Smart Watch application needs analysis and usability study: A proof of concept for university students

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ABSTRACT

The smart watch is part of the family of wearable computing devices, and can be viewed as an extension to the already existing smart phone interface. The smart watch has been identified as a potentially useful device for displaying information received on a paired smart phone, and has also raised interest in who might want to use such an interface. Through the use of questionnaires, information was gathered about university students' preferences in smart watch applications. Based on the feedback from students, a notification system and phone finder application were identified as potentially useful interfaces and then developed. A user study was then conducted where a sample of smart watch users were asked to test the developed applications. They were asked a set of questions designed to evaluate the usability of the watch and the applications installed. An interview was conducted with each user which also probed the usability aspects of the applications they were using. The design, development and evaluation of the notifier and phone finder applications are described in this paper.

Categories and Subject Descriptors

H.1.2 [**Models and Principles**]: User/Machine Systems – *Human Factors, Human Information Processing, Software Psychology*.

General Terms

Mobile Applications, Human Factors, Smart Watches.

1. INTRODUCTION

Wearable computing has been a growing area of interest with the increasing use of micro-electronics in a number of new devices. Most notably, the use of miniaturized electronics and low cost sensors have been the driving factor for the Internet of Things (IoT); the interconnection of multiple devices through the Internet (Luigi Atzori & Morabito, 2010). This interconnection has enabled wearable computers to become generalized problem solving devices (Rhodes, 1997). Wearable devices which once only solved single domain problems (Mann, 1997) now have the ability of extending their problem solving capabilities into multiple areas.

The smart watch has emerged to fit this paradigm of interconnectedness, which has the potential to be a possibly useful extension to a connected smart phone display (Narayanaswami & Raghunath, 2000). The smart watch's physical characteristics of being small, lightweight and highly portable have resulted in new ways of using it to view useful information which is present on a paired smart phone (Bieber, Haescher, & Vahl, 2013). The smart watch should allow for the unobtrusive display of information while a user participates in everyday activities (Starner, 2013).

The development of previous smart watch applications appeared to be at the discretion of the manufacturer and no user specific interaction was catered for (Bieber et al., 2013). With recent variants of the smart watch, specific Application Programming Interfaces (API's) have been made available to allow developers to create applications to cater for user application requirements.

Users now have the opportunity to develop applications which are useful to them and which fit their information needs, particularly in circumstances where accessing a smart phone could be difficult. This paper addresses the issue of whether university students would want to use a smart watch, and if they do, which applications they would consider to be useful. This was done via the use of a questionnaire. The design and implementation of these potentially useful applications are also discussed.

Based on feedback from students, a notification system and phone finding application were developed. The implementation of such a system is a proof of concept demonstrating the message passing capability between the smart phone and smart watch, effectively mirroring appropriate information. The concept of message passing is also prevalent in the phone finder application, where a message sent from the smart watch is able to bypass the phone's modality to force it into a ringing state.

Upon completion of the aforementioned applications, a usability study was performed in which participants were asked to use the notifier and phone finder applications for an allotted time period. The participants were then asked questions in the form of a questionnaire and an interview. The aim of the usability test was to determine the usefulness which the applications brought to the participants, as well as to assess user interaction with the smart watch.

2. RELATED WORK

User adoption of smart phone applications has been addressed previously by Seppala & Broens, (2013), where it was found that the key principle driving information access through any particular device was the experience in doing so. Usability on the smart watch and smart phone are different by their hardware and the nature of the applications which they host.

A previous smart phone user study was conducted by Sandars, Homer, Pell, and Croker (2008), where undergraduate university students were asked about the applications they would use most on a smart phone. Since the smart watch is paired with the smart

phone in terms of the information it is able to provide to the user, it is important to list these findings. It was found that social networking, email and instant messaging based native applications were used most frequently (Sandars et al., 2008).

Similar results have been noted by Bowen and Pistilli (2012), where university students were asked to answer which native applications they used most frequently. Social networking applications such as Facebook, Twitter and Instagram were most prevalent in the user study. In both studies, the use of native as opposed to web based applications was used to a greater extent by the participants. According to Sandars et al. (2008) this is due to the users' preferring native applications when accessing services of a personal nature.

Chen, Grossman, Wigdor, and Fitzmaurice (2014) state that users want similar services on a smart watch as from a smart phone, and the primary aspect which needs to be adjusted between the devices is the interface. Since users want similar applications from different devices, application development for both devices must adapt to meet a standardized output (Chen et al., 2014).

3. NEEDS ANALYSIS

Out of sample of 211 undergraduate Computer Science 1L students, 89 agreed to take part in answering a requirements gathering questionnaire. This questionnaire was designed to collect information about potential smart watch users, particularly for the Pebble smart watch, and their application preferences. The user questionnaire was a quantitative assessment where participants were encouraged to give feedback on a broad variety of questions geared towards the smart watch interface. The participants were informed about the questionnaire in their afternoon practical sessions. The questionnaire was hosted on Google forms, and the students were able to participate after giving their consent.

Demographic information such as age, gender, race, year of study and subject majors were asked. The question of whether or not they would use a smart watch was then asked. Assessing the desire for the use of a smart watch is a prerequisite for further analysis of the applications which are to be used. A list of possible applications was presented in the questionnaire from which participants were asked to select the ones which they would consider to be most useful, as well as providing ideas for other useful applications.

Perception of usability was then assessed by asking the participants if they thought the smart watch would be easier to make use of than a smart phone with regard to the applications they selected, they then provided an explanation to their answers. The results were collected with the Google forms answer analytics resource and the results were analysed.

Of the participants who answered the questionnaire, 72% were female and 80% were between the ages of 18 and 20 years of age. The race of the participants was composed of 43% African, 30% Coloured, 17% White and 10% other. 77% of participants were in their first year of study, and the majority (66%) were doing Pharmacy, Cell Biology and Chemistry as their major subjects.

The majority of participants (85%) answered that they would use a smart watch if they had access to one. Their reasons for wanting to do so were varied, but a common answer was the ease of use and convenience of an always viewable display on the wrist. The opponents of using the smart watch provided reasons such as the difficulty related to viewing a small display and its limited functionality.

Of the applications presented to the participants in the questionnaire, the most popular ones were found to be those which generated weather information, event reminders, email services and social networking updates.

Weather Information	70	76%
Event reminders	71	77%
Social networking updates (Facebook, Twitter, Whatsapp)	61	66%
Sending and receiving emails	61	66%
Gesture control of applications	49	53%
GPS services (View latitude and longitude information / current speed)	49	53%
Finding restaurants / coffee shops (Location based services)	48	52%
Number of steps taken while running / playing sport	43	47%
Voice activated commands	40	43%
Logging sleep patterns	37	40%
Results of your favourite sporting fixture	25	27%
Playing games	19	21%

Figure 1. User responses for application preferences

It was decided that weather information, event reminders and email notifications from Figure 1 would be incorporated into one application, where users would be able to test the proof of concept of passing notifications between devices. The participants were also asked if they perceived the applications to be more easily accessible on the smart phone as opposed to the smart watch interface. The results for this question showed that 61% of the participants felt that accessing information on a smart watch with regard to the applications they selected would be easier. This question was designed to provide some insight into user perceptions on ease of use related to the smart watch interface.

Finally, participants were asked to suggest any other applications that might be useful to them. From these applications, five participants suggested a phone finding system. This was selected for design and development in parallel with the notification system for use in the usability study.

4. DESIGN AND IMPLEMENTATION

The notifier and phone finder applications were both designed using mock-ups and prototyping techniques to first assess their logical screen transitions and user interactions. The applications mentioned were developed for the Pebble using the CloudPebble IDE which utilises the C language for its primary code base, as well as using JavaScript to import web based data for updates.

Both applications demonstrate the message passing between devices connected via Bluetooth 4.0 using Bluetooth Low Energy (BLE) for short range communication (Gomez, Joaquim, and Josep, 2012).

4.1 Notifier Application

The Notifier application is one which has multiple functionalities incorporated into it, namely: weather information (included as a watch face), email functionality, calendar and social networking updates. This mirrors the existing functionality of the Pebble smart watch which already has a native notification system. The objective of this exercise was to determine if message passing could be achieved with the notification application. If this was found to be true, it could be used to pass notifications between the phone and watch for any of the applications in Figure 1.

A. Weather

The weather functionality of the notifier application takes the form of a Pebble watch face, and thus is not responsive to any button presses besides the back button. The visible information has enough information to display the important details without making the display too crowded. This includes the temperature in degrees Celsius, an icon for the current weather conditions as well as the current date and time. The weather data is updated every 30 minutes via a JavaScript function which connects to an external weather API (openweather) that updates the appropriate weather data based on the current location of the connected smart phone.

B. Email

Functionality for the email service on the watch has been developed to link with the current Gmail account set up on the smart phone. Any messages which are sent to the smart phone will allow for a notification to be displayed on the smart watch. The notification service for emails allows for the display of the sender and subject fields, as well as the first few lines of text within 127 bytes of data (Bluetooth maximum message size) (Gomez, et al., 2012).

C. Calendar

Users of the notification application are able to view their personalised Google calendar through the use of the Google calendar API. A calendar reminder can be sent to the connected phone and relayed to the smart watch. The display of the calendar on the watch consists of two parts; the days of the month and the appointments for each day. These two displays can be seen in Figure 2. The user can navigate through the days of a particular month and view appointments for a selected day. The calendar is updated as per the update schedule configured on a user's Google calendar account.

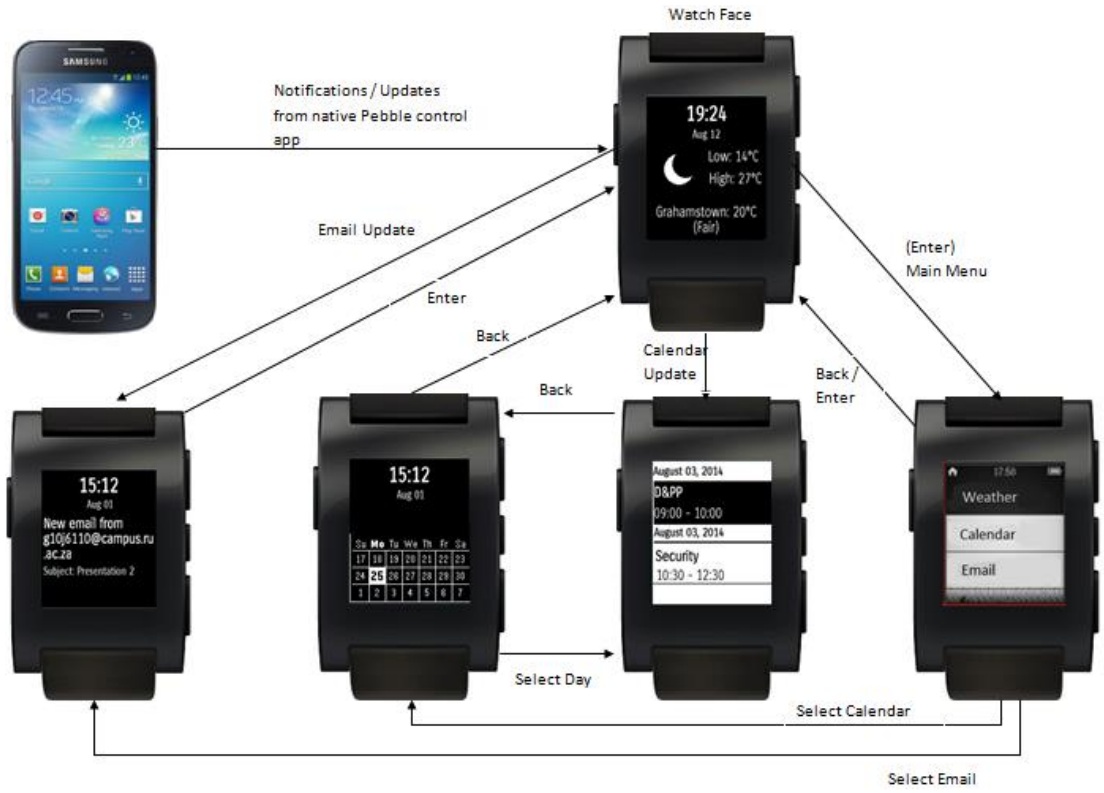

Figure 2. Application Mock-up of the notifier application

4.2 Phone Finder Application

Other phone finding applications are currently available to Pebble smart watch users, some notable examples would be Phone Pebble finder (Google Playstore, 2014a) and Pebble Rocker (Google Playstore, 2014b). However, these applications do not have the ability to bypass the Android modality settings and provide ringing functionality even when the phone is in silent mode.

A more thorough investigation into current phone finding applications for the Pebble smart watch revealed that there was no functionality in place to determine phone proximity as a function of Bluetooth signal strength. The Pebble Bluetooth API for Pebble firmware version 2.5 provides methods for determining whether a connection exist, but does not provide a method for determining signal strength.

This implementation of the phone finder application takes these factors into consideration and provides a solution through the use of an Android application that is installed on the phone. Messages sent from the watch are received through the mobile application installed on the phone through the use of a Receiver class and subsequently sent back. The round trip of the message sent from the watch to the phone, and back to the watch again is timed, resulting in a value relative to the distance between the phone and watch.

The application is able to transition between four different states, Ready, Ringing, Silencing and BT Ping. Once the phone has engaged its ringing state it can be silenced through the bottom button press on the watch, or through the application on the phone.

The phone finder Android application, which operates in conjunction with the Pebble phone finder watch application, has been developed using Java's Android Development Tools (ADT) which is integrated into the Eclipse IDE.

A. Bypassing Android modality

If the phone is in a silent mode during the time that a ring request is sent from the watch, the mode on the phone will be overridden through the allocation of appropriate access rights in the Android manifest XML file. The Android manifest is able to grant permissions to the running application if it requests any access to phone resources. In the case of the phone finder application, the watch requests the phone to receive incoming Bluetooth messages and engage the ringer service in order for a ringtone to sound.

B. Phone proximity as a function of Bluetooth signal strength

The Pebble API currently available has a library for Bluetooth connections, however the only methods available are to subscribe and unsubscribe to a Bluetooth service as well as access the current watch connection state (Pebble, 2014). This raised a challenge as to how to how to measure the approximate strength of the Bluetooth signal between the phone and connected Pebble watch.

Bluetooth signal strength between connected devices was ascertained through the use of timing the interval from when a message request was sent from the watch to the phone, and when the response was received from the phone to the watch. The watch vibrates at a frequency which is relative to the time period elapsed. An increase in the frequency of watch vibrations will indicate a closer proximity between both devices due to a stronger Bluetooth signal.

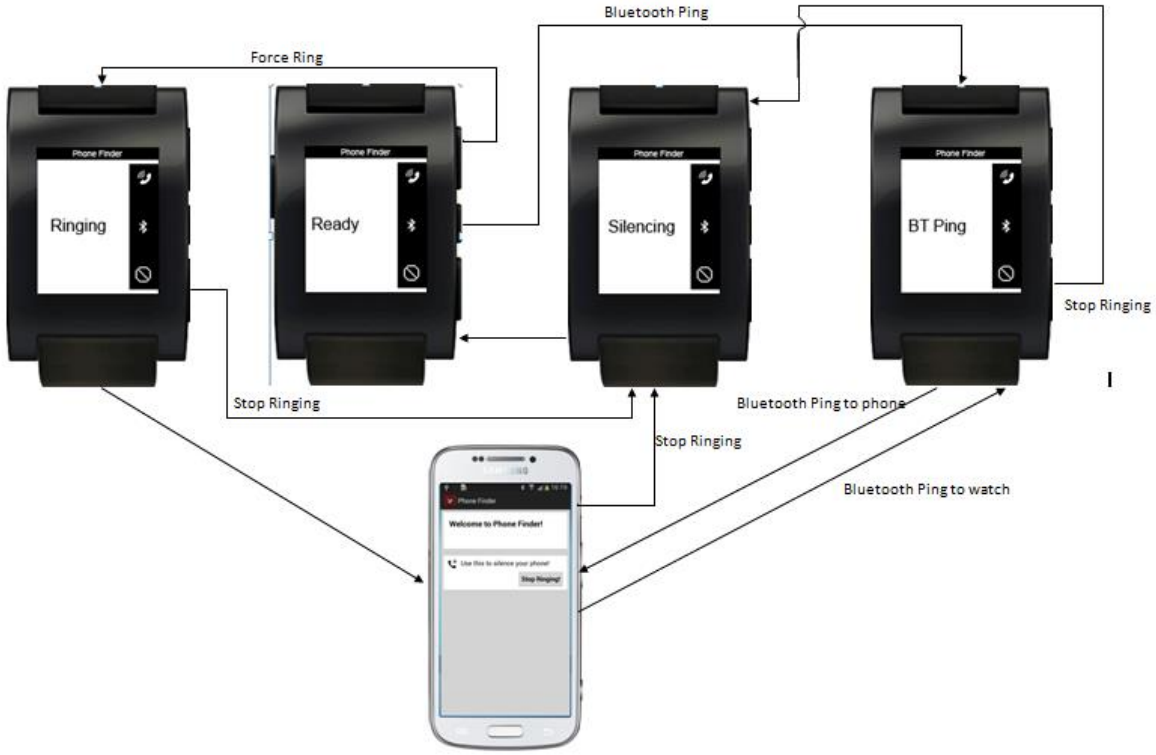

Figure 3. Application mock-up of the phone finder application

5. USER STUDY

The user study conducted was aimed at assessing the perceived usability of the notifier and phone finder applications developed for the smart watch. A number of questions were directed at the participants through the use of a questionnaire to assess the qualitative aspects of the developed applications. Thereafter a series of ten interview questions were asked, recorded and subsequently transcribed. Since the usability study was designed to be qualitative and not quantitative, the number of participants did not need to be large. A total of six participants agreed to participate in the user study. Demographic data was retrieved from the participants such as age, gender, race, major subjects and year of study.

The questionnaire was divided into two parts; one focusing on the notifier application and the other on the phone finder application. The participants were first asked to complete the section in the questionnaire relating to the notifier application which they used throughout the day. They were then instructed to use the phone finder application by initiating the ringer service which alerted them as to the phone's whereabouts within Bluetooth range. At the time of the user study the Bluetooth proximity functionality was operating with limited functionality and thus not tested. Subsequently, participants completed the phone finder section of the questionnaire.

The questionnaire design was based on the System Usability Scale (SUS) as a guideline to measure overall application usability (Nielsen, 1994). Each question was answered according to a scale between one and five, ranging from strongly disagree to strongly agree. (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). The mean and standard deviations for the notifier and phone finder parts of the user study can be seen in Table 1 and Table 2 below.

Notifier Application	Mean	Std. Dev
1. I would like to use this application frequently	3.33	1.5
2. I found the application complicated to use	2.16	0.98
3. I would need the support of a technical person to be able to use this application	1.67	0.81
4. I think most people would learn to use this application very quickly	3.5	0.83
5. I felt confident using the application	4.16	0.98
6. The information I received was useful to me	3.83	0.75

Table 1. Mean and standard deviations of scores for the notifier application

Phone Finder Application	Mean	Std. Dev
1. If I lost my phone I would use this application	4.83	0.41
2. I found the application complicated to use	1.5	0.84
3. I would need the support of a technical person to be able to use this application	1.33	0.52
4. I think most people would learn to use this application very quickly	4.33	0.82
5. I felt confident using the application	4.67	0.52
6. The information I received was useful to me	4.5	0.55

Table 2. Mean and standard deviations of scores for the phone finder application

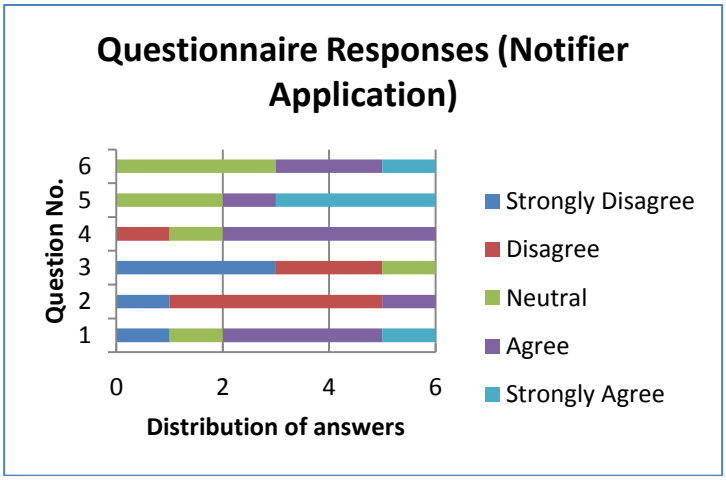

Figure 4. Responses from the notifier application questionnaire

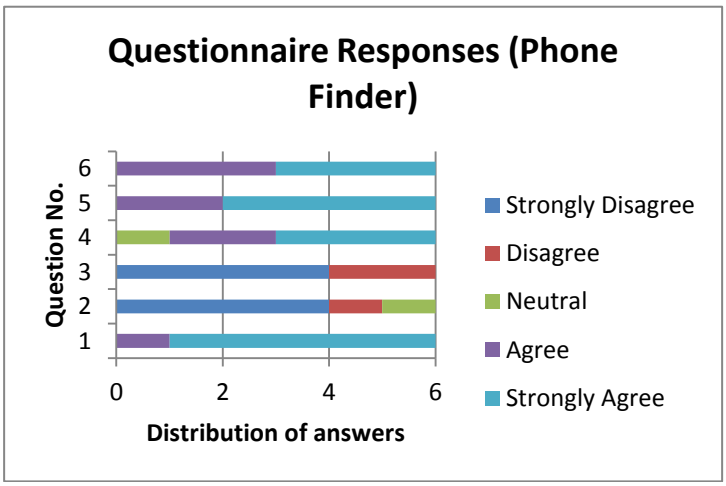

Figure 5. Responses from the phone finder application questionnaire

There were some notable findings from the mean scores in Table 1 relating to particular questions in the study. It was found that users were confident in using the application and the information

they received from doing so was useful. This can be seen from the mean scores of 4.16 and 3.83 in Table 1 respectively.

In Table 2 it can be seen that the participants would want to use the phone finder application if they lost their phone. This is evident with a mean score of 4.83 for that question. Participants felt confident when using the application and felt its operation could be learned quickly from the mean scores of 4.67 and 4.5 from Table 2 respectively.

The interview questions which were asked to the participants were designed to assess usability of using the smart watch by asking users how they interacted with the watch throughout the day and if there were any challenges they faced while doing so. The six participants were labelled from A to F for easier analysis.

Physical user interaction was assessed, where quite a number of the participants commented on the difficulty in pressing the buttons, particularly the three buttons on the right side of the watch. Participant A, D and E said it was difficult to place the correct fingers on the watch to apply pressure to the buttons. Participant C and F commented that they were not familiar with wearing a watch and found that wearing one was uncomfortable and felt unusual.

Most participants found they could use the information in a useful way when using the notifier and phone finder applications on the smart watch. The weather and calendar functionalities were particularly useful according to participants A, B and C. Participants also noted that they felt comfortable being aware of the notifications they received on their phones even though they were not physically using them. In addition, they acknowledged the limited functionality of the smart watch in comparison to their phones, and didn't expect too much from it in terms of what it could do.

It was found that there were situations where the participants found it easier to view information on the smart watch rather than on their phones. Participant C commented on the ease of viewing information while driving due to the position of the wrist on the steering wheel. Participants C, D and E found the Pebble especially useful during lectures as they did not have to use their phones but still were still able to view messages and emails. Participants B and C commented on the convenience of being able to decline calls from the wrist and controlling a music playlist instead of directly accessing the phone. The convenience of having a device on the wrist to quickly view small amounts of useful information, such as viewing messages while having both hands free, was found to be an important factor in using the watch.

All participants had never previously used a phone finding application before. They were asked if they would initially use the phone finder application if they lost their phone. Unanimously the answer was yes. Reasons included the novelty value of using such an application, and they thought it would be useful.

The participants were also asked what further functionality they would like to see included in the smart watch. Participant A stated there should be an easier way from the watch to turn off the Bluetooth pairing to the phone. Integrated GPS functionality for on-wrist navigation was proposed by Participant B. Participants A, C, D and E stated there was only so much a watch could be used for.

All participants had never had access to other smart watches before the user study took place. The general consensus was that they had not been aware of the smart watch and what they could use it for. The general criticisms of the smart watch were found to be the initial learning curve of what the buttons did, and the awkward way in which the buttons had to be pressed. The calendar application also required further refinement according to participant C and F.

It was also noted that all but one participant thought the watch was expensive and didn't believe the benefits outweighed its cost. All female participants commented on the large size of the watch on the wrist and that deterred them from wanting one. Some participants didn't feel the necessity for owning a smart watch citing reasons such as their phones already provided the functionality they require.

6. CONCLUSION

The purpose of this study was to address the issue of whether university students would want to use a smart watch, and if they did, which applications they would consider to be useful. The design and implementation of these applications were then discussed.

By addressing these application preferences, a notification system and phone finder application were developed. The implementation of these systems demonstrates, as a proof of concept, the message passing capability between the smart phone and smart watch. This does not only hold true for the applications developed in this study, but for any application which is able to send messages between the phone and smart watch. The messages passed between devices also demonstrate the way in which useful information can be displayed via the smart watch as an extension of the smart phone display.

The usability study which was performed with both the notifier and phone finder applications by participants was conducted in order to assess their usability on the smart watch. It was discovered by assessing the resulting scores of the questionnaire in conjunction with the interview questions, that both applications were considered to be useful by the participants, and although some criticisms were present, they managed to use them in a meaningful way.

There still seems to be some hesitance in the personal use of the smart watch despite the usefulness of the applications. Users appeared to not believe the usefulness of the smart watch outweighed its financial cost. Also, since the smart phone provides a far greater functionality than the smart watch itself, the participants noted they would still prefer to use their phones for receiving notifications.

Male participants appeared to be more willing to use the smart watch than the female participants. The male participants commented that if they had a watch without having to purchase one they would use it in their daily activities. There appeared to be a level of curiosity about the new technology, among the male participants which could have encouraged them to use the watch further.

All female participants in the study commented on the large size of the device and were not used to having a watch on their wrists

which deterred them from wanting to use it further, despite the usefulness of the installed applications. However, the majority of participants who were involved in the user study maintained that the watch and its applications were useful in particular circumstances where accessing a phone would be inconvenient. This highlighted the usefulness of the installed applications developed in this study in those particular circumstances, even if not all the participants wanted to use the smart watch on a daily basis if they had access to one.

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