Mobile HCI Coursework Example

Important Note

This report was submitted in the 2019-2020 academic year for the Mobile HCI coursework. It received a good A grade and is being made available as an example with permission from the project team.

I have edited formatting, adapted for accessibility, and removed some personal details, but the actual content is unchanged from the original submission. Appendices have not been included.

Please note that the assessed exercise involved a different application scenario (to create a novel interactive tour of the University of Glasgow campus and surrounding area) and was only worth 20% of the grade that year. It therefore varies in scope and contribution to the 2020-2021 assessment. However, it will give you an example of the content you may wish to include and is a good example of a varied and insightful interaction design process.

-Euan

Team: Physical Fact Bubble

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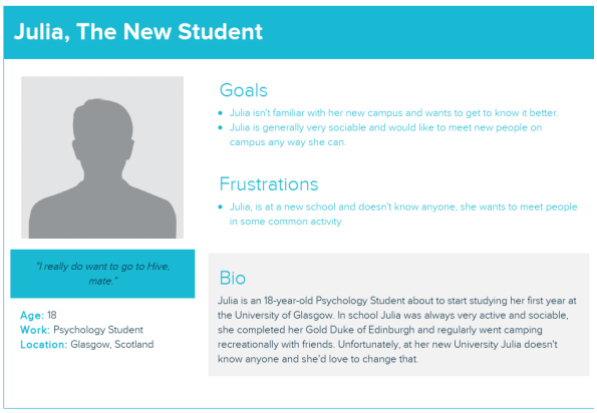
This report is divided into five sections, which each address a step in the authors' design process. The first section discusses how they gathered their requirements through user personas and storyboards, and introduces how the authors applied User-Centred System Design (UCSD) throughout the design process. The second section discusses the concept generation step, and how the authors took inspiration from existing apps in this space but also purposefully tried to diverge from them in the interactions they conceived. The third section discusses the production and evaluation of the first form of some of those concepts. The fourth section elaborates on the refinement process of those prototypes and their evaluation. The fifth section discusses the final prototype, its evaluation, and concludes with a general reflection. Overall, the authors felt that applying UCSD benefitted the process significantly, which is relevant to other student projects in which doing so is not mandated.

Section One – Understanding the Requirements

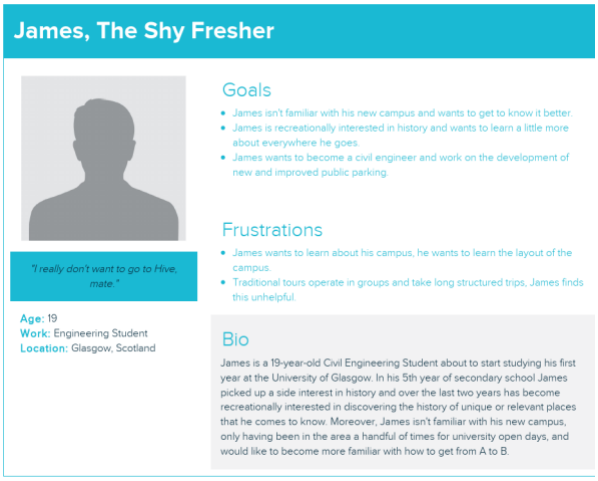
App Definition Statement: An app for students early in their life at the University of Glasgow to aid them in the discovery of their university campus. Using indirect, user-focused tour design the authors strive to take students on interactive and unstructured trips through their local area.

In the early stages of the project the authors wanted to understand and interpret the requirements that had been provided, keeping in mind several key design philosophies that they wanted to build around. The guiding principle was that of User-Centred System Design (Norman 1986), according to which the purpose of the system is to add value to the user, and not just be a fetching but impracticable interaction. As such the authors sought to involve potential end-users at all stages of the design process, something which later sections will demonstrate was not always easy but nonetheless very rewarding.

At this stage, the authors began by constructing an image of their potential users reflecting on their own first experiences on campus as well as talking to friends. They recalled our lack of knowledge on where to go for lectures or events and the mundanity of how they eventually came to understand the campus, since most only ever learned through trial and error or from looking at maps every time a new building was on their timetable. From these experiences the authors drew a picture of two potential kinds of students who might find value in the kind of application they were tasked to design.



The given requirements specification outlined that our app should support both individual and group touring modes, and the authors' initial casual conversations amongst themselves and other students in the lab they were working helped to give the authors insight into whom those two different modalities might appeal to. On the one hand, new students either overwhelmed by all the events going on during Fresher's Week at the university looking for something engaging to do on their own, and on the other hand new students looking to meet new people but not satisfied by the range of events student societies and the university itself offers during orientation. The fundamental characteristics the authors abstracted from our conversations are, however, abstract enough to apply to current students as well: for example, one of the authors noted that when they were a new student the events on campus during orientation did not appeal to them, and so they did not explore the campus much until classes started, at which point 'relevant routes' were limited. And because of that, the author discovered a path on campus they had not known about up to a few weeks prior to the time of writing, in their third year at the university. This experience is reflected in the broader literature, for example Gulliksen et al (2003) note that when they introduced user personas to a team of developers they were working with, their understanding of their end users was much more complete than through simple use case modelling. So, having some idea of who the end users might be, the authors moved onto storyboards.



The storyboards had the merit of contextualizing the users fleshed out through the created personas. Schmidt (date?) highlights that keeping the context of use, or in other words the situation(s) in which a system is going to be utilized by its users, leads systems which are capable of anticipating user needs, thus making them easier to use. In the case of the authors, referring back to these storyboards turned out to be very helpful when evaluating refined prototypes at a later stage of the design process.

Figure 2: *the authors two storyboards.*

Section Two – Concept Generation

Given the clear instruction of not re-inventing Google Maps presented in the specification sheet, the authors immediately knew to be bold and think beyond existing interaction paradigms for location exploration. They had a round of thinking of the most bizarre ways possible to entice users to move toward a certain location. The core tenet driving their creativity was always the notion of guiding a user towards important locations without explicitly telling them what to do. If a user wanted to ignore interaction entirely, that should be possible and doable without effort. Furthermore, the authors strove to create an experience that while allowing for group interaction, didn't mandate it. The authors quickly realized they needed to control the flow of ideas in order to create coherent, presentable concepts. To do this, they first broke the problem down into two categories: discovery and landmark action. The discovery component would gently guide the user toward landmarks, and the landmark action component would present details in a creative way. Concepts for both could easily be mixed and matched throughout the process. This helped structure their thinking.

For the discovery component, the authors first examined unique location interactions the authors had seen implemented in the past. The first experience that came to mind is the iPhone Wikipedia app. The app features a list of articles geographically near the user's current location. In that list, each item has a photo with an arrow on it. This arrow will point in the direction of the geographic location of the article, and move as the user turns (using the device compass). The authors found this an excellent alternative to a stereotypical map-based interface and hoped to create a tour with a list of potential landmarks and their attributes, perhaps including set of interesting features based on the user's preferences. Another well-known interaction experience the authors thought about was the early AR app Layar. Layar opened with a camera view and showed location search results in a camera view, on top of the location where the buildings would be in that view. The authors' take on this was a list of landmarks a user could explore only by rotating your phone around them. This would encourage exploration as users seek to discover the landmarks around them. A further experience the authors took note of was Detour, a popular tour guide app which went out of business a few years ago. Detour encouraged users to wear headphones, and then used GPS information to give the user one of many audio guided tours. While Detour tours were

completely guided, with a voice telling the user where and how to go, the concept could easily be adapted for exploration. The final app the authors took inspiration from was a vague memory of a very early AR experience on the iPhone 3g one of the authors vaguely remembered. Designed for kids, the key interaction remembered was a compass and a distance measure — after selecting a target on a map, the app guided the user toward a specific location using compass information. This experience could easily be adapted into an exploratory model — an interface which, without a map, simply nudged the user into walking toward a few landmarks.

Following on from this round of brainstorming, the authors iterated concepts, sorting them into "fake map" and "no map", in both cases avoiding a "real" map entirely. Ideas were submitted and drafted quickly, so these highlights are presented in no particular order. The first set of concepts revolved around a "fake map", where the users location was presented on a map, but only the most important buildings were shown. For example, in the "layar type fake map" concept (inspired by the Layar app), the user is shown major landmarks around them in a 120° field of view which rotates as the user rotates. This would encourage the user to move around and see what's around them, without explicitly sending them anywhere. On the same note, the "graphic fake map" experience was inspired by novelty maps of theme parks or large botanical gardens and featured a map featuring only the major buildings on campus, without roads. This would allow the user to choose and find the landmarks they are interested in exploring while still encouraging them to find the way themselves, and learn the campus for themselves — forcing them to stay safe. Taking this further, and being inspired by similar cartoon maps found in many video games such as Civilization or Assassin's Creed the authors iterated to the "cloudy map" experience. In this concept, the fake cartoon map from earlier (perhaps with a little more detail) is entirely obscured, aside from the users initial location. As the user explores the campus, the user's path becomes unobscured, allowing the user to both see the path they have taken as well as the buildings they have passed and explored. Wind, or other metaphors on the map, could be used to "nudge" the user toward a building they might find interesting.

This nudging functionality, a theme which transcended all concepts, could help the user find a group. The app could decide to guide the user toward a landmark with many users at it, or guide many solitary users toward the same empty landmark. It taken to an extreme in the next set of concepts, classified under "no map". In these concepts the map was removed entirely, forcing the user to be aware and remember their surroundings. The app would only help the user discover where landmarks exist in their immediate surroundings. The simplest of these concepts was the "no map compass". This concept would simply show a compass, as a toy for the user more than anything. If the app didn't detect productive movement for a certain amount of time, a location and compass specific hint would be displayed beneath the compass, gently nudging the user toward a nearby landmark. Again, this nudge could be influenced by nearby groups, as well as the user's preferences. Audio could also have assisted in this experience, with ambient music or sounds growing as the user approaches a landmark. The authors iterated even further on this idea, deciding to drop the visuals entirely, and create an entirely auditory experience — guided by the authors' discussion of detour. Detour A bank of audio recordings could have been used to guide the user in even the most specific ways. Using something like iBeacon, the user could even be located within a room or larger space, providing extremely accurate directions such as "Have you tried going up those steps?". In a fierce debate, this was considered as one of the most innovative concepts, however fell short on counts of encouraging group exploration, which the authors knew was an important context to support based on the work outlined in the previous section of the report: modern isolating headphones would severely diminish the group experience, even if multiple users could somehow be fed the same audio feed, or multi-user audio experiences were to be developed.

For the location component of the overall experience, many ideas were floated, some so abstract and strange they would have been difficult to storyboard. Once again the authors were inspired by much of the recent AR demos they had seen lately. The authors thought about, and researched, the various sensors available on most modern smartphones and brainstormed how to use these creatively. The authors took inspiration from recent AR multiplayer experiences such as LEGO Builder on iOS devices and the Star Wars game on both iOS and Android. However, the authors remained focused on dissipating information about a landmark in the most efficient yet interesting way possible to both entertain and engage users as deeply as possible. The first, and maybe most obvious way to both entertain and teach a group of perhaps sceptical users is via quizzes or riddles. The interaction would keep users

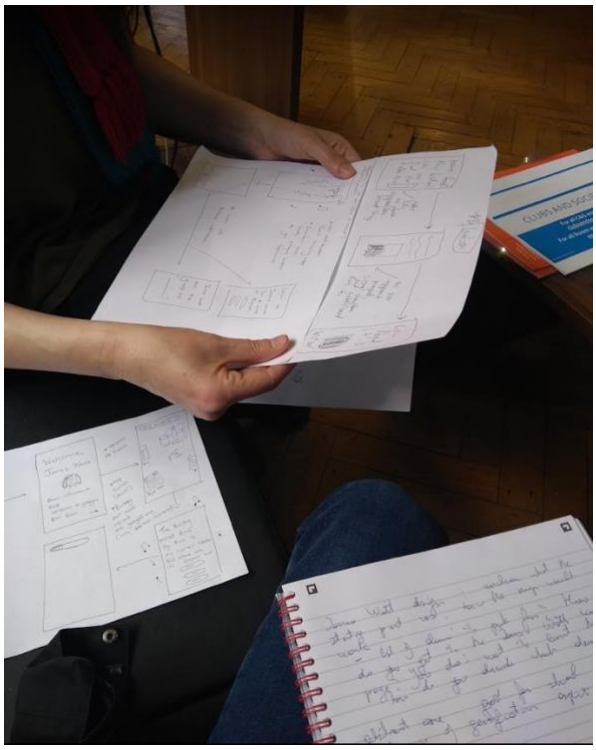
engaged, and the potential for group activity (where one user has the question and the rest have the answers) is clear Facts could be distributed to various users in the same way. Playing videos, perhaps even distributed across users phones (forcing them to work together and assemble it into the right order), was also considered. Yet the authors wanted more interaction with the space. Any concept which could

have worked just as easily inside a room was filtered out. Thinking about the sensors available to them, the authors iterated towards a magnetometer approach: by hiding small but powerful magnets on statues, sides of buildings, or other noteworthy sections of landmarks, the user would have been able to scan the structure, and the phone with a hot-or-cold bar would have been able to tell the user when they found the important part. Upon finding it, the user could have received some sort of reward.

Section Three – Initial Prototyping

The authors' concept generation phase was aided by the use of their storyboards and user personas. These were principally inspired from their own experiences, discussing with other students, and from the assignment specification sheet itself as it included guidelines on the app's target audience. In that stage, the authors decided to focus on brainstorming as many engaging interactions possible based on the information the authors had. For this stage of initial prototyping, the authors first sketched some of the concepts they had discussed onto paper, to illustrate what the key functionality might look like. Then, they decided to involve a new stakeholder, the Student Representative Council (SRC), which at the time the authors are writing regularly runs historical campus tours of the University. The meeting's stated objectives were to learn more about our potential users, get the perspective of the SRC on the app the authors were to design, and evaluate our paper prototypes.

Because the authors sought to apply the principles of UCSD to their design work, when designing the campus tour application, they felt it was important to have the paper prototypes evaluated, before moving onto creating higher-fidelity versions. This section of the report will thus illustrate the results of the meeting and the evaluation referring back to the literature on UCSD, as it has been the theoretical framework which has guided the design process. It will then conclude with a brief discussion on what the authors learned and decided to keep in mind for the next iteration, to be discussed in the fourth section of this report.



The meeting began with a discussion around the historical campus tours, in the form of an unstructured interview. The unstructured style was

chosen because it is generally accepted as the most appropriate in the beginning of the research process when relatively little is known about the people under investigation, in this case potential end users. Indeed, asking structured questions at the beginning of any ethnographical process risks biasing the results with the designer's pre-conceived notions, whereas unstructured interviews leave the interviewees free to talk (Fetterman 1998). Another methodological point worth highlighting is that the author who ran this interview deliberately withheld any specific information on the design brief when setting up the meeting. The SRC representative was told that the authors were tasked to design a new kind of campus tour for one of their courses, but nothing about how it might function. This was to try and prevent unconscious bias towards the prototyped interactions the authors had created, thereby conditioning the information the interviewee might have given during the interview part of the meeting (Fitzpatrick 2013).

Regrettably, the author was not able to actually take one of the tours at the time as they were fully booked. However, because the interview was about literal tours, the author was able to begin the interview with a 'grand tour' style question, asking the SRC representative to describe them from the beginning to stimulate open discussion and allow the interviewee to raise points they thought were important (Fetterman 2010). The key takeaway from this part of the interview was that the SRC tours were described as highly structured, delivered from a script and with a set itinerary. The next main section of the interview concerned the type of people who took the SRC historical campus tours. Here, the author learned they were a heterogeneous group, mainly subdivided in tourists, students from other universities, alumni, and school groups. Indeed, it appeared their only common characteristic was that they were not students or staff at the University of Glasgow. The third and final key part of the interview revolved around the SRC's tour protocols for what to do when the weather was poor, the University was busy for events or filming, as well as their general safety precaution. All three of the topics covered in this interview turned out to be important for our design process and would be incorporated in different ways in the post-evaluation discussion held by the authors.

The evaluation of the paper prototypes, some of which are pictured in Figure 1, was conducted in the style of a think-aloud evaluation. The SRC representative was given three paper interfaces drawn from the "fake map" and "no map" concepts detailed in the previous section of the report and asked to explore them, in other words to get a feel for what the app could do if it were fully functioning. They were encouraged to voice their thoughts and questions at each step. The Nielsen Norman Group, a leading design consultancy, considers think aloud evaluations to be the number-one tool in a designer's arsenal, because it can quickly catch at least some concerns potential real users might have with a system quickly and relatively effortlessly on the designer's part (Nielsen Norman Group, 2012). To some extent, this was reflected in the evaluation conducted by the author. For example, the interviewee raised concerns about how character selection might work in one of the prototypes pictured in Figure 1, in which the authors were imagining alumni-based tours of the campus buildings. More generally, the interviewee appeared to have some difficulty understanding how some of the prototypes were meant to be navigated.

Having collated the remarks from the interview and the evaluation, the authors met to discuss the results and decide on the priorities for the subsequent iteration. The principal insight yielded by the interview was that the app's intended audience as per the specification, new and current students, was only partially served by the University's existing offerings – the only students to take advantage of the campus tours were students from certain other universities, and even then for bespoke purposes such as relating to one of their courses. Consequently, the authors chose to focus as much as possible on engaging interactions and customizable experiences, so the authors cut one of their early ideas generated in the previous step, the Wikipedia-like app which would have integrated a compass with a list of relevant places around campus. Furthermore, one of the remarks on the fact that sometimes the tour guides had to be careful not to disturb other events or students during exam time prompted the authors to cut another concept they had imagined whereby the tour would happen primarily through audio narration coming from the app. In this way, engaging with a stakeholder at such an early stage of the design process already turned out to be fruitful.

The results of the evaluation part were mixed. Something one of the authors noted was that the SRC representative was not one of the intended users of the app, which was clear from the assignment specification and their own words, so

the comments made in the evaluation should be taken with some caution. This is something which has been emphasized in the literature – users that evaluate your app must be representative of the end users themselves (Gulliksen et al, 2003). Nonetheless, the confusion the interviewee expressed when trying to navigate some of the prototypes is something that would come up again in the evaluations the authors conducted in the next step of the process, to be discussed in the following section of this report.

Section Four – Refined Prototyping

The authors decided to take forward two of the paper prototypes at this stage, one from the "fake map" group and one from the "no map" group. Based on the results of the evaluation with the SRC representative detailed in the previous section, for the "fake map" prototype, the idea of avatar-based exploration, shown in Figure 1, was removed in favour of building-focussed exploration, to avoid any uncertainty on what to do before the tour even started. In the "no map" prototype, the authors decided to add an explanatory note in the app's main screen to give more direction to potential end-users, based off the confusion displayed by the SRC representative when evaluating it. Some screens from the prototypes at this stage are shown below.

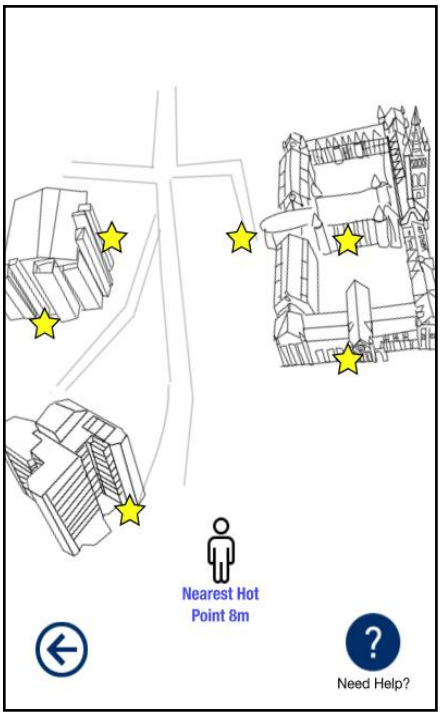


Figure 5: *the main screen from the "fake map" prototype.*

Figure 6: *the main screen from the "no map" prototype.*

These prototypes were realised in Drama, an application which allows users to prototype designs quickly through a drag-and-drop interface, and simulate interactions through animations and image transitions. The authors determined that at this stage it was still far too early to proceed with a programmed version because there was still a significant amount left to evaluate. It should be noted that part of the reason this decision was made is because the authors were not expected to deliver a functioning product at the end of the course. If that had been the case, then they would have weighed the merit of Drama's speed versus the demerit of a lack of scalability into an eventual production version, a design concern expressed in Gould et al (1998). Nonetheless, given the circumstances, speed was preferred. Besides the main screens, the authors designed a few more that displayed possible interactions, for example quizzes, fun facts and so forth. In the case of the "no map" prototype, one of the ideas from the concept generation section made its way back into the prototype at this stage, that is, the idea of an Augmented Reality display of information, such that users could interact with the information associated to the building they were in. This would also allow for groups of users to interact by spontaneously teaming up to uncover information, which was consistent with the authors' desire to encourage but not mandate interaction.

Once the two prototypes were assembled, the authors proceeded once more to evaluate them. The method chosen for evaluation this time was a heuristic evaluation. In a heuristic evaluation, the evaluators, who are not necessarily end users themselves, check the layout and functionality of the prototype system against a set of widely recognised usability principles, known as heuristics (Nielsen Norman Group 1994). The Nielsen Norman Group notes that this method is suitable to be used early on in the engineering lifecycle since real tasks do not need to be performed, which is why the authors thought it would be appropriate at this stage. The authors chose to evaluate the two prototypes against two sets of widely recognised heuristics, Schneiderman's Eight Rules and Nielsen's Ten Heuristics. It should also be noted, however, that the authors did not follow up on these evaluations with another cognitive walkthrough or an evaluation which involved a potential end-user. This was ultimately due to time constraints on this project and others the authors had to deliver. The authors choose to highlight this potential shortcoming in this report to note that this is a phenomenon which is very much felt in "the real world" as well: for example Gulliksen et al (2003) note that even though the developers they introduced UCSD principles to benefitted greatly from them, when the production deadline was rapidly approaching many of these practices were dropped in favour of more traditional methods of delivering software projects.

For both the "fake map" and "no map" prototypes, the main concern that emerged from the heuristic evaluation was that of the importance of feedback, and its lack. In the case of "fake map", the authors noted that it was hard to tell how close one actually was to the building, since indicating distance as a unit of measurement did not necessarily translate to a clear perception of distance to the user. The problem of user-system perception mismatch described in Schmidt (date?), where the system display does not match up with what the user can physically see, was also noted as a scalability problem, given that the map was fixed in place and could become overwhelming if many location stars were added. Furthermore, referring back to the context highlighted by the storyboards designed in Section 1, purely visual feedback would not work well outside of a noisy building or in the conditions of poor visibility which Glasgow is well-known for. Other points that were raised around the "fake map" prototype were questions of consistency, both "internal" and "external" (Levinson and Schlatter, 2013) – some buttons were not in the same location throughout the app and changed colours, which damaged internal consistency, and also the buttons and layout of the app looked neither like the iOS or Android style guides, which damaged external consistency. This would negatively impact recognition, one of Nielsen's heuristics. Additionally, limited and inconsistent navigation, such as the buttons taking the user back to different screens at different places, also hampered this.

The problem the "no map" prototype had with feedback was similar. Feedback was entirely visual, which would be a problem given the context of the interactions specified. Additionally, there was the same problem of distance being unclear, as well as the edge case specific to this prototype of the user being too far away from any hot point and being presented with an entirely blue, directionless screen. Furthermore with this prototype, one of the authors raised safety concerns, prompted by the results of the SRC evaluation described in the previous section: how would the application keep users away from busy roads and intersections? What about warnings at night in poorly-lit areas? These were all questions which would have to be addressed. The authors also had a debate about internal and external consistency here, but because there were fewer buttons internal consistency was less of a problem, and uniqueness was ultimately prioritised over external consistency. The authors judged that adding more features simply to make the app 'feel like' a standard Android or iOS app would have been damaging.

After a discussion of the relative merits and demerits of both prototypes, evaluation results in hand, the authors decided to go ahead with the "no map" prototype to implement as our final prototype, which will be discussed in the next section of this report. Ultimately, they decided to stay true to their intentions of providing a unique interaction experience with the university's locations, which they set out to do in the concept generation phase outlined in section two. This desire was now supported by the result of the discussion with the SRC representative discussed in section three, since the university already offers, at least at the time of writing, a structured and one-way tour experience. The authors felt that the "no map" concept was more unique than the "fake map", and once feedback was improved following on from the evaluation's results, they felt the overall result would be stronger.

Accordingly, we redesigned the main screen to simplify it, removing the blue to indicate lack of points of interest and using only red to indicate such a point. As well as conforming to the minimalist design principle in Nielsen's heuristics, the authors also felt this made the system more accessible as users now did not require to know the not necessarily ubiquitous red-blue hot-cold association. Buttons were also simplified and colour schemes were made consistent throughout the application. The authors also added a compass which would inform the user which way the system thought they were facing, to help reduce user-system perception mismatch. More navigation options were also added and these were made consistent to help ease recognition. Notifications, theoretically relying on the hardware system, were introduced to augment visual feedback with audio and haptic feedback given the context of use.

Section Five – The Final Prototype

The final prototype was again implemented in Drama, with the changes above being introduced. Our intention was to evaluate the final prototype with another think-aloud evaluation, but simulating a more realistic environment such as outside a university building. However, given the current virologic situation on campus, the final evaluation had to be re-scheduled as a virtual event. Three evaluators, representing the users drawn from the type described in our personas and storyboards, were asked to perform a virtual think-aloud evaluation of the final prototype. The author facilitating the evaluation showed the different views of the application and prompted the users for their thoughts, as well as for what their next action would be. Two of the three evaluators were able to intuitively navigate the prototype fully, and discovered all functionality the prototype had to offer. One was confused at the beginning and remarked that additional documentation would be helpful, and was also unclear as to what type of feedback would be provided – because Drama does not allow its designs to interact with actual hardware, the evaluator had to explain that notifications and their vibrations would have been theoretically implemented but were not due to technical constraints. This evaluator also commented on the fact that the application was not exactly stylish, which is something the authors would have worked on had they had more time, but it was a low-priority item compared to implementing the changes from the heuristic evaluation. All three of the users understood and reacted positively to the app's Augmented Reality fact-finding interaction, including in group mode.

Figure 7: *the app screen for the "Augmented Reality" fact-finding component, with a minimalist visual prompt for users.*

Overall, the authors feel that this project was educational. When given the specification sheet at the beginning, they immediately set about brainstorming interactions which they thought were unusual or innovative. Many of the authors' colleagues in the course also started in the same way, so the authors feel it is natural to want to design something which is interesting-looking. This was the first theme which stayed constant throughout the authors' work: the concept of "no map" persisted from the concept generation phase to the final prototype itself, as well as the idea of Augmented Reality interaction with information, albeit in a modified form from some of the ideas that were initially thrown out.

However, this desire was tempered and corrected by the authors' commitment to apply the theory learned throughout the course. This was the second theme of the authors' experience. From the storyboards outlined in the first section of this project reminding the authors that context of use was important when discussing feedback in section four, to off-hand comments made by the SRC

evaluator leading the authors to drop a concept entirely in section two, and the heuristic evaluation in section four highlighting important maintenance and usability fixes that went into the final prototype, the authors stuck to some of the principles of UCSD even when abandoning discipline in favour of creativity would have been easier. On the other hand, the challenges of adhering to UCSD despite approaching deadlines was also noted. This grounding in the theory was further highlighted throughout this report by reference to human-computer interaction and usability literature, and case studies, where appropriate.

The authors feel they cannot say with confidence that the interactions tested in this project should be deployed in a real system. There were evaluations with different stakeholders involved, and the heuristic evaluations ensured that the final prototype adheres to basic usability best-practices. Some level of enthusiasm was demonstrated by those stakeholders when the prototypes at different stages were shown. Whether that would translate to sustained use by a broad enough base of university students to justify the resources to put this system into production is another matter. However, the authors can from personal experience say that considerations for UCSD principles would benefit similar university projects moving forward. One of the authors applied some of the principles learned in this course in another university project by conducting research surveys with end users and deploying an early version of their system to gather real-world feedback, and the project's sponsors satisfaction rating was very high. This is perhaps the most broadly applicable lesson to be drawn from this experience report, that mindfulness of usability principles and practices does in fact lead to better systems.

Bibliography

Fetterman, D.M. 1998, Ethnography: step by step, 2nd edn, SAGE Publications, Thousand Oaks, Calif;London;.

Fitzpatrick, R., 2013, The Mom Test: How to talk to customers & learn if your business is a good idea when everyone is lying to you, 1st ed, CreateSpace Independent Publishing Platform.

Gould, J. D., Boies, S. J. and Ukelson, J. 1997, How to Design Usable Systems. In M. Helander, T. K. Landauer and P.Prabhu (eds), Handbook of Human-Computer Interaction(Amsterdam: Elsevier Science B.V)

Gulliksen, J., Göransson, B., Boivie, I., Blomkvist, S., Persson, J. & Cajander, Å. 2003, "Key principles for user-centred systems design", Behaviour & Information Technology, vol. 22, no. 6, pp. 397-409

https://siliconangle.com/2011/09/20/layar-telefonica-for-new-visual-search-technology/layar-screenshot/

Levinson, D.A. & Schlatter, T. 2013, Visual usability: principles and practices for designing digital applications, Morgan Kaufmann Publishers is an imprint of Elsevier, Amsterdam.

Nielsen, J., 10 Usability Heuristics for Interface Design, https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/ [last accessed 19 March 2020]

Nielsen, J., 2012, Thinking Aloud: The #1 Usability Tool, https://www.nngroup.com/articles/thinking-aloud-the-1-usability-tool/ [last accessed 19 March 2020]

Norman, D. A. 1986, Cognitive engineering. In D. A. Norman and S. W. Draper (eds)User Centered Systems Design (Hillsdale, NJ: Lawrence Erlbaum Associates Inc.).