Exploring the Usefulness of Visual Indicators for Monitoring Students in a VR-based Teaching Interface

Yitoshee Rahman * Arun K Kulshreshth † Christoph W Borst ‡

University of Louisiana at Lafayette, Lafayette, Louisiana, United States

Abstract

Teaching remotely using immersive Virtual Reality (VR) technology is becoming more popular as well as imperative with the ever-changing educational delivery methods. However, it is not easy for a teacher to monitor students in VR since only student avatars are visible. We designed and tested two educational VR teaching interfaces to help a teacher monitor students. Our comparative analysis using a preliminary study with 5 participants showed that the teaching interface with centrally-arranged emoticon-like indicators, displaying a summary of student information, performed better than the interface with avatar-located indicators in terms of teaching duration, and classroom management.

Keywords: Virtual Reality; Eye-tracking; Visual Cues; Education.

Index Terms: Computing methodologies—Computer graphics—Graphics systems and interfaces—Virtual reality; Applied computing—Education;

1 Introduction

Since COVID-19, more and more educational institutes are leaning towards remote learning, and educational Virtual Reality (VR) applications are becoming an interesting topic of research. Several researchers have emphasized the importance of real-time classroom awareness and how these interfaces are aiding in improved teaching performance [4], [5]. These applications are of various types including but not limited to ambient displays, wearables, or learning analytics dashboards [1]. Broussard et al. [2] proposed a VR interface for teachers that displays several visual cues to support teacher awareness of students and their actions, attention, and temperament. They did a preliminary study of user preferences for different cue types and their parameters, but, in their study subjects did not teach a class while using the interface. In order to test the efficacy of the visual cues interface proposed by Broussard et al., we designed a user study to compare their centrally-arranged emoticon-like visual indicator interface with an avatar-located indicator interface, while doing a teaching task to simulate real world application of these interfaces.

Cognitive load relates to the amount of information that working memory can hold at one time. Due to limited capacity of working memory in humans, our goal is to avoid overloading the teachers with additional activities that don't directly contribute to teaching. Thus, we also evaluate the cognitive load of the teachers while using the two interfaces to see which interface is better for managing the classroom with minimal cognitive load increase for the teachers. We used heart rate data of participants to measure the cognitive load since it has been used in the past [3] to measure cognitive load. Additionally, we are also interested to see how the cognitive load of the teacher changes as we increase the number of students that needs a teachers' attention (called important students in our experiment).

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Figure 1: Centrally-Arranged Indicators

Figure 2: Avatar-Located Indicators

2 The Interfaces

Our experiment had two interfaces: one with centrally-arranged emoticon-like visual indicators and one with avatar-located indicators. Both the interfaces have a fixed number of simulated student avatars placed at a random distance inside a classroom. A slideshow presenter is placed in front of the subjects that they can use to teach the students. Students in the interface can have three different actions: raising hand, speaking and typing. Students who had raised their hands were considered as important students, needing a teachers' attention. The two interfaces are described in the following sub-sections.

2.1 Centrally-Arranged Indicators (CAI)

Centrally-arranged emoticon-like indicators represent all students in the classroom (based on the interface proposed by Broussard et al. [2]). The indicators appear in multiple rows and in front of a teacher but with a slight offset below so that it does not hinder the subjects' view of the classroom. These emoticons or indicators range in colors from red to green based on the attention level of the student. The green color means an attentive student and the red means a distracted student. A red colored tether connects the important student's avatar and their representative indicator. Hand raise, speaking and typing action icons appeared on top of the indicators.

2.2 Avatar-Located Indicators (ALI)

This interface (Fig. 2) is similar to the interface described above. However, emoticons-like indicators are not present. Action icons for hand raise, speaking and typing icons appeared on top of the avatars.

3 User Experiment Design

We designed a user study to compare the two interfaces. Subjects played the role of a teacher and were teaching students basic JAVA programming related concepts. While teaching, subjects were asked to identify (look at students for more than 5 seconds) important students who raised their hands using both the interfaces. We used eye tracking data to detect if the important students have been correctly identified. The subjects were asked to ignore the color of the emoticon in case of visual-indicator interface and only pay attention to the hand raised icon. Our experiment had 2 independent variables: interface type (CAI and ALI)) and the number of important students (1, 2 or 5). Thus, in total we had $2 \times 3 = 6$ conditions for each subject. Until a subject had detected all the important students, the subject was not allowed to continue with the educational slides. The dependent variables are response time, accuracy for correctly identifying important students, and educational lesson duration. Additionally, we collected cognitive load related information (subjects' self assessment, NASA TLX questionnaire, and heart rate).

The VR device used was HTC Vive Eye and we calibrated the eye-tracker for each participant. The heart rate tracker used was Polar Verity Sense. The participants were first trained to use the system and their baseline heart rate was collected at this time. They practiced looking at student avatars using the training scene with the help of a visual gaze indicator (a sphere) on the screen. In the study, subjects were asked to detect important students (with no gaze indicator shown) and their response time was recorded. The response time was defined as the time take by the subject to look at an important student since it became important.

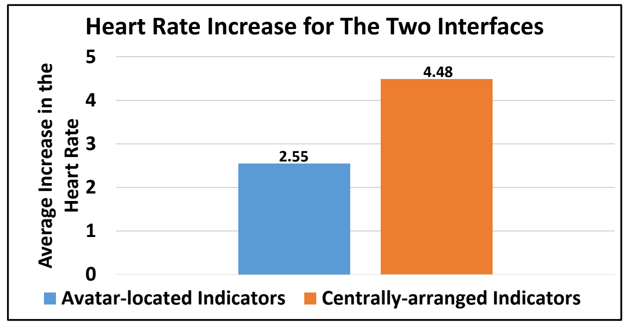

Figure 3: Average increase in the heart rate of subjects

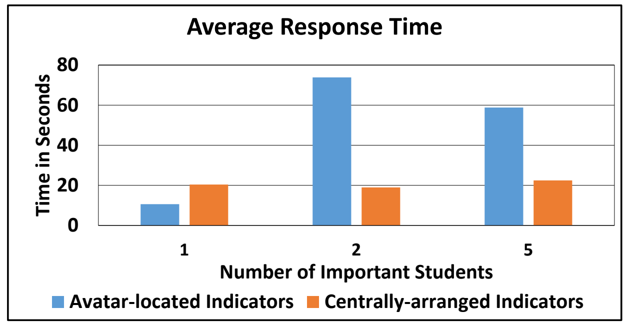

Figure 4: Average response times for attending to all the important students

4 Preliminary Study Results

We conducted a preliminary study with 5 subjects (4 males and 1 females, aged 20 to 35). Four of the five subjects preferred the centrally-arranged indicators over the avatar-located indicators. Based on the subjects' responses of the cognitive load related questionnaire and their self assessment of classroom management, their cognitive load and classroom management were not affected by the increasing number of important students. This indicates that, with the help of the centrally-arranged indicators, the subjects could manage the classroom just as well without too much increase in cognitive load. Subjects were asked to self evaluate their classroom management technique using a 7 point Likert scale questionnaire. Their average response rate was 4.8, indicating that the subjects thought they managed the class little better with centrally-arranged indicators compared to avatar-located indicators. Only one subject stated they did not like looking at centrally-arranged indicators while teaching.

Subjects mentioned that they felt more time pressure in case of centrally-arranged indicators since the centrally-arranged indicators gave them a sense of urgency to address the important students immediately. This explains the average increased heart rate of the subjects in case of centrally-arranged indicators compared to the avatar-located indicator version (See Fig. 3). Since the average change in heart rate is still minimal and an increase in heart rate is expected while teaching, we can safely assume that either interface does not add too much to the cognitive load of the teachers. On an average it took subjects 59 seconds more to finish the same slides with the avatar-located indicators compared to the centrally-arranged indicator interface. Figure 4 shows the average important student response time for both the interfaces. The average student response time for the avatar-located indicator interface was 53.58 seconds and for the centrally-arranged indicator interface was 34.38 seconds.

5 Conclusion and Future Work

We compared two interfaces: one with centrally-arranged emoticon-like indicators and one with avatar-located indicators to study the efficacy of these interfaces for VR-based teaching. The emoticon-like visual indicators show the teacher a summary of student actions and states. Our preliminary study revealed that centrally-arranged indicators help the teacher to respond to students needing the teacher's attention quickly. Additionally, these indicators do not increase the cognitive load of the teacher while teaching. Thus, these visual indicators are a viable solution to monitor students while teaching a VR-based class.

In the future, we plan to conduct a follow-up study with more participants to further validate our results. Furthermore, we would like to collect more sensor data (such as EEG, eye tracking, heart rate variability, etc.) to better gauge their cognitive load while teaching.

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