Informative Scavenger Hunt Mobile Application

Noella Kolash
Rochester Institute of Technology
1 Lomb Memorial Drive
Rochester, NY 14623, USA
nak8595@rit.edu

Chinar Patil
Rochester Institute of Technology
1 Lomb Memorial Drive
Rochester, NY 14623, USA
cpp2653@rit.edu

Sourabh Kulhare
Rochester Institute of Technology
1 Lomb Memorial Drive
Rochester, NY 14623, USA
sk1846@rit.edu

Amanda Yung
Rochester Institute of Technology
1 Lomb Memorial Drive
Rochester, NY 14623, USA
aky2875@rit.edu

Abstract
This project investigates methods for encouraging students to learn more about their campus via a scavenger hunt game application.[1] We developed a mobile application for both an Android phone and Google Glass in order to compare the two interfaces and determine which may be the more enjoyable experience. During the study, participants used Google Glass or an Android phone to match clues to locations on campus. Gameplay included scanning QR codes to verify locations and receiving optional aid in the form of extra information or GPS navigation for difficult clues. The study measured to what extent participants learned during the scavenger hunt and if the application encourages socialization between students and other members of the university community. We envision this application to be used for assisting new students during student orientation events.

Author Keywords
scavenger hunt; university orientation; heads-up displays

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous

[1] For a video summary of the project:
https://www.youtube.com/watch?v=GeqlxrO3db4

Introduction

When new students start college, they are commonly unfamiliar with the large campuses they will live on for approximately the next four years. However, the orientation process can be mundane and time consuming, even though the information provided in orientation events is important to a student's acclimation to his or her new environment.

One alternative method for encouraging students to know more about their campus is gamifying the orientation experience. Previous work has explored this domain with generally positive results [4, 9, 12]. Studies have also looked at using heads-up displays for presenting information about one's surroundings, including campuses [3, 10]. However, little research exists which explores the combination of these two concepts.

With the growing public interest in heads-up displays, we sought to investigate the feasibility and potential benefits of a scavenger hunt game played via Google Glass. Unlike smartphones, these devices provide users the ability to stay aware of their surroundings while information is displayed within their peripheral field of view [7]. Heads-up displays may provide unique ways for students to experience and gain knowledge about their campus. Additionally, using the Glass application to navigate around campus may also encourage new students to socialize with other individuals involved with the game or others in the campus community.

Our application could be a valuable tool for augmenting the orientation experience for new students. The main goal of the proposed Glass application is to help people be aware of their new environment and teach them helpful information they can use in the future. Furthermore, this project contributes to the growing research focused on discovering meaningful uses for Google Glass technology, and potentially other heads-up displays.

This study explored a novel method for educating students about their campus via Google Glass. We hypothesized that using a scavenger hunt game with Glass would be a more enjoyable experience for students compared to using a smartphone to play the game. We also hypothesized that the scavenger hunt game would allow participants to learn more about their campus. To test our hypotheses, we conducted a study consisting of two parts: we first developed a scavenger hunt game for both Glass and Android phones. We then conducted a comparative field study between the Glass and Android phone versions of the scavenger hunt game application.

In this paper, we will summarize previous work on improving student orientation experiences using mobile devices, which has guided our design of the application. We will also note relevant work with heads-up displays for navigation on campuses, as well as current Google Glass projects that also pertain to wayfinding and exploration of unfamiliar spaces. We will then explain the design and gameplay mechanics of the scavenger hunt application. Furthermore, we will describe the evaluation process and the results. Finally, we will outline limitations of the study and future work.

Related Work

We present relevant previous research that has influenced the development of this project. We have focused on research that aims to improve student orientation and heads-up displays for wayfinding.

Student Orientation Improvement

Previous studies have looked at augmenting new college student orientation activities with technology for a more engaging experience [9, 12]. Talton et al. developed a scavenger hunt application run on a handheld PC used by incoming freshman students in the computer science de-

partment; students who participated in the study reported that the application helped them become more familiar with their campus, and the application also aided in increasing the retention rate for the department. Schwabe and Goth also created an orientation game on a PDA that focused on guiding users to significant places, people, and events. Many of the users found the game to be more valuable than a traditional guided tour. However, limitations of the study at the time were low precision of the location information provided to users, slow updates for current user position, and difficulties navigating and moving simultaneously.

Based on the positive results from these studies, in our study we further explored mobile applications for student orientation assistance. Particularly, we expanded upon their findings for helping students learn about their campus; however, we also compared the use of Google Glass with the use of a handheld mobile device in order to determine potential differences when using a head-mounted device may make. We investigated if current GPS navigation systems and faster computers built into mobile technology would overcome the location information and slow updates issues in Schwabe and Goth's study. Moreover, Google Glass's heads-up display may decrease problems with navigating and moving simultaneously, as the screen can be viewed while still keeping one's eyes looking ahead.

Fitz-Walter et al. [4] have explored gamifying the orientation experience as well, which gave users achievements in-game based on the activities they completed during orientation. While the game motivated participants to explore their campus, it also encouraged people to simply cheat in order complete achievements, such as by guessing answers by trial and error without needing to go to a specific location or event. Our game requires direct QR code scanning in order to deter cheating in such a manner.

Heads-Up Displays and Wayfinding

Although there is limited research in using Google Glass or other heads-up displays during student orientation events, many have studied using these types of displays for similar purposes, particularly learning about points of interest in one's surrounding environment. Researchers at Carnegie Mellon University developed a head-mounted display for navigating to locations and people on campus [10]; however, it only displayed the path from the user's current position to the point of interest. We created a more interactive experience that incorporates gamification with navigation, which has shown effective results in user motivation to learn about their campus, as described previously. Pingel et al. also created a custom heads-up display for navigation while walking and investigated the efficiency and speed of finding a set of waypoints using their device [8]. While our application also studies how users can find waypoints with Google Glass, we focused more on measuring user experience with the application.

Feiner et. al [3] conducted early research about the use of overlaid information over points of interest using a head-mounted display by using a user's GPS position for location information; an additional handheld computer provided supplemental information about the location. We extended this research, but simplified the amount of information presented to the user during the scavenger hunt game. We chose such a design in order to keep the game more engaging and to prevent overloading users with information that deters them from continuing to play.

Additionally, several mobile applications currently exist for helping tourists learn about the places they are visiting using location based-services that are context dependent [11]; one in particular, GuidiGo [5] does implement Google Glass for displaying information about museum exhibits

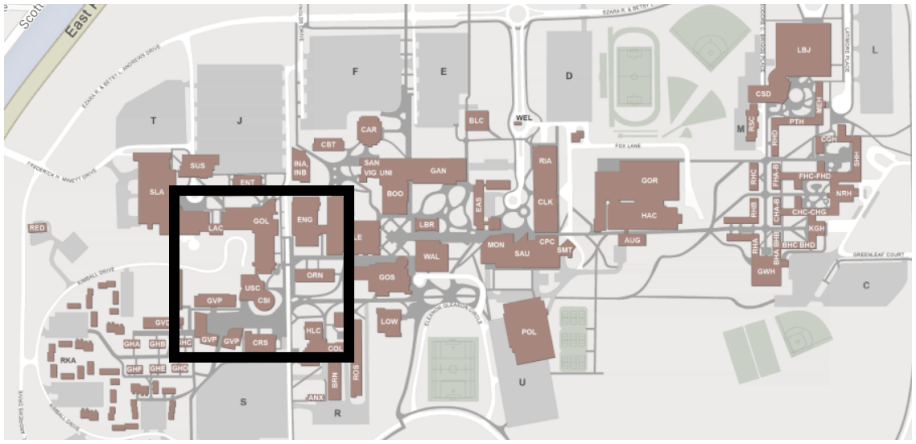

Figure 1: Area of RIT's campus where the scavenger hunt occurred (indicated by the area within the black box).

and historical sites in the form of a guided tour. Instead of a guided tour, however, our scavenger hunt game may compel users to be more active in their discovery of points of interest, since they must search them out rather than passively viewing them as they walk by. In this study, we investigated whether such active engagement results in a better learning experience.

Design

To teach new students about their university, we designed a scavenger hunt game based around locations on campus.

Gameplay

Student orientations not only serve to familiarize students about their campus, but also to allow students to meet others and share learning experiences together. Consequently, we sought to design a collaborative game where players work as a team to complete the scavenger hunt. Furthermore, performance as a team has been shown to improve when competing against other groups [1]. Based on these findings, we also incorporated friendly competition where teams vie for the high score.

The gameplay for the scavenger hunt is designed to have a time limit to find a set number of locations relevant to students. Players work in pairs to complete the scavenger hunt in the designated playing area on the Rochester Institute of Technology (RIT)'s campus (see Figure 1). Teams receive one clue at a time; these clues are facts related to what they need to find. Once the players find the correct location, they must scan a QR code at the spot to verify their answer to earn points. The correct answers will provide them the next clue.

Players are given a series of lifelines to aid them with difficult clues. Lifelines vary in the amount of useful information they provide. The extra clue lifeline (Clue+) provides ad-

Figure 2: Hot/cold lifeline appearance. When a player is far away, the background is blue. The color gradually changes to red as a player moves closer to the target location.

Lifeline	Cost
Extra clue (x2)	-2
Hot/cold proximity	-5
Skip (one per game)	-5

Table 1: Point deductions for using lifelines per location.

ditional information about the location in question, which can be used twice. The second lifeline (Temp) provides a hot/cold proximity sensor: the background screen appears as blue when the team is far away from the target location. It changes to red as the team gets closer to the location (see Figure 2). A numerical value representing players' approximate distance away from the target was also displayed when this lifeline was active. This proximity sensor is based on the team's GPS coordinates in relation to the location's GPS coordinates. The third lifeline (Skip) allows the team to skip the current target. This third lifeline can only be used once throughout the entire game, in order to keep the game challenging.

During the game, players are updated about their team's current score in addition to the remaining time left to complete the game on their screens. Teams can receive a maximum of 100 points, where 10 points are gained for each location (9 locations in total), and an additional 10 points are earned for completing the game. Points are deducted when a team uses a lifeline (see Table 1). While the extra clue and hot/cold lifelines can be used for each location, the skip lifeline can only be used once in the entire game. The team with the highest score wins the game.

Implementation

We developed the scavenger hunt application using the Android SDK.[2] For QR code scanning, we integrated the ZXing open source QR scanner [13]. We used the GPS location provider in the Android SDK for determining both a player's current position and their distance from the current target. This distance value was used in the hot/cold proximity lifeline. We designed the color indicator to stay blue at

[2]We openly share our application code via our GitHub repository: https://github.com/RIT-Glass-Scavenger-Hunt

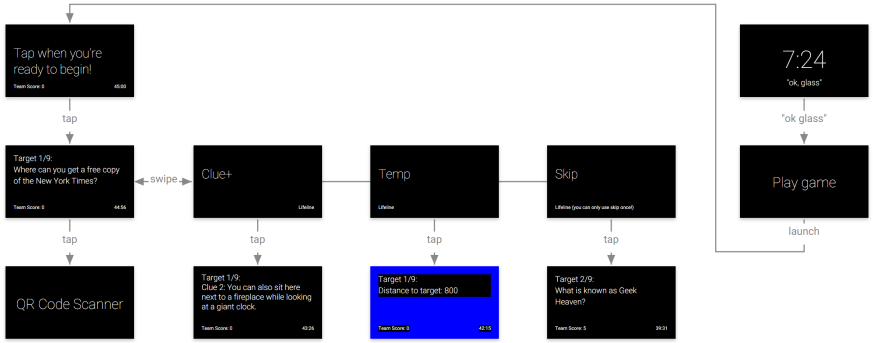

Figure 3: Interface design for the Glass version of the scavenger hunt game.

distances further than 510 feet. Once a player's proximity to a target fell under this threshold, the red hue increased. When closer than 255 feet, the blue hue began to decrease. This created the effect of participants seeing the screen become "warmer" as they got closer to a target and "colder" as they moved farther away (see Figure 2).

Score was calculated within the application based on the scoring system previously described. A timer was also built into the application for displaying to the players how much time remained during the game.

For the game, we selected nine locations based on their relative distances between each other, in order to prevent players from traveling extensively between locations. We compiled three clues for each location based on our own knowledge of the locations and facts obtained via the RIT website. We obtained the GPS coordinates for each location by physically going to each location and recording the reported coordinates where the printed QR codes would be placed. We then integrated these clues and GPS coordinates into the application.

To conform to the recommended interface design for Google Glass applications, modifications were made to the Google Glass version of the application using the Glass Development Kit (see Figure 3). Unlike the phone version which included buttons for each lifeline and for scanning a QR code, the Glass version required players to swipe forward on the Glass touchpad, revealing each lifeline sequentially. Players would then tap on the visible card to activate that lifeline. To activate the QR code scanner, Glass players tapped on the Glass touchpad when the game's main screen was visible.

For hardware, we installed the application on Android phones (Google Nexus 5) and on Google Glass (Explorer Edition 2.0). For Glass to receive GPS signal, we also paired them to additional Android phones (Samsung Galaxy S4).

Evaluation

To evaluate users' enjoyment of the game and their overall learning, we conducted a field study with post-study questions to detail and measure participants' experiences.

Methodology

Based on the game design described previously, we conducted an evaluation study where participants played in teams against each other. A team consisted of two participants, and only two teams played the game at a time. One team used two pairs of Glass, while the other team used two Android phones. All devices had the game pre-installed on them. The order of locations was pre-set in the game; for the opposing team, this order was reversed in order to prevent teams from following each other during the game.

Before starting the study, we explained the game rules to the participants and allowed them to play with their assigned device, including practicing scanning QR codes, until they were comfortable to start the game. At this time, participants also asked any questions they had to clarify any part of the study. This entire learning process took approximately 5 minutes.

Once the game started, team members were not allowed to split up during the game and were instructed to use the same lifelines; for example, if one team member used the extra clue lifeline, the other team member also had to use the same lifeline. Additionally both team members were required to scan each QR code in order to progress in the game. Besides the programmed elements in the game, participants were also allowed to ask other people, other than the researchers, about the clues presented in the game. This was not restricted during the field study, as we wanted to observe how the game would encourage participants to interact with other members of the RIT community.

Sample Socialization Questions
Did you learn more about your partner?
Do you think this should be part of an icebreaker activity?
Sample Likert Scale Knowledge Questions
The game helped me to learn more about RIT's campus.
This game would be helpful for people who are new to RIT.

Table 2: Sample questions included in the post-study survey.

We followed each team as they completed the game in order to remind participants about game rules and to take notes about participants' experiences. For participants using the Android phones, we observed their interactions directly from their phone screens. For those with Glass, we observed their interactions via the MyGlass application on each paired phone. Participants were given 45 minutes to complete the game, based on the time it took to visit all nine locations during a pilot study.

After completion of the game, participants filled out a post-study survey which included Likert scale questions taken from the Questionnaire for User Interaction Satisfaction (QUIS) [2] to measure their overall reaction to the application. The survey also measured their experience pertaining to socialization and knowledge about RIT's campus. Socialization questions focused on the participants' reflections about the game while interacting with their partner, in addition to their thoughts about the game as an icebreaker activity; knowledge questions asked participants to self-report how much they learned, in addition to asking how much they expected new students to benefit from playing the game (See Table 2). We also asked open-ended questions to determine positive and negative aspects of the game.

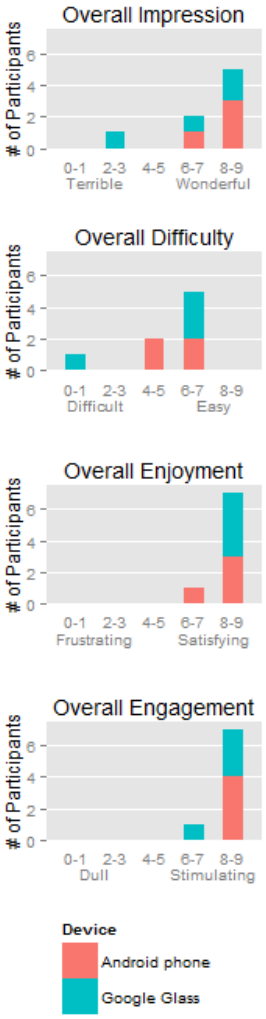

Figure 4: Survey results from questions based on the Questionnaire for User Interaction Satisfaction.

We compared the post-survey data between the Google Glass groups and the Android phone groups to see if any differences or similarities existed in regards to overall experience, socialization, and learning about RIT.

Participants

We recruited 8 RIT students (all male, mean age = 26.5) via a convenience sample. 7 of the participants had been at RIT for 2 years or less, while one participant had been at RIT for 6 years. All reported having moderate familiarity of the campus. Participants were paid for their participation in the study. Due to Glass's design, participants wearing prescriptive glasses could not use Glass and had to be assigned to the phone team. However, we randomly assigned all other devices to the remaining participants.

Results

When we introduced participants to the scavenger hunt game on their assigned devices, many found the game interface easy to use. Those who used Glass needed a couple more minutes to familiarize themselves with the device, as all but one of the Glass participants had never used Glass before. However, after practicing the interactions of tapping, swiping, and scanning QR codes with Glass, participants felt comfortable with the device.

While Glass participants initially encountered some difficulties scanning QR codes at the start of the game, three became proficient after a couple of completed targets. However, one member of a Glass team had extreme difficulty throughout the game. As a result, he needed his team member to use his Glass and scan the QR codes at three locations for him. This participant also accidentally triggered one of the game's lifelines by inadvertently tapping on the Glass touchpad. We observed no issues with participants using the Android phone version.

All teams preferred using the extra clue lifeline to the other two lifelines. Only one team used the skip lifeline. Three of the four teams used the hot/cold proximity sensor lifeline at least once; the remaining team did not use it at all. When one of the phone teams used the hot/cold proximity lifeline indoors, it was not very accurate due to the weak GPS signal being received. However, it did aid participants in pinpointing locations when outdoors. Participants tended to continue moving as the distance value decreased, and then turned around when it began to increase.

Three teams also decided to ask strangers on campus about clues they received in game to determine a location. This strategy typically helped participants, as people were generally willing to offer location suggestions. These strangers also did not appear hesitant to interact with the participants wearing Glass; in fact, many individuals asked questions by the Glass teams were very eager to offer help. They seemed curious, rather than cautious, around the Glass devices. We observed no sense of reluctance by these strangers, as may have been initially expected due to the current trend of public concern regarding privacy issues with Google Glass [6].

All participants successfully completed the full scavenger hunt game. All teams also ran between locations during the game, even though they were not instructed to do so. As a result, at least three of the participants commented that they thought the game was a good form of exercise.

For overall reaction to the game, we present the results in Figure 4. Most participants found the game to be wonderful, satisfying, highly stimulating, and did not find it too challenging. The participant who rated his overall impression as low and also rated the game's difficulty as high had the most difficulty interacting with Glass.

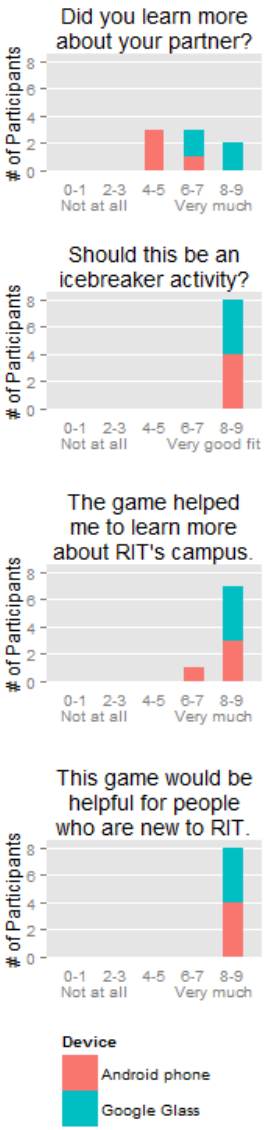

Figure 5: Survey results regarding socialization and learning experiences.

For results regarding socialization, more than half of participants reported they learned more about their team member during the game, and all participants highly agreed the scavenger hunt game should be part of an icebreaker activity (see Figure 5). All participants also stated that the game should be played as a multi-player game, rather than single-player.

In terms of learning experiences, all participants also reported that the scavenger hunt game helped them to learn more about RIT's campus. P5 commented that he learned *"interesting facts about campus,"* while P1 noted that the game was a *"very good way to explore an unknown place."* Additionally, all participants thought the game would be very helpful for people who are new to RIT (see Figure 5).

Besides the survey results, we also observed instances during the game where participants immediately benefited from the information they learned. In particular, we presented the clue *"Where can you get a free copy of the New York Times?"* for one of the locations. A participant did not know what this location was, but once he and his partner found the spot, he showed great enthusiasm that he now knew this information: after exclaiming, *"Really? It's free?"*, he swiped his student ID card to access a copy and took it with him after the study.

Discussion and Future Work

Based on the survey results and participants' reactions to the game, we found no significant difference between the Google Glass version and the Android phone version of the scavenger hunt game in terms of enjoyment or learning. While Glass participants needed more time to learn the game's interface, most participants besides one individual did not have difficulty using the device during the game. More time may be needed to fully familiarize players with how to use Glass, particularly when scanning QR codes.

Overall, all participants found the game fun and felt that they learned from the experience. The lifeline features also ensured the game would not become too frustrating for players when they got stuck on a clue, as illustrated by players' high enjoyment ratings. While some participants noted they knew some of the location facts before the game, they still felt engaged and did not find the game boring. Future versions could incorporate more locations and more beneficial facts, such as more clues regarding free items or helpful services around campus. Others on campus also gladly offered assistance when players asked for help during the game. As such, the application may foster a greater community spirit and a more welcoming atmosphere for newcomers.

One of the limitations of the game is its need to be played mainly outdoors in order for the devices to receive a GPS signal. This could be improved for future iterations of the application by allowing location coordinates to be determined via cellular networks and WiFi signals. The area in which the study was conducted had weak WiFi signals and three of the four phones used during the study did not have cell service, which limited the ability to use such features to boost GPS accuracy.

Additionally, since the game application continually searched for a GPS signal, this significantly drained Glass's battery, such that a fully charged Glass only lasted for one run of the game. Glass also heated up very quickly during the game, which resulted in one participant commenting on how hot the device was, although no harm came to the participant. Optimizing the use of GPS in the application would be required for a final version of this game, or alternatively, an improved battery life for Glass.

The lack of reliable WiFi signal also resulted in the removal of one main feature of the application. We had developed a MySQL database to coordinate interactions between team members, store location and score information, and to update teams about each others' scores. However, when this feature was tested prior to the evaluation study, it consistently froze when used out in the field. Since it was not a necessary feature for the evaluation of the game, we removed it during the study. However, we would re-implement this feature either when the game could be played in an area with reliable WiFi or when the phones used in the game have cell service.

Otherwise, we completed all milestones successfully. Participants showed great enthusiasm while playing the game and highly recommended it for use in teaching people about RIT's campus. While we are unable to recommend one device over the other for use in this scavenger hunt game based on our results, our data suggests that either device would provide a great experience for students during student orientation events. It may be possible that both Glass and an Android phone could be used together in one team; since Glass must be paired with a phone for the game to work, one team member could use Glass while the other could use the paired phone, as the MyGlass app allows shared interactions between the phone and Glass.

We would like to run more participants with less experience on RIT's campus to further investigate the application's ability to teach new students about their university. Testing the game during RIT's freshman student orientation would be a future goal for this study. Additionally, this type of scavenger hunt game does not need to be limited to university campuses: it could be extended to any area of exploration where one would like to learn more about a location.

Conclusion

We developed a functional scavenger hunt game for both Android smartphones and Google Glass to teach students about their campus. We compared the two versions of the application in a field study. We found both versions to be highly enjoyable by our study participants. Participants also reported that they learned about their campus during the study and believed the game would help new people learn about the campus as well. Our study demonstrates that a scavenger hunt game provides considerable enjoyment when learning about a college campus, and the type of device it runs on does not seem to highly affect a player's experience.

Acknowledgements

We thank Daniel Ashbrook for his helpful feedback.

References

[1] Gary Bornstein, Uri Gneezy, and Rosmarie Nagel. 2002. The effect of intergroup competition on group coordination: An experimental study. *Games and Economic Behavior* 41, 1 (2002), 1–25. DOI: http://dx.doi.org/10.1016/S0899-8256(02)00012-X

[2] John P. Chin, Virginia A. Diehl, and L. K. Norman. 1988. Development of an instrument measuring user satisfaction of the human-computer interface. *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '88* (1988), 213–218. DOI: http://dx.doi.org/10.1145/57167.57203

[3] Steven Feiner, Blair MacIntyre, Tobias Hollerer, and Anthony Webster. 1997. A Touring Machine : Prototyping 3D Mobile Augmented Reality Systems for Exploring the Urban Environment. *Personal Technologies* (1997), 208–217.

[4] Zachary Fitz-walter, Peta Wyeth, Dian Tjondronegoro, and Daniel Johnson. 2014. Exploring the Effect of

Achievements on Students Attending University Orientation. *CHI PLAY* (2014), 87–96.

[5] GuidiGo. 2015. Discover or create guided tours for Google Glass. (2015). https://www.guidigo.com/glass.

[6] Jason Hong. 2013. Considering privacy issues in the context of Google glass. *Commun. ACM* 56, 11 (2013), 10–11. DOI: http://dx.doi.org/10.1145/2524713.2524717

[7] Viet Nguyen and Marco Gruteser. 2014. First Experiences with Google Glassin Mobile Research. *ACM SIGMOBILE Mobile Computing and Communications Review* 18, 4 (2014), 44–47.

[8] T. J. Pingel and K. C. Clarke. 2005. Assessing the usability of a wearable computer system for outdoor pedestrian navigation. *Autocarto ACSM* 805 (2005). http://www.soi.city.ac.uk/~raper/JLBSpdfs/Autocarto2005-pingel-UsabilityonMobileNav.pdf

[9] Gerhard Schwabe and Christoph Goth. 2005. Mobile learning with a mobile game: design and motivational effects. *Journal of Computer Assisted Learning* 21, March (2005), 204–216. DOI: http://dx.doi.org/10.1111/j.1365-2729.2005.00128.x

[10] A. Smailagic and D.P. Siewiorek. 1994. The CMU mobile computers: a new generation of computer systems. *Proceedings of COMPCON '94* (1994). DOI: http://dx.doi.org/10.1109/CMPCON.1994.282881

[11] Alexander Smirnov, Alexey Kashevnik, Nikolay Shilov, Nikolay Teslya, and Anton Shabaev. 2014. Mobile Application for Guiding Tourist Activities : Tourist Assistant – TAIS. *Proceedings of The 16th Conference of Open Innovations Association FRUCT* (2014).

[12] Jerry O. Talton, Daniel L. Peterson, and Jalal Almuhtadi. 2006. Scavenger Hunt : Computer Science Retention Through Orientation. *Special Interest Group on Computer Science Education* (2006), 443–447. DOI: http://dx.doi.org/10.1145/1121341.1121478

[13] ZXing. 2015. Zebra Crossing Barcode Scanner. (2015). https://github.com/zxing/zxing/