

Useful but tedious: An evaluation of mobile spreadsheets

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Abstract

The processing power of mobile devices has greatly increased in recent years. This increased power has allowed for a greater range of applications to be deployed on this platform, providing constant access to information for end users. The limited size of these devices however, causes a number of usability issues which make these applications error prone and difficult to use. This paper presents current research being undertaken into the use of spreadsheets, an important end-user development environment, on a mobile device. The key errors observed during this work are presented here to highlight some of the problems with using spreadsheets in this way. We believe these problems may be due to the increased cognitive load placed on users who try to use spreadsheets in a mobile context.

1. Introduction

The introduction of smart phones, such as the iPhone from Apple or the Desire from HTC, has enabled a range of desktop applications to be used in a mobile context. The affordance of mobility however, has introduced a number of usability issues not seen in traditional computing environments. For mission critical applications, such as the spreadsheet application, these issues have the potential to cause serious repercussions.

A pilot survey [1] among experienced spreadsheet users has found that almost 80% of users have required access to spreadsheets where traditional computing devices were unavailable. Although access to these spreadsheets is available through mobile devices, users found them to be “*Useful but tedious*” [1].

To investigate why this is the case, this paper outlines some early observations from an on-going experiment which is examining the use of spreadsheets on mobile devices. During the experiment participants were asked to complete a number of navigation and alteration tasks on an existing spreadsheet using both a desktop computer and a mobile device. Despite the simple nature of the tasks, completing them on a mobile device proved to cause a number of issues for the participants.

As this study is still on-going a full report on the findings is unavailable. However, a number of errors were observed among the participants use of the mobile spreadsheet application. These errors have allowed for a better understanding as to why users find using spreadsheet applications on a mobile device to be tedious, and also highlighted a number of ways in which mobile spreadsheets can be made more usable, providing a more efficient and satisfying user experience.

Section 2 of this paper outlines some of the usability issues associated with mobile devices and highlights the risks associated with using mobile spreadsheets. A controlled experiment, outlined in Section 3, was conducted to better understand the specific issues associated with using spreadsheets in a mobile context. Section 4 presents some of the most common issues observed during the evaluation. This paper is then concluded in Section 5.

2. Related work

The rapid progression of technology has led to an increase in the number of mobile applications available. Although these applications offer a number of advantages in terms of portability and

convenience they do so at the cost of usability. Zhang and Adipat [2] have highlighted a number of issues that affect the usability of mobile applications, which are summarised below:

- **Mobile Context:** When considering mobile applications the user is not tied to a single location. This will also include interaction with nearby people, objects and environmental elements which may distract a user's attention.
- **Connectivity:** With mobile devices connectivity is often slow and unreliable and therefore will impact the performance of mobile applications which utilise these features.
- **Small Screen Size & Different Display Resolution:** In order to provide portability mobile devices contain very limited screen size meaning that the amount of information that can be displayed is drastically reduced.
- **Limited Processing Capability and Power:** In order to provide portability, mobile devices often contain less processing capability and power. This has the effect of limiting the types of applications that are suitable for mobile devices.
- **Data Entry Methods:** The input methods available for mobile devices are difficult and require a certain level of proficiency. This problem increases the likelihood of erroneous input and decreases the rate of data entry.

The above limitations of mobile devices further aggravate existing usability problems with spreadsheet applications. The limited screen size on mobile devices requires the user to perform considerably more navigation when looking at large spreadsheets. Users may find it difficult to conceptualise the overall spreadsheet and to see how the section on-screen fits with this overall picture, causing cognitive overload.

Flood et al. [3], have identified navigation as an issue that affects the performance of people debugging spreadsheets through voice recognition technology. By addressing this issue it was found that the debugging performance could be improved. It was also found that participants audited more cells with the improved navigation system, which is an important aspect of the debugging process.

Mobile devices generally do not contain a traditional keyboard as the size required would be too large to enable portability. Some devices incorporate a physical keyboard which utilises small keys while other devices use touch screen technology to present a keyboard to the user on screen. These keyboards require the physical keys to be smaller than traditional keyboards to fit all keys on screen. The iOS platform addresses this issue by providing users with three separate keyboards; one containing letters, one containing numbers and some special characters and a third containing additional special characters.

Chen et al. [4] conducted an evaluation of users entering text on a small size QWERTY keyboard. This evaluation required 15 participants to enter a passage of text using the small sized keyboard. On average participants used 540 keystrokes to enter the passage of text. The most prevalent type of error made by these participants during the task was a key ambiguity error, which occurred when a user entered a character other than the target character. It was found that on average, participants made about 9 key errors on the first typing task. It is also worth noting that all participants made at least one error of this type during the study.

Errors of this type, when made on a spreadsheet, may result in a misspelled word or in an incorrect reference in a cell formula, which could alter the bottom line value of a spreadsheet substantially. It has been shown repeatedly that even on desktop computers errors like this persist. Two independent studies [5, 6] have found that over 85% of the evaluated spreadsheets contained errors.

The limited processing power of portable devices has meant that existing spreadsheet applications may not function correctly when run on these devices. In an attempt to address this issue a number of developers have created spreadsheet apps which scale down the level of functionality to enable users

to view and use spreadsheets in a mobile context. However, most of these applications are limited in terms of functions available and spreadsheet size.

A recent evaluation [7] of mobile spreadsheet apps available for the iOS platform, used on iPhone and iPod touch devices, has found that the quality of these apps varies widely. Some apps feature in excess of 100 functions while other apps contain a relatively small number of functions, one application only provided the “Sum” function.

In addition to the number of functions available, a Keystroke level modelling (KLM) analysis of the apps has shown that there is a wide variation in the number of keystrokes required to perform even the most basic tasks, such as entering numerical data or formula. The number of keystrokes can vary by as much as 100% between applications.

The applications presented above are designed to replicate desktop spreadsheet applications. It has been found [1] however, that the needs of mobile spreadsheet users are quite different to those of desktop spreadsheet users. A survey of experienced spreadsheet users has shown that participants required mobile spreadsheet applications to either view or alter existing spreadsheets. It was also found that over 80% of participants required access to spreadsheets when traditional computing devices were unavailable. The paper demonstrates the importance of mobile spreadsheet applications and offers a number of ways in which these applications can be improved.

3. Experiment design

To investigate the usability of a mobile spreadsheet application, 12 participants were asked to complete a series of tasks using both a desktop computer and a mobile device, an iPod Touch. The participants were randomly assigned into two groups, Group 1 and Group 2. Group 1 were asked to use the desktop spreadsheet application followed by the mobile spreadsheet application while Group 2 reversed the order in which they used the technologies. This approach was used to counter any learning effects that may be experienced during the second completion of the tasks.

3.1 Tasks

In a survey conducted by Flood et al. [1] it was found that the most common need of spreadsheets on a mobile device was to view existing spreadsheets or to alter an existing spreadsheet. For this reason, participants were asked to alter nine cells and locate a further seven pieces of information located on the spreadsheet.

The spreadsheet used was adopted from Howe and Simkin [8] who used it during an investigation of spreadsheet debugging. The spreadsheet was used to calculate the five year projections of Acme Ltd. It contains 3 worksheets; Payroll, Office Expenses and Projections. The participants of the original experiment were expected to investigate the spreadsheet and locate and repair 42 seeded errors.

The aim of this study was not to investigate the ability of participants to debug a spreadsheet on a mobile device, but to investigate the usability issues associated with using a spreadsheet on a mobile device. For this reason, all but nine of the errors in the original spreadsheet were repaired. Participants were then informed as to the location of the remaining errors and the correct value of each cell. The nine remaining errors were made up of 5 cells containing numerical data, 2 cells containing textual data and 2 cells containing formulae.

For the location tasks, participants were given a brief description of the cell and asked to navigate to this cell and change the background colour to one of their choosing. By asking participants to change the background colour, in this way they are forced to first enter the cell once it has been located allowing the navigation time to the cell to be determined.

3.2 Software

During the evaluation the following software components were used:

- Microsoft Excel 2007 was used as the desktop spreadsheet application;

- Spreadsheet by AppAuthors was used for the mobile spreadsheet application;
- CamStudio was used to record the input from the camera and the screen of the participants while using the desktop computer;
- Yawcam was used to stream the picture from the camera to the CamStudio software.

3.3 Data Collection

During the evaluation a number of data items were collected. At the beginning of the experiment participants were asked to complete a short demographics questionnaire relating to their previous experience with spreadsheets and mobile devices. This questionnaire also asked participants about their previous experience with mobile spreadsheet applications.

During the experiment the participants' interactions with the spreadsheet application were recorded. For the desktop application CamStudio [9] was used to record the participants' screen for the duration of the experiment. As it was not possible to use screen capture software on the mobile device, a camera was mounted on top of the device which continually recorded the users' interaction with the device. The set up of the mobile device can be seen in Figure 1. Once the participants had completed the tasks, the spreadsheet artefact was collected.



Figure 1: Camera mounted mobile device

As well as the video recordings a number of questionnaires were used to solicit users' opinions of the technology. The System Usability Scale [10] was used to measure the level of satisfaction users had with each technology. The SUS questionnaire requires participants to state how strongly, on a 5 point scale, they agree or disagree with a number of statements. Using these answers it is possible to quantify how usable the participants found the system to be.

As well as the SUS questionnaire, participants were also asked to complete a second questionnaire relating to specific aspects of the tasks. For each one the participants were asked to state how strongly they agreed or disagreed that the task was easy.

3.4 Procedure

The experiment was conducted individually with each participant who took approximately 45 minutes to complete. For the duration of the experiment, the participants were placed in a small office with only the first author to oversee the experiment. The same procedure, described below, was used for all participants with the order of the technologies altered for participants in each group.

When the participants arrived for the experiment, they were greeted by the first author and given a short verbal description of the experiment. This description outlined the aim of the experiment and a brief description of what they were expected to do. The participants were then asked to read a participant information sheet outlining the aims of the experiment and their responsibilities during the experiment. When participants had finished reading the participant information sheet, they were

given the opportunity to ask any questions and then asked to sign a consent form agreeing to participate in the experiment.

The participants were then asked to complete a short demographic questionnaire asking about their previous experience with spreadsheets and mobile devices. The questionnaire also asked participants if they had used a mobile spreadsheet application previously. Only 1 participant had used a spreadsheet in this way and quickly abandoned it as they found it to be too frustrating to use.

Once they had completed the demographics questionnaire, the participants were asked to complete the set of tasks using the first technology. For those using the mobile device, their interaction with the spreadsheet was recorded through a mounted camera, illustrated in Figure 1. For those using the desktop computer CamStudio was used to capture the screen for the duration of the experiment.

When the participants were satisfied they had completed all of the tasks or were unable to complete the tasks, they were asked to complete the System Usability Scale (SUS) questionnaire [10] relating to the technology they had just used and an additional questionnaire asking them how strongly they agreed or disagreed that the tasks were easy. The style of question used was chosen to be consistent with the style used on the SUS questionnaire, so as not to cause any confusion for the participants.

Once the questionnaires were completed participants were offered the opportunity to take a short rest before proceeding to the second set of tasks. None of the participants took advantage of this, instead choosing to proceed to the second set of tasks which asked them to complete the same set of tasks using the second technology. After this the participants were asked to complete the same questionnaires relating to the second technology. This concluded the experiment and participants were thanked for their participation.

4. Results

During the course of the experiment a number of errors were observed that had a substantial impact on the ability of the users to perform the tasks efficiently. This section details some of the most prevalent errors observed during the course of the experiment.

Inaccurate cell selection: One of the most common errors observed during the course of the experiment was the inaccuracy of cell selection. While trying to select a particular cell it was found that participants would inadvertently select an adjoining cell. It was noticed that in the majority of cases this occurred, the participants were aiming at the text in the cell. As the numerical text in the spreadsheet typically contained only a small number of characters, the users target area was quite small. This in conjunction with the right alignment of numerical text has resulted in users pressing the cell located to the right of the desired cell. It was also observed in a number of cases that participants selected the cell below the target cell.

A subsequent experiment is planned to investigate the way in which participants select cells using a touch screen device. This experiment will consider the impact of the alignment of the text, the type of text in the cell and the number of characters within the cell on users' selection behaviour. A better understanding of the impact of each of these factors will enable us to produce a set of guidelines to help prevent this kind of error in the future.

A technical solution to this problem could also help address this issue. It was clear that the point at which the user touched the screen was usually only a small number of pixels from the target cell. By introducing extra space between the edge of the cells and the text located within the cell would reduce the likelihood of this type of error from occurring.

Character selection: Another common problem observed during the evaluation was the participants' difficulty in navigating to individual characters within a word. One of the errors within the spreadsheet required participants to repair a misspelling ("compony"). The default behaviour of the participants was to try and select the incorrect character. However, the default behaviour of the system placed the cursor at the end of the selected word.

To provide fine grained navigation within a text string users are required to use a long press, where the participants holds the screen for a few seconds and drags the cursor to the correct location. Only

participants familiar with the iPhone platform discovered this functionality. Arrow keys could be used to provide fine grained navigation among characters which may ameliorate this problem as it would allow recognition rather than recall [11]. For more experienced users the existing approach may be more efficient.

Unexpected Behaviours: In a number of scenarios the system failed to react in the way the user expected. In addition to character selection, outlined above, this issue was also seen when users were trying to set the background colour for the first time. When the user discovered the colour pallet they selected the colour they wanted and expected the system to return to the spreadsheet with the background colour of the cell set. Instead the system only highlighted the colour. To return to the spreadsheet, the user was required to hit the back key and then close the format cell options. When the system had not responded as expected the users assumed that the system did not recognise the input and retried, selecting the colour again multiple times.

This behaviour can be explained by an inconsistency with traditional desktop applications in which a user only needs to click the desired colour once from the colour pallet to set the background colour of the cell. The consistency between platforms is another of the heuristics defined by Nielsen [11] for designing good user interaction and is also recognised good practice for design.

Unintended actions: The final problem we observed occurred with only one participant. This issue however, should be mentioned due to the serious consequences of the error. During one of the tasks the participants were asked to alter a formula to repair an incorrect reference. To complete this task the participant had to remove the incorrect reference, using the backspace key and then type in the correct cell reference.

While doing this task, one participant accidentally pressed the ‘done’ button while removing the incorrect reference. This had the unintended consequence of moving the user to the following cell, which contained a similar formula (a common occurrence in many spreadsheets). The user did not notice this shift and continued with the change, changing the wrong cell. When the user finished the change they looked back at the original cell and repaired the error again. The participant therefore introduced an error into the spreadsheet which, as previous research [12] has shown, can have severe consequences.

This error is partly caused by the requirement for the user to focus on the keyboard while entering data. On a traditional desktop computer, users can feel the keys and therefore are not required to focus as much on the keyboard during data entry. The use of touch as a guidance mechanism is lost when data entry is done through touch screen technology and the users’ view is then split between the data entry location (i.e. the cell) and the keyboard.

5. Conclusions

This paper presents a controlled experiment which aims to examine the usability issues that arise when using spreadsheets on a mobile device. The small screen size and limited processing power have forced mobile app developers to review the way users interact with spreadsheets. Although this redesigned interaction has offered many benefits in terms of portability and convenience, it does so at the cost of usability.

A number of problems were observed among most of the participants. Poor recognition, inconsistency of interfaces and poor visibility all contributed to a useful but tedious experience with mobile spreadsheet applications for the users in our experiment. It is quite likely that the increased cognitive load placed on the users is partly to blame for this.

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