Virtual Reality as an Education Medium for Dental Students

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1 INTRODUCTION

Virtual Reality (VR) in today's world has become an important medium for education [9]. This is more prevalent after COVID as the pandemic forced people into a bubble restricting their abilities to interact with the outside world. VR technology is expensive, but the emergence of consumer-based head-mounted displays (HMDs) reduced cost and greater user accessibility. Improvement in user experience and cost reduction has allowed the integration of virtual reality into practice-oriented jobs like dentistry. Every human has teeth, and most of us care about our teeth. They are not only crucial for food ingestion but are also associated with a person's hygiene and aesthetic beauty. It goes without saying that there is a considerable market for dental professionals.

Virtual Reality provides an immersive experience in a realistic setting, and it will be beneficial for prospective students to learn tasks like teeth scaling and teeth extraction. It would be challenging to achieve realistic practice with these kinds of tasks without having visual references to identify with the tasks. According to the Centers for Disease Control, 63.0% of adults over the age of 18 had a dental visit in 2020 [3] which indicates that there is a big market for the dental practice.

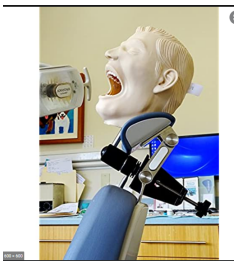

Fig. 1. Manikin Simulator

Virtual Reality allows us to integrate the aspects of the work environment into our local environment. This power of VR can be utilized to help students in dentistry-related tasks. For this research, we specifically focus on two such tasks which are teeth scaling and teeth extraction. The medium currently used for dentistry education is a Manikin Simulator shown in Figure 1. Students are able to access this medium along with equipment like scalers, saliva ejectors, X-ray machines, and more at an institutional lab, but this is a big setback for a lot of students as they have to be at that location for practice, plus they might have to wait for their turn. We propose a new prototype to resolve accessibility issues for the students that will allow all students to access the lab, with all the tools, without having to wait for their turn.

Our prototype is a Virtual Reality Simulator for Dental Labs. Using the immersive power of VR we integrate the setting of a real-life dental operation into the local environment which helps the users in interacting with different objects like the operation tools and the patient with awareness about their actual presence. We aim to observe the efficacy of the VR simulator in dental education. Our assumption is that the students will find little difference in the practical operations of the lab and our prototype. The success of our prototype can result in improving the quality of dentistry education.

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2 RELATED WORK

The foundation of virtual reality is based on creating the illusion of being present somewhere without actually being there. The Ultimate display paper presented the earliest concept of virtual reality using a computer display. The author recognized the potentiality of computer display which could be utilized to simulate reality to the point where one could not tell the difference between actual reality. He suggested a virtual world that can be viewed through an HMD and appeared realistic through augmented 3D sound and tactile feedback [11]. However, displays in the earliest century only had the built-in line-drawing capability. Later, the author created the first VR / AR head-mounted display (Sword of Damocles) that was connected to a computer and not a camera. The computer-generated graphics for that device were very primitive and the user had to be strapped down to the object [12]. Virtual reality advanced rapidly over the last decade due to technological innovations, and the rapid adoption of smartphones. The most widespread interest in virtual reality has been in leisure and entertainment. Since virtual reality provides an exclusive personal experience that alters one's perception of their surroundings thus it can assist education [8].

At the onset of COVID-19 adaptation to online classes is on the rise. Despite the fact that online learning has been used as a supplement teaching method for distance dental education since 1990, dental education must still rely on face-to-face education in physical classrooms due to its characteristics [13]. One of the major constraints in online class is the lack of interaction. The use of simulation can aid in reducing the constraints of existing challenges in dental education. Multiple research suggests that VR could facilitate the improvement of performance and conceptual understanding of a specific set of tasks thus enhancing the outcome of education [2]. Recent research provides empirical evidence for the use of VR in science education. The experimental results reveales that the group that used VR technology in the classroom settings performed better in terms of academics and engagement than the group that used traditional classroom settings [7].

The University of Pennsylvania, School of Dental Medicine proposed a VR-based simulator to teach root canal anatomy. However, the simulator lacks haptic feedback [1] which is necessary for learning purposes. The research showed the students performed better by the usage of virtual simulators and the students preferred this mode of teaching. DenX Ltd., a company based in Australia proposed a computer-directed simulation system named DentSim. The system employs a simulator linked to a computerized learning module that can direct the teaching of dental tooth preparation in real-time and can evaluate the product by providing students with instantaneous feedback as they work. The author conducted a study for assessing DentSim technology and found that students learn at a faster rate, developing their skills in significantly less time [5]. Reymus describes the creation of a virtual reality simulator for a dentist's office, complete with immersion in a VR scene and a simulation of tooth drilling. The author believes that this kind of simulator can contribute to evolving capacities of motor skills and hand-eye coordination [10] and conducted a study which supports the belief. Our work is heavily inspired by this work. At this time, we didn't find any work creating a virtual reality simulator focusing on tooth extraction and scaling.

3 METHOD

Our study focused on finding the effectiveness of a virtual reality-based simulator over the traditional simulation system in dental education. Furthermore, our study intended to find the similarity between virtual simulators and practical setups. We created a VR-based simulator allowing students to learn about tooth extraction and scaling. The first-year dental college students were the study's target user group. We wanted to use experimental investigations on students to answer our research question. The following section outlines participants, materials, design, and procedure.

3.1 Participants

Our targeted participants for this experiment were students attending dental college. We selected students from a 2nd-year class at Baylor College of Dentistry, and the total number of participants was 40. We included all the genders in our study. We advertised our study to the college professor. We conducted the study in a summer class, and no incentive was provided to participate in the research. The students participated in the study for extra credits for the class. The selected students had completed a module on basic dental morphology.

3.2 Materials

The experiment includes two setups: one is the real dentists lab with the Manikin Simulator and the equipment required for dental procedures like mouth mirrors, dental probes, scalar, cotten forceps, dental drills and more. The lab is about the size of a normal apartment living room with a movable hospital bed in the center and a chair for the student. Attached to the bed is a movable handle with all the necessary equipments listed above. The other setup is the virtual reality based simulation that we have designed which is a virtual formation of the first setup. The detailed description of the second setup can be found in the prototype section below.

3.3 Study/ Design

The experiment divided the participants into two groups and utilized the between-group design. One group was assigned to the Virtual Reality Simulator (Group-1) as a teaching tool. The traditional system(i.e., video) was used to teach the other group(Group-2). The independent variable for this experiment is the virtual reality simulator and traditional teaching tool (video). We chose the participants who had basic dental knowledge but did not have experience in performing the tooth extraction surgery. The students were not familiar with the Virtual Reality Simulator used for a dental practice. All the students were given the same introductory lecture and demonstration on the clinical practice of tooth extraction and scaling. Additionally, students of group-1 had one day of training on the use of VR simulators. The dependent variable of the experiment was the students' performance in the tooth extraction process. We measured the performance of the students received on the final test.

3.4 Procedure

We conducted the experiment in the 2nd year class of Baylor College of Dentistry, Dallas. After the semester, a final test assessed the student's performance in both groups. The final test was a written exam that was 45 minutes long and set by an expert academic-practitioner. This test aimed to assess abstract knowledge gained during the class. The test consisted of five short answers and five multiple-choice questions from materials taught during the class. The answers were graded by the expert who set the questions. The measurement scale is based on the standard grading scales A-F followed by education. A denotes excellent performance, B indicates good performance, C denotes adequate performance, D is marginal performance, and F is inadequate performance.

The second phase of the test was to operate tooth extraction and tooth scaling an actual manikin simulator. It helped to measure student's performance on practical aspects. Two experienced academic trainers assessed this part of the test scored on the grading scale of A-F.

The last phase of the study included questionnaires for the participants of group-1 (assigned VR simulator). We asked the participants to rate their answers on a Likert scale of 5. We asked the following question to gain insight into the usability of the prototype.

Do you agree the VR simulator helped me to gain understanding for orthodontic process?

1– Strongly disagree 2– Disagree 3– Neither agree or disagree 4– Agree 5– Strongly agree

Do you agree the VR simulator exhibited property of the real time dental setup?

1– Strongly disagree 2– Disagree 3– Neither agree or disagree 4– Agree 5– Strongly agree

The measures that we used to evaluate learning for the students were the student grades to compare the learning curve for the two groups of students. The distribution of the grades and their sparseness in terms of standard deviation and variance was used to come the prototype with the real dental lab setting.

4 PROTOTYPE

Our Virtual Reality Dental Lab Simulator has been designed to provide the users with a realistic experience of dental procedures. We focused on three things for the development of our prototype. The development of a virtual reality staged to mimic an actual dental procedure similar to that of a dentist's office, simulations of tooth scaling and extraction, and a virtual reality device to bring the pieces together. We have used computer vision image processing technologies to achieve these tasks.

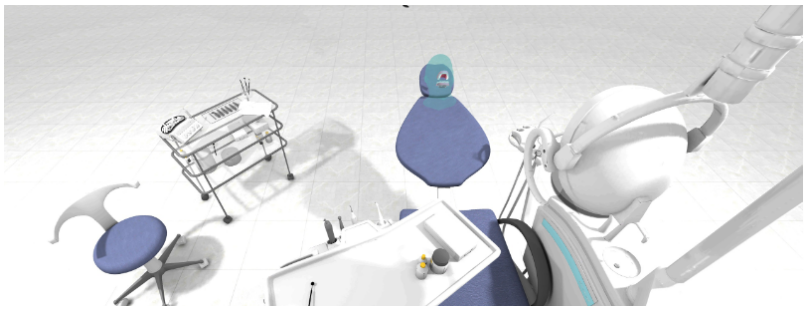

Fig. 2. 3D space view

Fig. 3. realistic simulation

We created a realistic 3D model for a dentist's office using the Unity XR framework. We simplified the setting with less vertex volume because of the limitations of the VR device in handling complex 3D models. Figure 2 shows the 3D space view of the dentist's office. The second milestone was to create a realistic simulation of two dental procedures: teeth scaling and teeth extraction. Kim et al. [6] created a realistic simulation of tooth extraction using a vox-based collision module; we used a similar approach to create our simulations. The collision module allowed detection of the interaction between the user and the other objects in the 3D space, which was an essential factor for our experiment on practice-oriented dental procedures. The oculus quest headset is a commonly used device for the development of realistic VR spaces, and we used this headset to present our experimental dentist's office model to the user. Meese et al.[4] showed how the Oculus Quest headset could be used in cardiopulmonary resuscitation training. We opted for a similar approach in creating our experimental VR space. Figure 3 shows a realistic simulation of a dental procedure with a user.

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