GlassClass: Exploring the Design, Implementation, and Acceptance of Google Glass in the Classroom

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Abstract. Google Glass is worn like a pair of eye-glasses and is controlled with a small screen, touchpad, and microphone. A variety of Augmented Reality and Mixed Reality Glassware applications are available for Glass. However, due to the size and position of the screen, it is hard for onlookers to discern what the user is doing while using these applications. Additionally, the user can surreptitiously take pictures and record videos of nearby people and things, resulting in privacy concerns. We hypothesized that use of Glassware in a specific domain, where onlookers were apprised of the use of the Glassware, would be better accepted than the more generic use of Glassware. This paper reports on our design, implementation and evaluation of several Glass applications to enhance communication between teachers and students in the classroom and presents results from a study that suggests that students accept the use of Glassware in this environment.

Keywords: Augmented reality · Google glass · Glassware · Educational applications of glassware · Wearable computing

1 Introduction and Motivation

Human Computer Interaction has been defined by the Association for Computing Machinery Special Interest Group on Computer Human Interaction (ACM SIGCHI) as being "concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them." [4] Wearable computing, a subfield of Human Computer Interaction, studies the integration of technology with clothing and other fashion accessories. Some examples of wearable computers that are currently being explored include watches, fitness trackers, and perhaps most controversial, the Google Glass.

Glass, which has not yet proven itself to be as useful as other forms of wearable computing, is worn like a pair of eye-glasses and is controlled with a small screen, touchpad, and microphone. Figure 1 shows how Glass appears when worn by a user. A variety of Augmented Reality and Mixed Reality Glassware applications are available for Glass. However, due to the size and position of the Google Glass screen, it is hard for onlookers to discern what the user is doing while using these applications. Additionally, the user can surreptitiously take pictures and record videos of nearby

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people and things, raising privacy concerns. The term “glassholes” has even been coined to describe public users of Glass (see, for example, [5]).

Fig. 1. Google Glass on a user

We hypothesized that Glass would be better accepted, and more useful, when it was applied to a specific domain instead of being worn in more general settings. There are other examples of wearable computers that are both useful and accepted in specific domains, although they are not fit for more general use. A classic example are the headsets that are used by fast-food workers to process drive-through orders. Because everyone understands why the headsets are being worn, and everyone understands the value of the headsets in this particular context, they do not seem out of place or intrusive.

We believe that use of Glassware in specific domains, where onlookers understand the value of the Glassware, would result in the pushback than we have seen with more public, and possibly invasive, uses of Glassware. To test this hypothesis in an educational setting, we designed and implemented several Glass applications to enhance communication between teachers and students in the classroom and conducted a pilot study to measure student acceptance of Glass in the classroom.

2 System Design

We designed and implemented three software systems for use in a classroom or laboratory environment in which each student is doing work on a standard laptop or desktop computer. For example, the students may be using the computers to take notes, to solve problems using discipline specific software, to write computer programs, etc. Each of our systems is comprised of a student component that runs on each student’s

desktop or laptop computer as well as a teacher component that runs on Google Glass. Each of the three teacher components is written in Java and uses Google's GDK (Glass Development Kit [1]) which is an add-on to the Android Development Kit [2]. Two of the student components are written using standard web technologies (HTML, CSS, JavaScript) and the third is written as a C#.NET application. In each case, the teacher component interoperates with the corresponding student component through a backend that uses parse.com [3] as a database to permit information to be exchanged between the teacher and students.

2.1 Glass Gauge

The first application, called *Glass Gauge*, is designed to be used while the teacher is presenting new material to the students. At the start of the class period the teacher starts the *Glass Gauge* application. The *Glass Gauge* application signals to parse.com that the class is in progress. Students can then login to the web site that comprises the student component of *Glass Gauge*. By entering a code provided by the teacher, each student can connect to the teacher's class. Once logged in and connected, each student can set and/or reset his or her level of understanding to indicate if he or she "understands", "mostly understands" or "does not understand" the topic the teacher is presenting. The students set these statuses using a drop-down menu. The teacher, wearing Glass, sees an aggregate of the students' statuses in real-time on the eye display. This allows the teacher to naturally adjust the pace of his or her presentation based on the aggregated level of understanding of the class.

2.2 Glass Screen Share

The second application, called *Glass Screen Share*, also has a student component and a teacher component. In this case, the student component is written in C# .NET and runs in the background on each student's computer. The student component of *Glass Screen Share* takes a screen shot of the student's display every fifteen seconds. A thumbnail version of each screen shot is uploaded silently to parse.com. The thumbnails are retrieved by the teacher version of *Glass Screen Share* every fifteen seconds and are automatically presented on Glass as a list of thumbnails that the teacher can scroll through. Each thumbnail is labeled with the name of the corresponding student, which allows the teacher to see which students are on task. If a student is not on task, the teacher can approach the student to help refocus the student or to offer help. This dissuades students from becoming distracted with applications such as Facebook while using computers in the classroom.

2.3 Glass Request

The final application is called *Glass Request* and is designed for use in a laboratory or other active-learning environment. At the start of the class period, the teacher starts the *Glass Request* application, which signals to parse.com that the class is in progress.

Students can then login to the web site that comprises the student component of *Glass Request*. By entering a code provided by the teacher, each student can connect to the teacher's class. Once logged in and connected, each student can use a menu to indicate when she or he needs attention from the teacher. The student can either indicate that she or he needs assistance in completing a step of the assignment, or that she or he has completed the assignment and is ready to be checked off. Using Glass, the teacher sees a summary of the number of students who requested attention either because they have a question about a step of the assignment or because they have completed the assignment and are ready to be checked off. The summary that the teacher sees is shown in Fig. 2.

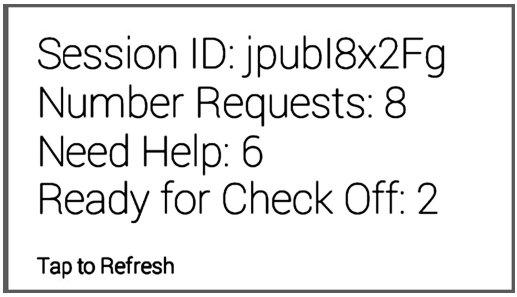

Fig. 2. Initial display of the teacher's *Glass Request* application. The teacher can tap to refresh the display or can scroll to see list of the individual students who have requested attention.

The teacher can scroll from the summary card through a list that represents the specific students who have completed the assignment and are ready to be checked off. This list is ordered by the length of time each student has been waiting. One entry from this list is shown in Fig. 3. The list of students who are ready to be checked off is followed by a list of students who need assistance with one of the steps of the assignment. Again, this list is ordered by the length of time each student has been waiting. An example entry from this part of the list is shown in Fig. 4.

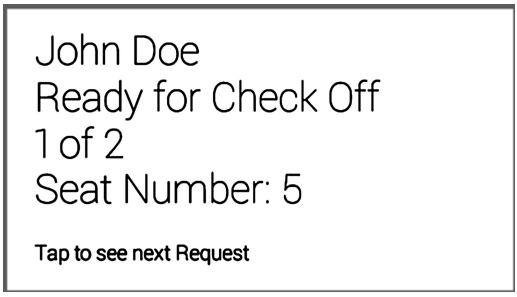

Fig. 3. Teacher's Glass Request application, showing a student who is ready to be checked off. The teacher can scroll to see additional students who have requested attention.

Fig. 4. Teacher's Glass Request application, showing the first student out of six students who need assistance with the assignment. This student is seated in location 7 in the room. The teacher can scroll to see additional students who have requested attention.

3 Laboratory Study

3.1 Study Design

In order to test student acceptance of a teacher's use of Glass in a classroom, we received Institutional Review Board approval to conduct a user study related to the *Glass Request* application that was described in the previous section. As a proxy for a real classroom activity, students who participated in the study were asked to read sample GRE and SAT passages and they were next asked to answer objective questions about those passages on a paper answer sheet. After completing certain parts of the activity, students were told to ask the experimenter (who was acting as the classroom teacher) to check their work before they moved on to answer questions about a new set of passages. In order to ask the teacher to check their work, students had to get the teacher's attention. We varied the technique that was used by the students to get the teacher's attention.

For the purpose of this study, we built a version of the teacher component of *Glass Request* that runs on a standard Android phone, in addition to the version that runs on Glass as previously described. The phone version of the system displays the list of students who need attention on the phone interface instead of on Glass, but is otherwise similar to the Glass version. This allowed us to compare student acceptance across three conditions:

- In the **no-technology (hand raising) condition,** students requested attention from the teacher by raising their hands and waiting for the teacher to notice them. The teacher did his best to respond to requests in the order received.
- In the **cellphone condition** students requested attention from the teacher by making a request through the student component of *Glass Request*, which was running on a web site on a laptop computer at each student's desk. The teacher monitored these requests using the teacher version of *Glass Request* running on a cellphone. The teacher responded to the requests in the order they were received.
- In the **Glass condition** students still requested assistance from the experimenter by making a request through the student component of *Glass Request,* which was

running on a web site running on a laptop computer at each student's desk. However, the teacher monitored these requests using the teacher version of *Glass Request* running on Google Glass. The teacher responded to the requests in the order they were received.

The pilot study was completed as three separate class sessions, one for each of the three conditions. Subjects were college students who were recruited primarily via an email message that was sent to all students who were on-campus working for the summer. As subjects volunteered to participate, they were assigned to one of the three conditions and were given a day and a time to participate in the study. In total, 25 students participated in the study.

Regardless of the condition, the study procedure consisted of five parts, as described below. Taken in total, the five parts took just under an hour to complete.

In **part one** each student completed an Informed Consent form. The form presented the presented with an overview of the experimental procedure for the condition the student had been assigned to.

In **part two** of the study the teacher oriented the classroom of students to the task they would be asked to complete. Specifically, the teacher explained to the class that they would be reading passages taking from publically available SAT and GRE practice exams, and would be answering objective questions about those passages. For the cellphone condition and the Glass condition the teacher also showed the class how to request attention from the experimenter using software running in their web browser. However, for the no-technology condition the teacher told the class that they could request attention by raising their hands.

In **part three** of the study each student was given a handout that contained two sample GRE/SAT reading comprehension passages. Each passage had between three and ten objective questions associated with it. The students were asked to read the passages and to record their answers to the questions on the paper, which also served as an answer sheet. When a student completed all of the questions for the set of passages, they requested assistance from the teacher (by raising their hands if they were in the no-technology condition, or by using the web browser if they were in the other conditions).

When a teacher assisted a student, the teacher used an answer key to check the student's work and wrote a check or an X next to each answer. If there were any mistakes, the student was asked to review the reading, correct the work, and ask for attention again. When a student eventually answered all of the questions correctly, the teacher collected the handout and then asked the student to repeat the process with a second handout with two additional passages and associated questions. This process was repeated with a third and final handout as well.

In **part four** of the study, after each student had correctly answered questions for all three handouts, the teacher administered an exit survey. In addition to basic demographic information, students were asked questions about their satisfaction with waiting for help from the teacher and about their satisfaction with their experience. Subjects were also asked to provide any additional information they wished to share.

In the **fifth and final part** of the study, each subject was debriefed, thanked and paid $10.00 in cash as compensation for his or her time.

3.2 Study Results

In total, 25 students participated in the study. The students ranged in age from 18 to 22 and 8 of the students were female while 17 were male. There were 8 students in the Glass condition, 9 in the cell phone condition and 8 in the no technology (hand raising) condition.

At the end of the study each student completed an exit survey indicating her or her satisfaction with various aspects of the experience. Each student responded to the satisfaction questions by indicating his or her level of agreement with statements using a Likert Scale where 1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree. The mean response for subjects in each of the three conditions is shown in Table 1 for several of the key questions on the exit survey.

Table 1. Summary of key survey questions

Question	Google Glass	Cell phone	Hand raising
The process that was used for the teacher to see that I needed to have my work checked made me uncomfortable.	1.6	2.3	2.0
The process that was used for the teacher to see that I needed to have my work checked interfered with my experience today.	1.6	1.8	1.4
The process that was used for the teacher to see that I needed to have my work checked enhanced my experience today.	3.5	3.7	3.0

Students in the Google Glass condition made open-ended comments including:

- "Didn't enhance [my experience] obviously, but it in no way interfered with my experience"
- "The process that was used enhanced my experience. I liked it a lot better than, say raising my hand to indicated I needed my answers to be checked."
- "It made it easier for me to interact with the teacher, and my arm didn't get tired from being stuck in the air for minutes at a time."
- "The method the teacher used to check my work had no influence on my experience."
- "The instructor was grading my work within seconds of my signaling of assistance."
- "When there were numerous people ready to have their answers checked it could take a few minutes to be acknowledged, which is to be expected with one teacher."

4 Conclusion

Students in this study did not feel uncomfortable by the teacher's use of Google Glass to monitor requests for assistance. The students also did not believe that the teacher's use of Google Glass interfered with their experience. However, the students were neutral when asked if their teacher's use of Google Glass enhanced their experience.

These results are limited by the small sample size and relatively homogeneous group of subjects who participated. However, it appears that the concerns that are sometimes raised when Google Glass is used in a general setting may not carry over to the use of Google Glass in more focused environments such as classrooms.

5 Future Work

Potential future work includes conducting a larger user study that evaluates student acceptance of the other applications in the suite. In addition, we would like to study the use of our applications in a real classroom environment to see how students and teachers respond to the applications in this context. We are also interested in extending the teacher's side of the applications, for example by adding functionality that allows teachers to track and analyze various data such as the number of times a student requested help and time intervals between requests. Finally, we would like to build and test domain-specific Google Glass applications for environments other than the classroom and user populations other than students. This would help us to determine the extent to which our results generalize to other domains and to other types of users.

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