



A New Future: A Review of Virtual and Augmented Reality in Biomedical Engineering Education

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Abstract. Virtual reality (VR) and augmented reality (AR) are advancements of computer technology simulating real world experiences. With these advancements, virtual and augmented reality (VAR) are easy to use and becoming more accessible for all ages. These realities enable alternate methods to an in-person experience, leading to the adaption of VAR in classrooms especially at an undergraduate level. Biomedical engineers work with complex, expensive and in some cases immovable equipment. These technologies can promote biomedical engineering (BME) students to gain a new prospective and engage with such materials prior to receiving “hands on” real world experience. BME students who choose the premedial route can witness both clinical applications and medical procedures before entering clinical rotations. VAR can assist BME students who work in medical design, to identify problems and observe clinical needs as they gain hands on experience with medical equipment. This review discusses virtual and augmented reality in biomedical engineering classrooms and analyzes survey student responses, student grades and professor perspectives.

Keywords: Virtual Augmented Reality, Biomedical, Education.

1 Introduction

Virtual reality (VR) is the act of immersion of experiences with computer technologies [1]. VR can engage users with sensory, realistic and hands on interactions. Virtual reality allows real world experience from anywhere, especially a classroom. Specifically, biomedical engineering students can learn clinical applications and understand medical devices. VR enables engagement as students are intrigued with the new technology and are eager to try it [2]. Virtual reality offers another opportunity for visual learners. VR can give a global perspective, as it can place students in another part of the world. Students can learn more about a culture expanding their mind and empathy [2]. Virtual experience in the classroom can benefit students in a real-world professional setting.

Augmented reality (AR) is the addition of a virtual object within a real environment. AR can measure real world objects and place them to scale in the augmented reality [3]. Students can use AR to interact with the real world with added features that may not be accessible to them prior to entering the classroom. With the use of AR, biomedical

engineering students can analyze objects that may be impossible in a learning environment to analyze in the real world, including chemical reactions and material properties.

Many biomedical engineering students take anatomy-based courses, and benefit to 3D models of the body as opposed 2D models. With the use of augmented and virtual reality (VAR), students can examine, and ask questions regarding the human body and about the usage and applications of medical equipment in a safe learning environment. [4]. VR and AR invite a new perspective into the classroom, encouraging students to try something new while engaging and motivating them.

2 Literature Review

Higher education classrooms all around the world have adapted virtual and augmented reality into their curriculum. Some of these studies depict these technologies as an alternative to in person instruction. Some compare 2D and 3D experience while analyzing students' opinions and test scores. Institutions, and their use of VAR in the classroom are outlined below in Table 1.

Table 1. Description of Studies of Virtual and Augmented Reality in Biomedical Engineering Classrooms

Institution	Department	Type of Equipment	Analysis of Data	Student Responses	Ref.
Munich University of Applied Sciences, Germany	Biomedical Education and Research Center	VR Headset and Augmented Reality (AR) glasses	Likert scale student survey, and analysis of student exam results	Students felt more engaged with the content, and they were able to understand physiology of the body. Some students experienced motion sickness. The upper range of exam scores increased.	[4]
University of	BME	3D video	Likert Survey	VR allows	[5]

Arkansas USA		laboratory component – Google Headset	Responses	students to work at their own pace, but improvement of equipment is required for advancements in education.	
Widener University (USA) and Drexel University (USA)	BME	Clinical applications 3D video laboratory component – Insta 360 EVO 3D180 VR camera	Survey Assignment Questions and Responses	Based on responses, students felt the VR helped their understanding of clinical applications.	[6]
Pennsylvania State University (USA)	BME	360° videos – GoPro Max 360° camera via ThingLink	Students completed See, Think Wonder: “What do you see?” “What do you think about that” “What does it make you wonder?”	When watching 360° videos, students were able to properly visualize a potential BME career. They felt they were not watching a video but rather experiencing it.	[7] [8]
The University of Hong Kong, China	Biomedical Sciences (BMS) and BME	VR System (HTC VIVE Pro) and VR app: Skeletal muscle contraction	Student Questionnaire	Most students had a positive experience with the VR. Some students experienced dizziness when utilizing the equipment.	[9]

<p>University of California Irvine, USA</p>	<p>BME</p>	<p>180 stereoscopic cameras to video operating room and physician point of view. Oculus Meta Quest 2 and Google Cardboard</p>	<p>Optional fan study survey Student Questionnaire the end of stu along with interview</p>	<p>Several students felt physical discomfort with the equipment. Due to limitations of the VR system, students were required to work independently. Students did enjoy the VR classroom setup, but students and professors agree that improvements of equipment could be made.</p>	<p>[10]</p>
<p>Monash University, Malaysia</p>	<p>School of Engineering, department not specified.</p>	<p>VeeR MINI VR Glasses</p>	<p>Student Questionnaire and Analysis of Brain Reaction.</p>	<p>Students learning was enhanced in the 3D learning environment as opposed to 2D.</p>	<p>[11]</p>

A study done at Munich University of Applied Sciences in Germany utilized VAR when learning about medical imaging and equipment, cardiovascular diseases, neurological disorders, and tumors [4]. VAR allows students to engage in mechanisms of these diseases and how they affect the human body. Majority of students agreed that VAR in this study helped their experience of learning human physiology. The upper range of their exam scores improved as opposed to no implantation of VAR in the classroom [4].

To prepare BME students with clinical applications, the department of Biomedical Engineering at University of California Irvine in the United States created a clinical immersion program with virtual reality [10]. Both 2D and 3D videos of an operating

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with physician point of view were made. 3D videos could be viewed on either a Google CardBoard VR Headset or Quest 2 VR Headset. Students with access to either a phone, tablet, or a computer could successfully view the videos. The purpose of this experiment was to enhance undergraduate students' skills of identifying clinical needs. Students completed an optional survey regarding demographics, opinions on VR in a classroom and students experience with VR. At the end of semester, all students completed a survey and some a brief interview to identify whether the students believed 3D VR was beneficial in the classroom. VR was found to provide students the ability to learn clinical needs through the virtual application [6] [10].

Amongst the studies, students felt immersed and engaged in the environment when they utilized VR. Students felt that they were in the experience as opposed to watching it in a classroom. VR helped to show students a perspective of their potential future career [7]. Students also felt that through clinical application, they were able to understand their responsibilities but also the roles of the nurses [6].

Some students experienced challenges with the use of virtual reality. Several student were uncomfortable and experienced motion sickness [4]. Some of the VR equipment were not accessible in the classroom. Professors noted that when students could use VR equipment, specifically Quest 2 Headsets, from the school library, the students opted for Google Cardboard as it was a hassle for them [10]. Students were required to work independently when utilizing the VR systems. Professors recognized independent work as a limitation to the technology as working in a team is an important aspect of engineering [10].

3 Conclusions

Virtual and augmented reality have been used in biomedical engineering classrooms as an alternative to in person labs and clinical application needs. Students experience a new perspective when using VAR. Students can visualize their interest of study as a potential new career and recognize their role and responsibilities as biomedical engineers. Based on both student responses and grades, students can learn about clinical needs of patients with VR in the classroom and feel both engaged and motivated when learning. Some challenges occur with VR including some students feeling uncomfortable, motion sick, and dizzy. Advancements must be made to ensure students feel comfortable with VAR while promoting learning for all. Adjustments to equipment, virtual and augmented reality can engineer a new future for biomedical engineering education.

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