

A COMPARATIVE STUDY OF SPREADSHEET APPLICATIONS  
ON MOBILE DEVICES

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**Title**

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## ABSTRACT

Advancements with mobile-screen sizes and enhancements to current-day features for mobile applications have increased the number of users accessing spreadsheets on mobile devices while away from desktop computers. In recent years, these behaviors have led to increased development of mobile spreadsheet applications. For this study, open-source mobile spreadsheet applications, such as OfficeSuite Viewer 6, Documents To Go, ThinkFree Online and Google Drive, were selected for comparison. To analyze and evaluate these spreadsheet applications, we selected various usability principles. These principles were categorized into three criteria: visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience. Measures for each criterion were derived in the survey. To address the approach, existing research was studied, and the survey was divided into two phases and then compared by using the selected criteria and derived measures. Questionnaires were designed to address the measures based on the comparative criteria provided in the analysis.

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## 1. INTRODUCTION

The mobile-applications segment of mobile markets is growing at a great rate. The rapid growth and omnipresence of smart phones in the consumer market has led to easy access and reliability for the business, entertainment, gaming and social-networking sectors on mobile devices. It is estimated that, by 2013, mobile phone users will number more than 6 billion worldwide [1]. According to the International Data Corporation (IDC), Android and iOS, the number one and number two smartphone operating systems worldwide, combined for 91.1% of all smartphone shipments during the fourth quarter of 2012 (4Q12) [2]. Smartphone vendors and Apple shipped a total of 207.6 million units worldwide during 4Q12, up 70.2% from the 122.0 million units shipped during 4Q11 [2]. The emerging growth of hardware components, increased processing power and the availability of high-speed internet have enabled the smartphone industry to grow at a very fast pace. Increased mobile usage has made many vendors focus more on mobile application development. Over the last few years, flexibility with mobile-application development has resulted in the creation of 675,000 applications and games for the Android operating system (OS) and 775,000 applications for iOS [4, 5]. Now, mobile applications are more people-centric and user friendly. Major software distribution platforms in the mobile industry are Google Play, the Apple Store, Windows Phone Store, BlackBerry World and the Nokia Store. The common mobile operating systems available are Android for Google, Inc.; BlackBerry 10 for BlackBerry; iOS for Apple, Inc.; S40 (Series40) for Nokia and Windows Phone for Microsoft (Figure 1-1).

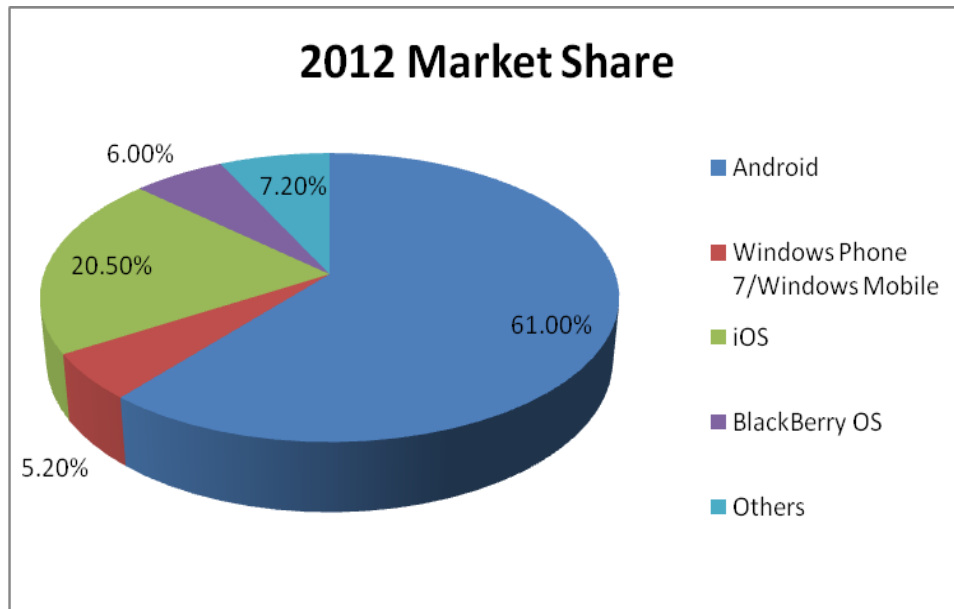


Figure 1-1. Share of major mobile-phone operating systems [6].

Winston [7] estimates that 90% of all industry analysts perform calculations with spreadsheets. Spreadsheets are used for inventory administration, educational applications, accounts, sales analysis, scientific modeling, financial systems and more.

It is estimated that, for strategic planning practices at major U.S. corporations, 72% of users relied on spreadsheets exclusively to do strategic planning [8]. Financial intelligence firm Coda reports that 95% of U.S. firms use spreadsheets for financial reporting and 47% of companies use stand-alone spreadsheets for planning and budgeting [8].

According to a study in Europe, it is estimated that 79% of people require access to a spreadsheet while away from their desktop or laptop computer [9]. The previously mentioned facts illustrate that the requirement for access to spreadsheets on mobile devices is growing.

Using mobile spreadsheet applications has increased drastically over the last few years. Downloads of mobile spreadsheet applications have crossed 10 million per app for

several applications in the top 10 list of the Google Play store. Mobile spreadsheet applications, such as Google Drive, OfficeSuite Viewer 6, Documents To Go and more, have download numbers greater than 10 million per application [10]. The majority of these applications have been built since 2009 and above numbers show the pace at which mobile spreadsheet applications are growing.

Mobile spreadsheet applications are available as stand-alone applications and also as office-suite applications. Office-suite applications come with base components, such as a word processor, spreadsheet and presentation program. Sometimes, they come with features for opening PDF and ZIP files.

Advantages offered by mobile applications are convenience, efficiency, mobility, portability, flexibility, accessibility and more [30, 20, 21, 12]. Mobile applications also come with several issues, such as usability and performance. In several recent surveys, authors have identified various attributes for usability and performance issues [9, 11, 12, 14, 15, 16, 17, 18]. These attributes include Learnability, Memorability, effectiveness, efficiency, simplicity, cognitive load, errors, user satisfaction, comprehensibility, consistency, readability, glancability, learning performance and more. These usability and performance issues for mobile applications make it increasingly difficult for developers to establish standards to create applications. A study to evaluate mobile spreadsheet applications is proposed in order to understand the various usability issues that people have and to compare the current features provided by applications with different operating systems.

This paper contains a survey that was conducted to compare and understand the needs users have when accessing spreadsheet applications on mobile devices. The survey

is compares four mobile spreadsheet applications on various aspects, such as user background and scope, visibility for the spreadsheets, glancability, zooming, the display size of the application, spreadsheet navigation, scrolling, data sorting, interaction and feedback of application to users, and more. The previously stated aspects are divided into four categories and considered as criteria for the evaluation: user background and scope; visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience. Four applications, OfficeSuite Viewer 6, Documents To Go, ThinkFree Online and Google Drive, are selected for the survey. Of them, three applications are in the top 10 list of the Google Play store [10]. The main purpose of these four mobile applications is to provide services for accessing spreadsheets and other documents. In our survey, these applications are only used for accessing spreadsheets. Each application has its own layout and user interface (UI) to display spreadsheets.

A survey was conducted to obtain the users' opinions. The survey was composed of questions in two phases, and invitations were sent to NDSU Department of Computer Science graduate students and random employees at various organizations. From the invitations and flyers, 80 participants took part in the survey. All the questions in both phases were objective type with options from which to select answers. Phase one had questions related to demographics, such as age, gender, frequency of using spreadsheets, participants' general behavior while accessing spreadsheets, their awareness about mobile spreadsheet applications and more. Phase two consisted of questions covering different categories, such as user behavior and scope; visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience. The 80 participants were divided into 4 groups for evaluating the mobile applications. Each group of

participants was given a specific mobile device and assigned a mobile spreadsheet application for the survey. Table 1-1 illustrates the groups used for the survey. Allocation of a mobile device with respect to a mobile spreadsheet application is listed as four groups as shown in Table 1-1.

Table 1-1. Groups into which participants are divided for the survey.

| <b>Group</b> | <b>Operating system</b> | <b>Mobile spreadsheet application</b> | <b>Mobile device</b> | <b>Number of participants</b> |
|--------------|-------------------------|---------------------------------------|----------------------|-------------------------------|
| Group 1      | Android                 | OfficeSuite Viewer 6                  | HTC Inspire          | 20                            |
| Group 2      | Android                 | Documents To Go                       | HTC Inspire          | 20                            |
| Group 3      | iOS                     | ThinkFree Online                      | Iphone 4s            | 20                            |
| Group 4      | iOS                     | Google Drive                          | Iphone 4s            | 20                            |

SURVEYGIZMO was employed as survey tool to provide participants with the necessary link and to collect responses from participants. To avoid duplicates and protect the accuracy of the generated responses, participants were assigned a unique ID using their IP addresses. The IP addresses were destroyed once the unique IDs were generated for each participant.

The key contributions of this paper are listed in summary form:

- Identifying three categories of various usability principles as the criteria for comparing the existing mobile applications.
- Comparing OfficeSuite Viewer 6, Documents To Go, ThinkFree Online and Google Drive according to the above criteria.
- Evaluating criteria and comparison of the user-survey results.
- Using various statistical methods to validate the following objectives:
  - Is the application meeting the users' requirements?
  - How closely are applications designed, and how similar are they?

- How can the users' experience with the applications be classified?

The rest of the paper is as organized as follows. Chapter 2 discusses Related Work that talks about previous research about mobile spreadsheet applications. The chapter outlines how authors classified three different categories of usability principles with different aspects to measure usability of mobile applications for this paper. Chapter 3 illustrates how questions in different categories are classified for the survey. This chapter also outlines the survey method employed for this paper. Chapter 4 discusses the User Background and Scope, outlines the aspects considered to evaluate category User Background and Scope, and compares the aspects in detail. Chapter 5 discusses the Visibility category in detail. Chapter 6 describes Navigation, Scrolling and Application Feedback. Chapter 7 discusses Interaction, Satisfaction, Simplicity and Convenience. Questionnaire design, survey results per category and other results are discussed in Chapter 8. Chapter 9 covers the observations outlined by this paper and suggestions for developers to create better mobile spreadsheet-application designs. Chapter 10 discusses the Conclusion for this paper.

## 2. RELATED WORK

Rapid advancements for the hardware of mobile devices and mobile application development have led to an increased number of users and more mobile applications. It is estimated that, by 2013, the number of mobile users will be more than 6 billion, which computes to 87% of the world's population [1]. According to the International Telecommunications Union (ITU) [11], the estimated number of active mobile-broadband subscriptions has increased to 1.2 billion. Even though mobile applications offer numerous advantages in terms of accessibility, availability, flexibility, convenience and portability, the applications come with several usability and performance issues. According to ISO 9241, Part 11, usability is “the extent to which a product can be used by specific users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” [11]. Because “usability” is too abstract a term to study directly, it is divided into the following attributes: learnability, efficiency, user retention over time, error rate and satisfaction [3, 12].

Zhang and Adipat [20] have mentioned a number of significant challenges for examining the usability of mobile applications, including mobile context, multimodality, network connectivity, small screen size, different display resolutions, limited processing capability and power, and restrictive data-entry methods. According to Zhang and Adipat [20], based on the standard ISO 9241, HCI handbooks and existing usability studies about mobile applications, there are nine generic usability attributes [14, 15, 16, 17, 18]: learnability, efficiency, memorability, errors, user satisfaction, effectiveness, simplicity, comprehensibility and learning performance. Heuristics that are proposed by Bertini et al. [19] and used for evaluating mobile applications are as follows:



- Visibility of system status and losability/findability of the mobile device.
- Match between the system and the real world.
- Consistency and mapping.
- Good ergonomics and minimalist design.
- Ease of input, screen readability and glancability.
- Flexibility, efficiency of use and personalization.
- Aesthetic, privacy and social conventions.
- Realistic error management.

In a recent survey Flood et al. [9], the authors have identified seven attributes about the usability of mobile applications: effectiveness, efficiency, satisfaction, learnability, memorability, simplicity and cognitive load. Of them, the effectiveness, efficiency, satisfaction and simplicity attributes are examined with this study's survey.

This paper outlines various usability issues and difficulties faced while utilizing mobile spreadsheet applications. After closer observation of the above usability issues from different research studies, the author of this paper have identified several usability evaluation attributes for mobile spreadsheet applications: simplicity, user satisfaction, user behavior, scope of the spreadsheet, interaction, convenience and display size, glancability, flexibility, zoomability, look and feel, scrolling, the ability to conceptualize spreadsheets on the screen section, navigation feedback, and neighborhood feedback.

These evaluation attributes are divided into four categories to study the issues users faced while accessing mobile spreadsheet applications: user background and scope; visibility; navigation, scrolling, and application feedback; and interaction, satisfaction, simplicity, and convenience. A user survey is conducted by utilizing these categories to

gather opinions to metric these aspects and to evaluate the four spreadsheet applications based on these metrics.

### 3. STUDY DESIGN

Classifying the usability evaluation attributes mentioned in Chapter 2 into different categories, a user study is conducted to measure the attributes' importance and to evaluate the users' opinions about the characteristics of four different mobile spreadsheet applications, OfficeSuite Version 6, Documents To Go, ThinkFree Online and Google Drive, on two different operating systems, Android and iOS. The four survey categories are user background and scope; visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience.

The user background and scope category focuses on grouping the users with two mobile operating systems that are available. It also gathers participants' general usage time and overall time spent accessing spreadsheets. The purpose of using spreadsheets while accessing them on mobile devices and the various features participants like are also evaluated. The size of spreadsheets utilized by users, the user preference to utilize spreadsheet applications on mobile devices and the importance of headers are also evaluated.

The visibility category seeks the users' opinion about the importance of the display size of spreadsheets on the screen, the display size of characters on the screen and their readability, the glancability of the spreadsheet, the zoomability to see spreadsheet data, and the look and feel of the application while displaying spreadsheets. Users are asked to evaluate the mobile spreadsheet applications by the above-mentioned aspects on a scale of 1 to 5 (1 being not satisfied and 5 being very satisfied).

The navigation, scrolling and feedback category outlines the importance of smarter navigation, horizontal and vertical scrolling, referencing data cells to their

corresponding headers, the ability to sort data, the ability to conceptualize the overall spreadsheets on the screen section, feedback from application in navigation, the ability to handle complex spreadsheet headers and the importance of neighborhood feedback from the application. Users are asked to evaluate the mobile spreadsheet applications regarding the above-mentioned aspects; a scale from 1 to 5 (1 being not satisfied and 5 being very satisfied) is utilized.

The interaction, satisfaction, simplicity and convenience category gathers input to find the importance of application interaction, satisfaction with viewing the spreadsheet as a desired by user, simplicity of application and convenience of the application. Users are asked to evaluate the mobile spreadsheet applications on a scale of 1 to 5 (1 being not satisfied and 5 being very satisfied) regarding the above-mentioned aspects.

The survey is conducted with 80 participants, from NDSU and professional organizations, who have used Excel in their day-to-day work. Participants are categorized into 4 groups with each group containing 20 participants. Each group is assigned a mobile spreadsheet application, data spreadsheet for survey and 2 survey questionnaires with a total of 19 questions. The survey is divided into two phases. Phase one is a pre-survey which had 10 general questions about the users' age, gender, ethnicity, mobile devices' operating system, usage of spreadsheets on mobile devices, purpose of usage and features of spreadsheets.

Phase two is a more advanced phase where nine questions cover four different categories: user behavior and the scope of spreadsheets users utilized; visibility aspects of spreadsheets; navigation, scrolling, and feedback aspects of spreadsheets in the applications; and interaction, satisfaction, simplicity, and convenience. During phase

two, users are given a mobile device, data spreadsheet and the corresponding mobile application that was allocated to the participant.

After obtaining consent to participate in the survey from users, all 80 participants are divided into 4 groups, and each group is allocated one mobile application for the study. The survey is conducted by using a secure tool called SURVEYGIZMO.

Participants are provided with two links, one for the pre-survey and another for the post-survey. Once participants complete the pre-survey, the next link to the post-survey along with the appropriate mobile device and mobile spreadsheet application is provided. For this survey, the authors have used two mobile devices: the Iphone 4s with iOS 6 and the Android HTC Inspire with OS version 2.3.3.

For the post-survey, 20 participants have taken part for each mobile spreadsheet application. The OfficeSuite Version 6 and Documents To Go applications are tested on the Android operating system while ThinkFree Online and Google Drive are tested on the iOS operating system.

## 4. USER BACKGROUND AND SCOPE

### 4.1. What is the user background and scope?

User background evaluates vital information such as who the users are, what their background is, what they know and what they can learn, their context for working, etc. User background will also help us understand the user's behavior for accessing mobile applications, the time spent on them and the purpose for accessing the application.

In our survey, the scope of the spreadsheets tells us the size of spreadsheets that users often utilize. Scope will also give insight about what type of headers users want in spreadsheets. The scope of the spreadsheets also helps us understand the users' interest to utilize spreadsheet applications on mobile devices.

### 4.2. Importance of user background

User background helps us understand the users' intention toward the application and also the environment in which the application is used. User background will help us to evaluate general patterns and the usability style of users.

### 4.3. Survey results for user background

In the current mobile operating-system market, the combination of Android and iOS operating systems is close to 81% as of 2012 [6]. In our survey, we gathered the percentage of operating systems used by our participants. These results also showed that the majority share is captured by the Android and iOS operating systems, with Android at 40% and iOS at 46%. Figures 4-1 and 4-2 will show the percentage of participants based on their age and gender respectively. Table 4-1 shows the percentage of users utilizing the mobile operating systems.

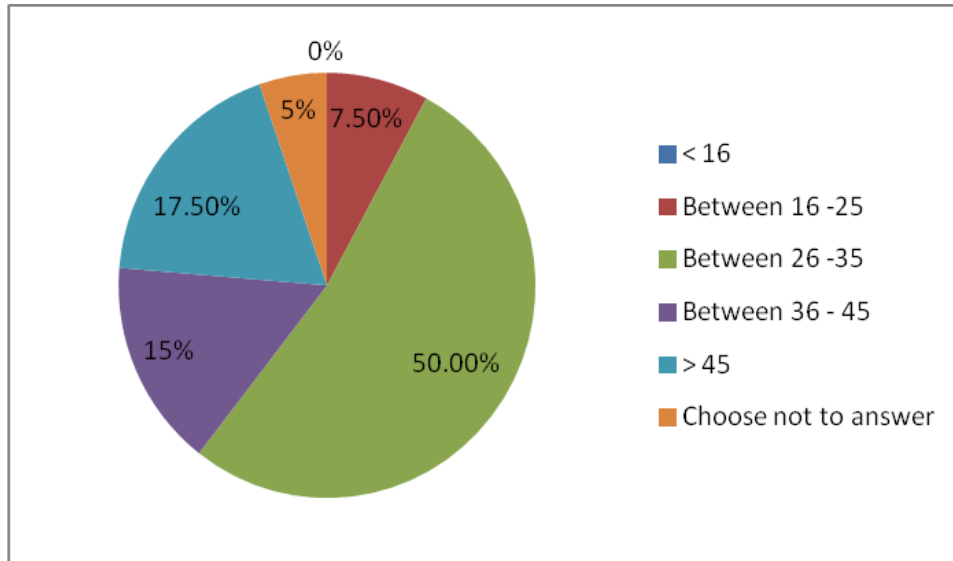


Figure 0-1. Percentage of users based on age distribution.

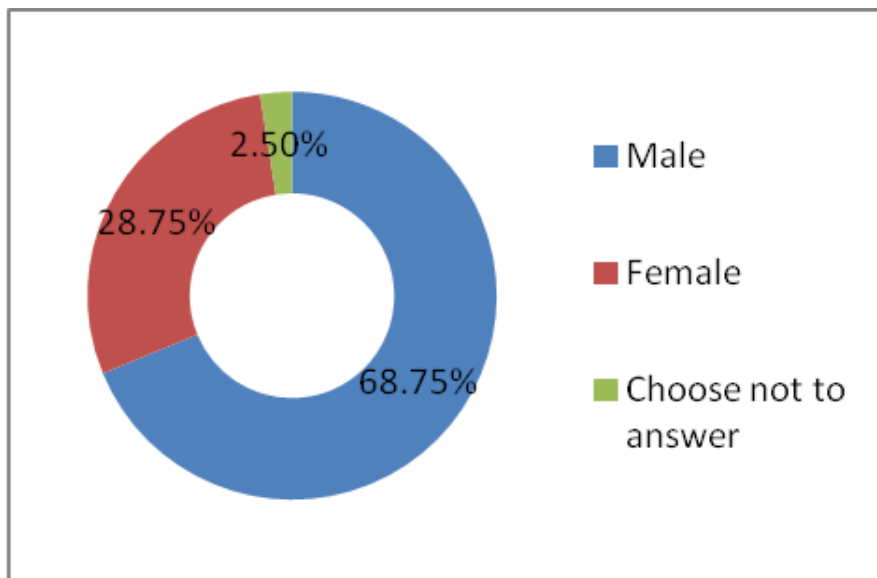


Figure 0-2. Percentage of users based on gender distribution.

Table 0-1. Percentage of users based on mobile operating systems.

| Operating System | Percentage |
|------------------|------------|
| Android          | 40%        |
| Iphone           | 46.25%     |
| RIM BlackBerry   | 5%         |
| Other            | 10%        |

Of the 80 survey participants, 51.25% of them access spreadsheets using their mobile devices at least once a month. Figure 4-3 shows the percentage of users based on the frequency of accessing spreadsheets on their mobile devices. The time users spend utilizing spreadsheets helps us understand the nature of participants and their behavior when using applications. Because the amount time spent accessing mobile devices varies from participant to participant, the average time is considered for evaluation. Figure 4-4 gives the percentage of users based on the average time participants spent accessing spreadsheets each week.

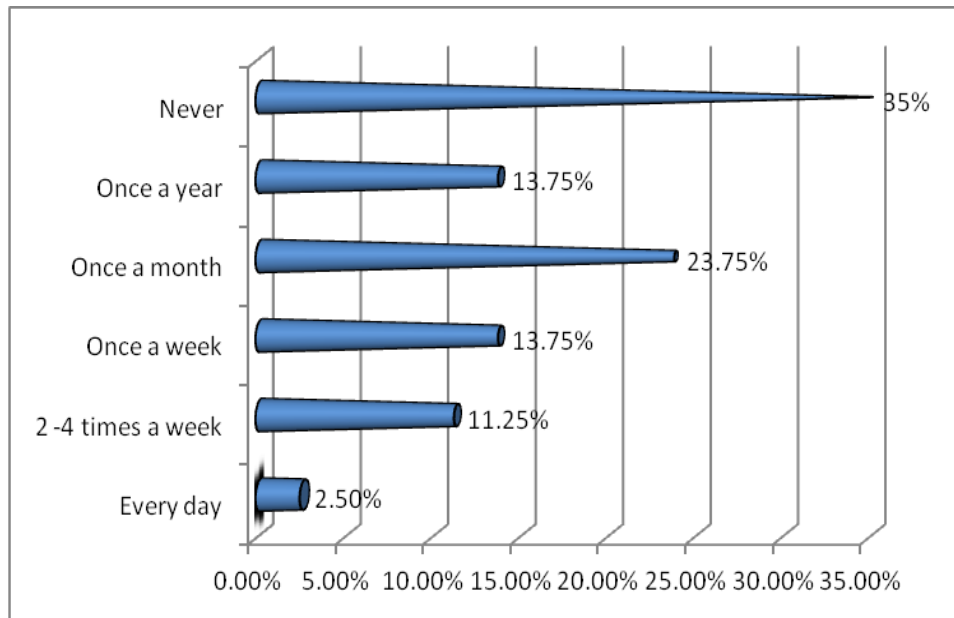


Figure 0-3. Percentage of users based on the frequency of accessing spreadsheets.



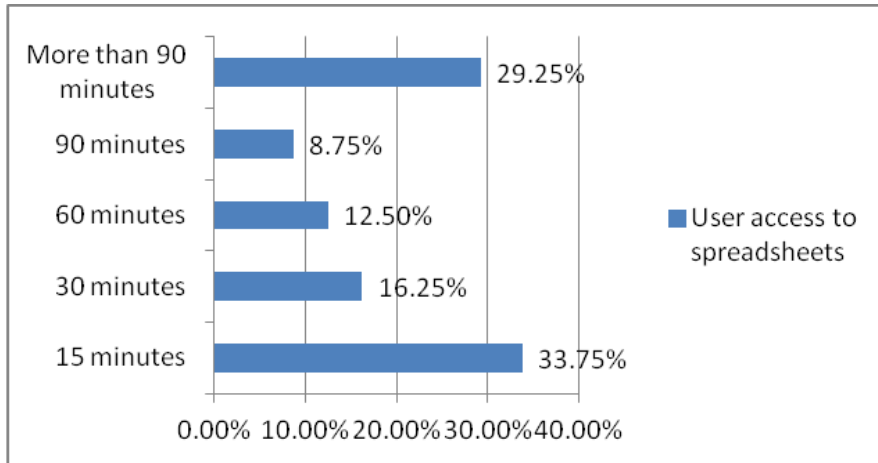


Figure 0-4. Percentage of users based on the average time spent accessing spreadsheets each week.

The survey clearly illustrates the fact that 65% of the participants spend at least 30 minutes accessing spreadsheets every week. Among those participants, we have 27.5% who access spreadsheets more than 90 minutes per week.

Figure 4-5 outlines the purpose of accessing spreadsheet on mobile devices; 51.25% of users felt that the purpose of accessing the spreadsheet was for viewing it. Only 8.75% of the participants felt editing spreadsheet was their purpose. Additionally, 17.5% of the participants felt that both reading and editing spreadsheets were their purpose.

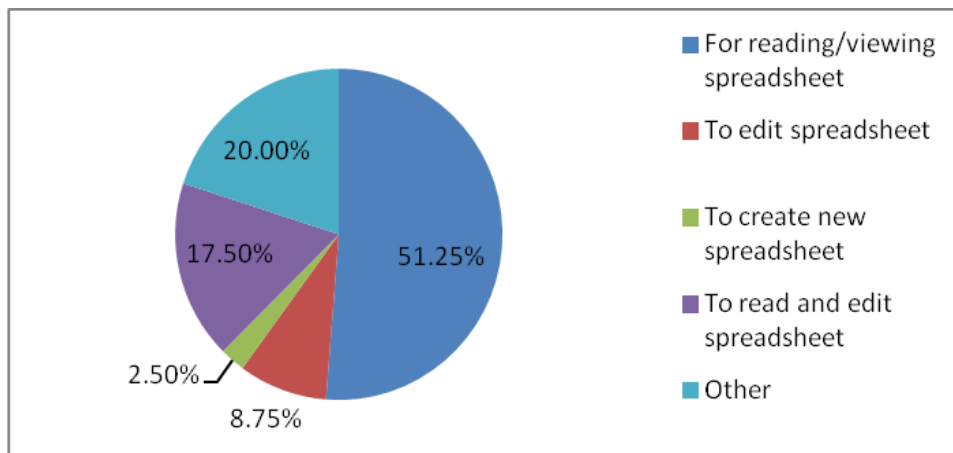


Figure 0-5. Percentage of users based on the purpose of accessing spreadsheets.

Figure 4-6 shows user opinions about the features they like in spreadsheets. The majority of the participants listed handling rows and columns; functions and formulas; column sorting; inserting and deleting; and copy, cut, and paste as the most-liked spreadsheet features.

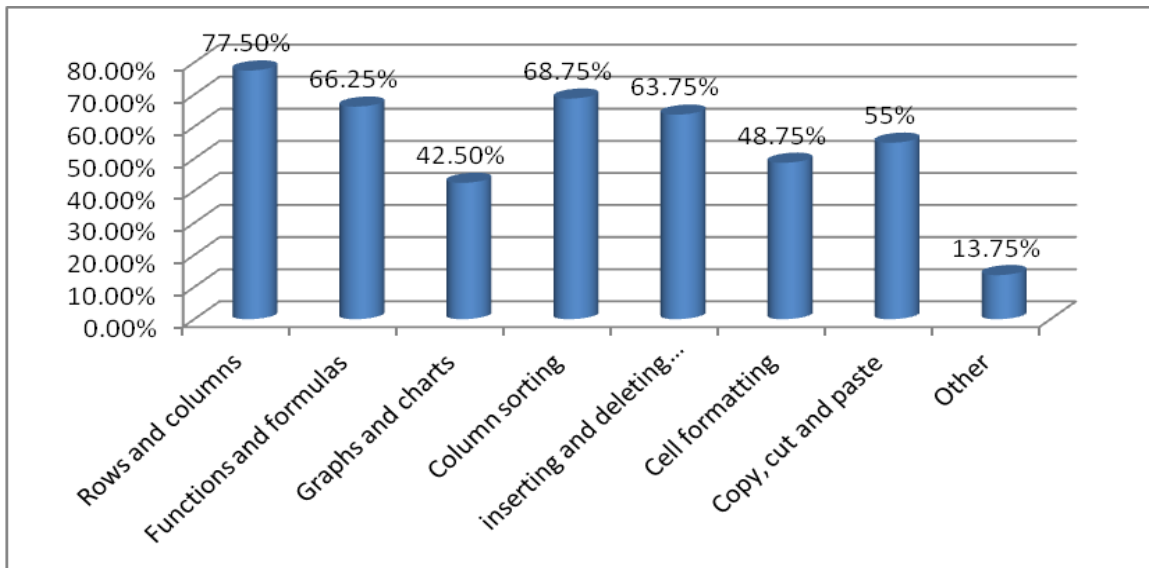


Figure 0-6. Percentage of user opinions based on the spreadsheet features.

The percentage of users based on ethnicity was evaluated with the survey to determine participants' demographics. Table 4-2 represents the percentage of users based on ethnicity. It clearly shows that the percentage of participants belonging to the Asian/Pacific Islanders, American and Caucasian ethnicities combined to 93.75%.

Table 0-2. Percentage of users based on ethnicity.

| <b>Ethnicity</b>        | <b>Percentage</b> |
|-------------------------|-------------------|
| Asian/Pacific Islanders | 56.25             |
| American                | 15%               |
| Caucasian               | 22.5%             |
| Latino or Hispanic      | 0%                |
| Middle Eastern/Arabic   | 0                 |
| African American        | 1.25%             |
| Other/Multi-Racial      | 1.25%             |
| Choose not to answer    | 6.25%             |

## 5. VISIBILITY

Visibility means that user interface should always keep the users informed about what is going on, through appropriate feedback within reasonable time [21]. Some collected usability principles are listed in Table 5-1 [21, 22, 23]. According to Constantine [23] and Nielsen [22], visibility is important metric to measure an application's usability.

Table 5-1. Usability principles as stated by different authors.

| Reference | Usability Principle  |
|-----------|--|
| [23]      | Structure principle, simplicity principle, visibility principle, feedback principle, tolerance principle, reuse principle  |
| [22]      | Visibility of system status; match between system and the real world; user control and freedom; help users recognize, diagnose, and recover from errors; recognition rather than recall; aesthetic and minimalist design; pleasurable and respectful interaction with the user; consistency and standard |

In this paper, we study the visibility of an application by using various aspects, such as display size of the spreadsheet on the screen, display size of the characters on the screen and readability, glancability of spreadsheets, zoomability to see spreadsheet data, and look and feel of the application while displaying spreadsheets.

Visibility of an application, based on the user's opinion, is the most important factor for the success of any application. Because the mind notices and interprets the actions and events connected to the actions, visibility plays a vital role in providing the mind with the necessary input for events happening around us. Visibility leads to a more accurate action from the mind and helps with job success. When using a mobile

spreadsheet application, if the character display size is not appropriate for the user's vision, then the user will have difficulty utilizing the application.

## 6. NAVIGATION, SCROLLING AND APPLICATION FEEDBACK

According to [24], navigation in the real world means users must be able to determine their position, to chart their course and to find out how far they have already come. In other words, for mobile applications, navigation ascertains the user's position in the application and lets him plan for future action by providing valuable interactive suggestions.

Scrolling means moving or sliding text, image or video object across display screens. According to [21], application feedback means the user interface must keep users informed about actions or interpretations as well as changes of state or condition using clear, concise and unambiguous language that is familiar to users. Feedback is viewed as an essential element of ubiquitous computing systems in the HCI literature for people to manage their privacy [25].

This chapter discusses various aspects of the navigation, scrolling and application feedback category. These aspects include navigation, scrolling, reference of data cells to corresponding headers, ability to conceptualize the overall spreadsheet on screen section and neighborhood feedback of application.

Navigation helps the users to very easily reach their desired location in the application. Without navigation, users have difficulty understanding their current position and will not be able to perform any desired future actions. Scrolling helps the users read the larger text contents within a single page. Without scrolling, the text on a page has to be divided into multiple, smaller pages so that the user can view the complete content with respect to the device's display size. Application feedback assists the users when they

are not sure of their next action. Without application feedback, users may have difficulty changing the application's state or condition.

## 7. INTERACTION, SATISFACTION, SIMPLICITY AND CONVENIENCE

Nielson [22] stated respectful interaction with the user as one of the usability principles. Human-computer interaction (HCI) is the study of interactions between people and computers [26]. The goal of HCI designers is to make computers more usable and more receptive to the user's needs [27]. Mobile interaction is the study of interactions between mobile users and computers. One of the main issues with mobile interaction design and evaluation is the need to understand the dynamics and details about the context that surrounds the users in a variety of settings and locations [28].

Customer satisfaction is a measure of the degree to which a product or service meets the customer's expectations. From a quality perspective, adapted from the Kano's established quality model that was published in the 1980s, Jokela [29] related usability in mobile devices with user satisfaction and divided usability into three categories: must-have, more-is-better, and attractive usability.

Simplicity means making common tasks simple to do, communicating simply in the user's own language and providing good shortcuts that are meaningfully related to longer procedures [21]. When mobile-phone interfaces are designed simply and clearly, users can conduct tasks easily and quickly, leading to better performance. Simplicity is also one of the usability principle stated by Constantine [23].

Convenience means increased ease with accessibility by increasing the available resources, time, effort and energy with less friction and discomfort. It is also said as state of being able to reach end goal with little effort or difficulty. Convenience helps users access their application with relative ease and will deliver more results.

This chapter discusses various aspects of the interaction, satisfaction, simplicity and convenience category. These aspects include application interaction, satisfaction in viewing the spreadsheet as desired by a user, simplicity of the application and convenience of the application.

Without interaction, satisfaction, simplicity and convenience, users will have a hard time using mobile applications. If an application is not designed with the proper interaction, users will not be able to understand what the application intendeds to communicate to the user. The application's market always depends on the users' satisfaction and review. A simple application attracts more users, irrespective of their proficiency or technical skill using that application, leading to more users and, eventually, a larger market share. Convenience lets the users utilize applications for an extended period of time, and this is, again, a market advantage for vendors.



## 8. USER SURVEY AND EVALUATION

### 8.1. Questionnaire design

This research is conducted with four mobile applications: OfficeSuite Viewer 6, Documents To Go, ThinkFree Online and Google Drive. Apart from the user behavior and scope category, the survey questions are designed with the three categories of usability issues in mind: visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience. For each category, there are different aspects and lists of question asked to cover each aspect. For example, in the visibility category, there are four aspects: display size, glancability, zoomability, and look and feel. For each aspect, participants are asked to answer questions which would provide the importance of the aspect on a scale from 1-5, where 1 is not important and 5 is very important. After getting the measure, the same participant is asked to evaluate the same aspect on a mobile spreadsheet application. Evaluation of aspect is done on a scale from 1-5, with 1 being not satisfied and 5 being very satisfied. In a similar fashion, all aspects in the four categories are evaluated in phase two of the survey. There are total of nine questions for phase two. Other evaluation scales used are 1, not meet expectations, and 5, exceeded expectations; 1, very difficult, and 5, very simple; and 1, not convenient, and 5, very convenient.

The same pattern is followed for all questions with the remaining categories. Measures are modified for all questions in accordance to the users' understanding. Care is taken so that participants need not possess any technical background to answer the questions. Along with the questions from the four categories, questions about

demographics (age, gender and ethnicity) were also asked to examine the usage of mobile spreadsheet applications. Additional questions, such as fluency in English, mobile phone operating system, frequency of spreadsheet usage, time spent on spreadsheets per week and different features accessed in spreadsheets, are asked of participants.

The survey tool selected for this survey was SURVEYGIZMO. This tool provided participants with survey links and collected their responses. To protect data accuracy and to avoid duplicates responses, users were assigned a unique ID with respect to their IP addresses as collected by the survey. After the survey, IP addresses were destroyed due to privacy issues. A person could only participate in the survey once.

## 8.2. Evaluation

Most of the evaluations related to three categories in Chapters 5, 6 and 7 are discussed in this section and sub sections. The evaluations are an overall summary of all three categories for all four applications and also by operating systems. The following subsections contain the overall evaluations for the visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience categories.

### 8.2.1. Visibility

Users are asked to rate various aspects in the visibility category on a scale from 1-5, where 1 is not important and 5 is very important. The mean and standard deviations for the participants' responses specifying aspects in the visibility category are calculated for each aspect. The results are shown in Figure 8-1.

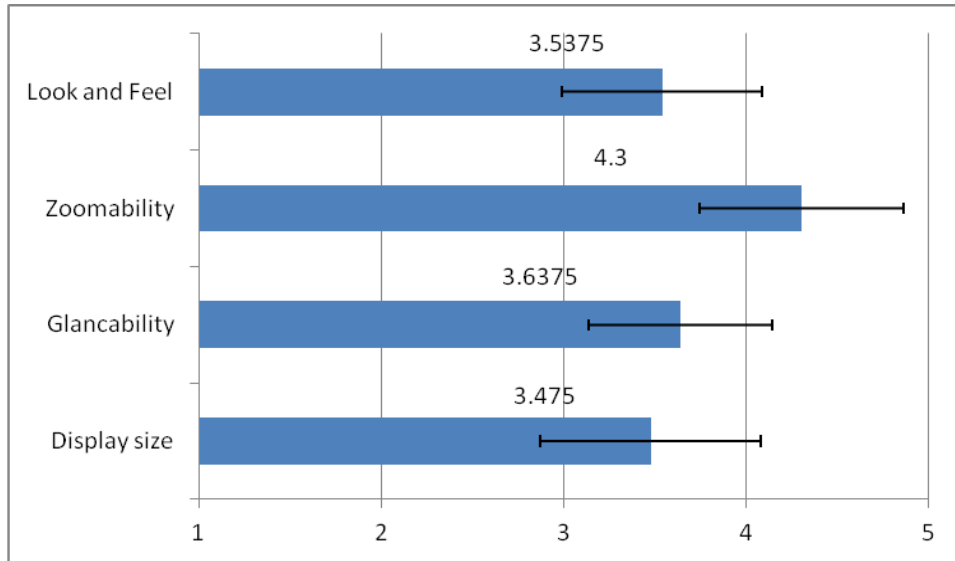


Figure 0-1. Measures specifying aspects for the visibility category.

Figure 8-2 compares the average ratings and standard deviations for users' responses about their satisfaction for the visibility category based on the application being used. Figure 8-2 clearly shows that the ThinkFree Online application has a low

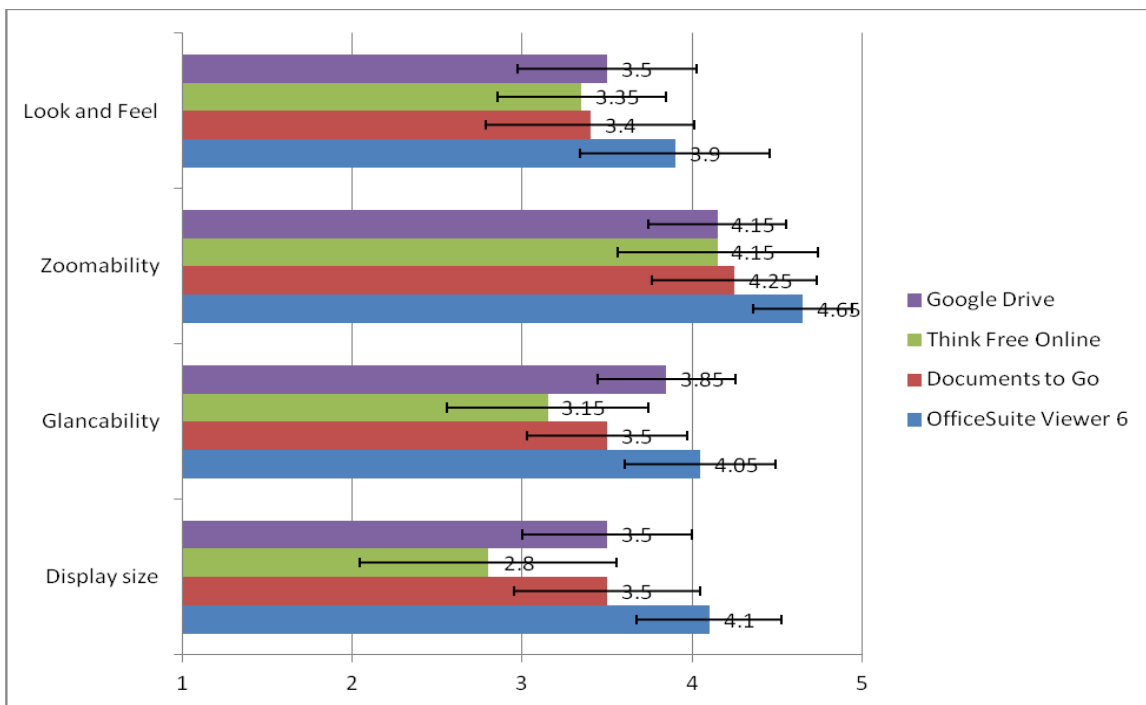


Figure 0-2. Average ratings and standard deviations for users' responses about their satisfaction in the visibility category.

average compared to other applications and that its standard deviation is high in terms of display size and glancability. Figure 8-2 shows that users have rated ThinkFree Online application relatively low compared to other applications in terms of display size and glancability in the visibility category.

#### 8.2.1.1. User opinions about visibility

The following sections outline the users' opinions for different aspects, such as display size, glancability, zoomability, and look and feel, in the visibility category.

Approximately 77.5% of the participants felt the table's display size on the mobile-device screen is important by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important. Glancability is the ability to quickly see and recognize the object. More than 68% of the participants felt glancability is important by rating 4 and above on a scale of 1-5, where 1 is not important and 5 is very important. Zoomability lets the user zoom in and out of any application so that the user can view the data or objects on a mobile screen very clearly (in the context of mobile devices). Around 90% of the participants believed that zoomability is one of the important features on mobile devices by rating above 4 on a scale of 1-5, where 1 is not important and 5 is very important. Look and feel is used with respect to graphical user interfaces (GUIs). It tells us about an application's user interface as well as the various objects on the screen, such as buttons, images, color coding, layout, and more. In a mobile context, look and feel attracts people to utilize applications more often. Approximately 75% of the participants felt that the look and feel of an application is important by rating 4 and above on a scale of 1-5, where 1 is not important and 5 is very important.

#### 8.2.1.2. Comparison of visibility between applications

For each of the four mobile spreadsheet applications utilized for the survey, the users were asked to rate the previously stated four aspects in the visibility category. For each application, 20 users were selected and were given the spreadsheet file and a mobile device that was allocated to their group. More than 82% of the participants felt that the majority of the applications showed the correct display size without zooming by rating 3 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied . Close to 40% of participants felt that the ThinkFree Online mobile spreadsheet application was below user satisfaction when they tried to get the correct display size without zooming by rating below 3 on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. More than 70% of participants felt that the OfficeSuite Viewer 6 application was above user satisfaction by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Overall, 60% of the participants felt that glancability was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Of all the applications, participants felt that Google Drive was more satisfactory regarding glancability; 70% of the participants felt that Google Drive was satisfactory while 75% felt that OfficeSuite Viewer 6 was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. More than 78% of the participants concluded that the zoomability of mobile spreadsheet applications is satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Of all the applications, OfficeSuite Viewer 6 was rated by 95% of participants as satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Approximately 70% of the participants

said that the look and feel of the application, while displaying spreadsheets, was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Also, 83% of the surveyed participants felt that the OfficeSuite Viewer6 application was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied.

### 8.2.2. Navigation, scrolling and feedback

Users were asked to rate various aspects in the navigation, scrolling and feedback category on a scale from 1-5, where 1 was not important and 5 was very important. The means and standard deviations of participants' responses for aspects in the navigation, scrolling and feedback category are calculated in Figure 8-3.

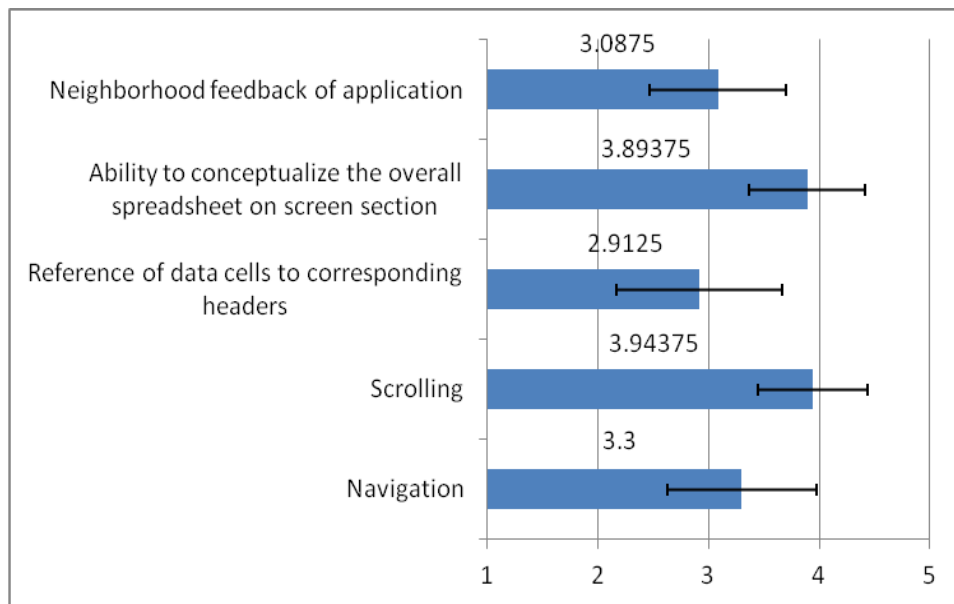


Figure 0-3. Measures specifying the importance of aspects for the navigation, scrolling and feedback category.

The users' results, after validating the different aspects in the navigation, scrolling and feedback category, did not reveal any significant difference among applications. All the applications are tied very closely in the users' ratings for this category. Even though

the overall rating was just over “slightly satisfied” for all aspects in this category, it is same across all the applications. Figure 8-4 shows the average ratings and the standard deviation for the users’ responses, by application, as the users expressed their satisfaction in the navigation, scrolling and feedback category.

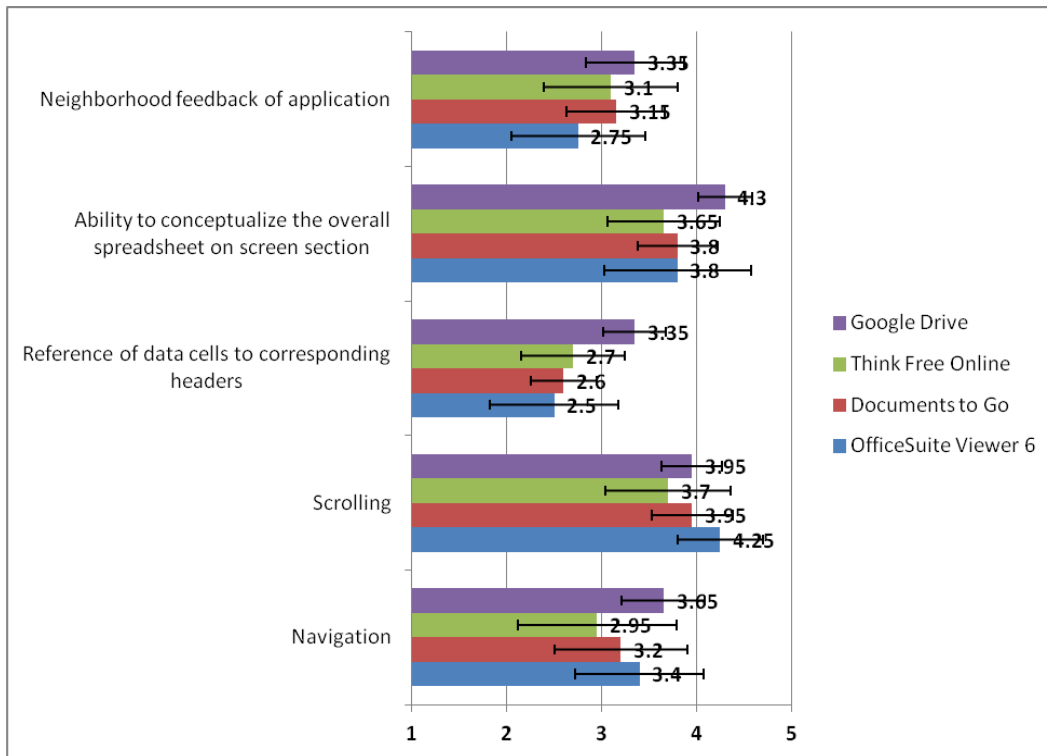


Figure 0-4. Average ratings and the standard deviation for users’ responses about their satisfaction in the navigation, scrolling and feedback category.

#### 8.2.2.1. Users’ opinions about the navigation, scrolling and application feedback category

This section discusses the participants’ opinions about different areas to find the importance of several factors in the navigation, scrolling and application feedback category. About 80% of the participants felt that smarter navigation to find a particular cell in the spreadsheet is important by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important. Scrolling is sliding or moving text, images, and videos across display screens. Scrolling is done vertically or horizontally. About 90% of the

participants felt that scrolling is important by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important. Referencing data cells to their corresponding headers clearly gives the position of user with respect to the spreadsheet. Most applications did not show the header labels when user traverses deep into a spreadsheet. Approximately 81% of participants felt that referencing data cells to the corresponding headers in the application is important by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important. Close to 65% of the participants felt that the ability to conceptualize the overall spreadsheet on a screen section of a mobile device is important by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important. Nearly 51% of the participants felt that the neighborhood feedback of the application on a mobile device was important by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important.

#### 8.2.2.2. Comparison of navigation, scrolling and application feedback between applications

Users were asked to rate the previously stated five aspects in the navigation, orientation and application feedback category. Only 52% of the participants felt that application navigation was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. In addition, 22% felt that they were slightly satisfied with navigation. Of all applications, 90% of the participants using Google Drive felt that the application was slightly more satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Seventy-five percent of the participants felt that scrolling was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. More than 80% of the participants



felt that Google Drive and OfficeSuite Viewer 6 were more than moderately satisfactory in terms of scrolling by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Only 38% of the participants felt that referencing data cells to their corresponding headers was satisfactory for all applications while 46% of the participants felt somewhat dissatisfied or not satisfied with the applications when it came for referencing data cells to their corresponding headers by rating below 3 on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Above results show an application design flaw when referencing data cells to their corresponding headers is not considered. When individual applications are considered, Documents To Go was rated low when it came to satisfaction with referencing data cells to their corresponding headers; 50% of the participants using the Documents To Go application felt that it was not satisfactory in terms of referencing data cells to their corresponding headers by rating below 3 on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. More than 73% of the participants felt that the ability to conceptualize the overall spreadsheet on a screen section was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Close to 87.5% of the participants who used the Google Drive application felt that it was satisfactory regarding the ability to conceptualize the overall spreadsheet on a screen section by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Only 36% of the participants said that the neighborhood-feedback aspect of the application was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. In contrast, 75% of the participants who used Documents To Go felt that the application was slightly satisfactory or not satisfactory by rating below 3 on a

scale of 1-5, where 1 being not satisfied and 5 being very satisfied. The following results show that neighborhood feedback for all four applications was below the users' expectations.

### 8.2.3. Interaction, satisfaction, simplicity and convenience

Users were asked to rate various aspects in the interaction, satisfaction, simplicity and convenience category on the scale 1-5, where 1 was not important and 5 was very important. The means and standard deviations for the participants' responses specifying the importance of aspects in the interaction, satisfaction, simplicity and convenience category are calculated in Figure 8-5.

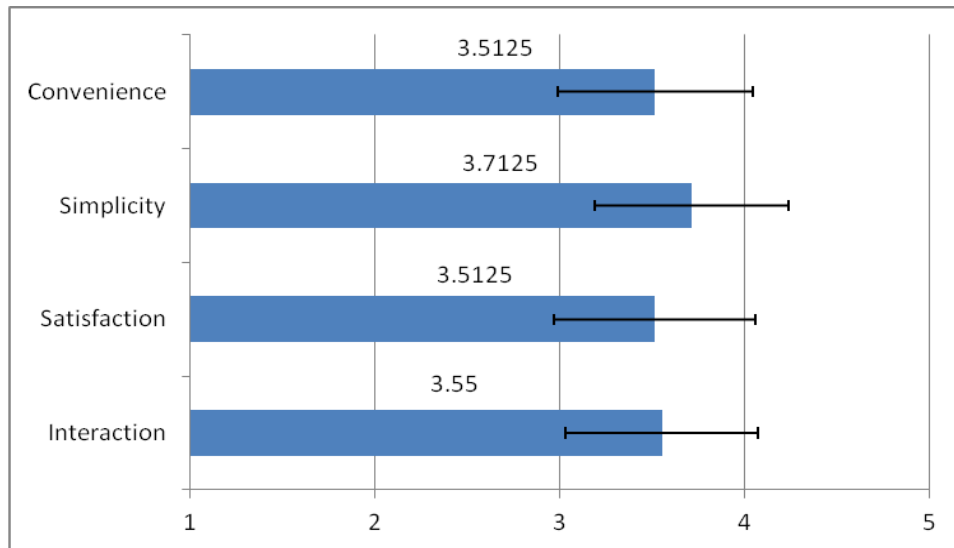


Figure 0-5. Measures specifying the importance of aspects in the interaction, satisfaction, simplicity and convenience category.

Figure 8-6 gives the results of the average ratings and standard deviations for users' responses about their satisfaction, by application, for the interaction, satisfaction, simplicity and convenience category. This result also indicates that the applications are very tightly coupled in the interaction, satisfaction, simplicity and convenience category.

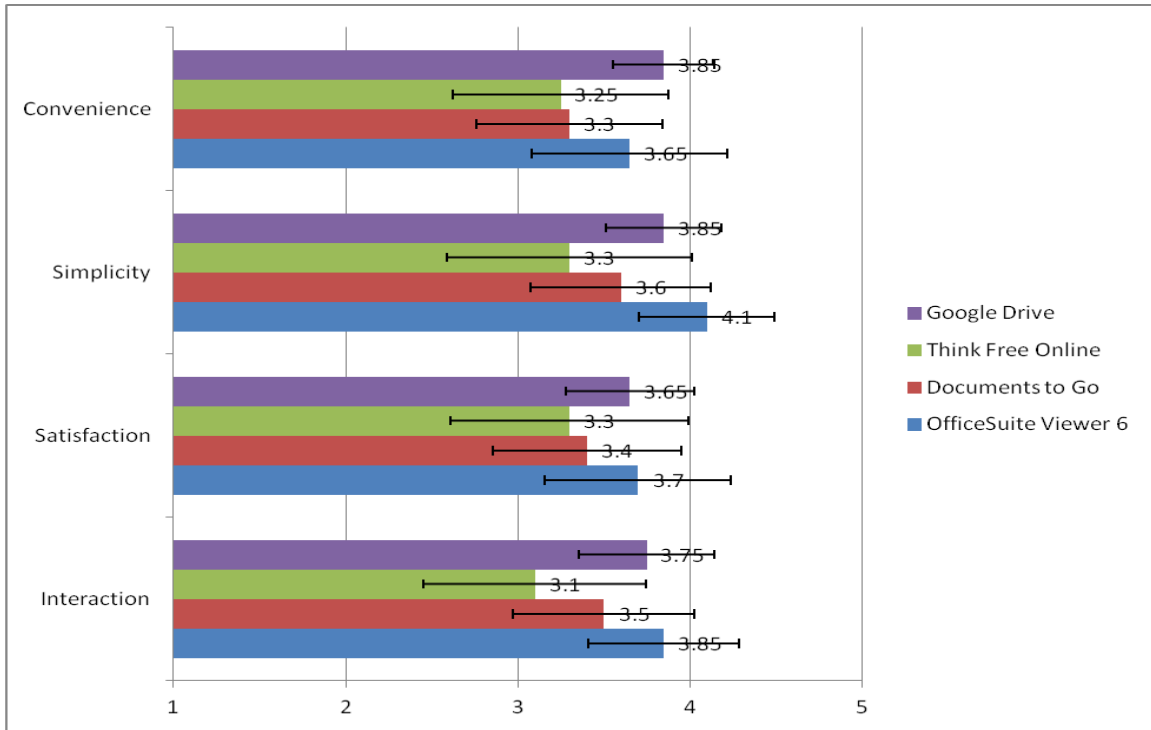


Figure 0-6. Average ratings and standard deviations for users' responses that expressed their satisfaction for the interaction, satisfaction, simplicity and convenience category.

### 8.2.3.1. Users' opinion about the interaction, satisfaction, simplicity and convenience category

This subsection discusses the participants' opinion about several factors in the interaction, satisfaction, simplicity and convenience category. About 86% of the participants felt that application interaction was important for a spreadsheet by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important.

Approximately 90% of the participants felt that satisfaction viewing spreadsheets as desired by the user was an important factor by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important. Around 80% of the participants felt that the application simplicity needed for better user understandability was important by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important. Close to 87% of the participants felt that convenience was an important metric to judge the mobile

application by rating 4 and above on a scale 1-5, where 1 is not important and 5 is very important.

#### 8.2.3.2. Comparison of interaction, satisfaction, simplicity and convenience among applications

Users were asked to rate the aspects interaction, satisfaction, simplicity and convenience. Approximately 61% of the participants felt that application interaction was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. In addition, 70% of the participants using Google Drive were satisfied with the application. Only 57.5% of the participants felt that the satisfaction in viewing spreadsheets as the user desired aspect was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Of all the applications, 60% of the participants felt that Google Drive and ThinkFree Online were moderately satisfactory or satisfactory in terms of the satisfaction in viewing spreadsheets as the user desired by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Around 60% of participants felt that the simplicity aspect was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Also, 31.25% of the participants felt slightly satisfied with the applications when it came to simplicity; 70% of the participants using Google Drive application felt that it was satisfactory in terms of simplicity by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Only 57.5% of the participants felt that the convenience aspect was satisfactory by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied. Of all applications, 75% of the participants who used Google Drive felt that it was satisfactory in terms of

convenience by rating 4 and above on a scale of 1-5, where 1 being not satisfied and 5 being very satisfied.

### 8.3. Statistical methods

#### 8.3.1. Chi Squared method

The Chi Squared method is used to see whether applications meet the users' requirements. For aspects in the categories defined in Chapter 2, the values that participants stated were important for all aspects within a category are taken as expected values (E). Similarly, the results which state the users' satisfaction regarding aspects within a category are taken as the observed values (O). User responses for question 4 [See Appendix B] are considered as the expected values (E), and user responses for question 5 [See Appendix B] are the observed values (O). For example, observed values per application for aspect display size within a category visibility are taken from the results of first row of the question 4 [See Appendix B] and expected values per application are taken from the results of first row of the question 5 [See Appendix B]. Using these two values, the Chi Squared method is employed, and the results are shown in the tables. If the p value is greater than 0.05, the application met the users' requirements. If the p value is less than 0.05, the application did not meet the users' requirements.

##### 8.3.1.1. Chi Squared method results for the visibility category

The results for question 4 in the post-survey are used for the expected values (E), and the results for question 5 in the post-survey are the observed values (O). Table 8-1 has the results for Chi Squared method. Because  $p > 0.05$  for all applications in terms of

visibility, by using the Chi Squared method, we can say that the applications are built very close to the users' requirements for the visibility category.

Table 0-1. Chi Squared results for the visibility category.

| <b>Operating System</b> | <b>Mobile Application</b> | <b>Visibility Category (p Value)</b> |
|-------------------------|---------------------------|--------------------------------------|
| Android                 | OfficeSuite Viewer 6      | 1                                    |
| Android                 | Documents To Go           | 0.999789                             |
| iOS                     | ThinkFree Online          | 0.95735                              |
| iOS                     | Google Drive              | 0.999929                             |

### 8.3.1.2. Chi Squared Method results for the navigation, scrolling and application feedback category

The results of question 6 in the post-survey are used for the expected values (E), and results for question 7 in the post-survey are the observed values (O). For example, observed values per application for aspect navigation within category navigation, scrolling and application feedback are taken from the results of first row of the question 6 [See Appendix B] and expected values per application are taken from the results of first row of the question 7 [See Appendix B]. The results of the Chi Squared method for the navigation, scrolling and application feedback category are in Table 8-2. Because  $p > 0.05$  for all aspects in this category, by using the Chi Squared method, we can say that, overall, the applications are built very close to the users' requirements for the navigation, scrolling and application feedback category.

Table 0-2. Chi Squared results for the navigation, scrolling and application feedback category.

| <b>Operating system</b> | <b>Mobile application</b> | <b>Navigation, scrolling and application feedback category (p Value)</b> |
|-------------------------|---------------------------|--|
| Android                 | OfficeSuite Viewer 6      | 0.987057   |
| Android                 | Documents To Go           | 0.999514   |
| iOS                     | ThinkFree Online          | 0.9615   |
| iOS                     | Google Drive              | 0.999236   |

### 8.3.1.3. Chi Squared method results for the interaction, satisfaction, simplicity and convenience category

The results of question 8 in the post-survey are used for the expected values, and results for question 9 in the post-survey are the observed values. For example, observed values per application for aspect interaction within category interaction, satisfaction, simplicity and convenience are taken from the results of first row of the question 8 [See Appendix B] and expected values per application are taken from the results of first row of the question 9 [See Appendix B]. The results of the Chi Squared method the interaction, satisfaction, simplicity and convenience category are in Table 8-3.

Table 0-3. Chi Squared results for the interaction, satisfaction, simplicity and convenience category.

| <b>Operating system</b> | <b>Mobile Application</b> | <b>'Interaction, satisfaction, simplicity and convenience' category (p Value)</b> |
|-------------------------|---------------------------|---|
| Android                 | OfficeSuite Viewer 6      | 0.021063  |
| Android                 | Documents To Go           | 0.995825  |
| iOS                     | ThinkFree Online          | 0.912888  |
| iOS                     | Google Drive              | 0.999919  |

The P value for the OfficeSuite Viewer 6 application is less 0.05, which means that this application is slightly different from other applications with respect to the users' requirements regarding the interaction, satisfaction, simplicity and convenience category. Other than the OfficeSuite Viewer 6 application, the three other applications are built very close to users' requirements for the interaction, satisfaction, simplicity and convenience category.

#### 8.3.1.4. Chi-Squared method by operating system

Table 8-4 gives the Chi Squared method results for all applications in categories by operating system. The results clearly show that all applications for the Android and iOS operating systems are very closely related. Close observation reveals that the Android operating system in the interaction, satisfaction, simplicity and convenience category has a P value of 0.4189, which is greater than 0.05, meaning that this hypothesis is valid and that, in this category, all Android applications are also closely related. Table 8-4 shows the results, by operating system, of the Chi-Squared method for all applications in three categories.

Table 0-4. Results of the Chi Squared method for all applications in three categories by operating system.

| <b>Operating system</b> | <b>Visibility</b> | <b>Navigation, scrolling and feedback</b> | <b>Interaction, satisfaction, simplicity and convenience</b> | <b>Overall</b> |
|-------------------------|-------------------|---|--|----------------|
| Android                 | 1                 | 0.999975                                  | 0.4189   | 1              |
| iOS                     | 0.999947          | 0.999839                                  | 0.999787   | 0.999993       |



### 8.3.2. Wilcoxon signed-rank test

The Wilcoxon signed-rank test is used to determine how close the applications are designed, how close the features of applications are and how similar the applications are. The Wilcoxon test is employed for the results questions 5, 7 and 9 on the post-survey. These questions give the user-satisfaction opinion about all aspects for all three categories: visibility; navigation, scrolling, and application feedback; and interaction, satisfaction, simplicity, and convenience. With this method, three comparisons (for the results of questions 5, 7 and 9) are conducted in three categories (four mobile spreadsheet applications). For example, comparison is done as follows: question 5 has 4 aspects (display size, glancability, zoomability, and look and feel) to compare. For each aspect, the mean is taken for an application (mean of 20 participant responses for that application). Similarly, for the same aspect, the mean is taken for another application. Similarly all four applications are taken and compared for each aspect. The results are compared for all the aspects in question 5. In our sample, we compare the t-approximation two sided  $Pr>|Z|$  value. If the value of  $Pr>|Z|$  is greater than 0.05, then applications are not different. If the value of  $Pr>|Z|$  is less than 0.05, then applications are different. This method also checks the differences in the features for different applications in the author-specified categories. This method is used to compare two related samples, repeated measurements or matched samples, to assess whether their population mean ranks differ.

#### 8.3.2.1. Wilcoxon test results for the visibility category

Wilcoxon scores are compared for two applications, OfficeSuite Viewer 6 vs Documents To Go and ThinkFree Online vs Google Drive with a total of 40 participants

for each test considered. Figure 8-7 shows the comparison of results for aspects in the visibility category for the OfficeSuite Viewer 6 vs Documents To Go applications.

Results indicate a slight difference in the application design for OfficeSuite Viewer 6 and Documents To Go because the value for  $\text{Pr} > |Z|$  is less than 0.05. Figure 8-8 shows the comparison for aspects in the visibility category for the ThinkFree Online and Google Drive applications. Results indicate no difference in the application design for the visibility category because the value for  $\text{Pr} > |Z|$  is greater than 0.05.

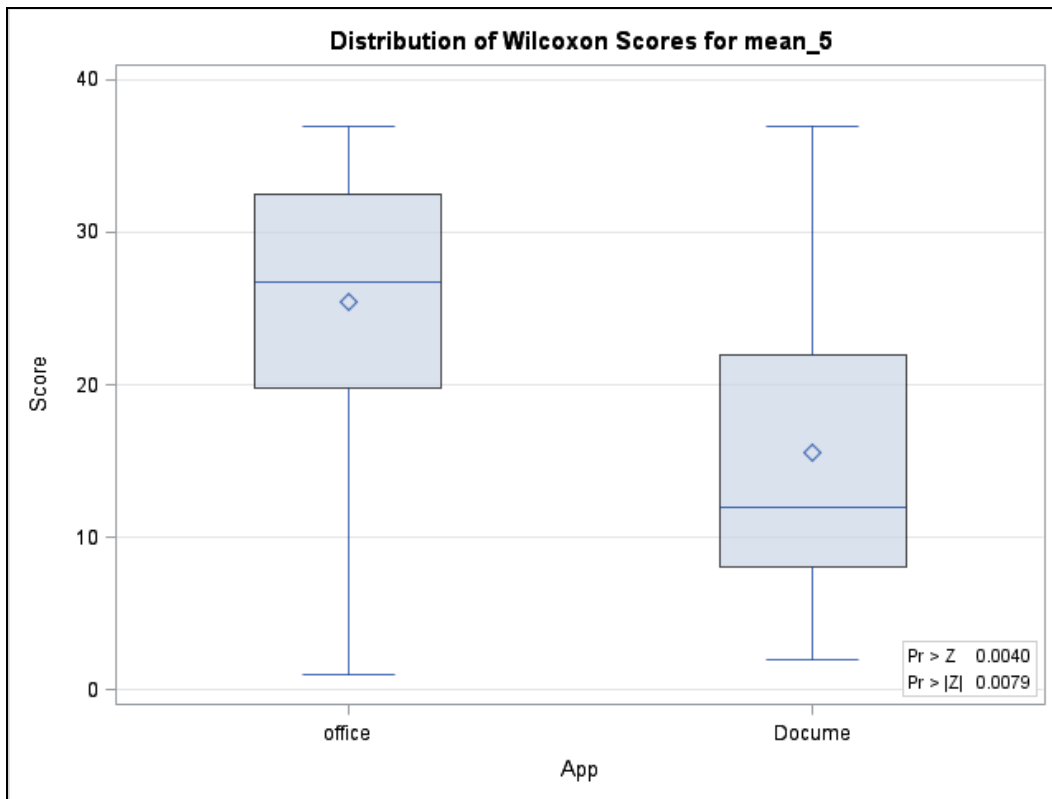


Figure 0-7. Scores between the OfficeSuite Viewer 6 and Documents To Go applications in the visibility category.



Figure 0-8. Scores between the ThinkFree Online and Google Drive applications in the visibility category.

### 8.3.2.2. Wilcoxon test results for the navigation, scrolling and application feedback category

Wilcoxon scores are compared between two applications, OfficeSuite Viewer 6 vs Documents To Go and ThinkFree Online vs Google Drive, with a total of 40 participants for each test considered. Figures 8-9 and 8-10 show the comparison of results for aspects in the navigation, scrolling and application feedback category for the OfficeSuite Viewer 6 vs Documents To Go and ThinkFree Online vs Google Drive applications. Test results show no considerable variance which means, overall, the applications are designed very closely in this category. For the results in Figure 8-9, the value for  $Pr > |Z|$  is greater than 0.05.

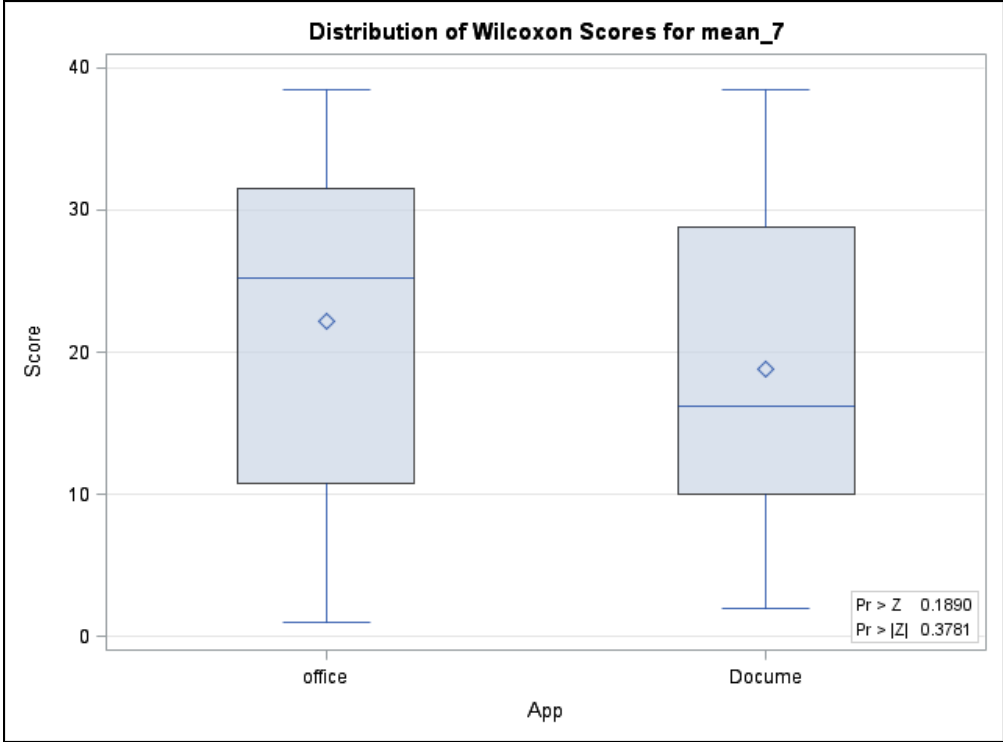


Figure 0-9. Scores between the OfficeSuite Viewer 6 and Documents To Go applications in the navigation, scrolling and application feedback category.

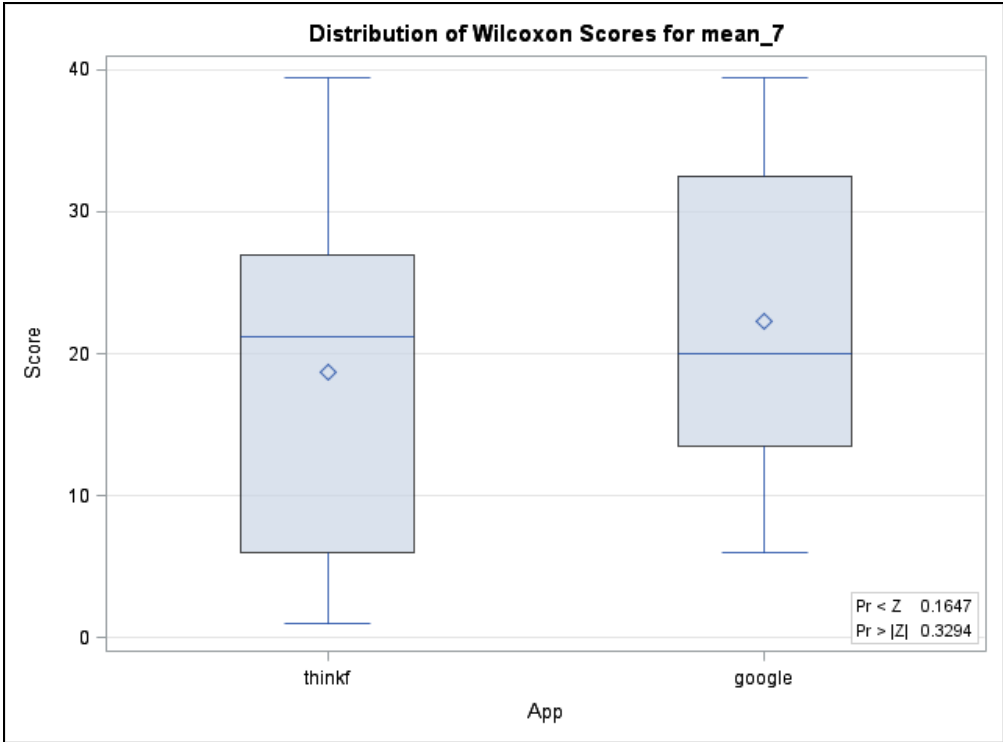


Figure 0-10. Scores between the ThinkFree Online and Google Drive applications in the navigation, scrolling and application feedback category.

### 8.3.2.3. Wilcoxon test results for the interaction, satisfaction, simplicity and convenience category

Wilcoxon scores are compared between two applications, OfficeSuite Viewer 6 vs Documents To Go and ThinkFree Online vs Google Drive, with a total of 40 participants for each test considered. Figures 8-11 and 8-12 show the comparison of results for aspects in the interaction, satisfaction, simplicity and convenience category for the OfficeSuite Viewer 6 vs Documents To Go and ThinkFree Online vs Google Drive applications. Because the value of  $Pr > |Z|$  is greater than 0.05, the Wilcoxon results show no noticeable difference. We can conclude that all applications are designed very closely in the interaction, satisfaction, simplicity and convenience category.

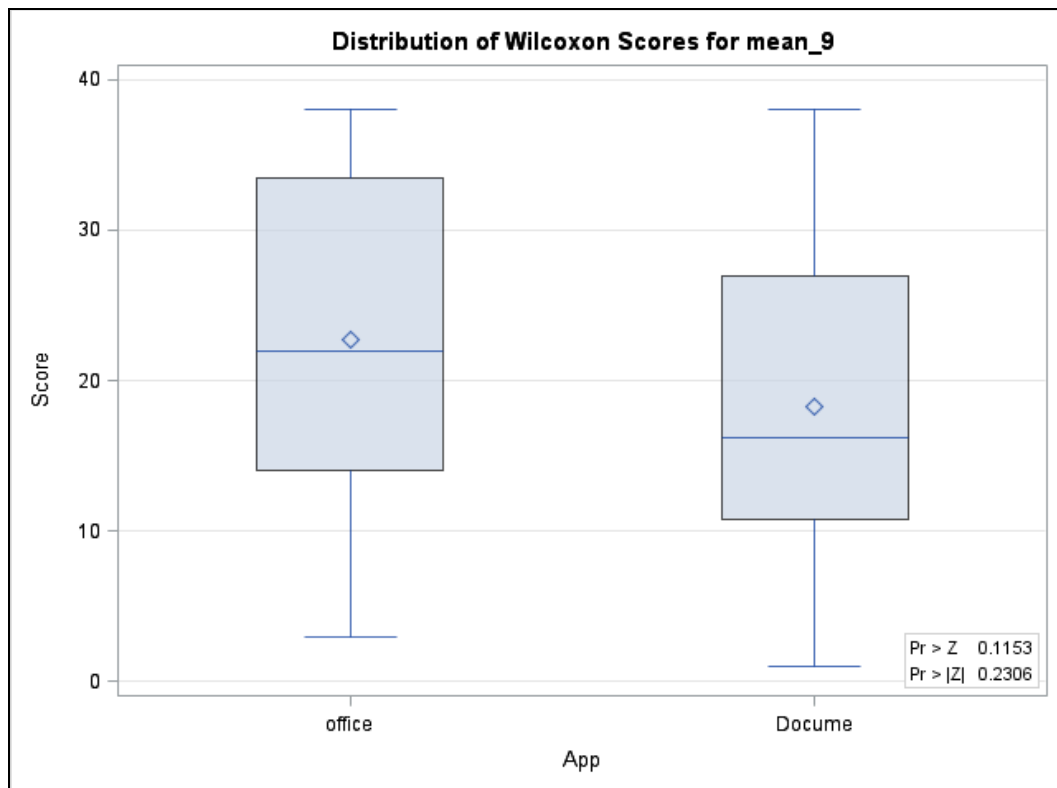


Figure 0-11. Scores between the OfficeSuite Viewer 6 and Documents To Go applications in the interaction, satisfaction, simplicity and convenience' category.

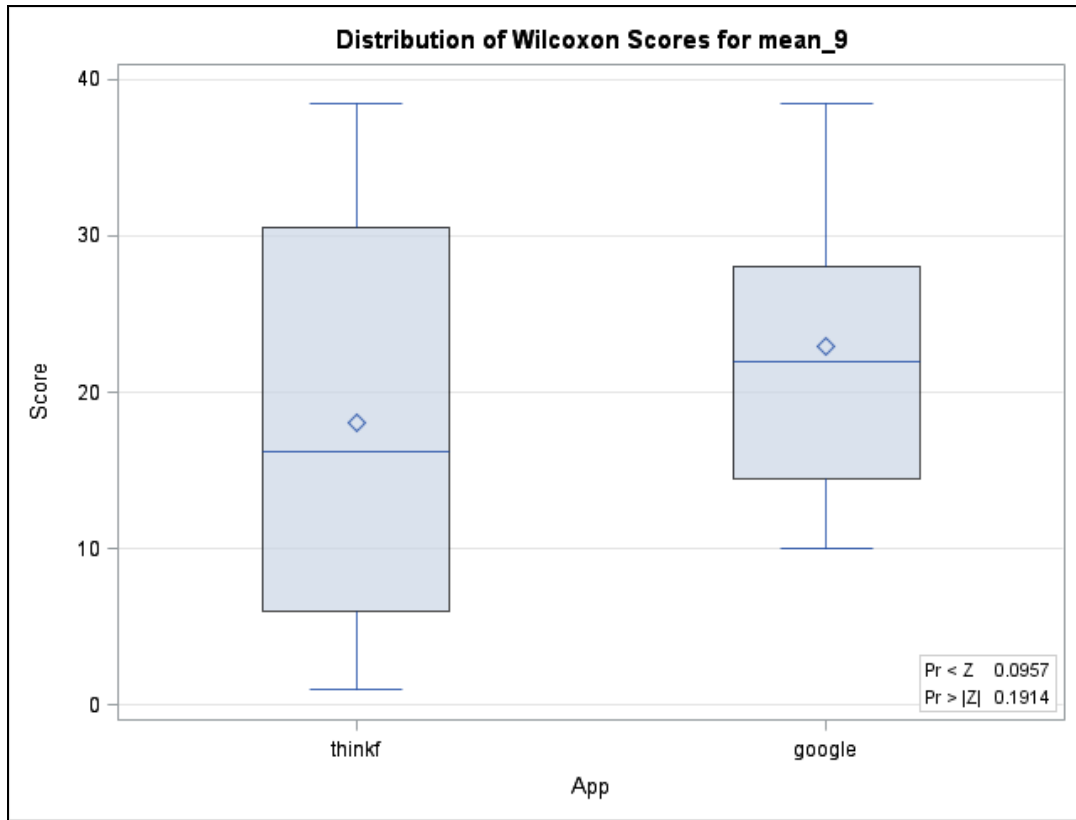


Figure 0-12. Scores between the ThinkFree Online and Google Drive applications in the interaction, satisfaction, simplicity and convenience category.

#### 8.3.2.4. Wilcoxon test results for all categories by operating systems

The following Wilcoxon score results are compared between two operating systems, Android and iOS, for all applications. All 80 participants for study are considered. Figure 8-13 shows the comparison of results, by operating system, for the visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience categories. The results clearly show that value of  $Pr > |Z|$  is greater than 0.05 and that all applications are very closely designed between the two operating systems (Android and iOS).



Figure 0-13. Wilcoxon results for comparing the results, by operating system, of the visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience categories.

### 8.3.3. Principle Component Analysis method

The Principle Component Analysis (PCA) method gives a pictorial representation about how close the applications are. If clusters are far from each other, then it means that the applications are not close. Initially, the raw data (not the means) of the results for questions 5, 7 and 9 are transformed into a set of values for linearly uncorrelated variables called Principal Components. The transformation is defined in such a way that the first principal component has the largest possible variance, followed by the second and then the third. A graph for first and second Principle Components, that together explain the highest percentage of variation, is used to illustrate the observations. If there are groups of observations (either by operating system or application) that are distinct,

then you see distinct data clusters. For our data, if we see that the observations are scattered in the cluster, then they are not different from each other.

### 8.3.3.1. PCA method for the visibility category

A graphical representation of the cluster clearly shows that all four applications are closely tied to each other for all aspects in the visibility category. In Figure 8-14, we can clearly see how closely all four applications are tied in the visibility category.

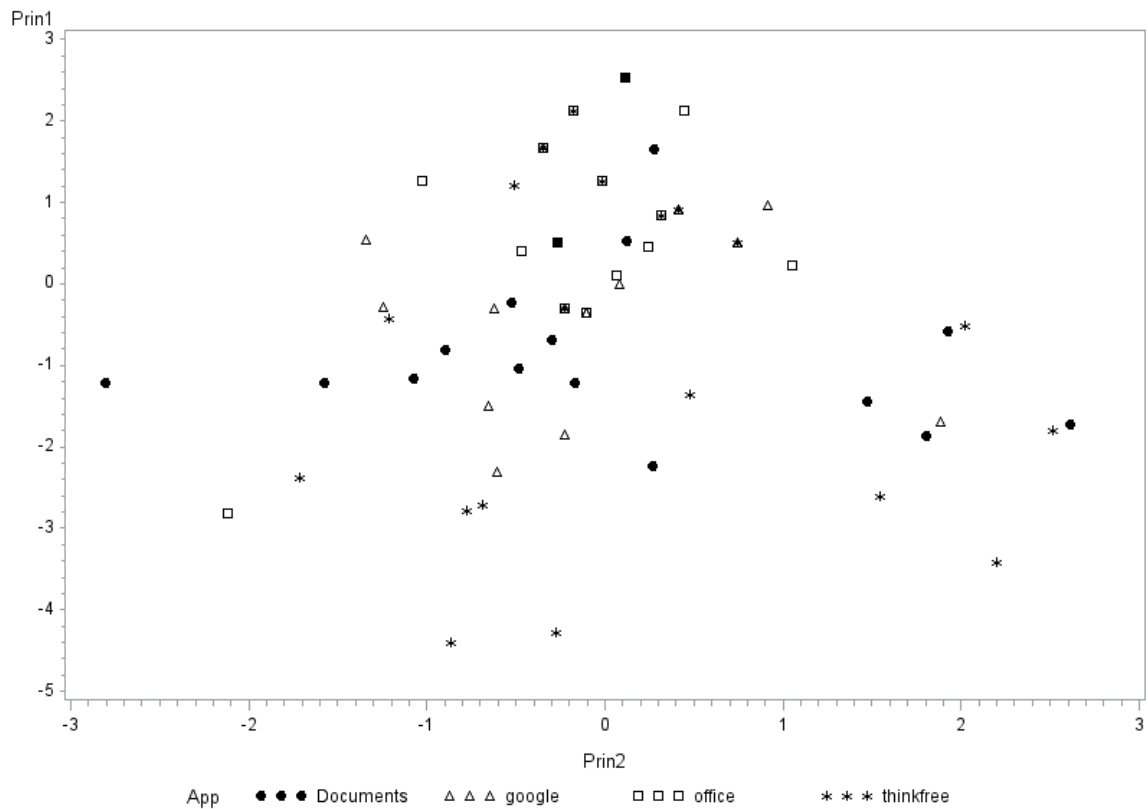


Figure 0-14. Results from the PCA method for all four applications and all aspects in the visibility category.



### 8.3.3.2. PCA method for the navigation, scrolling and application feedback category

PCA results for the navigation, scrolling and application feedback category clearly show that all applications are closely connected to each other. Figure 8-15 shows how closely all four applications are tied.

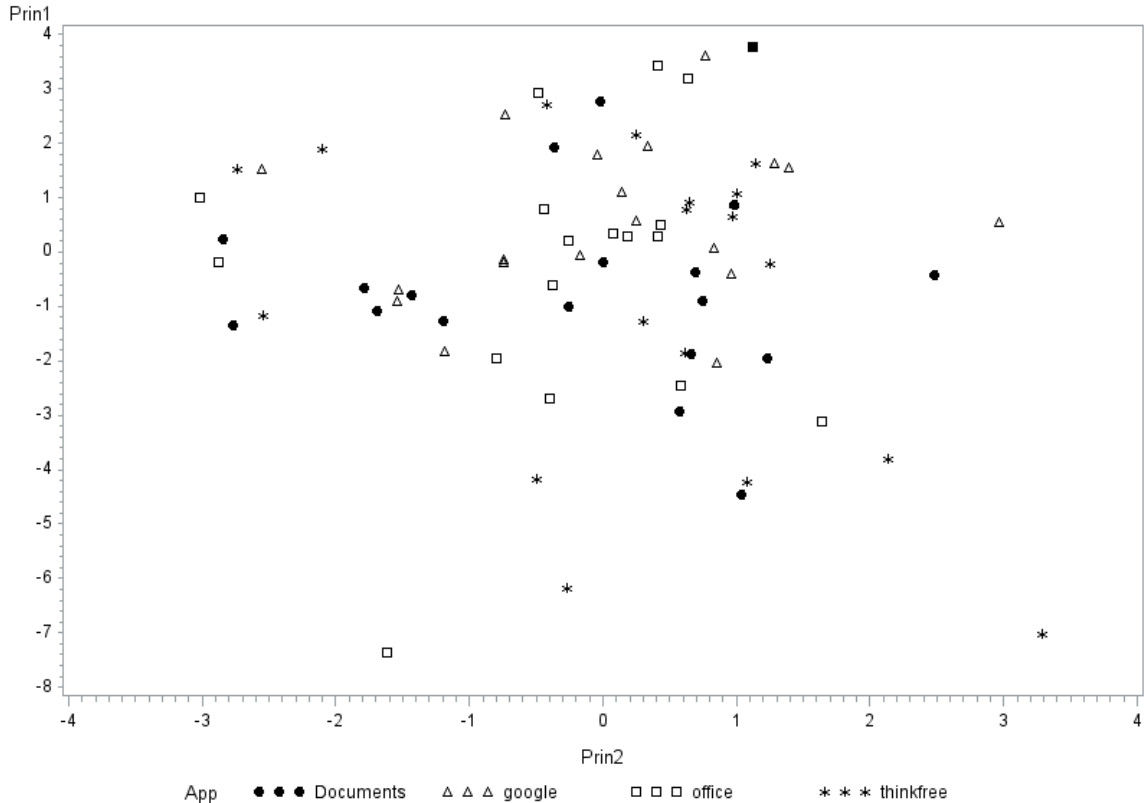


Figure 0-15. Results from PCA method for all four applications on all aspects in the category ‘Navigation, Scrolling and Application Feedback’.

### 8.3.3.3. PCA method for the interaction, satisfaction, simplicity and convenience category

Results of the PCA method for the interaction, satisfaction, simplicity and convenience category are listed in the Figure 8-16. We can clearly see how closely all four applications are connected.

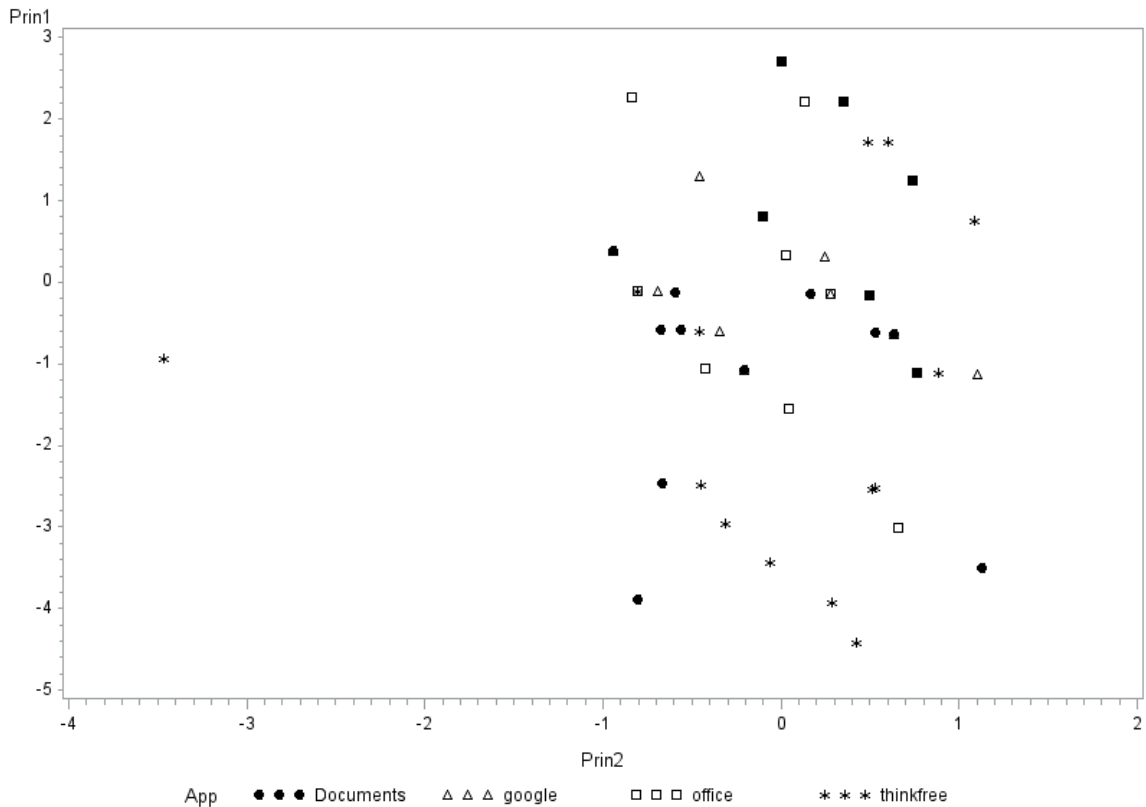


Figure 0-16. Results from the PCA method for all four applications and all aspects in the interaction, satisfaction, simplicity and convenience category.

8.3.3.4. PCA results, by operating system, for all three categories: visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity and convenience

PCA results, by operating system, for all applications in all three categories (visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience) show only one cluster. There is no division in the cluster, meaning that all applications are close. Figure 8-17 shows the results, by operating system, of PCA clustering for all applications in all three categories.

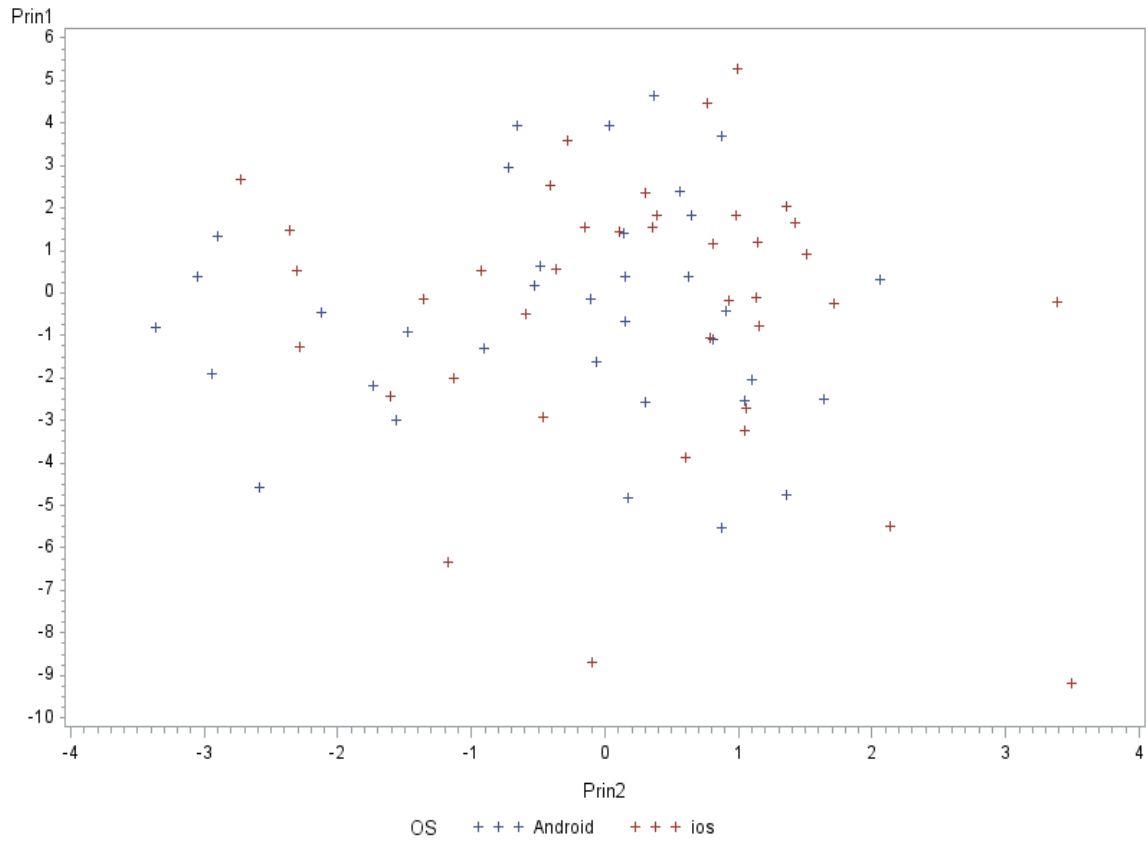


Figure 0-17. PCA clustering, by operating system, for all applications in all three categories: visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience.

## 9. RESULT SUMMARY

The survey has highlighted the importance of various usability issues and suggested several areas for future mobile application development. The significance of various aspects defined in Chapters 5, 6 and 7 has been identified in this paper. This paper also found that some common aspects of usability issues, such as zoomability, display size, glancability, look and feel, simplicity, ability to conceptualize the overall spreadsheet on the screen section, scrolling, navigation, interaction, satisfaction in viewing the spreadsheet as the user desired, and convenience, are currently used by most modern-day spreadsheet application designers. The study also suggests that, in addition to above common aspects of usability issues, aspects such as reference to data cells to corresponding headers and neighborhood feedback need to be included in all future mobile-application designs.

The author of this paper have identified the zoomability, simplicity, scrolling and ability to conceptualize the overall spreadsheet on the screen section are commonly taken in to consideration by the designers of modern-day mobile applications. The paper has also identified that, when applications are grouped by operating system, applications for the Android operating system have to be improved for the referencing data cells to their corresponding headers, satisfaction in viewing the spreadsheet as desired by the user and navigation aspects when compared to applications for the iOS operating system. For all the other aspects, applications for the Android and iOS operating systems are very closely rated.

For all future developments, the author of this paper have concluded that, for application to have good glancability, it should display apprehended with minimum

attention and simplified visual presentation. For the look and feel aspect, the application should keep the important features in front of the user, making the user want to open the application every time with UI elements. A good display size for an application is only defined when the complete screen and contents are visible to the naked eye. Applications should have the ability to load content which fits the screen and for users to read content with the naked eye for a better zoomability aspect.

Applications have to be designed with the ability to understand the current position, to plan their next course and to estimate the journey so far for good navigation. For the scrolling aspect, the application should have the ability to help users read large contents on a single page. The ability to identify the user's position in an application with respect to the spreadsheet is considered the most important feature for the referencing data cells to their corresponding headers aspect. For the ability to conceptualize the overall spreadsheet on screen section aspect, the application should be designed to give an actual idea about how the data in the spreadsheet look. Applications should be designed to keep users informed about the user's position with respect to the neighboring cells for the neighborhood feedback aspect.

For better interaction, applications should be designed to understand the actions users take and to communicate the next course of action back to the use. For the applications to have better satisfaction, they should meet the customers' expectations for using the application. Applications with the ability to communicate users easily and provide meaningful solutions to usage problems are considered as good design for the simplicity aspect. Finally, applications with easy accessibility for users with less time, effort and other constraints are considered best for the simplicity category. Based on the

findings from the paper, Table 9-1 is designed to provide a view for mobile application designers to see the aspects and necessary design metrics for all three categories mentioned in this paper.

The study clearly states that, for a majority of aspects in three categories, all the applications are designed very close to each other. Analysis of the survey results using statistical methods such as the Chi Squared method, Wilcoxon signed-rank test and PCA method has shown that all the applications are built very close to the users' requirements and that the users' experience with all applications is close. Even though applications are designed close to each other, there are several considerable aspects mentioned above that need to be improved for modern-day mobile applications. The author of this paper suggest that, for all future mobile applications, the designer should consider the aspects for usability issues that were suggested in Chapter 9.

Table 9-1. Aspects and necessary design metrics for all three categories.

| <b>Aspect</b>  | <b>Design metrics for developers</b>  |
|--|---|
| Glancability   | Should show display apprehended with minimum attention and simplified visual presentation.                                    |
| Look and feel  | Show important features right in front of the user, making the user want to open the application every time with UI elements. |
| Display size   | Complete usage of the screen with content visible to the naked eye.   |
| Zoomability  | Ability to load content fit to the screen and make content readable with a naked eye.   |
| Navigation   | Should understand current position, plan the next course and estimate journey so far.   |
| Scrolling  | Should help users read large contents on a single page.   |
| Referencing data cells to corresponding headers                        | Should identify the user's position in an application with respect to spreadsheet.  |
| Ability to conceptualize the overall spreadsheet on the screen section | To give an actual idea of how the data in the spreadsheet look.   |
| Neighborhood feedback  | Ability to keep users informed about their position with respect to the neighboring cells.                                    |
| Interaction  | Should understand the user's actions and communicate the next course of action back to the user.                              |
| Satisfaction   | Should meet the customers' expectations for using the application.  |
| Simplicity   | Should communicate users easily and provide meaningful solutions for usage problems.  |
| Convenience  | Should easy the accessibility of applications by users with less time, effort and other constraints.                          |

## 10.CONCLUSION

The main objective of this paper was to identify three categories of various usability issues as criteria for comparing existing mobile applications: OfficeSuite Viewer 6, Documents To Go, ThinkFree Online and Google Drive. In order to compare the applications, a user survey, based on the criteria derived for those categories, was given. The work in this paper met the proposed objectives. This paper presented four categories including three categories of usability issues (visibility; navigation, scrolling, and feedback; and interaction, satisfaction, simplicity, and convenience) and ‘User Behavior and Scope’ category. All four mobile spreadsheet applications were compared, in detail, based on the aspects defined in the three categories, and differences among them were summarized. A questionnaire was designed to obtain users’ perceptions about the various aspects in the above-defined categories and to understand how these aspects address the usability issues in all four applications.

As part of this paper, a user survey was conducted in two phases, and responses were collected. The survey results showed that all aspects defined for three categories of the survey were considered as appropriate by the users. Average ratings for these results were above 3 for the given scale of a 1-5 importance level. These results clearly showed that the aspects considered in the three categories can be used to evaluate mobile applications. Because the applications considered for this survey had similar features, the same aspects were considered for all four applications. Survey results clearly showed that the applications are very close to each and that there is not much difference between their end results for the aspects considered by this survey.



In the future, user surveys can be extended to the other categories of usability issues that were listed in Chapter 2. The research can also be extended to other operating systems, such as Windows Phone, S40 (Series40 for Nokia), etc. Research can be extended by having participants from different industry disciplines other than IT. The survey can be more effective by giving users more time to utilize the applications and to gain knowledge before rating the importance of aspects for the categories.

## REFERENCES

- [1] World Bank Search, “Mobile cellular subscriptions,” 2013. [Online]. Available: [http://search.worldbank.org/quickview?name=%3Cem%3EMobile%3C%2Fem%3E+cellular+subscriptions&id=IT.CEL.SETS&type=Indicators&cube\\_no=2&qterm=mob+ile+phone+users](http://search.worldbank.org/quickview?name=%3Cem%3EMobile%3C%2Fem%3E+cellular+subscriptions&id=IT.CEL.SETS&type=Indicators&cube_no=2&qterm=mob+ile+phone+users) [Accessed: 07-April-2013].
- [2] International Data Corporation (IDC), “Android and iOS combine for 91.1% of the worldwide smartphone OS market in 4Q12 and 87.6% for the year, According to IDC,” 2013. [Online]. Available: <http://www.idc.com/getdoc.jsp?containerId=prUS23946013#.UTuO4hzvs-I> [Accessed: 07-April-2013].
- [3] Bevan, N. (2001). International standards for HCI and usability. *International Journal of Human-Computer Studies*, 55(4), 533-552.
- [4] Apple, Inc., “App store tops 40 Billion downloads with almost half in 2012,” 2013. [Online]. Available: <http://officialandroid.blogspot.com/2012/09/google-play-hits-25-billion-downloads.html> [Accessed: 09-March-2013].
- [5] Google, Inc., “Google play hits 25 billion downloads,” 2012. [Online]. Available: <http://officialandroid.blogspot.com/2012/09/google-play-hits-25-billion-downloads.html> [Accessed: 07-April-2013].
- [6] International Data Corporation (IDC), “Android expected to reach its peak this year as mobile phone shipments slow, according to IDC,” 2012. [Online]. Available: <http://www.idc.com/getdoc.jsp?containerId=prUS23523812#.UT4cQxzvs-I> [Accessed: 07-April-2013].

- [7] Winston, W. L. (2001). Executive education opportunities. *OR/MS Today*, 28(4), 8-10.
- [8] Panko, R. R., & Ordway, N. (2008). Sarbanes-Oxley: What about all the spreadsheets? *arXiv preprint arXiv:0804.0797*.
- [9] Flood, D., Harrison, R., & McDaid, K. (2011). Spreadsheets on the move: An evaluation of mobile spreadsheets. *arXiv preprint arXiv:1112.4191*.
- [10] Google, Inc., "Search for spreadsheet app with sort as popularity," 2013. [Online]. Available: <https://play.google.com/store/search?q=spreadsheet+app&c=apps&sort=0> [Accessed: 07-April-2013].
- [11] International Telecommunications Union, "The world in 2011: ICT facts and figures," 2012. [Online]. Available: <http://www.itu.int/ITU-D/ict/facts/2011/index.html> [Accessed: 07-April-2013].
- [12] Bevan, N. (2006), "International standards for HCI". Available: [http://nigelbevan.com/papers/International\\_standards\\_HCI.pdf](http://nigelbevan.com/papers/International_standards_HCI.pdf) [Accessed: 07-April-2013].
- [13] Ferré, X., Juristo, N., Windl, H., & Constantine, L. (2001). Usability basics for software developers. *Software, IEEE*, 18(1), 22-29.
- [14] Danesh, A., Inkpen, K., Lau, F., Shu, K., & Booth, K. (2001, March). GeneyTM: Designing a collaborative activity for the palmTM handheld computer. In *proceedings of the SIGCHI conference on human factors in computing systems* (pp. 388-395). ACM.

- [15] Frøkjær, E., Hertzum, M., & Hornbæk, K. (2000, April). Measuring usability: Are effectiveness, efficiency, and satisfaction really correlated? In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 345-352). ACM.
- [16] Nielsen, J., & Hackos, J. T. (1993). *Usability Engineering*. Boston: Academic Press.
- [17] Öquist, G., & Goldstein, M. (2003). Towards an improved readability on mobile devices: Evaluating adaptive rapid serial visual presentation. *Interacting with Computers*, 15(4), 539-558.
- [18] Ziefle, M. (2002). The influence of user expertise and phone complexity on performance, ease of use and learnability of different mobile phones. *Behaviour & Information Technology*, 21(5), 303-311.
- [19] Bertini, E., Gabrielli, S., & Kimani, S. (2006, May). Appropriating and assessing heuristics for mobile computing. In *proceedings of the working conference on advanced visual interfaces* (pp. 119-126). ACM.
- [20] ZHANG, D. & ADIPAT, B. (2005) Challenges, Methodologies, and Issues in the Usability Testing of Mobile Applications. *International Journal of Human-Computer Interaction*, 18, 293 - 308.
- [21] Ji, Y. G., Park, J. H., Lee, C., & Yun, M. H. (2006). A usability checklist for the usability evaluation of mobile phone user interface. *International Journal of Human-Computer Interaction*, 20(3), 207-231.
- [22] Nielsen, J. (1994, April). Usability inspection methods. In *conference companion on human factors in computing systems* (pp. 413-414). ACM.
- [23] Constantine, L.L. (1994). Collaborative Usability Inspections for Software. In *Software Development '94 Proceedings*. San Francisco: Miller Freeman.

- [24] Leuthold, S. (2010). *User interface, navigation design and content representation: Three perspectives on World Wide Web navigation*. Available:  
[http://www.academia.edu/1396279/User\\_Interface\\_Navigation\\_Design\\_and\\_Content\\_Representation\\_Three\\_Perspectives\\_on\\_World\\_Wide\\_Web\\_Navigation](http://www.academia.edu/1396279/User_Interface_Navigation_Design_and_Content_Representation_Three_Perspectives_on_World_Wide_Web_Navigation) [Accessed: 07-April-2013].
- [25] Tsai, J. Y., Kelley, P., Drielsma, P., Cranor, L. F., Hong, J., & Sadeh, N. (2009, April). Who's viewed you?: The impact of feedback in a mobile location-sharing application. In *Proceedings of the 27th international conference on human factors in computing systems* (pp. 2003-2012). ACM.
- [26] Dix, A., Finlay, J. Abowd, G. and Beale, R. (1993) *Human-Computer Interaction*, Prentice-Hall.
- [27] Huang, K. Y. (2009, October). Challenges in human-computer interaction design for mobile devices. In *proceedings of the world congress on engineering and computer science* (Vol. 1, pp. 236-241).
- [28] De Sá, M., & Carriço, L. (2011). Designing and evaluating mobile interaction: challenges and trends. *Foundations and Trends in Human-Computer Interaction*, 4(3), 175-243.
- [29] Jokela, T. (2004). When good things happen to bad products: Where are the benefits of usability in the consumer appliance market? *Interactions*, 11, 28-35.
- [30] Flood, D., Harrison, R., & Nosseir, A. Useful but tedious: An evaluation of mobile spreadsheets. Available: <http://www.ppig.org/papers/23/16%20Flood.pdf> [Accessed: 07-April-2013].

## APPENDIX A. QUESTIONNAIRE

This appendix contains details about the questions users were asked.

### **Category: User behavior for accessing spreadsheets:**

- 1.) Please indicate your age?
  - < 16
  - Between 16 – 25
  - Between 26 -35
  - Between 36 – 45
  - > 45
  - Choose not to answer
  
- 2.) Please indicate your gender?
  - Male
  - Female
  - Choose not to answer
  
- 3.) How fluent are you with English?
  - Not fluent
  - Basic
  - Fluent
  - Very fluent
  - Choose not to answer
  
- 4.) Please indicate your ethnicity?
  - Asian/ Pacific Islanders
  - American
  - Caucasian
  - Latino or Hispanic
  - Middle Eastern/Arabic
  - African American (Non- Hispanic)
  - Other/Multi-Racial
  - Choose not to answer
  
- 5.) What is the OS of your mobile device?
  - Android
  - Iphone
  - RIM BlackBerry
  - Other

- 6.) Do you use mobile devices or smart phones for accessing spreadsheets?  
 Yes  
 No
- 7.) How often do you access a spreadsheet using you mobile device?  
 Every day  
 2 -4 times a week  
 Once a week  
 Once a month  
 Once a year  
 Never
- 8.) How much time do you spend on using spreadsheets per week?  
 15 minutes  
 30 minutes  
 60 minutes  
 90 minutes  
 More than 90 minutes
- 9.) For what purpose do you use mobile devices while accessing spreadsheets?  
 For reading/viewing spreadsheet  
 To edit spreadsheet  
 To create new spreadsheet  
 To read and edit spreadsheet  
 Other
- 10.) What features do you like in a spreadsheet?  
 Rows and columns  
 Functions and formulas  
 Graphs and charts  
 Column sorting  
 inserting and deleting columns or rows  
 Cell formatting  
 Copy, cut and paste  
 Other

## APPENDIX B. QUESTIONNAIRE FOR POST-STUDY

### **Questionnaire for Post - study:**

#### **Category: Scope of spreadsheets used by users:**

- 1.) What is the usual size of the spreadsheets (Rows \* Column cells) used by you in a day to day life?
  - Less than 20 \* 20 cells
  - Less than 50 \* 50 cells
  - Less than 100 \* 100 cells
  - Less than 500 \* 500 cells
  - Greater than 500 \* 500 cells
  
- 2.) What type of header spreadsheets do you often use?
  - Spreadsheets with only column headers
  - Spreadsheets with only row headers
  - Spreadsheets with both row and column headers
  - Spreadsheets with complex headers
  - Spreadsheets with no headers
  
- 3.) Do you like to use spreadsheet applications on mobile device to access spreadsheets?
  - Likely
  - Very likely
  - Not interested
  - May be interested in future
  - None



**Category: Visibility and display aspects of spreadsheets on applications:**

Participants will be given mobile device to access two spreadsheet files using a spreadsheet application and will be asked to answer the below questions.

- 4.) Please rate the importance the following questions regarding visibility and display aspects of spreadsheets in the application( scale of one being not important and five being very important):

|  | (Not important) | 2 | 3 | 4 | (Very important) |
|--|-----------------|---|---|---|------------------|
| Display size of table on the screen                                |                 |   |   |   |                  |
| Display size of characters on the screen and readability           |                 |   |   |   |                  |
| Glance ability of spreadsheet                                      |                 |   |   |   |                  |
| Zoom ability to see data of the spreadsheet                        |                 |   |   |   |                  |
| Look and feel of the application while displaying spreadsheets     |                 |   |   |   |                  |
| Scaling down of the spreadsheet to fit to the screen of the device |                 |   |   |   |                  |

- 5.) Please rate the following questions for the spreadsheet application from scale of 1 to 5. Scale is defined independently for each question.

| Questions   | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Is the app showing the correct visible size of the table without zooming (scale 1 being not satisfied and 5 being very satisfied)   |   |   |   |   |   |
| Rate the readability of characters in the table ( scale 1 being not readable and 5 being very clear)  |   |   |   |   |   |
| Is zoom-in and zoom-out feature in the app very useful ( scale 1 being not useful and 5 being very useful)  |   |   |   |   |   |
| How effective is glance ability - how quickly and easily the user is paying attention to the display of the application. (scale 1 being not able to pay attention and 5 being able to pay complete attention to the display ) |   |   |   |   |   |
| Rate the overall look and feel of the application (scale 1 being not satisfied and 5 being very satisfied)  |   |   |   |   |   |

**Category: Navigation and orientation of spreadsheets in the applications:**

6.) Please rate the importance of the following questions regarding navigation and orientation of spreadsheets in the application (scale 1 being not important and 5 being Very important):

| Questions  | Not important | 2 | 3 | 4 | Very important |
|--|---------------|---|---|---|----------------|
| Smarter navigation to a find a particular cell on a mobile device  |               |   |   |   |                |
| Horizontal and vertical scrolling of spreadsheets in the application   |               |   |   |   |                |
| Orientation of spreadsheet with respect to device movement (landscape to portrait)   |               |   |   |   |                |
| Reference of data cells to the corresponding headers in spreadsheet  |               |   |   |   |                |
| Ability to sort data in columns for spreadsheets   |               |   |   |   |                |
| Ability to conceptualize the overall spreadsheet to on screen section  |               |   |   |   |                |
| Is the feedback from application useful in navigation of spreadsheets  |               |   |   |   |                |
| Should the application be able to handle complex header spreadsheets   |               |   |   |   |                |
| How important is that to have neighborhood feedback from application (to tell about the surrounding cells in larger spreadsheets ) |               |   |   |   |                |

Participants will be given mobile devices to access a file to test the spreadsheet application and will be asked to perform following tasks:

Note: Before performing task please read the questions.

Task a.) Please find the parking info of person Jim in the sample spread sheet.

Task b.) Please find the average salary of person Bullard in the sample spread sheet.

7.) Please rate the following questions for all the applications from scale of 1 to 5. Scale is defined independently for each question.

| Questions  | Very difficult | 2 | 3 | 4 | Very easy |
|--|----------------|---|---|---|-----------|
| How is navigation to reach particular target cell ( scale 1 very difficult and 5 being very easy)        |                |   |   |   |           |
| How is slide/scroll left navigation to reach the target (scale 1 very difficult and 5 being very easy)?  |                |   |   |   |           |
| How is slide/scroll right navigation to reach the target (scale 1 very difficult and 5 being very easy)? |                |   |   |   |           |

| Questions  | Very difficult | 2 | 3 | 4 | Very easy |
|--|----------------|---|---|---|-----------|
| How is slide/scroll top navigation to reach the target (scale 1 very difficult and 5 being very easy)?   |                |   |   |   |           |
| How is slide/scroll bottom navigation to reach the target (scale 1 very difficult and 5 being very easy)?  |                |   |   |   |           |
| How is zoom-in feature to reach the target (scale 1 very difficult and 5 being very easy)?   |                |   |   |   |           |
| How is zoom-out feature to reach the target (scale 1 very difficult and 5 being very easy)?  |                |   |   |   |           |
| How difficult is keeping the reference to the headers of table in the application (scale 1 very difficult and 5 being very easy)?  |                |   |   |   |           |
| Rate the usefulness of table headers within the spreadsheet for navigation (Scale 1 being not satisfied at all and 5 being very satisfied)   |                |   |   |   |           |
| Rate the usefulness of conventional headers for navigation (conventional headers are 1 to ~65000 numbers for row headers and A to ZZ for column headers) (Scale 1 being not satisfied at all and 5 being very satisfied) |                |   |   |   |           |
| How is neighborhood feedback from application is useful while navigating the spreadsheet (to tell about the surrounding cells in larger spreadsheets ) (Scale 1 being not satisfied at all and 5 being very satisfied)   |                |   |   |   |           |

**Category: Interaction, satisfaction, simplicity and convenience towards user interaction:**

8.) Please rate the importance of the following questions regarding Interaction, satisfaction, simplicity and convenience of application towards user interaction (scale 1 being not important and 5 being very important):

| Questions   | Not important | 2 | 3 | 4 | Very important |
|---|---------------|---|---|---|----------------|
| Is application interaction with the user is important   |               |   |   |   |                |
| How important is understanding the consequence of each action performed while viewing the spreadsheets for data (for example: understanding something like double click on some apps will automatically zoom in even though user might not need that feature while looking for particular data cell. This might increase the search time) |               |   |   |   |                |
| Is satisfaction in viewing the spreadsheet as desired by the user important   |               |   |   |   |                |
| Is simplicity of application needed for better user understandability   |               |   |   |   |                |
| Is convenience an important metric to judge the mobile applications   |               |   |   |   |                |

9.) Please rate the following questions for all the applications from scale of 1 to 5. Scale is defined independently for each question.

| Questions   | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| How is interaction of application helping you to achieve your goal (goal is to reach specified data cell)? (scale 1 being did not meet expectation and 5 being exceeded your expectation)                             |   |   |   |   |   |
| Please rate the overall satisfaction of application while achieving your goal (goal is to reach specified data cell) (scale 1 being not satisfied at all and 5 being very satisfied)                                  |   |   |   |   |   |
| Please rate the simplicity of application while using and viewing the data in the spreadsheet (scale 1 being very difficult and 5 being very simple)  |   |   |   |   |   |
| Please rate the convenience of using application for viewing spreadsheets (state of being able to proceed with something with little effort or difficulty) (scale 1 being not convenient and 5 being very convenient) |   |   |   |   |   |

# APPENDIX C. IRB APPROVAL LETTER

**NDSU**

**NORTH DAKOTA STATE UNIVERSITY**

*Institutional Review Board*

*Office of the Vice President for Research, Creative Activities and Technology Transfer  
NDSU Dept. 4000  
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701.231.8995

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Federalwide Assurance #FWA00002439

**IRB Certification of Exempt Human Research Project**

**January 23, 2013**

Protocol #**SM13138**

**“Comparative study to understand application compatibility and user interaction of spreadsheet applications such as 'Google Drive', 'Office Suite Viewer 6', 'Documents to Go', and 'ThinkFree online' on mobile devices”**

**Jun Kong**

Dept. of Computer Science,

Co-investigator(s) and research team: **Veera Chintapalli**

Study site(s): **NDSU, Minneapolis businesses**

Funding: **n/a**

It has been determined that this human subjects research project qualifies for exempt status (category # 2) in accordance with federal regulations (Code of Federal Regulations, Title 45, Part 46, *Protection of Human Subjects*). This determination is based on the revised protocol application received 1/23/13 and consent/information sheet received 1/23/13.

Please also note the following:

- This determination of exemption expires 3 years from this date. If you wish to continue the research after 1/22/2016, the IRB must re-certify the protocol prior to this date.
- The project must be conducted as described in the approved protocol. If you wish to make changes, pre-approval is to be obtained from the IRB, unless the changes are necessary to eliminate an apparent immediate hazard to subjects. A *Protocol Amendment Request Form* is available on the IRB website.
- Prompt, written notification must be made to the IRB of any adverse events, complaints, or unanticipated problems involving risks to subjects or others related to this project.
- Any significant new findings that may affect the risks and benefits to participation will be reported in writing to the participants and the IRB.
- Research records may be subject to a random or directed audit at any time to verify compliance with IRB policies.

Thank you for complying with NDSU IRB procedures; best wishes for success with your project.

Sincerely,



Teryl Grodz, MS, CIP  
Manager, Human Research Protections Program