A TEFL Virtual Reality System for High-Presence Distance Learning

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Abstract. VR technologies can be effective for distance learning. However, currently available virtual reality systems for teaching English as a foreign language (TEFL) are limited: they are often a supplementary experience within a traditional classroom or do not offer a high level of student-teacher interaction. This research considers an HMD-based platform with two linked subsystems to address these issues. The first is a series of high-presence learning scenarios with roles played by the student(s) and teacher through avatars. The second is an interactive web portal within the VR environment that allows for learning, testing, and feedback. In order to assess the potential of this proposed system, student learning outcomes and ease of use are evaluated through preliminary testing, and this research also posits a more comprehensive system for managing longer-term courses.

1 Introduction

The field of educational technology has seen many advancements in virtual learning environments, including the use of online platforms, games, and various testing applications to improve educational outcomes [1-4]. All of these have been used with varying effects in distance learning [5-6]. However, the use of consumer VR head-mounted displays (HMDs) is still in its growing stages, and their efficacy as a standalone teaching tool has been understudied for teaching English as a foreign language, or TEFL [7].

Though there is a plethora of new research examining the potential of VR as an educational aid, only a small portion has focused on the intersection of HMD-based systems and TEFL. Yet, there are many reasons why the two fit. For one, VR is useful for active learning [8], which has been suggested to be more effective for knowledge retention and testing performance than passive methods [9]. In addition, VR can be independent of the time and place in the physical world, so it can be used to provide virtual access to environments and situations that may ordinarily be inaccessible physically. This can be a good complement for task-based, scenario-based learning. Finally, distance learning technologies paired with VR may also provide a layer of safety, decreasing social phobias about speaking or interacting with others [10]. As many beginning English learners may be shy, this can facilitate productive communication.

There are a few more peculiarities that distinguish the use of VR for TEFL. One of the most effective English-teaching methods, face-to-face instruction by a skilled, experienced teacher, can provide students with real-time solving of pronunciation issues, grammar correction, and other tasks in a way current software might have trouble doing. Current VR TEFL offerings may rely on relatively passive learning [11], and even integrating software using adaptive learning can have its limits [12].

While the above offerings can be quite useful, especially with scalability for large learning groups, this research hopes to address the research gap on the use of a live, professional teacher. Much research has expounded on the effectiveness of a live teacher using video chatting software for TEFL, but relatively little has been done on the use of a high-presence VR environment and HMDs. Using an interdisciplinary approach, this research blends educational technology with system design to create a network-based system for a live instructor to teach and evaluate English skills through VR. This includes an integrated testing solution which students can operate without having to remove the headset or exit the virtual teaching environment.

This research seeks to answer three main questions. Firstly is, "Does this VR system have positive educational outcomes?" It will test if this VR-based teaching tool can be effective at transmitting English knowledge. Secondly is, "Is the VR system embraced by students?" It will assess if the students have trouble with system usability and find if they are interested in using VR for future learning opportunities. Third is, "Is the VR system reliable?" It will explore if the many features and components required for a standalone VR teaching system can be put together with the higher levels of reliability needed for educational settings.

Finally, this research also aims to be a stepping stone for a more elaborate system, one that can emulate the functionality of a traditional classroom and tailored for long-term TEFL use. Thus, areas for improvement will also be addressed.

The remainder of the paper is organized as follows. Section 2 provides an overview of the main subsystems, Section 3 covers the experimental design, Section 4 contains the results of the experiment, and Section 5 offers some future trajectories for this research and its conclusions.

2 System Architecture

As shown in Fig. 1, the left oval is the student-centered portion of the system. Using an HMD and powerful PC, the student can access a high-presence VR world through a chat program client, VRChat. This is paired with a web-based testing portal running through Oculus Dash, a virtual desktop display. On the right is the teacher-centered portion, in which the instructor can interact with the student using the HMD system. Once the lesson is over, the instructor can receive test data and conduct the lesson evaluation using a traditional desktop setup for increased workflow. In the middle stand the third-party servers that handle the VR scenario and testing management.

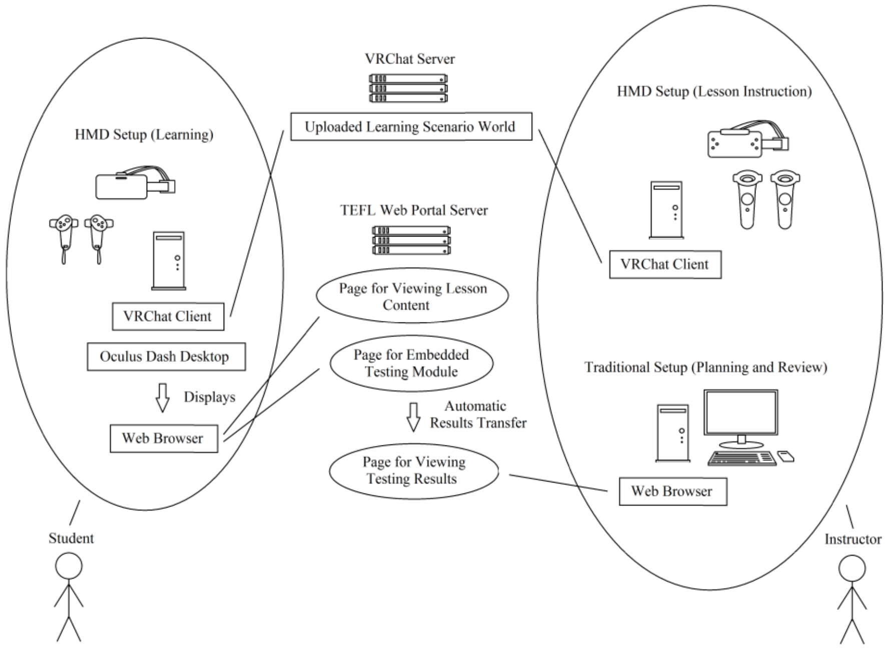

Fig. 1. An architectural diagram showing the major connections within the holistic VR system.

While the system network is separated into three sections, there are two subsystems that are the focal point of this research. These are the High-Presence Learning Scenario and the TEFL Web Portal. They appear on the student's VR display as two parts, as shown in Fig. 2. They are also relatively independent of one another, as the Web Portal can be used with other VR chat platforms (such as High Fidelity), and the Learning Scenario can be coupled with other web-based testing systems. They are explained in greater detail below.

2.1 The High-Presence Learning Scenario

The first subsystem of interest is the High-Presence Learning Scenario, which runs and is stored on the VRChat servers. VRChat is an online chat platform created with the Unity engine, and it is optimized for VR functionality. Features include voice chat using HMD microphones and object manipulation with HMD controllers. Using the Unity Editor alongside the VRChat SDK, a customized virtual learning scenario was created. The scenario takes place inside an office building during a mock career fair. The scenario is limited to one room, an interview office room. Here, the teacher leads the student by explaining business interview behavior, useful phrases, and guidelines for answering interview questions. Inside the room, various props and items fitting the scenario, such as books, manuals, and company products, have been inserted, and these items can also be manipulated using the HMD controllers. Blender was used to create and texture a portion of the models, and others were procured from content databases such as Sketchfab.

The use of a virtual office and movable objects allows for task-based learning [13]. As an example, one step of the scenario is for the teacher, roleplaying as a particular company's representative, to ask, "Could you bring me the manual we give to new workers? It's on the furthermost table." This task allows testing multiple levels of comprehension. First is being able to discern the manual using context clues, as the manual is titled "Employee Guide" and features a cover with a relevant photo. The second is being able to move as if in physical space to the furthermost table, cementing the learning process.

An additional feature is that the teacher and student can use a virtual whiteboard. For this scenario the teacher uses it to emphasize important information, also asking the student to write or highlight certain points of interest.

2.2 The TEFL Web Portal

The second main subsystem is a web portal optimized for use with HMD controllers and displayed within the Learning Scenario. This has been accomplished through the recent introduction of Oculus Dash and its virtual desktop capabilities. While previous virtual desktop offerings had low integration with the HMD interface or had high levels of lag and stuttering, this new version is smoothly integrated and has a negligible performance impact.

The Web Portal subsystem is limited to the student during the teaching phase, and it is overlaid above the Learning Scenario as a window. The portal window is pegged not to the movement of the HMD but to the standing location of the student's avatar. Thus, the student can turn to the portal window when necessary and away from it when not. Yet, the window will follow the student around rather than stay in a stationary point within the Learning Scenario world.

The web portal includes a few functions, the most important being a testing feature in which students can use the HMD controllers to scroll through multiple-choice questions and select the answers they wish. Future updates may have audio answer submissions that use speech-to-text technology to test pronunciation quality. This testing system uses Google Forms, which has a quiz-making function that can also automatically send data to a control panel that can be accessed by the teacher using a traditional desktop setup at a later time.

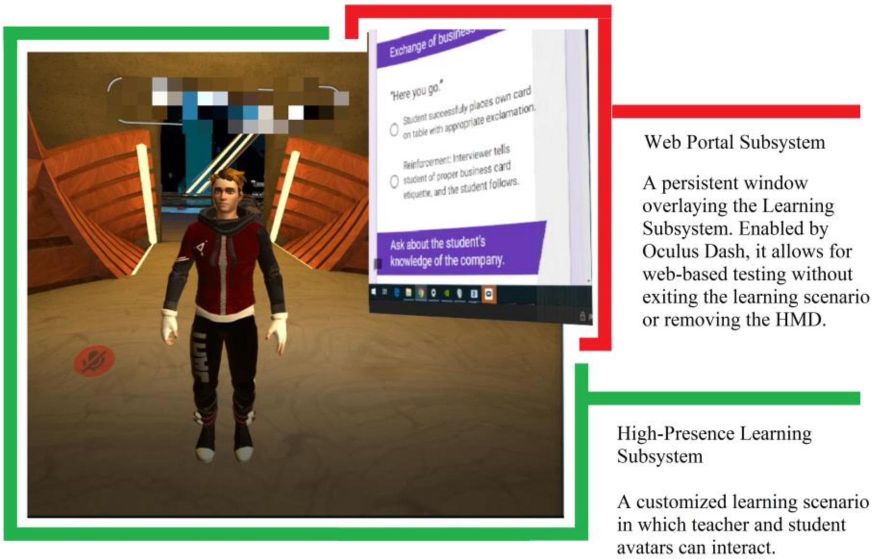

Fig. 2. An example of how the Web Portal Subsystem overlays the High-Presence Learning Subsystem.[1]

Special attention was made for the Web Portal's ease of use with HMD controllers, so the large buttons and simple menus (for example, no drop-downs, which failed in preliminary testing) require comparably little effort to navigate. Scrolling is also intuitively supported by Oculus Dash. Thus, after preliminary testing, an older system, which had one question at a time displayed and allowed going back and forward using buttons, was removed. The new system, with the entire quiz as a scrollable single page, was easier to use.

2.3 Hardware and Other Elements

As seen in Fig. 1 and mentioned earlier, the hardware can be separated into student and teacher setups. Most of the system components, both software and hardware, are easily available off-the-shelf. The student setup consists of an HMD (Oculus Rift, Consumer Version 1, including touch controllers) connected to a high-performance notebook (HP Omen 15, Gen. 8 Intel i7, Nvidia GTX 1070 Max-Q, 16 GB Ram). The teacher setup is an HMD (HTC Vive base setup, including controllers) paired with a high-performance desktop (Gen. 5 Intel i5, Nvidia GTX 980, 16GB Ram). Of course, there are also the various servers of third parties (Google Forms, VRChat, etc.) and the VR platforms Oculus Home and Steam VR.

[1] Due to difficulties in simultaneously screen-capturing the Oculus Mirror Compositor and the Oculus Dash virtual desktop, a mockup was created.

3 Research Methodology and Experiment Details

There are two main experiments. The first is an evaluation of student learning outcomes using data from the completed pre- and post-tests. The second is a usability study using data from student surveys. Eight students separately completed a full testing and survey session, each lasting around 45 minutes to an hour. Before each experiment, students were briefed on the system and its controls.

3.1 Testing Learning Outcomes

The learning outcomes evaluation was done through the pre- and post-testing method. Five questions were made following an example of the commonly-used "one-shot" pre- and post-test study [14]. As in the example by Karshmer and Bryan, the same quiz was used for pre-and post-testing, each question touching on one English learning concept as explained in the Learning Scenario. This includes vocabulary recall, context clues, and task completion. Students could select from four choices, as well as an "I don't know" to reduce the possibility of guessing influencing the results [15]. Students were also encouraged to not guess. Following Patton's guidelines [16], the experiment population was drawn from a selection of criteria, finding non-native English speakers with a self-assessed "intermediate" English level or higher on a set scale. In addition, some potential students with debilitating levels of VR sickness were winnowed out during the selection process. The testing was conducted entirely within the Learning Scenario while using the HMD.

3.2 Usability Study

The user interface was evaluated through a usability survey, which included multiple-choice questions about audio and video quality, lag, the learning experience, gained interest in using VR for education, and other qualities related to the research questions [17]. As VR has been shown to improve student motivation [18], confidence in being prepared for a similar situation in real life was also checked. These choices were given on a Likert scale. In addition, a free answer portion allowed students to respond about anything they liked or did not like about the experience that was not listed on the survey. See Fig. 4 for a simplified overview of the multiple-choice questions and results. During preliminary testing, testers were offered two different setups based on the different HMDs. The majority of preliminary testers preferred the virtual desktop function of the Oculus, so all students used it during the main testing phase. There were no other hardware or software preferences found with the preliminary testers.

4 Experiment Results

4.1 Learning Evaluation Results

It is clear that the system allows for the transfer of knowledge, though there are certainly some areas for improvement. While "I don't know" constituted the majority of answers in the pre-test, over 50%, it decreased to less than 20% in the post-test. Correct answer rates improved from under 40% on average to over 70%. However, during the free answer portion of the survey, three students expressed that it was difficult to learn the lesson content because they were having to focus on manipulating the HMD interface. This is supported by past studies referencing the increased cognitive load of certain VR applications leading to a steeper learning curve [19]. Perhaps future, long-term experiments can lessen this problem after the first few lessons, given that people may become acclimated to VR and the HMD control system.

4.2 Usability Study Results

The majority of users had an overall positive experience with the system, as seen in Fig. 3. Of note is the high proportion of students who considered it an "interesting" experience and gained enthusiasm in using VR for English learning. The majority of students also responded positively when asked if they have more confidence in being prepared for a similar situation in the future.

However, three students complained of motion sickness to varying degrees. This has been dubbed "VR Sickness", and while it has been studied in learning situations, it seems there are currently no highly-reliable ways to eliminate it [20]. While some described the sensation as very mild, others said it was troublesome to the point of distraction. In addition, as mentioned earlier, two experiments had to be stopped in the preliminary stage because of extreme nausea. This may mean VR has some exclusionary qualities, as some may be left out during VR group activities or may have trouble joining a VR-exclusive course.

As a portion of testing was conducted at corporate offices, it was noticed that the experience was heavily dependent on network quality, which includes internet speed and a lack of firewalls or other blockages preventing access to necessary servers. One experiment had to be abandoned because of a network issue, and others were delayed. In addition, the system has a long setup time, an average of over 30 minutes, and a relatively high setup cost. This of course could be part of the reason for the slow adoption of desktop-based VR headsets in the educational field. VRChat is still an Alpha release, and there are often updates that change the program's content, as well as updates for Oculus Dash that lead to compatibility issues. After six of the eight experiments were completed, an update to VRChat changed some design elements for one of the virtual rooms used.

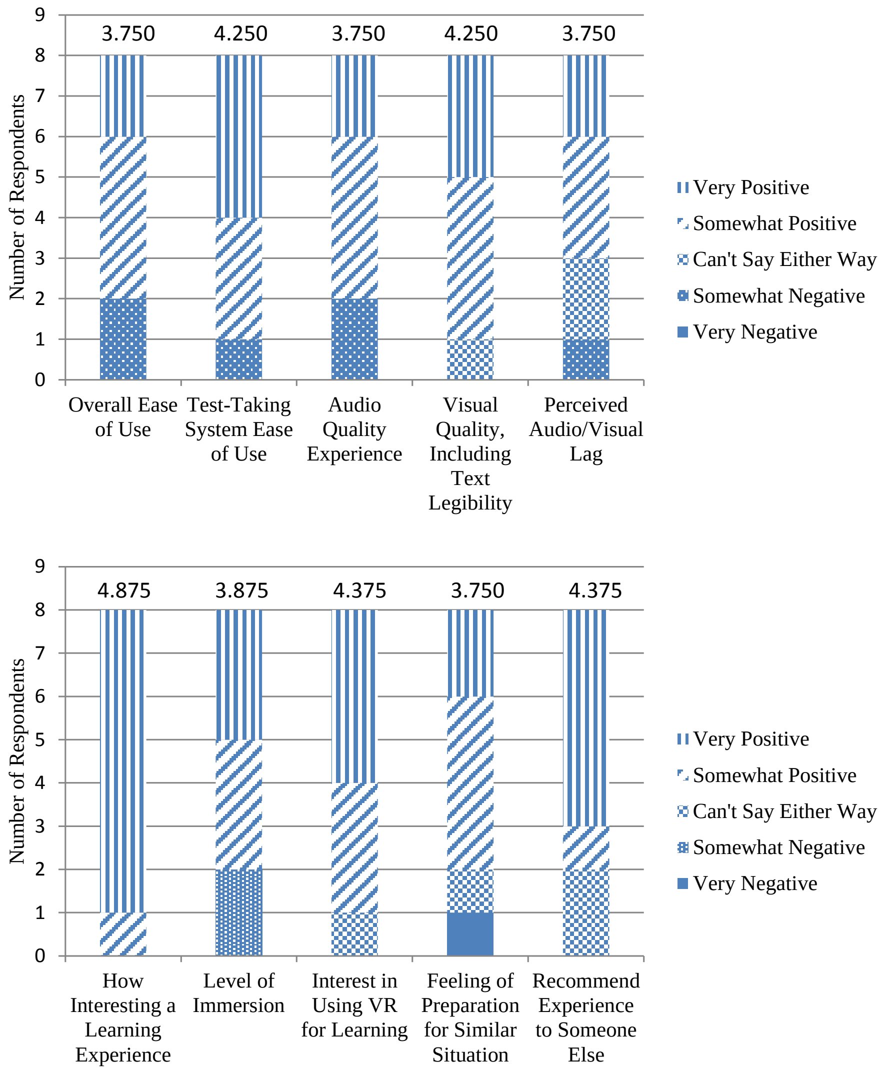

Fig. 3. Usability survey results from the eight fully-tested students. The number above each bar is the average of the Likert scale responses, with 5 points for "Very Positive" down to 1 point for "Very Negative."

5 Future Work and Conclusion

There are three main areas in which this research aims to progress, starting with reconciling a similar VR system with an existing set of educational criteria or guidelines. Two examples would be the MEXT (Ministry of Education, Culture, Sports, Science, and Technology) educational guidelines for high schools in Japan or the Common European Framework of Reference for Languages. Second, there is a distinct lack of research on long-term VR use for TEFL, such as a standard half-year course or yearlong course. There is also little research on VR as the sole method of education, outside of the traditional classroom. The combination of these two qualities can lead to further steps towards a new goal, an accredited VR-based TEFL learning course.

Hardware will also be shifted to a homogenized system in which both the student and teacher use the same hardware and software setup, which will cut down on setup time. In addition, the use of the overlaid web portal will be expanded. While the current system has only the student using web portal contents and the teacher relying on a memorized lesson plan, the future portal aims to lower teacher prep time and increase usability by having a teacher control panel on the web portal. There, the teacher can access a lesson script for asking questions, as well as monitoring and controlling the flow of the lesson. Thus, many of the functions of a traditional classroom (writing, speaking, multimedia, testing) can be emulated. The lesson script can be modified to provide adaptive learning opportunities for students who have trouble progressing or understanding, choosing the next set of questions or activities based on student performance in the previous set. The expansion is also planned to have multiple learning scenarios connected by a single hub, in which students can use the “portal” feature of VRChat to travel among them. Last of all, a new research design, co-opting the plethora of previous research on CALL (Computer Assisted Language Learning), can be used, following the study of Virtual Reality Assisted Language Learning, or VRALL [21].

While there are many hurdles to large-scale educational adoption, including reliability issues, the targeted use of high-performance, high-presence VR scenarios can be useful for task-based language acquisition, increasing student interest and confidence, and providing alternative immersive learning methods with a high level of student-teacher interaction.

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