiently at home or school. Blended learning has no set of rules defined as such, and it depends upon the need of the student, online material and trainer requirements. The most important goal of blended education is to combine the methods used for face- to-face interactions and the models used in online methods efficiently. The face-to-face models are used to teach programming and hardware-based courses and other courses are taught online. Blending learning can take place anytime, anywhere and it is not limited, as many students can learn at the same time without any limitation barrier as compared to regular classrooms. The students achieve better results in blended learning as compared to traditional method.

Gamification in MOOCs [7]: This research focuses on a MOOC based on gamification. The study investigates various factors influencing student motivation, collaborative capabilities and learning. Through this method, access to traditional course materials, such as filmed lectures, readings, and problem sets is also made available. The use of games for learning purposes has evolved since the beginning of this century. Through gamification in education there can be enhancement in student's learning experience while teaching complex subjects. Moreover, gamified MOOCs are also available as a result of integration of game-based learning with Massive Open Online Courses. The results of survey done in this study indicate positive student feedback for use of gamification and social media in education, especially in MOOCs.

A Distant Engineering Lab Built on Augmented Reality for Teaching Electronics [9]: Most of the graduates have good theoretical knowledge but they lack in practical knowledge and the main reason behind it is lack of resources like labs, instruments, etc. Different methods to overcome this problem has been taken into practice like remote labs that are presented with graphical visualization in order to assist the students for development of their skills but that is not efficient since these systems lack reality. It is easier to understand when you perform the experiments in real. In order to overcome this problem this research was done which aimed at testing and validating of augmented reality (AR) that can be used in demonstration of experiment related interfaces in distant labs, in which students can perform experiments with real and virtual elements for better understanding. Some fields in which it is applicable are augmented reality, virtual reality and computer vision, E-learning and online learning, educational engineering labs, distributed system architecture. The real time video of instruments and equipment of an experiment can be presented and students can transfer smoothly from augmented video

demonstrations of equipment in remote lab to real equipment in a real lab.

Blended Learning [10]: In the traditional delivery of an engineering course, the instructor teaches the course material by delivering lectures during class time, and students are able to complete homework and assignments on their own, outside of class time. By using the flipped classroom pedagogy, the settings of lectures and homework are reversed: students learn the course material at home (for example, through online videos), and students are engaged in activities during class time. In a control systems course (mechanical engineering), it was reported that students performed equally or better when the course was taught using a flipped classroom (compared to a traditional classroom). On the other hand, in a thermodynamics course, Canino compared a flipped classroom to a traditional classroom that included active learning components. He found that between instructional methods, there was no statistically significant difference in test and exam performance. These reports, ultimately, show that the student workload can be maintained at a manageable level by using a true classroom flip—a flip that effectively brings the homework into the classroom. At the University of Toronto, blended learning was practiced by flipping a portion of a third-year energy conversion course with positive results. Flipping only a portion of a course can significantly reduce the initial time burden on an instructor. Students, on the other hand, appreciate a variety of instructional methods.

4 COMPARATIVE ANALYSIS OF EDUCATION TECHNOLOGIES

The technologies discussed in the above-mentioned sections have been compared in terms of development, implementation, learning, efficiency and ease of use. Let's take a concise look at all the aforementioned technologies and their advantages and disadvantages in Table 1.

Table 1: Comparison of Technologies for Engineering Education

TECHNOLOGY	APPLICATION AREA	ADVANTAGES	DISADVANTAGES
Augmented Reality [2, 3, 9]	• Computer Engineering Labs. • Embedded Systems Labs.	• Favours comprehension and retention of technical concepts. • Facilitates memorization and recall. • Real time representation of instruments and machines can be presented.	• Expensive to develop and maintain. • Mishandling of costly AR equipment by students. • Low performance levels of AR devices can occur during testing.
Virtual Reality [3]	• Visualising Civil Engineering concepts. • Easy visualisation and understanding of Electrical Power Systems.	• Visualizations of complex structures is possible without having to visit the actual site. • Increases student engagement.	• Expensive to develop and maintain. • Lack of standardization. • It may induce medical side effects in some participants.
Gamification and MOOCs [4, 7]	• Gamification(gcMOOC) and building virtual communities to promote group learning effort. • Improving the access, quality and scaling of education.	• Increased participant learning. • Learning opportunity for everyone. • Self-paced learning.	• Evaluation and assessment is computer graded. • Course completion rates are low. • Lack of direct teacher-student interaction. • Production of video lectures may hit a bottleneck.
Blended Learning [6, 10]	• Algorithmic thinking ability/ Computer Science Engineering. • Nearly any field in education as a whole.	• Better lecture time utilization. • Improvement in learning curve and better student results. • Easy for teachers/instructors to inculcate this technique in their pedagogy.	• Acquiring software and hardware technologies for the blended course can be costly. • Cognitive load. Teachers over delivering and students not matching the pace.

5 CONCLUSION

The trends and technologies discussed in this paper have been tested and proven to be beneficial in engineering education and also education as a whole. Different technologies have been reviewed like blended learning, gamification and MOOC's, virtual reality and augmented reality that are advancing day by day and making a vast ocean of opportunities for the bright future of the students. Different blends and experiments of merging technologies are performed to create a new technology for better understanding and better output yield in the field of engineering education [12, 13]. Every technology reviewed here has the potential to remove the blind spots that otherwise are left unchecked by traditional brick and mortar learning institutions. Incorporating these techniques into the teaching pedagogy can prove to be an effective tool. The technologies such as learning through games, MOOCs and Augmented and Virtual Reality will also be helpful to bring out the change in imparting engineering education even during COVID-19 pandemic. Although the initial costs of setting up these technologies can be high, but in the long run it will substantiate to a better learning environment for the students and in turn craft better engineers for the industry. Better understanding and effective learning provided by these technologies can hold a bright future and a valuable growth of the individual.

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