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* Experiment data available on accompanying CD.

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GLOSSARY

Term	**Meaning**
Adult first-time user	Adults who are not computer literate.
AE	Activity effectiveness
AS	Activity speed
CRP	Completion rate per participant
CRPA	Completion rate per activity
CRTA	Completion rate per task and activity
CT	Completion time
DF	Degree of frustration
Digital closure	The act of making ICT tools available to all those who need it.
Digital gap	Perceived or known separation between those who have access to ICT and those who do not.
EMR	Electronic medical record
GDE	Gauteng Department of Education
GUI	Graphical User Interface
Handheld tablet	Computing device with the full capability of desktop systems but in a smaller size.
HCI	Human-computer interaction
ICT	Information and Communications Technology
ID	Index of difficulty
IP	Index of performance
IR	Interaction rate
MT	Movement time
Navigation	The process of moving from one task, area, or process to another.
NEPAD	New Partnership for Africa's Development
NGO	Non-governmental Organisation
Remote communities	Communities that are located away from main towns and cities, and their infrastructures is of poor standard.
RT	Reaction time
SPSS	Statistical Package for the Social Sciences

Term	Meaning
SR	Success rate
TBE	Time-based efficiency
TS	Task speed
UK	United Kingdom
US	User satisfaction
USA	United States of America
USB	Universal Serial Bus
UX	User experience
UXM	User experience metric

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2. Toko, G. 2015. *The role of open source software in higher education institutions*. Germany: Lambert Academic Publishing.

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4. Toko, G. 2013. *Software systems versus intellectual property rights: A moral and ethical challenge for higher education in developing nations*. Paper presented at CSEDU 2014, 6^{th} International Conference on Computer-supported Education. Barcelona, Spain.

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CHAPTER 1

STUDY PRELIMINARY

1.1 INTRODUCTION

The advent of computing systems has changed many aspects of our daily lives; including the way we communicate, entertain, navigate, travel, study, generate knowledge, seek medical help, and relax (Barnicle 2000:103).

Initially, computer systems development was restricted to computer scientists. Computers have now become working instruments available to whoever has the means to acquire and use them, irrespective of social status, disability, geographical location, education level, and gender (Madrigal & McClain 2010:3).

Lately there has been a significant re-valorisation and adaptation of computing devices, whether physically, electronically, or logically, which resulted in more user-friendly and innovative computing systems and interactive systems. This led to the wide adoption of computer systems as a household electronic item, just like any other electronic device found in the household, such as the microwave (Brewster & Dunlop 2004:8).

This research project primarily intends to explore and examine User eXperience (UX) dynamics regarding the relationship between humans and handheld computing systems, and, most importantly, regarding adult first-time users.

1.2 BACKGROUND

Not so long ago, being literate meant being able to read and write in one's mother tongue, a foreign language, or sign language (Hsu 2010:535). Today, with the proliferation of computer systems and complementary accessories, society driven by current technological ambition has coined the term "computer literacy". Although close to the original meaning, being computer literate refers to one's ability to use, comprehend, and control a computing system regardless of the core function.

This research project therefore postulates that physical access to any computing device, whether handheld, desktop, or any other type, may not automatically translate into "effective and efficient" usage, unless an educative initiative is taken prior to the experiment. In other words, simply providing physical computing devices to any potential user may not lead to systems adoption; unless those who are on the receiving end can effective and efficiently use the acquired systems (Garrett 2010:52).

No matter how proactive, meticulous, and efficient the interactive design team of any electronic gadget, household appliance, or computing system is, it is not always possible to predict all human behaviour and instincts at the time of development and it is also difficult to predict social aspects pertaining to the conditions the end users will be exposed to.

1.2.1 Human-computer interaction (HCI)

HCI is a science in its own right. It examines the relationship between humans and computer systems or the way humans interact with various electro-mechanical appliances (Dix et al. 2004:18). HCI is based on human cognition, cognitive psychology, experimental psychology, behaviour, the surrounding environment, sociology, anthropology, computer science, and cognitive science (Preece, Rogers & Sharp 2015:63).

Furthermore, as MacKenzie (2013:2-3) stated,

> "The human-computer interaction factor is both a science and a field of engineering, it is concerned with human capabilities, limitations, and performances, and with the design of systems that are efficient, safe, comfortable, and even enjoyable for the human beings who use them. It is also part of an art in the sense of respecting and promoting creative ways for practitioners to apply their skills in designing systems."

Similarly, Lazar, Feng and Hochheiser (2010:2-3) stated,

> "In the current context, where everyone is using computers, it may sound a bit odd, but back in the 1970s, almost no one outside of the computing, engineering, and mathematics specialists were using computers. Computers were not in school classrooms, they were not in homes, and there were no bank machines or airline check-in machines, before this shift towards non-engineering use. This shift created the sudden need for the field of human-computer interaction."

Many authors and researchers have been exploring and unpacking the HCI relationship for many decades and continue to do so as new and innovative computing systems are invented. New types of computer systems are constantly invented globally in an attempt to reach all potential users, depending on their respective budgets. Some of the most recent technological devices may be challenging to use, even for experienced users, while others are very easy to use and control (Yu & Hu 2010:769).

Amongst these recent inventions and innovation technologies are handheld tablet systems, which are making their mark on users and potential users across the world due to their size, long-lasting battery life, and ease of connectivity (Nodder & Nielson 2009:13). Handheld tablet systems can pose a number of usability challenges to anyone who encounters them for the first time. Examples include device orientation, the reduced physical size, and angle of positioning, the latter of which determines the display of icons on the screen (Nielsen & Pernice 2009:31).

The above are just some of the challenges that one needs to be aware of when using any handheld computing device. In addition, the level of education of those who may have these devices should be taken into consideration (Norman 2006:14). Some of these challenges could frustrate any user, let alone an adult first-time user, and lead them to abandon the experiment (Nielsen 1995:30).

In terms of those adult first-time users who continuously use a handheld tablet device regardless of their interactive adversities, one may ask questions regarding the time it takes them to complete a task, the number of errors made, the SR of their actions, and, most importantly, their level of UX (Preece & Shneiderman 2009:45-46).

An example of a usability challenge which is still relevant is that, as sad as it may sound in the year 2016, the Gauteng Department of Education (GDE) instructed all school principals in the province's public schools not to take in any Grade 1 and 8 applications for the 2017 academic year unless the parent completed an online application and provided a reference for it (GDE 2016:1).

It was easier said than done as many uneducated parents struggled to complete the online application due to poor computer literacy and computer interaction knowledge, leading to poor UX (Gelderblom 2008:105). For many parents it was and still is a nightmare as it was almost impossible for them to complete the online form without external assistance (GDE 2016:2).

The system's interactive design team was not totally exempted from blame or criticism but the bulk criticism was on parents' poor understanding of how computing interaction works (GDE 2016:1).

1.2.2 Computing systems needs

Standard and commercialised desktop and laptop computing systems are considered a "scarce commodity" in most remote and impoverished areas of South Africa (Toko & Mnkandla 2011:15). There are many non-governmental organisation (NGO) and government projects which are meant to enable access to low-cost computing systems for these less affluent communities; some of these projects are still in progress and others may have been completed or were simply abandoned (New Partnership for Africa's Development (NEPAD) 2014:4).

These applauded initiatives are mostly focused on the acquisition of physical devices and in some cases on interconnectivity but they rarely examine end-user usability and UX (Shen, Everitt & Ryall 2003:282). The current drive to create a paperless education system in South Africa may be applauded because it may create employment opportunities, enable access to the most needed handheld tablet systems where there are none, and create fast and secure wireless network connections.

Learners in these communities may come across the most advanced computing innovation while they are still at school, but can all of the above address computing-effective and -efficient usability? In other words, are those receiving these devices capable of using them as per developer prescription? (Schneiderman & Plaisant 2006:30).

1.2.3 Handheld tablet systems usability

The handheld tablet system, just like the standard desktop or laptop computer system, is a fully functional computer system (Wild 2013). It is very small in size compared to a laptop or desktop, but slightly larger than the average smartphone, and to take advantage of its full computing capability, handheld tablet systems can be connected to available Wi-Fi in a public place, via a private network, or connected using an existing commercial mobile network (Mphidi 2011:12).

The physical size, form factor, and weight of handheld tablet systems present hurdles that anyone who wants to use it must first overcome before having a pleasant UX, and this highlights the question of the system's usability (Alzomai & Josang 2010:79). There are no universal computing usability rules and guidelines *per se* as is the case with the automotive industry; in any electro-mechanical device, there are a myriad of ways to handle or use it effectively (Lazar 2007:61).

Furthermore, Lazar (2007:345) stated that "universal usability is simply good design, and there are precedents in the physical world around us; universal usability means that all people have access to technology".

Renowned HCI researchers Shirlina, Hovard and Vetere (2005:18) stated that

> "less than half of 114 research papers on mobile usability include usability evaluation, and when the research papers included mobile usability, typical traditional techniques were employed, e.g. the think-aloud protocol collected in artificial laboratory settings, lacking contextual cues and influence".

Sometimes it requires more expertise than can be predicted regarding what users may need and how they would respond when confronted with various usability challenges (Tractinsky, Shoval-Katz & Ikar 2000:130).

Handheld tablet usability comes with two distinctive features, namely the ease of using it on the one hand, and the elegance and clarity on the other, making it a lifetime challenge to developers and users (Nielsen 1995:13). Reiss (2012:185) also stated that "usability deals with an individual's ability to accomplish specific tasks or achieve broader goals while 'using' whatever it is you are investigating".

1.2.4 The usability side of computing

The ultimate questions of usefulness, which is the focus of this study, remains: is the device necessary, for whom is the device required, and for what purpose will it be used? (Mayhew 1999:7).

Rogers, Sharp and Preece (2013:275) highlighted the usability of a computing device:

> "A central concern of interaction design is to develop interactive products that are usable. This is generally meant to be easy to learn, effective to use, and providing an enjoyable user experience. A good place to start thinking about how to design usable interactive products is to compare examples of well- and poorly designed ones."

Nielsen and Pernice (2009:60) also stated that

> "any properly designed computing interaction must look at the visibility of the system status, match between system and the real world, user control and freedom, consistency and standards, error prevention, recognition rather than recalls, flexibility and efficiency of use, aesthetic and minimalist design, help users recognise, diagnose, and recover from errors, help and document".

A handheld tablet system may be a utility, but do all its intended users fully understand its functionalities? The majority of handheld tablets can be usable for an experienced user, but technically and structurally they may not be user friendly to everyone. It very often leads to resentment, frustrations, and abandonment when a user struggles to use it (Tegarden, Dennis & Wixom 2012:16). Figure 1.1 provides an inkling of what makes a computer system successful or acceptable in general.

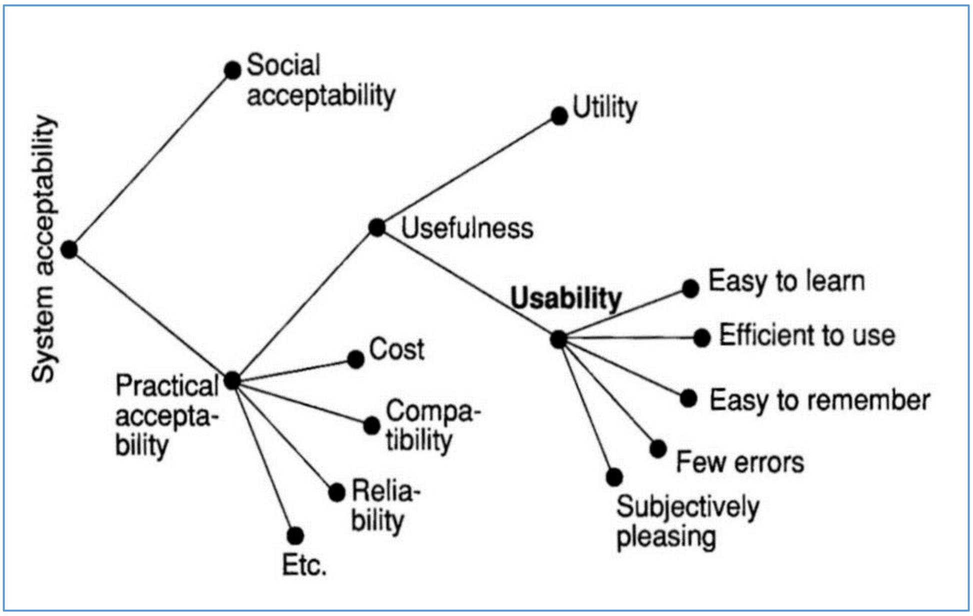

Figure 1.1: Usability and cognition

Source: Nielsen (1993)

For any developer, system tester, or designer, there is what is known as social acceptability that must be borne in mind when conceptualising a system (Tullis & Albert 2008:63). If the system is not socially acceptable, then nobody will accept or use it (Tsukada & Yasumura 2002:339).

1.2.5 Usability problems of handheld tablet systems

In order to gain a deeper understanding of the handheld tablet system and its impact on users, it is important that the physical structure is examined in-depth as it is often found to have physical defects (Molina et al. 2010:410).

A closer look at tablet systems indicates that they are physically larger than mobile phones or current personal digital assistants but smaller than standard-sized laptop computers (Krejcar et al. 2010:131). Tablets have integrated flat touchscreens, which were originally designed to be operated by touching the screen rather than by using a traditional keyboard as with a normal computer; this poses the first challenge that users have to overcome (Smith-Atakan 2006:43).

Most of the time, there will be an on-screen keyboard which may be used with a stylus (Liang et al. 2011:315). Under normal conditions, or when needed, users may rely on an external keyboard which comes with the device; this keyboard connects via a Universal Serial Bus (USB) and is detachable (Mancini et al. 2009:77).

If users are not seated or cannot place the device and the keyboard on a flat surface, it can be challenging to physically orientate the device when the user wants to view the screen output at a particular angle (Maiden et al. 2007:48). Some users, including people who have never used a computer before, have reported that the touchscreen is uncomfortable to use (Preece et al. 2015:101).

Due to size constraints, the applications installed on tablet systems are not always sufficiently designed to facilitate better user interaction or cognition (Madrigal & McClain 2010:31). For example, touching an area to open a new window does not always take the user to that window and the user must then use the back button to return to the initial window. In addition, some links or tapping areas are too small for adult fingers (Seebach, Ortmeir & Reif 2007:4216).

Under normal conditions, a touchscreen will operate in two forms; namely resistive touchscreen and capacitive touchscreen (Nielsen & Loranger 2006:107). The former is passive and can respond to any kind of pressure on the screen and provides a high level of precision, accuracy, and therefore a stylus is often used; with the fingernail not commonly used (Hsu

2010:40). Capacitive touchscreens, on the other hand, tend to be less accurate, but are more responsive than resistive touchscreens (Nielsen 1995:50).

There are also major problems with the way the device should be handled (Krejcar et al. 2009:44). For right-handed people, it makes sense to hold the device in the left hand while using it; however, if holding it in the right hand, the touchscreen will be at least partially obstructed by the working hand (Krejcar et al. 2009).

As observed in most cases, no or poor provisions are made for left-handed people to deal with physical limitations (Harms et al. 2015:333). In addition, tablet systems do not offer space to rest the wrist, and may thus result in some physical health problems (Alzomai & Josang 2010:17).

Some of the most prominent usability challenges with handheld tablet systems are touchscreen technology, handwriting recognition, physical shape, holding orientation, pen-enabled applications, and touchscreen applications.

1.2.6 System navigation impact

Navigating on a computing system is the process of moving from one site, page, angle, or application to the next. During this process the user makes use of the knowledge and understanding of the system to gain access to some components of the system where useful or interesting information is situated (Lazar et al. 2010:20).

Computing systems' ease of navigation is both cognitive and psychological as it is manual; the cognitive site makes reference to what the user is able to know about the system and then instructs the manual operation to be completed by the manual interaction (Preece et al. 2015:41).

There are no agreed-upon handheld usability standards regarding the navigation of computing systems, and there are no unique approaches of designing any form of navigation; any designer implements what they see and believes is right or good (Lazar 2007:47).

There is a very close relationship between system navigation and the Graphical User Interface (GUI) design; in fact, many believe it to be identical. However, the fact is that system navigation is part and parcel of computing systems' GUI (Lazar et al. 2010:16).

During the interactive navigation design process, the design team pays close attention to steps that must be taken in order to accomplish that usability task; too often attention is placed on the task completion speed rather than on the need of user (Lazar 2007:11).

System navigations are powered by the computing system's speed; a computing system with low speed tends to reduce the navigation speed as well. The same can be said about the overall interaction and GUI (Lazar 2007:18).

1.2.7 Tapping, clicking, or pointing

When interacting with any computing system, there are many points of contact which can be made with a device; the user as the primary enabler of the action would need to make contact with the device in order to trigger an action (Jan 2001:63). It may take various forms or processes to be accomplished, and, depending on the chosen designer preferences, the user would have to start the process for their action. It is important to state that users do not deliberately choose the type of interaction they want; it is chosen or imposed by the systems designer (Lazar 2007:1).

Some interactive systems require that the user taps on a particular area for an action to be registered. The finger-sensitive button would react to the contact by providing a response which is the reflection of the action initiated by the user. The user may perform the same task using a pointing device and simply clicking on that very same spot (Lazar 2007:18).

Most portable devices these days require tapping and sometimes pointing, where the user would have to make use of a stylus in order to select a particular function (Lazar 2007:16).

1.2.8 Task and activity completion time (CT)

In most cases, when an action is needed, one would have to perform an action in order to accomplish the activity. This action requires various levels of constraints, reaction time (RT), completion rate, activity speed (AS), and levels of difficulty – some more complex than others (Rogers et al. 2013:13).

Task CT is the duration that one takes to complete any task; it assists in determining the user navigation and usability experience. A user who knows the system well would take less time exploring and accessing system resources (Preece et al. 2015:11). To measure the task CT of any user, the starting time can be recorded from the onset and stop when the target is reached.

It enables one to see if it is fast or not, or whether it requires the user to make some improvements (Preece et al. 2015:16).

Task CT is mostly coupled with the number of errors made. As the task is being measured, an observation is also being made about the target SR to determine whether or not the particular task was completed successfully (Preece et al. 2015:16).

1.2.9 The role of psychology and cognition

The user mindset, state of the mind, and level of cognitive ability are all that a user engaging with a system requires in order to master and accomplish an activity or task. User psychology is part and parcel of the HCI spectrum (Smith-Atakan 2006:17).

Discussing HCI without incorporating the role that human psychology plays would lead to misinterpretation of the results. With this said, it must be specified that psychology as a field will not be covered by this research project, although the researcher's intention is to provide an overview of the impact it may have on the user (Akamatsu, Yoshida & Satoch 2015:569).

Psychology refers to the reaction and behaviour of humans and animals when faced with some dilemma. In the context of this study, it basically explores how the user sees the computer system in general (Argyle 1994:40).

The impact that it may have on us can be immense. We as humans need to constantly review our actions before we do things; the same can be said regarding how a user interacts with computing systems (Akamatsu et al. 2015:560).

The word "technophobia" is one of the directives which originated from the way some people see and interact with electronic devices; some may develop fear while others may develop joy (Du Plessis & Rousseau 2012:68).

1.2.10 User eXperience (UX)

The UX, which is coupled with system memorability, enjoyability, learnability, and performance, is a set of individual characteristics that any system should provide its users in order to remain relevant and useful (Gelderblom 2008:97).

Any interaction development team should not take this aspect lightly as it will determine the success or failure of the entire interactive design project. Measuring the degree of UX is one of the most important aspects of system evaluation; it gives the user an overview of the system and how the user or potential user would interact with it (Rogers et al. 2013:13).

Poor or low user UX can lead to sudden abandonment and self-resistance if no timeous correction is made. Developers and interactive designers should pay close attention to these critical UX aspects (Petta, Pelachaud & Cowie 2011:14).

The assessment of the UX is not conducted with the completion of the interactivities only, nor at an early phase, but rather throughout the process of system development in order to enable corrective measures to be taken while the product is still under development (Rosson & Carroll 2002:50).

1.2.11 Interaction and interface design

The terms "system interaction", "system design", "interface development", and "GUI design" may sound different, but in reality could well mean the same thing. A computing system is a set of algorithms which are computer readable only and which control the hardware system (Dix et al. 2004:101).

Algorithms are in binary format, which makes it even more difficult for ordinary users to decipher their content since the ordinary person relies on decimal, alphabetical, and alphanumerical representation to comprehend meaning (Rogers et al. 2013:11).

These days, GUIs are more specific than they used to be, thanks to the ingenuity of some developers, but the fight is not over yet as new challenges are on the rise. Interaction is what stands between humans and a computing system's algorithm and provides us with information that we need in a format that humans can better understand (Duchowski 2007:30).

The reality is that, as systems are independently developed, there will be good and poor interactive design products developed by good and poor designers (Lazar 2007:109).

1.2.12 The place of interface metaphors/prototypes

In terms of system development and more specifically GUI design, there are tools which are used by most developers to master their tasks, and the tool that is used most often is the design metaphors, sometimes referred to as walkthroughs, prototypes, or sketches, that are simply a set of hand drawings which enable the early delimitation of projects. These are mostly done on paper, wood, or any other cheap material, and give the developing team an idea of what is required from them (Lazar 2007:41).

The purpose of these metaphors is to enable developers to visualise the entire project before it even begins, and saves a lot of money. In most cases, early testing is done on these metaphors to ensure that they comply with the set prerequisites of the system (Lazar et al. 2010:67).

Metaphors are not automated but provide developers with some precise artefacts regarding the product under development. In other words, developers can make use of a metaphor to foresee how the system would work after completion or execution (Lazar 2007:71). This research project made use of low- and high-fidelity prototypes throughout to develop, assess, and test participants at all levels.

1.2.13 Good and poor design

Can any user, designer, or tester, when asked to conduct a GUI usability assessment, uncover any form of poor design without an HCI test instrument? Just like we may have poor systems users, can we also have poor systems interaction designers or developers? The answer is yes; just as there are good designers, there are also poor designers. An interaction design is seen as poor when users have difficulty using it, and is seen as good when users find it easy to interact with (Lazar et al. 2010).

As much as it may be hard to identify good designs, it is also difficult to identify poor designs and sometimes it takes a professional opinion to do so (Allber 1993:73). Design appreciation are dependent on an individual's taste and aspiration, and what may be perceived as poor design by some could be seen as good work by others (Lazar 2007:258).

In terms of system interaction development, the absence of interaction design universality leaves room for various interpretations and analyses, but the reality is that when ordinary users are unable to control and use an interactive product, the design team is to blame (Lazar 2007:74).

For a good interactive design, under no circumstances should users have to struggle, constantly explore, memorise steps, ask for help when navigating, question task positions, and not enjoy the process (Lazar 2007:74).

Poor interaction design discourages continued usage, frustrates the user, limits interactivity, develops user resentment, and discontinues interaction. It is therefore advised that an in-depth assessment be conducted before any system is released to the public (Lazar 2007:75).

The next section will show the connection that may exist between adult first-time users and tablet system controls and challenges.

1.2.14 Challenges for adult first-time tablet users

When one takes computing systems in general into consideration, the most difficult aspect that needs attention is how to teach an adult first-time user to manipulate a device without causing any form of frustration or anxiety (Nielsen & Budiu 2001:31).

The challenge experienced by many left-handed users is the fact that, in many instances, the pre-installed applications system, or system meant to be downloaded, is mostly meant for right-handed users (Coleman-Martin et al. 2005:82).

This may cause exasperation and frustration for some first-time users or later deter them from further exploring the handheld tablet, or, in the case of most users, it may take them longer to get used to the device and adapt to it (Nielsen 1990:45).

1.2.15 Fitts' law

Fitts' law is a mathematical model that assesses and measures human movement and is used in many disciplines. It describes the speed-accuracy trade-off and pays attention to ergonomics (Reiss 2012:103). Essentially, Fitts' law helps to calculate the duration necessary to move to a particular target area, which involves the size of the object, the distance to reach it, and the accuracy of the movement (Reiss 2012:106).

In many instances, Fitts' law is primarily used to model the act of pointing, reaching, facing, coming into contact, and focusing either by physically pointing at an object or a computing or handheld system (Shibata, Takano & Tano 2015:559).

When Fitts' law is applied, it is possible to establish the average time taken by any user of a handheld device to complete a task or movement. By doing so, details such as starting and stopping time, and the distance to the targeted device are all taken into consideration (Feuerstack & Wortelen 2015:120).

1.2.16 Other mathematical models

In this study, various mathematical models are used; these formulae are still relevant today and are applicable to this research project. The model employed by the researcher in this study are as follows.

Efficiency: The efficiency model is primarily used to determine the mechanical efficiency of some tools. It enabled the researcher to compute the effort of a particular participant given the number of tasks that he or she needs to perform within a specified amount of time.

Action speed (AS): Here the researcher tried to assess the speed at which a particular participant may complete an action. This formula was borrowed from the mathematical field.

Index of performance (IP): The researcher used this formula to compute and assess a participant's performance, enabling the researcher to measure the degree of productivity of a particular user.

Index of difficulty (ID): Used here to assess the level of complexity that the user is experiencing when using the system.

UX: This is one of the unknown variables which was determined in the research project. Knowing this variable assisted the researcher in determining the degree of adult first-time user adaptation regarding interactivity. One way of determining the UX is to create a metric which will provide the researcher with a clear indication.

CT: This formula was used to calculate the difference between the time at which an activity is started and the time it is completed.

The rationale for the study is discussed next and will enable the reader to understand the researcher's motivation to conduct this study.

Sources of mathematical expression: it is important to note at this stage that all mathematical expressions presented in the study are discussed in the literature review and extracted from the arithmetic and mathematical field, and are therefore considered existing knowledge.

1.3 RATIONALE FOR THE STUDY

People who live in rural communities are less exposed to new developments in information and communications technology (ICT) than those who live in urban and affluent areas; however, their needs and aspirations can be identical to other citizens (NEPAD 2014:2).

Computing systems in general and handheld systems in particular are becoming popular worldwide, mostly among the most affluent citizens. These systems enable fast access to vast amounts of knowledge and information that could possibly transform the users' day-to-day transactions, such as telephonic communication, Internet access, financial transactions, etc. (Kock 2010:13).

Handheld computing systems have also brought about a new kind of undertaking and aspirations in more fortunate communities. Although access to the Web is not something new, nor the use of handheld computing devices, the ability to easily access the Web from a computing device in appropriate and intimate environments is an advantage (Kerren, Ebert & Meyer 2006:107).

The digital gap is mostly felt among adult users and mostly in rural, poor, and remote areas where telecommunications infrastructure is non-existent, the level of literacy for some is low, and businesses are absent (Surty 2012:16). At the heart of the absence of digital communication, the question of computer literacy in most cases persists (Surty 2012:17).

The needs of the ordinary user are at the centre of all creations or inventions and without them, none of the inventions would exist. Some claim that the polarisation of societies makes it difficult, if not impossible, for every individual to have access to the same technological tools and facilities, thus rendering them technologically isolated (Priest 1988:96).

The challenge is to narrow the existing technological gap by enabling access to new users at a higher rate than the increasing number of first-time users who are mastering the available ICT tools in a reduced timeframe than the number of people who are moving away from it (Nielsen 1990:17).

The researcher will engage with a string of mathematical arguments to assess the success rate (SR), movement time (MT), completion time (CT), activities effectiveness (AE), task speed (TS), activities speed (AS), user satisfaction (US), reaction time (RT), completion rate per task and activity (CRTA), completion rate per participant (CRP), time-based efficiency (TBE), system index of difficulties (ID), index of performance (IP), degree of frustration (DF), and interaction rate (IR) of all participants.

1.4 MAIN RESEARCH QUESTION

This section clearly states the purpose of this study by listing the main research question, the research objectives, the supporting questions, and the corresponding chapters.

Table 1.1: Research questions

Main research question			
How does one develop a UX metric (UXM) which is based on the usability of handheld systems in order to assess adult first-time user adaptation?			
Number	**Objectives**	**Associated research questions**	**Corresponding chapter**
1	To calculate key systems usability measures.	How does one mathematically compute key usability measures?	Chapter 4
2	To identify, analyse, and address usability hurdles of handheld systems.	How does one identify, analyse, and address handheld usability issues?	Chapter 5
3	To develop, test, and implement a UXM.	How does one develop, test, and implement a UXM?	Chapter 6

Table 1.1 elaborates on the various segments of the research questions. Not only does it provide a clear idea of the central research question but it also lists all the sub-questions which would address the main research question and therefore the overall study. It does not include the three initial chapters (Chapters 1 to 3), or Chapter 7, which is the conclusion.

1.5 HYPOTHESES

Table 1.2 highlights the research hypotheses, given the use of the mixed-methods research approach.

Table 1.2: Hypotheses

Research hypotheses
UX in adult first-time users is poor because of the low level of US during the interaction.
High SR may not translate into lower DF.
Decreasing the DF during interaction would contribute towards the positive improvement of the UX.
Lower RT is ultimately the result of lower MT.
Adult first-time user IP is increasingly linked to ID.
Controlling the TBE of first-time users will lead to high AS of users.

1.6 VARIABLES

Table 1.3 indicates the various variables which were tested to fully comprehend the issues discussed in this study. It is important to note that the researcher used a number of independent variables which assisted the dependent variables.

Table 1.3: Research variables

Variables	
Independent variable	**Dependent variable**
TBE	DF
SR	US
AS	MT

Table 1.3 indicates the variables which played a role towards understanding this research. The independent variables are identified on the left and the dependent variables on the right.

1.7 OBJECTIVES OF THE STUDY

The main objective of this study was to assess the current level of usability of handheld tablet systems for adult first-time users who are mostly based in remote communities in South Africa (also referred to as the “missing middle”), or people who missed the computer literacy drive in the 1990s and 2000s and who cannot educate themselves.

The UXM which was developed and tested, was directed by users’ needs, ensuring that it is user friendly and adapted to the South African context. By considering these points, it is anticipated that the low penetration of advanced computing devices, smart devices, and Internet connectivity in remote and impoverished communities in South Africa will be understood.

1.8 PRELIMINARY METHODOLOGY

Before discussing the various components of this study, it is important to explain that a mixed-methods research approach was used to conduct this research since it was impossible to rely on a single research method as it would have yielded little positive results.

In order to conduct effective and efficient research, the researcher selected a number of instruments which are vital in terms of guiding the accomplishment of the research task. For this reason quantitative data analysis was used, which is mostly about number manipulation of computation in order to achieve some outcome which can also be interpreted.

Qualitative methodology was also used, which is basically the second set of tools used. Interviews took place before and after the experiment and qualitative data were collected and analysed to shed light on the topic.

The third and most crucial method was the experiment, which was conducted in the field using the targeted research population. The results of the experiment are also analysed and debated.

1.9 BENEFITS OF THE RESEARCH STUDY

This research study comes at a time when new and customised ICT solutions are being found to address the digital gap and when some provincial government departments in South Africa are taking the initiative to introduce a paperless education system in their school programmes. It also comes at a time when the GDE is rolling out online school registration that is compulsory for all public schools (GDE 2016).

The world is viewed as a global village where new technologies are constantly flooding the market and which address some of the most fundamental needs of human life and life style, thereby assisting in closing the gap (Wild 2013). The price of ICT devices or tools and related accessories nowadays is more affordable than a decade ago if one takes 2017 as the reference point (Surty 2012:1).

The advent of mobile phones has created faster and better communication, thereby reducing, if not removing, the dire need for national and local governments to first construct roads and telecommunication infrastructure, as well as cabling infrastructure, in all their geographical areas in order to connect local populations to the national telecommunication network grid (NEPAD 2014:3).

Regardless of where they may be situated, users are now connected by means of a single access point, antennas, or towers in the most remote villages, which instantly enable the entire community to connect with the rest of the world (NEPAD 2014:3). According to the World Bank (2015), a limited number of households in South Africa currently have access to telephone landlines, compared to urban households that have access to mobile coverage.

In order to conclude the assessment, it is critical that an in-depth adult first-time usability study based on UX be conducted. This will be an objective research study which does not focus on a specific tablet brand.

For many decades, academia has been at the forefront of social issues, searching for and providing answers to unexplained and unforeseen phenomena, guiding decision makers regarding the impact of some of their policies, conducting research, discovering new ICT tools, etc. Conducting this study is in line with this philosophy (Delanty 2005).

The proposed study provides an opportunity to obtain a clear and reliable usability level regarding the state of the ICT rollout in the national spectrum. It would help to situate the level of ICT adoption amongst adults in South Africa.

In addition, information pertaining to the use of handheld devices such as the tablet system in the most remote communities in the country in general as well as the level of handheld usability awareness of portable systems in particular is provided. The output may in return benefit other researchers and contribute towards broad ICT research communities worldwide.

1.10 ETHICAL CONSIDERATIONS

Conducting research such as this requires or compels researchers to take other considerations into account, such as the protection of the people involved. For this reason, institutions compel all students conducting studies involving humans to adhere to internal university policies and regulations before any fieldwork can be undertaken.

The researcher therefore submitted a request for ethical clearance before conducting the research. A copy of the form which was completed and signed by all participants is available in the annexure.

1.11 OUTLINE OF THE RESEARCH

Chapter 1: Introduction – This chapter introduces the entire study and all relevant aspects. This section is valuable because it covers almost all the key characteristics of this study such as the title, the importance of the study, the motivation, the main research question and sub-questions, the objectives, and many more key details of the study in order to demonstrate that it is feasible.

Chapter 2: Literature Review – In this chapter the most recent literature on the topic is presented. This chapter demonstrates that the researcher widely read and understood the topic under investigation. The researcher wanted to explore all available theoretical work which has been conducted on this topic. One may not simply ignore existing literature unless one wants to repeat what someone else could be doing at the very same time. It also gives a broader perspective about the topic under discussion, as well as assists the reader to comprehend the topic.

Chapter 3: Research Design and Methodology – This chapter deals with the research approach and methods used. This section of the study sets the ground rules which were needed to complete the research project. Without these rules, there would be no guidelines and simply free navigation. The research methodology is an important chapter and must be seen as the glue which holds the study together.

Chapter 4: Qualitative and Quantitative Data Analysis – This chapter explores in greater detail the specific research questions which are based on the quantitative methodology. Calculations are made based on some of the mathematical formulae which were identified and listed as essential in developing a UXM. This chapter also examines the data which were collected before and after the experiment and also explores participants' responses regarding some critical issues and how the outcome is related to the previous chapters.

Chapter 5: Experiment Data and Analysis – This chapter focuses on the actual usability interaction by examining the level of user involvement, level of difficulty, attempts, and success, which are captured on camera and which would later be examined.

Chapter 6: UXM, Post-experiment, and Framework – This chapter explores and analyses the practical experiment which involved adult first-time users and analyses their ability to comprehend and master computing tools. The UXM will be developed and post-experiment data analysis will also be conducted.

Chapter 7: Conclusion – This chapter summarises the research and marks the end of the project and also enables the reader to have an overall perception of the final thesis.

1.12 SUMMARY

This introductory chapter explored in great detail the question of the usability of handheld devices for adult first-time users. The frequently discussed topic of closing the digital gap in South Africa was discussed. Most importantly, aspects that hamper the process of digitalisation of rural communities where very little is done to help improve the standard of education, and where most unemployed people find refuge were discussed.

The "missing middle", as they are referred to in this study, are simply people who missed the major ICT literacy drive campaigns of the 1990s and 2000s which targeted people who wanted to learn how to use a computer system. Various types of computing devices which may be used or which are available today were examined, with emphasis on tablet systems.

The handheld tablet system was scrutinised as an alternative to standard computing systems. As mobile as it may be, it comes with its own set of challenges that any aspiring user may have to overcome to fully take advantage of it. This chapter reviewed the background that led to the undertaking of this research study.

This chapter presented the main research question and sub-questions, coupled with the research objectives, to which the researcher needs to find possible answers in the chapters to come.

The next chapter, which is the literature review, exposes what the researcher discovered while conducting the preliminary investigation. It elaborates on the subject under investigation and demonstrates the importance of conducting such a research project. It is also important to note that the next chapter gives the reader an idea of the holistic picture which brings together the entire study.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This section presents a detailed investigation of existing literature in the area of study and also identifies the existing knowledge gaps.

The computing systems present everywhere in our lives is here to stay. Our dependence on them is constantly growing and our ability to break free is diminishing day after day (Turban et al. 2008:41). Our introduction to computing systems is a thing of the past, yet we are constantly being reintroduced to them as if we are coming into contact with them for the very first time (Oz & Jones 2008:40). Their presence is so obvious and invading that we are constantly keeping track of them and observing the next trends to ensure that we are the first to discover new products being released (Shely, Cashman & Walker 2015:51).

The constant innovative nature of computing systems makes them ideal tools to impact society at large. They have impacted almost all aspects of our lives, from the way humans sleep and wake up, travel, eat, and communicate, to the way we interact with everyone and everything around us on a daily basis and beyond (Reiss 2012:30). The impact of computing systems and overall systems usability is so important that numerous scientific studies are conducted with the aim of investigating their impact, their progression, and how to foresee their evolution and possibly control them in the short, medium, and long term (Prietch & Filgueiras 2015:20).

In this study, computer users are seen as all potential users, including adults who happen to be first-time users as they may not have been in contact with any form of computing system before, given the remote and impoverished communities they live in. The question of whether or not users of handheld computing systems are able to effectively and efficiently use and control their devices remains a hurdle that must be addressed, as the question of how one may assess usability, adaptability, and UX remains scientifically unanswered by existing ICT tools, methodologies, and processes.

2.2 BACKGROUND

For some people, handheld computing systems come as a supplement of their desktop or laptop computers, or is one of their multiple personal computing systems, but for others, or maybe the majority of South Africa's aspiring computer users, it may seem as the only known computing system they will ever own (Gilward, Moyo & Stork 2010:20). It will most likely be the only computing device they can afford that will allow them to stay in touch with the rest of the world (Toko & Mnkandla 2011:151). As more and more people start using computers, the trend of having to deal with people who may never have used or interacted with any form of ICT is a reality and high on the agenda of policy makers as the lack thereof may well limit social development (Fowler, Beck & Brant 1999:111).

These untapped user communities can be young or very young, but some of them may be people who have never had an opportunity to access or use a computing device in their lives for reasons such as their geographical location, advanced age, poor school grade, and low literacy level (Vatavu, Anthony & Brown 2015:1). This group, referred to in this study as adult first-time users or senior first-time users, are people who may have realised the importance of computing systems at a later age and are willing to fully explore them in order to become more accustomed to new ICT innovations (Feuerstack & Wortelen 2015:176).

The history of South Africa exposed some sections of the population to high levels of various vulnerabilities, which resulted from many negative and depriving types of human segregation, and further contributed to two distinctive segments of the country's population (Adebajo 2016:14).

This is where the digital divide originates (SA Jews 2010:1). The digital divide is a widely debated and publicised topic and does not originate from the lack of technological skills or technophobia, but rather from deep socio-economic disparity (Mphidi 2011:13). Closing the digital gap would to some extent depend on the steadily increasing number of new users. By doing so, one may expect to absorb the number of computer illiterate people to the profit of the computer literate people and in so doing, close the digital gap (NEPAD 2014:4). The question may be that if computing systems were made more affordable to low-income potential users, would that make them computer literate?

Computer usability is still a hurdle that computer designers have to address when developing or innovating new products; overcoming this hurdle requires developing a computing system that is easy and simple to use by everyone (Herselman & Briton 2010:6). The same can be said about any brand or model of handheld computing systems. This hurdle led to the creation of the computer science subfield of usability studies, which examines the impact of using any computing device, and one of the models used to measure its impact on humans is Fitts' model, also referred to as Fitts' law, which was created more than four decades ago and explores and measures the adaptation ability of computer users (Balakrishman 2004:3).

The next section will demonstrate why conducting such research may be important for the academic world and especially on a continent where there are very few publications related to the computer systems arena.

2.3 WHY IS THIS RESEARCH OF INTEREST TO ACADEMICS?

Academia has always been at the forefront of social issues, searching for and providing answers to unexplained and unforeseen phenomena, guiding decision makers regarding the impact of some of their policies, discovering new ICT tools, etc. (Delanty 2005:13). The role of the academic community in this case is to ensure that preventative measures are put in place to guarantee that any aspects that might jeopardise the relationship between humans and computing are investigated (World Bank 2015:10).

The second aspect is the fact that, currently in South Africa, ICT researchers have to rely on secondary data (World Bank 2015:10). Thirdly, this research will provide the academic community with some answers regarding the underlying issues that still persist in maintaining the digital gap. And lastly, the project will develop an index of adaptability matrix, taking into account aspects such as features, usability level, and physical characteristics.

This metric can then serve as a basis for critical review, evaluation, and analysis by other researchers in order to improve the current state of research in general and ICT in particular in the country and, most importantly, the comprehension of handheld usability.

The next section discusses the importance of handheld computing systems in our daily lives and how they have an impact on us.

2.4 HANDHELD COMPUTING DEVICES

The days when users were forced to be confined to a chair or location, whether at work or at home, in order to use a computing system are gone (Schonauer et al. 2015:165). It is also a thing of the past that employees at workplaces have to walk to a connected desktop computer system or personal computer (PC), which used to cover a large area of the desk surface, in order to conduct business (Katchi & Toko 2014:13). We are living in a world where users of handheld tablets seem to have access to all the functions of desktop computing systems, a world where corporate communications are forwarded to personal handheld devices, and where employees can conduct their normal daily work without having to sit at their desk or physically be at their workplace (Katchi & Toko 2014:13).

Handheld computing systems are not limited to tablets only; they also include smartphones and any form of computing devices that are operated remotely and connected either via radio frequency, infra-red technology, or satellite communication. The purpose of handheld computing systems may not necessarily be voice and video transmission or transfer but any packet transfer, including data (Lubos et al. 2015).

Handheld computing systems in general and tablet systems in particular are becoming more popular. The ownership of a type of computing system does not exclude the presence of other types of computing devices; in fact, most users, to some extent, have access to more than one type of computing system (Egusa et al. 2014:259).

The developers of these devices are observing what is happening in the market, what the users' needs and aspirations are, and, most importantly, they know users' spending power regarding their handheld computing devices (Petta et al. 2011:14). From their inception to date, handheld computing devices have experienced many internal transformations and innovations to meet the needs of users and the quality of operating systems installed on them is constantly improved (Petta et al. 2011:13).

2.5 COMPUTING MOBILITY NEED

Computing mobility primarily defines the ability of any computing systems user to move around while using a handheld device (Allber 1993:15). At this stage of wide acceptance and integration, there is no doubt about their prominence; their necessity reflects the pinnacle of our society's aspirations: to be on the move and to have access to the same information as when one uses a normal computer system (Massa et al. 2015:315). This is becoming a lasting reality due to constant technological or ICT modernisation (Novikova, Ren & Watts 2015:239). Users just have to adjust to it, accept and embrace it, and learn to use it.

From a user perspective, questions and opinions are rarely asked or deemed important at the conception phase, and when they are asked, it is solely about aspects which are not linked to the decision of developing a new product or not (Duchowski 2007:17).

Figure 2.1 depicts an overall description of what may be seen as the link that may exist between handheld systems (in this study tablet systems in particular) and people wanting access to computing systems. The figure also constitutes the agglomeration that defines in the true sense of the word the reason why we as users always want to be connected to computing systems at all costs (Sikhakhane, Lubbe & Klopper 2005:44).

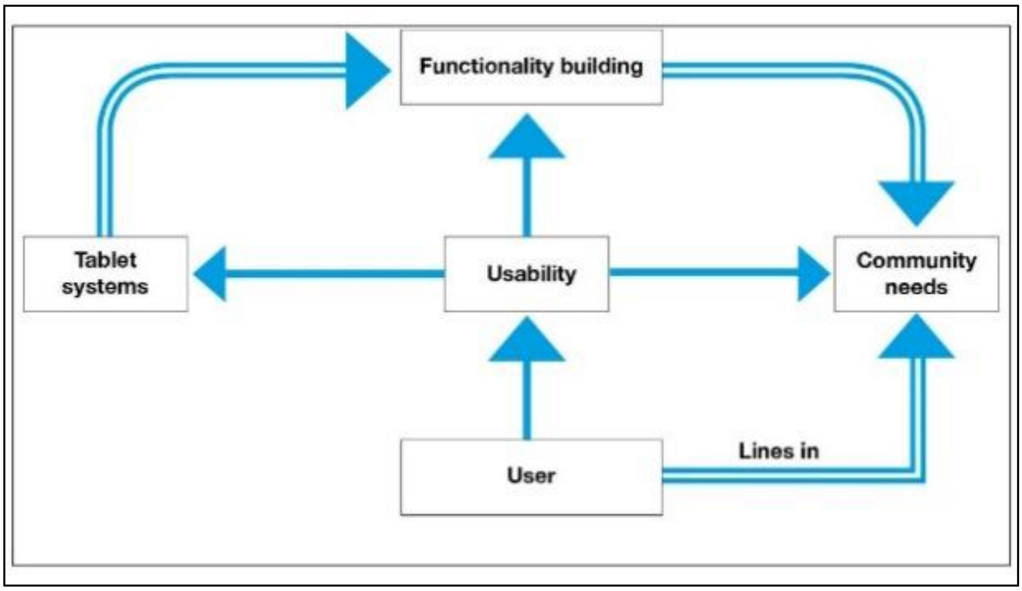

Figure 2.1: Usability needs

On the other side of the same systems need process, users as consumers are expect to have access to certain types of computing systems that may contribute to alleviating their hardship; this is very often triggered by challenges within their industry or society (Sikhakhane et al. 2005:44).

Figure 2.2 shows another inner section of the ICT global need that amplifies some of the societal artefacts that make people always want to get in touch with their computing systems. This is one of the reasons people today always carry their mobile computing systems wherever they go (Harms et al. 2015:333).

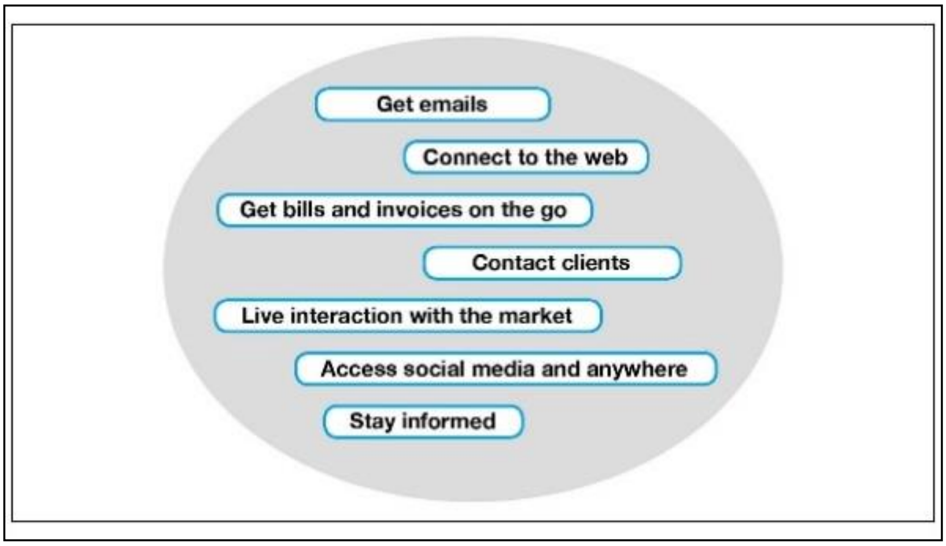

Figure 2.2: The importance of mobility and connectivity

Getting emails on the go and staying up to date with current stock market speculations are just some of the reasons why we always have a form of computing system with us, and our world is speedily embracing this idea and learning to live with it (Harms et al. 2015:333). The need for computing systems may well fall under any of the categories stipulated above; but there could be other underlying reasons (Centieiro et al. 2015:341). Thus, regardless of the angle from which one may see it, both ends seem to inspire each other (Centieiro et al. 2015:341).

Above all, when one takes some time to observe human behaviour around mobile computing systems, it may lead us to believe that what our mobility, communication, connectivity, and social interaction need is the soul that drives the computing industry and particularly the handheld computing sphere (Harms et al. 2015:334).

2.6 HCI

2.6.1 The history of HCI

HCI is a mix of computer science, sociology, communication, psychology, and occupational fields. Some may go to the extent of calling it an amalgam of several scientific fields (Kobayashi, Sosik & Huffaker 2015:116). It is a set of sub-scientific groups which examine all aspects of computer machinery and how humans interact with them (Kobayashi et al. 2015:116). It was introduced many decades ago and continues to be at the forefront of all types of research involving computing systems and human behaviour (Kobayashi et al. 2015:116), whether in the workplace, in the home, or any area where there would be a need to have any form of interaction between computing systems and humans (Madsen et al. 2015:132).

The aim of this research project is to enable a better comprehension of the relationship that humans have with their immediate companions, which are computing systems, and the potential impact that constant innovation and creativity may have on us in the short and long terms (Madsen et al. 2015:132).

The main focus of this research is on adult first-time users – people who have discovered the power of ICT and want to join the user groups but for some reason are still struggling to cross over (Ojha, Jovanovic & Giunchiglia 2015:149).

As fascinating and complex as HCI may sound, especially when one starts to explore its sub-components, one may realise that it mostly investigates things that we do almost every day (Madsen et al. 2015:132). Due the enormous task of the field and the need to widely collaborate, HCI professionals have met annually since 1982 at a conference in the United States of America (USA), which has taken multiple dimensions (Ojha et al. 2015:149).

Figure 2.3 depicts and summarises the overall role that HCI plays in interactivity. It shows the role that it may play in examining the relationship that exists between academic disciplines and GUI industry leaders. The approach and similarities are real and visible, and more inclusive regarding areas such as ergonomics, psychology, cognitive thinking, etc. (Ojha et al. 2015:149).

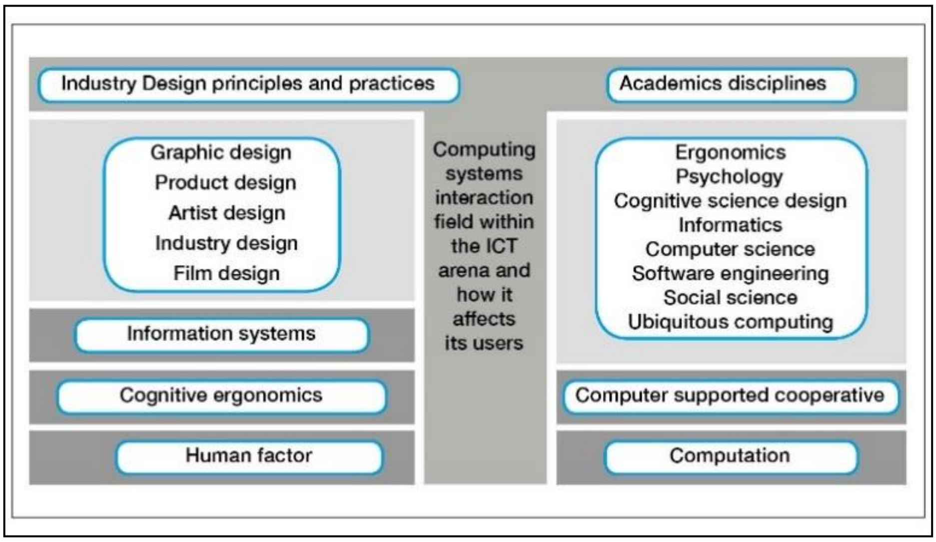

Figure 2.3: The field of human interactivity

The HCI field has undergone significant transformation over the years in order to stay updated and to accommodate the rapid vicissitudes occurring in the computing fields in general, and particularly the sub-field of handheld computing systems such as tablet systems (Sliwinski, Katsitis & Jones 2015:150). HCI was originally created to pay attention to simple office automation such as interaction with word-processing applications, databases, dialog boxes, etc. (Sliwinski et al. 2015:201). It is now expanding far beyond its origin to reach all corners of electro-computing systems, including aspects such as websites, handheld computing, and computer peripherals (Sliwinski et al. 2015:150).

The ability of the field to function was to some degree based on instruments which could assist in measuring any form of HCI, such as the simple measurement of the successful completion of pre-set tasks and activities, time to learn/master, performance time, US, error rate, and the number of errors committed during the period of observation and recorded in the metric for further analysis (Gill 2008:101). Sometimes it is based on a particular progress scale (Jan 2001:131).

HCI is widely recognised by the industry and standards-related organisations, including the International Organization for Standardization (ISO) (Burgess 1984:141). Today, we are noticing an improved and gradual shift in the field (Lazar et al. 2010:254). The field is automatically shifting to a more updated and innovative computing environment and is constantly integrating new tools and techniques which may be needed to match new computing aspirations (Wurhofer et al. 2015:203).

Furthermore, it is common knowledge that the metrics were not appropriate for exploring some of the ICT then, and transforming some of its philosophy to today's computing world came with application limitations as it seems to be more about the ability to assess and measure UX (Wurhofer et al. 2015:203).

2.6.2 The role of HCI

The role and significance of HCI in the broad sense cannot be overemphasised as it guides and directs both vendors and developers of computing systems regarding the existing set of users' knowledge of usability, which is required to fully understand user needs and aspirations (Abdelrahman et al. 2015:376). It presents a set system of usability control, which may help guide the development of any new and existing GUI or computing device (Abdelrahman et al. 2015:376).

The twofold process is designed to pay attention to both the user and designer of any ICT device or tool and at all processing layers, such as at the physical level, built-in and self-installed software level, and, finally, at the interaction level (Abdelrahman et al. 2015:376).

The role of HCI is more about developing interaction between two major and independent compartments; namely the computing device and the human factor (Vermaat et al. 2016:101), or, as Preece et al. (2015:08) put it, "designing interactive products to support the way people communicate and interact in their everyday and working lives". This is the essence of interaction design and the role played by these devices when interacting with humans (Dingler et al. 2015:402).

Some may also see the role of HCI as a particular socio-technological artefact whose primary role and responsibility are to unleash the strength and capability of computing systems and inter-communication tools to become an accessible approach that is useful, working, and easy to learn, control, set up, and manage for communication and recreational purposes (Dingler et al. 2015:402). On the other side is cognition, which is the essence of the human ability to disseminate and bring all individual components together to form the HCI arena (Sorensen et al. 2015:410).

HCI is seen as a combination of social and technological tools as it pays attention to societal and environmental artefacts as well as immediate human environmental issues, or, simply put, "human need", and its role spans beyond some of the preconceived technological boundaries (Greenberg 1993:77), and into sub-areas such as "quality of life" (Kock 2010:101).

The role of HCI takes a different meaning; the presence, usage, and function of computing systems devices in fields such as medicine are real and undeniable (Kerren et al. 2006:67). Its ability to assist in the medical field and the results it may produce are as good as its usability, and poor computer usability may lead to death or the impairment of a patient (Kerren et al. 2006:34). Any computing system, regardless of its robustness and speed, is rendered useless if the people trusted with its usage are not adequately trained to control it (Monroe & Dugan 2015:418). Computing tools of any kind, regardless of their specifications, or any powerful medical computing system, can only be as effective as the medical practitioner's ability to effectively and efficiently use them (Lehmann & Staadt 2015:436).

2.6.3 HCI principles

The field of interactive design, just as any other applicable science field, comes with its own set of internal norms, guidelines, and principles, and anyone who engages with it must abide by these in order to bring into line the new design with an existing set of preconceived design principles. Doing so will alleviate the burden on all users; who, if these are not applied, will be forced to continually learn new usability techniques or unlearn existing usability techniques (Bellino 2015:231).

These designs principles affect the set of built-in features, physical size, form factors, and usability that all form part of the overall capability of the systems. Since computing systems may not all fulfil the same purpose, this set of capabilities would differ from one device to another (Bellino 2015:231).

One aspect which is significant here is the fact that all these principles are to some extent thoroughly researched and implemented from a developer's perspective before being implemented (Bellino 2015:231). Others may argue that the source of developers' inventions or innovations is the desire to develop computing systems that are as unique as possible, extraordinary, and never seen before. In most cases they are challenged by the current market offering and their inner ambition to overcome the challenge of competitors (Erazo, Pino & Antunes 2015:442).

As in many free markets, the first and the best "takes all" (Aregbeshola et al 2013:14). Most, if not all, developers are well aware of these rules and in most cases research into new products and the development team are continuously gearing their efforts to unleash the best regarding these endeavours (Erazo et al. 2015:552).

In pursuing these absolute computing interactivity tasks and goals, some outcomes, which are the final product outcome, may set users' usability skills on the back foot (Erazo et al. 2015:553). What makes any product unique are the types of features offered; however, users may sometimes become overwhelmed and fail to recall the basics (Erazo et al. 2015:553). In some cases, we do not only refer to the overall features as seen in most product advertisements depicting their importance, but rather to the impact that these built-in features may impose on interaction and later on the user (Zhang et al. 2015:570). The transition may not be as simple as one may think, but it is important to note that the more features any handheld computing system has, the more complex it becomes (Zhang et al. 2015:570) and the harder the learning process, adaptation, satisfaction, efficiency, and memorability are (Zhang et al. 2015:570).

These principles are imposed by system requirements which may not always be based on user interest (Zhang et al. 2015:570). An example of this phenomenon is the introduction of digital keyboards; as the size of handheld computing devices decreased, the number of built-in features increased, as well as the need to have more key strokes which could cover all letters of the alphabet. Some researchers started reviewing existing physical keyboards, and realised that it took more space on the handheld device than some physical displays, therefore there was a need to reinvent them (Ferreira, Anacleto & Bueno 2015:578). This led to innovative keyboards but also to more usability constraints (Ferreira et al. 2015:578).

Examples such as the above are experienced on a daily basis regarding handheld computing systems and all from the vendors' own perspective, and the end user on the receiving hand (Ferreira et al. 2015:578).

2.7 HANDHELD COMPUTING SYSTEMS

2.7.1 Handheld systems and screen rotation

This study intends to explore all aspects of handheld computing systems which may have an impact on users in general and adult first-time users in particular. Controlling a handheld device such as a tablet system can be extremely challenging; therefore this section discusses the issue of screen orientation of handheld devices.

The device on its own is light and physically small, therefore it may be trickier to operate than other computing devices. It also comes with various orientations which may confuse users (Albert, Tullis & Tedesco 2010:41).

There are two types of orientation: portrait and landscape. The portrait orientation displays the screen in a vertical form, enabling the user to see its contents in a more restricted or compact form, while landscape orientation is horizontal and wider regarding content display (Albert et al. 2010:42).

Before going into detail, it is important to note that users may prefer one orientation over the other, or the system may impose one orientation based on the physical position of the device (Albert et al. 2010:42-43). If the user chooses one form, it will remain as such until changed by the user (Forsell & Johansson 2010:60). These two orientations are important because users choose the type of orientation that is appropriate to the task they want to perform (Forsell & Johansson 2010:32).

For young and/or inexperienced users, controlling these features can be problematic, and even more so for an adult first-time user. It can be tricky to master how to hold the device with one hand and control the way it displays the content (Smith-Atakan 2006:47).

2.7.2 Handheld usability

A retort to this interrogation can be as simple as identifying anyone who may come into contact with any handheld computing system, and in this case, to be more specific, a handheld computing system such as a tablet or smartphone. Someone else may take the debate to a different dimension by classifying and grouping handheld computing systems according to their level of importance and type of contact with the computing device (Garcia-Sujuan et al. 2015:195).

More emphasis is placed on the roles of users regarding the design of computing systems, specifically regarding the reassessment of user roles from the elicitation phase until the implementation of the agreed design principles (Garcia-Sujuan et al. 2015:195).

The connotation of "user-centred" design seems to be one of the most significant principles that combine the overall user-computing principles (Garcia-Sujuan et al. 2015:195). Over the years, user needs have moved to the forefront on the scale of interaction design and user needs (Garcia-Sujuan et al. 2015:195).

It is obvious that handheld users are those who use a handheld device, but it goes beyond this one-dimensional definition by including, for example, those who manage direct users, i.e. people who, by their job description or position, must receive products or services from the handheld computing systems (Lee et al. 2015:607). It also includes people who, considering their close relationship with the user, may have to make the final decision to purchase the handheld device without being the actual user, as well as people who may have access to or use a competitive handheld product (Rogers et al. 2013:333).

That is how some scientists may primarily classify users, and over and above this detailed classification, some may also group them as primary users, which in this case are people who are directly and physically in contact with the device; or secondary users, who are occasionally in contact with or use the device; and tertiary users, who are to some extent affected by the release of the handheld device in question (Lee & Kim 2015:203).

In most cases, before reaching the outcome, which is the set of skills any user or potential user must possess in order to effectively and efficiently use a handheld computing device, any design team may have to explore primary questions such as: Who are the primary users? What are their current needs and aspirations? What is it they want to achieve? What are their possible levels of cognition regarding the availability of similar devices? (Lee et al. 2015:607).

2.8 THE USER

2.8.1 Adult first-time user

The primary target of this study are people perceived as the missing middle. These are people who are over the age of 18 and have no or little educational background. They are mostly employed in the informal sector and even though they have no previous computing skills, they want to know how computing systems work. They live in the rural areas of South Africa, yet still value the power of the Internet (Allber 1993:61).

Having stated the above and knowing the importance of having better computer skills, this study targeted this segment of the population because, in many other studies, researchers seem to be the targeted population (Lee et al. 2015:607).

The researcher explored and assessed the needs of the missing middle using a new form of computing system that has since become more popular than other types of computing systems and is therefore more approachable but may not be as user friendly as traditional types of computing systems (Winckler et al. 2015:211).

At first glance, given the number of people one may see on the street using handheld devices, and also given the number of these devices sold in shops across the country, many South African adults are currently using handheld computing systems (Winckler et al. 2015:211). This perception may be misleading given the fact that people who are contemplating using handheld devices do not visibly indicate that they need one, they do not live where we live, and very often they do not talk about it in fear of being humiliated (Winckler et al. 2015:211). They know the power of computing systems and some can even save enough money to purchase such a device; however, the issue is how to effectively and efficiently use it (Lucero 2015:231).

One of the most important characteristics of adult first-time users is the fact that they live in rural communities across the country, barely have a primary school education, are single parents, and do any informal work or work in the mines as unskilled labourers to survive (Argyle 1994:65).

The link between the existence of the digital gap and computer illiterate adults is the fact that they are counted as part of the overall population, and would always form part of it as long as they exist (Lucero 2015:231). At some point, political and social leaders would want them to form part of the greater group of computer literates so that they can gain access to all civil services which are fast becoming digital (Lucero 2015:231). They are classified as first-time users simply because they have never used a computing device before, even if the majority may have used outdated cell phones in the past.

The next section attempts to establish the link that may exist between the keywords of this study with the aim of clearly situating the research scenario.

2.8.2 User-centred approach

Designing and adopting any computing system in general and handheld GUI for popular use is one of the most important steps for designers, since not all users would agree or disagree on its interactivity. The approaches and views of users are as diverse as the people participating in the evaluation process; different cultures, religions, races, skill levels, experience, and the aspiration of the designer have to be considered (Yuan et al. 2015:249).

In most cases, GUI designers would take it on themselves to pass what they believe to be the most appropriate interaction onto the unsuspecting user (Yuan et al. 2015:249). Adopting a user-centred approach enables the interactivity development team to distance themselves from all possible divisions and diversions while focusing on the "user problem" (Gelderblom 2008:67).

Placing the user's needs at the centre of all preoccupations and establishing lasting solutions (Yuan et al. 2015:249), and considering the aspirations of the tangible user and not simply the type of mechanism, can be considered the driving force behind GUI interactivity and innovation (Duysburgh & Slegers 2015:292). The aim of the user-centred approach is combining all human skills, both natural and acquired, as well as rolling out consistent usability judgement to support users rather than limiting them (Preece, Rogers & Sharp 2002:44).

The user-centred approach takes some very important principles into consideration, which include early focus on users and tasks, empirical measurement, and iterative design. Preece et al. (2015:327) listed the following three characteristics of the user-centred approach:

- "**Early focus on users and tasks:** This means first understanding who the users will be by directly studying their cognitive, behavioural, anthropomorphic, and attitudinal characteristics. This requires observing users doing their normal tasks, studying the nature of those tasks, and then involving users in the design process."
- **Empirical measurement:** Early in development, the reactions and performance of intended users to printed scenarios, manuals, etc., are observed and measured. Later on, users interact with simulation and prototypes and their performance and reactions are observed, recorded, and analysed.
- **Iterative design:** When problems are found in user testing, they are fixed and then more tests and observations are carried out to see the effects of the fixes. This means that design and development is iterative, with cycles of 'design, test, measures, and redesign' being repeated as often as necessary."

These principles of the user-centred approach which were originally developed by Gould and Lewis (1985) seem to be widely adopted by the GUI and computing community as the basis of meaningful user-centred development. The priority seems to be on users' task aspirations and goals, and it pays close attention to users' behaviour and environment, which are the principles that highlight the priorities, preferences, and implicit user intentions (MacKenzie 2013:41). It also examines users' internal characteristics; users are consulted throughout the process of development and are invited to meetings when decisions are to be made (Preece et al. 2015:101).

Figure 2.4 highlights the roles of the user, which are very often misunderstood and poorly defined, if not misrepresented. Users are sometimes represented as consumers, who are known as people who consume or make use of a computing system and its related components (Tarkkanen et al. 2015:131).

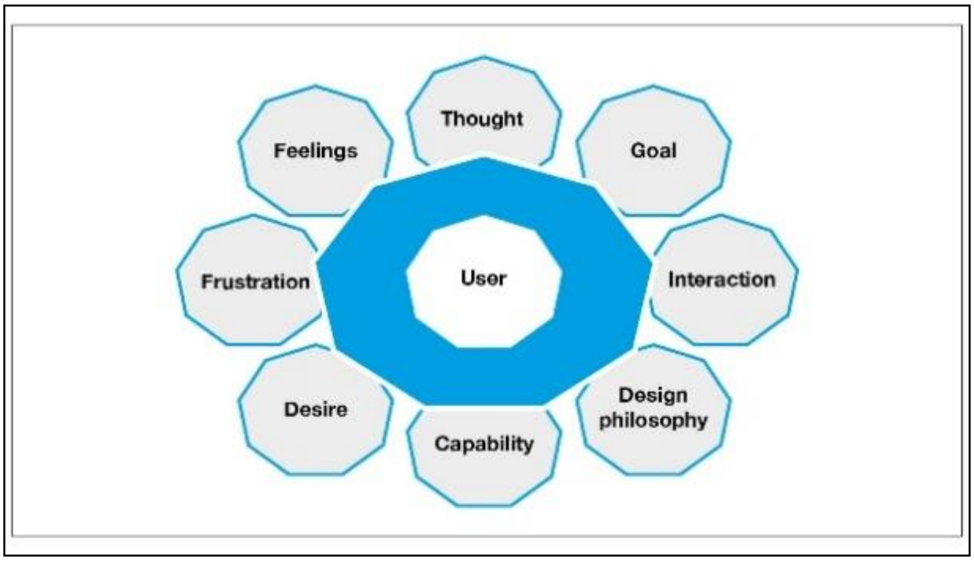

Figure 2.4: User-centred approach

Many other misunderstood aspects are closely linked to users, such as the fact that age and geographic area are not associated with level of systems knowledge and usability. This leads to the perception that if one is classified as a user group, one must be able to perform a certain amount of interactive activities, but the reality is that the level of interactivity is based on cognitive ability, which is linked to age, generation, and natural environment (Tarkkanen et al. 2015:131).

Older users may not be as interactive as younger users; in other words, someone who is over the age of 60 year old and who discovered computing systems less than 15 years ago may not be as well versed as a teen of 17 years old who started using computer systems when he or she was two years old; the same can be said about people from different living communities and with different income levels and education (Tarkkanen et al. 2015:132).

The next section discusses the issue of handheld usability and how it affects its user or, most importantly, its first-time users.

2.8.3 Usability: Role and responsibility

Computing system usability in the broadest sense refers to the ability to effectively and efficiently use any computing system or equipment that requires human interaction or any other third-party equipment in order to provide or receive instructions which are needed for the successful completion of the machine's intended operation (Dermody & Farren 2015:499). Computing systems usability is very important during all the stages of system development and is taken very seriously since it may determine if the final system or product can be used or not, or if it will be accepted or rejected by the intended users (Dermody & Farren 2015:499).

A general perception of the public is that system usability and friendliness are only meant to explore the interaction between humans and machines. This is not entirely accurate, since it also considers how some devices interact with third-party computing devices of the same or different nature with the aim of achieving a particular goal (Dermody & Farren 2015:499). The most remarkable example of interaction between two distinctive computing devices is an independent monitor screen and a laptop system. The two devices need each other in order to fully function. All computing operations are done on the system unit housing the processor and the other interactive unit, while the displaying role is confined to the display screen (Lee et al. 2015:607).

This specific research study focuses particularly on a section of the human usability of computing systems, and more specifically on systems usability, i.e. how a handheld computing system is particularly used by a certain group of the population (Lee et al. 2015:607).

Some users are fast learners, while others are rather slow but can still retain instructions. The purpose of testing one's usability skills may not be to see whether or not someone may easily complete a task within a specific period, but rather how long it may take a user to adapt to the particular computing system and use it with ease (Lee et al. 2015:607). The ability to master any new utility instrument lies in the user's ability; one may look at the physical aspect, psychological state, and the age group of the user (Heinicke et al. 2015:514).

Further exploration of the physical aspects may lead to how the device is developed, its size, and the exterior appearance of the device. The aesthetic aspect of the device is one of the contributing factors that may hinder the adoption of any computing system (Heinicke et al. 2015:514).

On the psychological side, the ability of any user to adopt a device lies with the current state of mind, i.e. what the user is thinking at the time. This aspect is well outside the scope of this project but one may list factors such as how the user feels at the time, or the cognitive psychology of the user, and all types of technological intimidations that may influence the user during the learning process (Heinicke et al. 2015:514).

Regarding the age group aspect and the impact that it may have on the whole process, it is important to note that this is one of the most important factors that play a very important part in terms of computing systems. Nowadays, younger people find it easier to adapt to new technology than adults. The younger the user group, the better their ability to adapt to and adopt the new computing device (Heinicke et al. 2015:514).

Figure 2.5 shows the entities that surround usability.

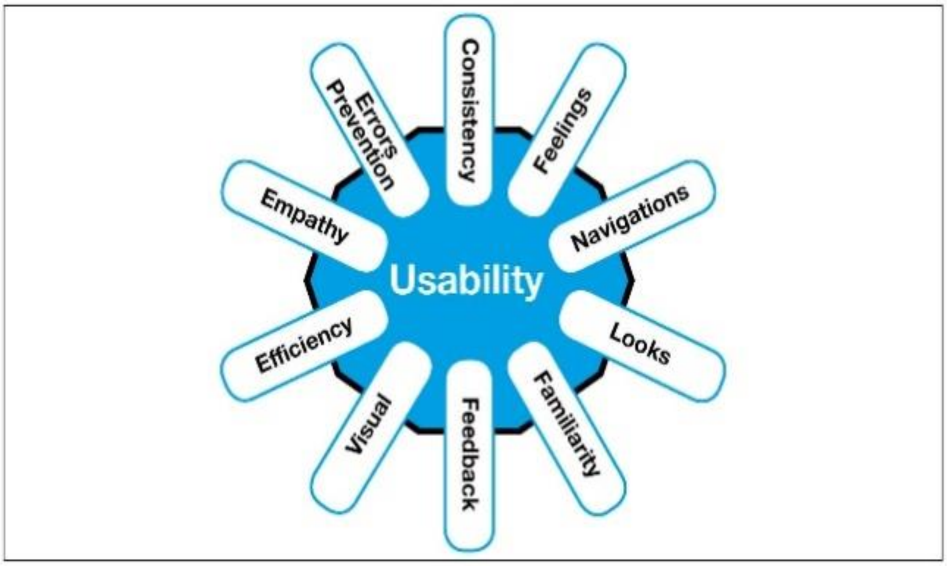

Figure 2.5: Usability approach

Usability skills are not as simple as the ability to move the cursor from one corner of the screen to the opposite corner, but rather a continuous inner ability to effectively and efficiently control or use a computing system. This involves many other aspects such as visual clarity, feedback, familiarity, looks, navigation, feelings, consistency, error prevention, empathy, and efficiency (Albert et al. 2010:47).

As the world is constantly discovering new electro-machinery that requires human interaction, new terms are also emerging to describe how they must be developed in order to fast-track adaptation and adoption. One of these terms is universal usability, which describes usage steps that are generic enough to allow anyone to manipulate a system without having to spend a considerable amount of time to learn all the procedures as relying on intuition to complete the tasks at hand can be useful (Al-Megren et al. 2015:78).

Other schools of thought simply describe universal usability as good, plain design; in other words, interface design that is simple and easy to work with, and interactive design that is based on natural human metaphors and easily made to enable its user to constantly create the link with its closed atmosphere (Ballmer 2010:38). Although the most simplistic and accommodating approach is to describe usability simply as good, plain design, can we merely call it that? That rejoinder may come from the statement that system usability comes with more sub-aspects and that simply developing perfect GUI during the development stage is widely debatable (Ghosh & Pherwani 2015:529).

The usability-related aspects of any computing system's GUI or interaction require considerable research time during all phases of growth and is a never-ending cycle (Ghosh & Pherwani 2015:529). The importance of usability is entrenched in computing systems' GUI development that designers need to consistently pay attention to. This includes components such as learnability, which is the user's ability to explore, and how easy it may be for any first-time user to complete a particular process and repeat it without having to learn it all over again (Ghosh & Pherwani 2015:529). Efficiency, on the other hand, explores the action of any user to determine if they are able to accomplish the task they initially intended to accomplish (Ghosh & Pherwani 2015:528).

Memorability plays a very important role regarding systems usability. It examines the process to determine if the user should recall all the steps all of the time, or if after being away from the GUI system for some time they would be able to complete the same tasks without complications all over again (Mayas et al. 2015:537). Errors or erroneous processes, which deal with how often users make mistakes (once or consistently), how often they repeat these errors, and the severity of those errors, are all part of memorability (Mayas et al. 2015:537).

Finally, the level of US deals with how good the users feel about themselves after completing these tasks and whether it was a pleasant experience or not (Mayas et al. 2015:537).

Figure 2.6 shows the alignment between usability, user, and utility, which is essential regarding better control of computing systems. The user may not find a computing system suitable if it does not provide any utility. Utility only provides meaning if the system is able to be exploited by the user through any usability technique (Mayas et al. 2015:11).

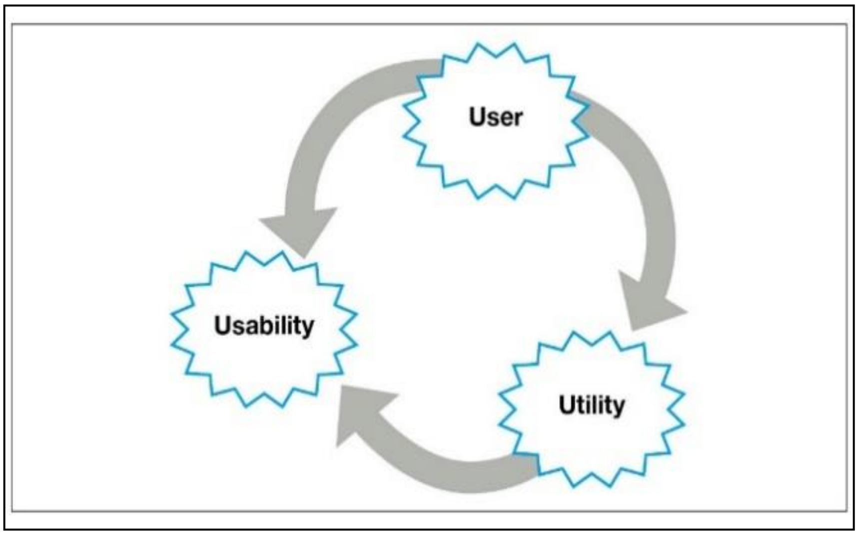

Figure 2.6: The user-usability-utility alignment

Regarding system usability and especially interaction design, a designer always needs to consider the following ten heuristics, which include the visibility of system status. The question is whether the handheld system always keeps its users informed about what is happening or whether it provides feedback when needed (Nielsen 1995:170).

Does the handheld interaction artefact match the real world, does the computer interact with real users or people who live in their natural environment, or does the system for some reason speak their language or use acceptable language deviation, and use their concepts? (Mubin, Mahmud & Shahis 2015:542).

Handheld user control and freedom simply mean enabling the user to correct themselves without having to go back to the initial window. Developing an interaction that spans across several windows may be ideal, but sometimes users may find themselves in some area by mistake and want to leave without having to go back step by step (Mubin et al. 2015:542).

Consistency and standards are the true essence of popular tools and machinery. Whenever a designer designs or develops a tool that would be used by the masses, the designer must ensure that it is consistent and standardised as many experienced users would always refer to their existing and stored knowledge when approaching a new artefact (Mubin et al. 2015:542).

Error prevention is also of the utmost importance. As stipulated above, the interaction must be designed with some form of guideline, or be fool proof, to prevent the user from making unnecessary errors which create avoidable frustration (Mubin et al. 2015:543).

Recognition rather than systematic recollection: Users, especially first-time users, are often bogged down with many usability recalls (Lazar 2007:36); these are things that users must recall regularly in order to continue using the systems, so the system development should at all times ensure that the recollection artefacts are in place to guide the decisions of the user (Shahid & Mubin 2015:555).

Flexibility and efficiency of use: Good interaction at some point will have to cater for all users, which also include expert users, i.e. those who know better about how the systems work and do not have to go through all the basic steps all the time in order to be effective (Shahid & Mubin 2015:555).

Aesthetic and minimalist design: Some call it the "look and feel" of the system, which is the first focal point where people decide if they want to hold the device for the first time. Designers may spend a considerable amount of time improving on this area as it is the first aspect that draws the potential user's attention (Shahid & Mubin 2015:555).

Helping users to recognise, diagnose, and recover from errors: No interaction designer will be able to cater for all users, and not even the best interaction designer can prevent even the most experienced user from making mistakes. It is essential that all possible forms of assistance are incorporated during the design process, and more importantly, that designers are able to recover from their mistakes with less setbacks (Shahid & Mubin 2015:556).

Many decision makers believe that by simply providing adequate financial funds for solving a problem, the problem will automatically be solved. A good example is the Indian version of the tablet; despite the funding, the second version produced in 2012 still has usability hurdles that were encountered in the first version (Akamatsu et al. 2015:569).

One may argue that this is how all ICT projects are conducted these days; however, many problems can be avoided by conducting proper and purposeful research before starting with production (Akamatsu et al. 2015:569).

It thus appears that research using actual users was not conducted in order to establish user "usability" level or design with a "user-centred" principle, which are important considerations regarding any computer system project. Financial and technical feasibility studies were considered more important than "usability" feasibility. Figure 2.7 places the issue of system usage at the centre of productivity.

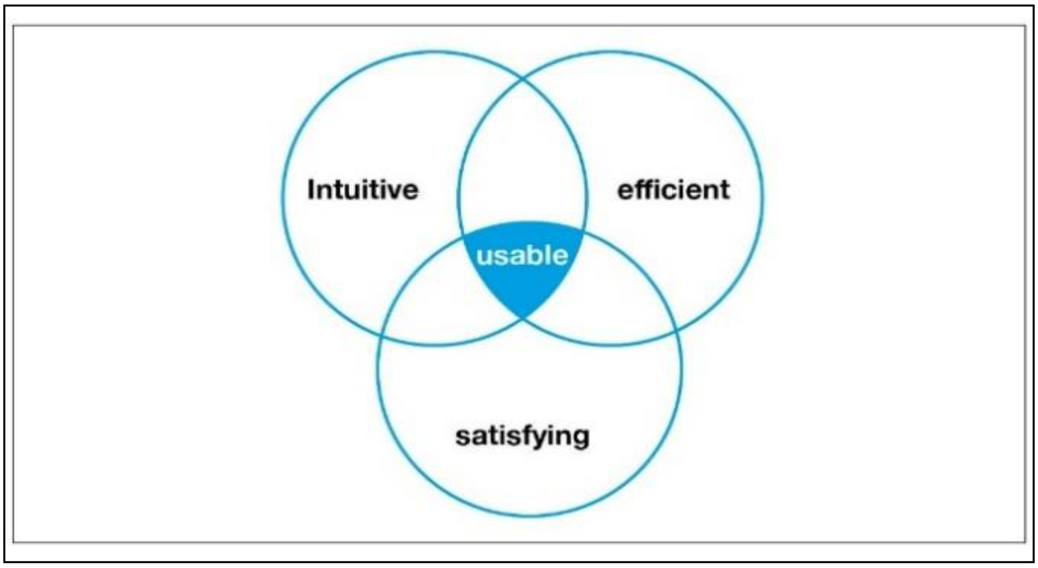

Figure 2.7: Usability of computing systems

Figure 2.7 enables us to identify the single point of unification between three important aspects of computing. The first is intuition, which is the essence of usability. It enables the user to not solely rely on learned functionality, but also on current brain feedback (Akamatsu et al. 2015:569). The second aspect is satisfaction, which comes from a sense of accomplishment after performing a particular task. The last aspect is efficiency, which is the feeling of having completed a task the way it was meant to be completed. All three together, and when juxtaposed, leave a missing middle, which is the usability of the systems (Akamatsu et al. 2015:569).

2.8.4 UX and the role of the metric

UX is slowly becoming an independent subfield within the HCI spectrum. Many new HCI or interactive researchers are becoming interested in this field solely based on the fact that it is becoming an increasingly important issue within the usability field (Yu & Kim 2015:550). It contains some very intriguing aspects of interactive system development or, more specifically, GUI design characteristics.

UX is the central piece of any form of interaction development regarding a computer system (Yu & Kim 2015:550). One will not be wrong in stating that UX encompasses how any user deals with a device, or how any user feels while interacting with a device (Yu & Kim 2015:550). UX is described as a binding concept that reflects the services offered, the actual device, and the developing team, all of which later create user anticipation and execution of the ultimate prototype or product (Yu & Kim 2015:550).

It may be naive to blindly state that UX is simply about good industrial design, multi-touch interactions, or a fancy interface, rather than a perception that transcends the physical material, and more about creating or inventing an emotional experience and contact through the handheld computing device (Yu & Kim 2015:550). This includes any device, regardless of the type, design accuracy, degree of interactivity, and robustness of its internal memory, processing speed, and cost of acquisition (Ni, Al Mahmud & Keyson 2015:546).

Lasting emotional experience of the user is a sort of ultimate "baptism" the user had when interacting with handheld computing systems such as a tablet for the very first time and that may be a profound experience for a first-time user (Ni et al. 2015:546). It creates UX in the true sense of the word.

UX involves a user's deep emotions about and devotion to the computing product, and highlights the experiential, affection, connotation, and value factors of the HCI aspect of the device (Ni et al. 2015:546). It involves the sensory effect a user may feel after touching or tapping a particular link or pressing on a particular task; for example, how it feels after clicking a button, tapping on a particular icon, and how text is displayed after keys are pressed. Nevertheless, it should also be stressed that during computing systems development, it is almost impossible to design "any UX", but one may design "for UX" (Ni et al. 2015:546). It simply means that even the best designer may not design a sensual experience but rather include some particular design features that may have a sensual effect on the user (Day, Buchanan & Makri 2015:578).

At times, UX may be subjective in its natural sense. It is more about individual views and imagination with regards to the system versus the known experiment, and at times designers immerse themselves in the user's natural environment to emulate their line of thinking. It may also be dynamic as it is constantly modified over time due to changing circumstances and new publications on the subject (Day et al. 2015:578).

It is impossible for a designer to sit for days on end to design any UX. No designer can create it by simply documenting it, but the ideal design may come as a designer applies it, in other words by doing it (Day et al. 2015:578). In any true and acceptable GUI design, there is a need to design a product that offers the best UX for any potential user. The magnificence of any product first comes from its external physical appearance and then from how the user feels after touching it for the very first time (Leo de Oliveira, Miletto & Flores 2015:590). It is an empirical goal to develop a product that does what it is supposed to do and make sense to the user; a device that has all the best and innovative features one may wish for. However, this may no longer be enough because the designer also needs to develop devices that are understandable, usable, exciting, and fun for its user while also making it user-friendly (Leo de Oliveira et al. 2015:590).

McCarty and Wright (2010:212) wrote the following:

> "There are four core threads that make up our holistic experience: sensual, emotional compositional, and spatio-temporal:
>
> *The sensual thread*: This is concerned with our sensory engagement with a situation and is to the visceral level of Norman's model. It can be equated with the level of absorption people have with various technology devices and applications. Most notable being computers games, smartphones, and chat rooms, where users can be highly absorbed in their interactions at a sensory level. These can involve thrill, fear, pain, and comfort.
>
> *The emotional thread:* Common examples of emotion that spring to mind are sorrow, anger, joy, and happiness. In addition, the framework points out how the emotions are intertwined with the situation in which they arise. Example: a person becoming angry with a computer because it does not work properly. Emotions involve making judgements of value. For example, when purchasing a new cell phone, people may be drawn to the ones that are most cool-looking but be in an emotional turmoil because they are the most expensive. They cannot really afford them but they would really like to have them.
>
> *The compositional thread*: This is concerned with the narrative part of an experience as it unfolds and the way a person makes sense of it. Example: when shopping online, the option laid out to people can lead them in a coherent way to making a desire purchase or they can lead to frustrating experiences resulting in no purchase being made.
>
> When in this situation, people ask themselves questions such as: What is this about? Where am I? What happened? What is going to happen next? What would happen if…? The compositional thread is the internal thinking we do during our experiences.

> *The spatio-temporal thread*: This refers to the space and time in which our experiences take place and their effect upon those experiences. There are many ways of thinking about space and time and their relationship with one another. Example, we talk of time speeding up, standing still, and slowing down, while we talk of space in terms of public and personal places, and needing one's own space."

The UXM is of extreme importance in comprehending how user assessment must be conducted; the current absence of reliable forms of evaluation is paramount to the total absence of control mechanisms in a society which needs to evaluate almost all types of activity. A well-built metric can address the issue of subjectivity that is observed regarding user computer skills.

2.8.5 Handheld user challenges

Regarding handheld computing devices, users, especially first-time users, must first deal with the challenges of having to physically control the device with one hand and having the other hand operate it while moving around or standing still (Lee et al. 2015:607). Whether the user is left- or right-handed, the challenge is the same; only one hand is freely available (Lee & Kim 2015:203).

The other challenge that any user faces is the actual interaction; whether using the stylus or the finger to tap, the user needs to think very carefully about how the systems might react. At times the link may not be as visible as the user may expect, or their adult fingers are too big for the contact point where one needs to tap, which results in selecting and accessing undesired targets (Liang et al. 2011:607).

Navigation is one of the most difficult aspects to control for most adult first-time users. Some may have had basic traditional computing experience and may want to navigate in the same way as when using their desktop computing system, but they will still be confronted with unexpected mobility problems (Marquardt 2015:644). Controlling tabs for some may be as hard as any other navigation problem; they may want to return to the main screen without using an external button (Marquardt 2015:644).

The most common hurdle regarding handheld computing systems and first-time users is the emotional aspect during the interaction. Most are fearful of the device, while others, although they are current cell phone users, cannot clearly see the link between the tablet system and their cell phone (Marquuardt 2015:644) and tend to move away from their existing cell phone's usability knowledge and try to use the tablet as if it were a completely new device (Marquardt 2015:644).

Figure 2.8 displays three ways in which tablets can be handled and manipulated. For most ICT experts, this is why using handheld devices is so hard, as users must not only hold and control the device but must also interact with it. One should also know if the user is left- or right-handled in order to use the system because his has to do with system orientation and control.

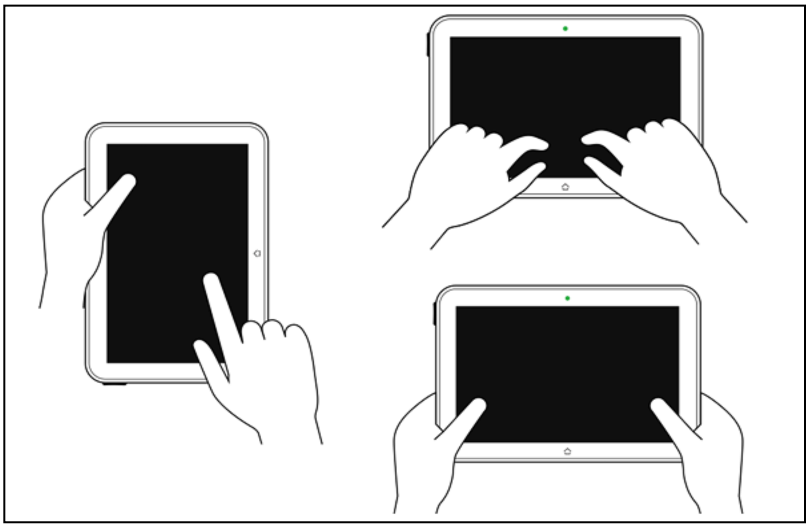

Figure 2.8: Types of interactions with tablets

Source: Duncan (2015)

Figure 2.9 shows a user with incorrect and unhealthy posture. This posture will cause the user's neck, back, and wrists to suffer. It also shows that only one hand is used to physically control or hold the device, and only one hand is left for navigation.

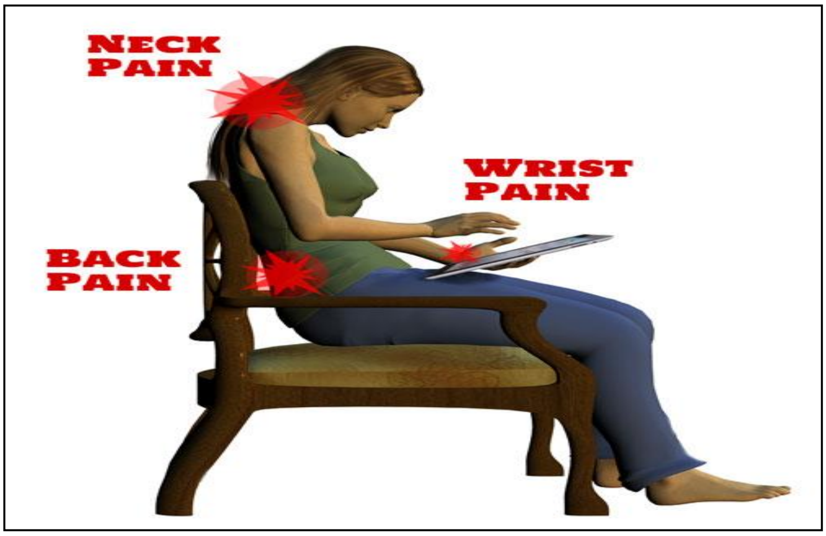

Figure 2.9: Handheld and posture problems

Source: Duncan (2015)

2.9 INTERACTION WITH HANDHELD SYSTEMS

HCI is a subfield of computer science which focuses on the relationship between humans and computer systems. Lazar et al. (2010:300) stated,

> "The field of HCI is really an amalgam of other fields, including computer science, sociology, psychology, communication, human factors, engineering, industrial engineering, rehabilitation engineering, and many others. This is what makes HCI such a fascinating area of study and, at the same time, so complex."

In this research study, the main focus is on handheld systems. HCI is an important area of this study because many users of handheld devices complain about numerous physical aspects that make it extremely difficult for them to operate or use the system in the most effective and efficient manner (Saund & Lank 2003:2014). The very first thing any new handheld user has to learn is to use one, two, or three fingers, depending on the action or stylus, to select items or icons rather than using the traditional keyboard and mouse (Lazar et al. 2010:161).

According to Lazar et al. (2010:180),

> "In the current context, where everyone is using computers, that may sound a bit odd, but back in the 1970s, almost no one outside of computing, engineering and mathematics specialists were using computers. Computers were not in school classrooms, they were not in homes, there were no bank machines or airline check-in

> machines, before this shift towards non-engineering use. This shift created the sudden need for the field of HCI."

Thus we now have to renegotiate our relationship with new computer systems once again (Silberschatz, Galvin & Gagne 2011:41). The primary aim of HCI is to assess, plan, develop, and design the interaction between people and computer systems, and in this particular case – the handheld device. HCI is sometimes described as the psychology of human-computer relationships (Ahmad & Shahid 2015:436). It takes a look at both the hardware and software systems, as well as the environment, the physical size, humans, ergonomics, and the social impact with the sole purpose of creating and improving better interaction between humans and machines (Ciccarelli & Faulkner 2006:109).

2.9.1 Ergonomics of handheld computing systems

Ergonomics is a science that explores the relationship between humans and computers, or machines and the immediate working environment. To be more precise, it explores the connection between a human and a working instrument that is located in the user's workplace or living environment (Zhou, Jung & Chen 2015:550).

In this case it looks at how humans utilise any form of mechanical or electronic instrument without physically or morally compromising themselves in the true sense of the word. An example is the posture that one takes when sitting in front of a computer. The height of the chair and the table must be at an appropriate level to avoid hurting the user's back in the short, medium, and long term (Zhou et al. 2015:550).

Ergonomics is mostly stipulated by the Department of Labour and concerns a safe working environment regarding the analysis, planning, development, implementation, and maintenance of a safe and enjoyable workplace (Zhou et al. 2015:550).

This particular study investigated the relationship of handheld users and tablet systems, focusing on adult first-time users as they interacted with computing systems, and what impact it may have on adult users who may have only a single hand to hold and operate the device. The study also asks questions such as: How easy would it be for people who never used the system before to move from one point to the next, and how many errors will they make? What is the speed like? To what extent can the user freely navigate around the GUI without affecting their physical posture? (Zhou et al. 2015:550).

The purpose of including ergonomic study in any form of computing system investigation is to ensure that the end user's needs are protected and that the devices meet safety requirements as prescribed by various local medical councils and best labour practices (Shibata et al. 2015:559).

Figure 2.10 shows some aspects which are important regarding understanding the relationship between humans and computing systems. The first and most critical aspect is how to handle or hold the device and how to position it relative to the user (Shibata et al. 2015:559).

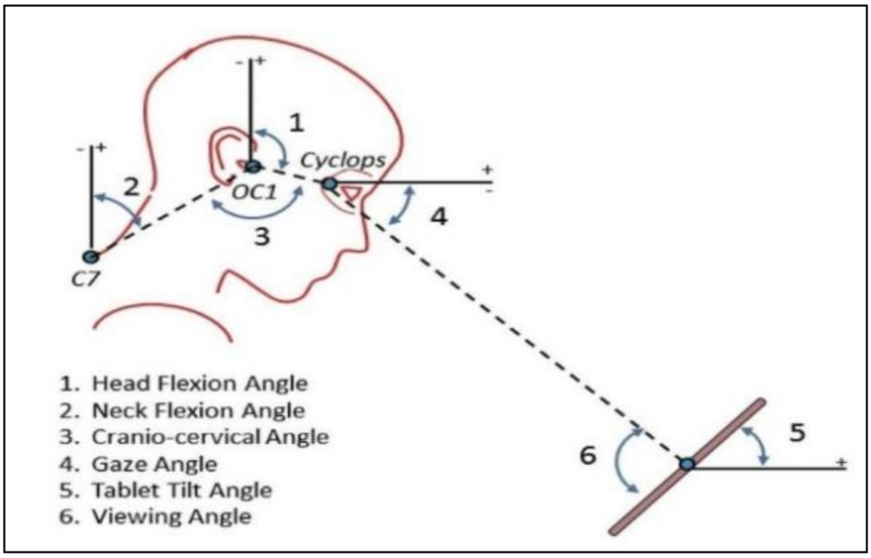

Figure 2.10: Ergonomics regarding the position of a handheld device

Source: Duncan (2015)

The figure above shows the viewing angle and the tablet tilt angle. The user's ability to clearly view the content depends on the movement that occurs when the head moves to feed the viewing angle. The head flexion, neck flexion, crania-cervical, and gaze angle in the figure are, however, outside the scope of this particular study.

Figure 2.11 shows two figures in a standing and sitting position. The important aspects in this picture are the height of table, the sitting height, and the viewing position of the user. All these aspects must be taken into account when research and design are undertaken (Shibata et al. 2015:559).

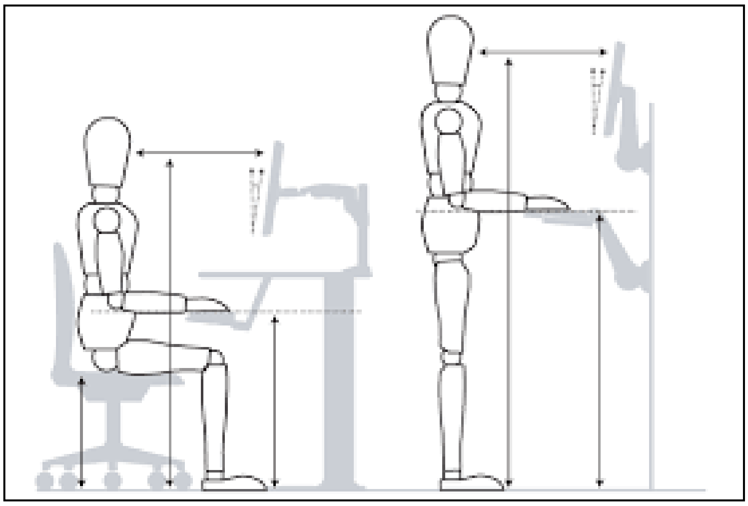

Figure 2.11: Appropriate standing and sitting height

Source: Seitz (2015)

Figure 2.12 shows a user in four positions that are all possibly challenging and may lead to different forms of physical damage if done for too long.

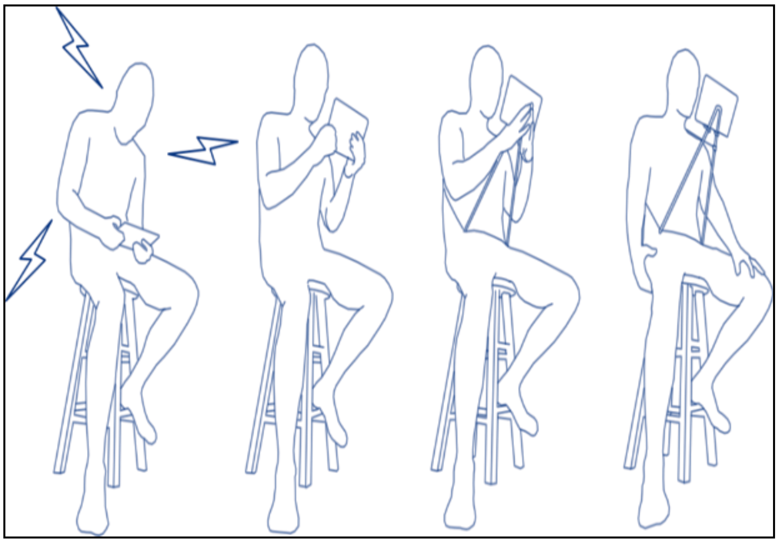

Figure 2.12: Inappropriate postures

Source: Seitz (2015)

2.9.2 Tablet system interaction problems in the South African context

According to Garth (2012), a sales manager at the Incredible Connection computer and accessories chain in South Africa, which has over 60 stores countrywide, between January 2014 and January 2015 alone, 384 handheld systems were returned to their shop due to mishandling, 189 handheld systems were returned due to user frustration, and 525 handhelds were returned due to dissatisfaction and usability problems. It is important to note that the total number of items sold are not known or were not released but any item which was returned due to poor usability is one too many. This all happened within a period of one year and thus these figures are rather alarming; particularly considering the unit cost per device.

Figure 2.13 shows an embedded set of components, which are essential to mastering the triangulation of computing systems and their natural environment. In the inner circle, there are three important participants: the user, technology, and the task. In the outer circle, there are satisfaction, efficiency, memorability, error/safety, flexibility, learnability, effectiveness, and satisfaction.

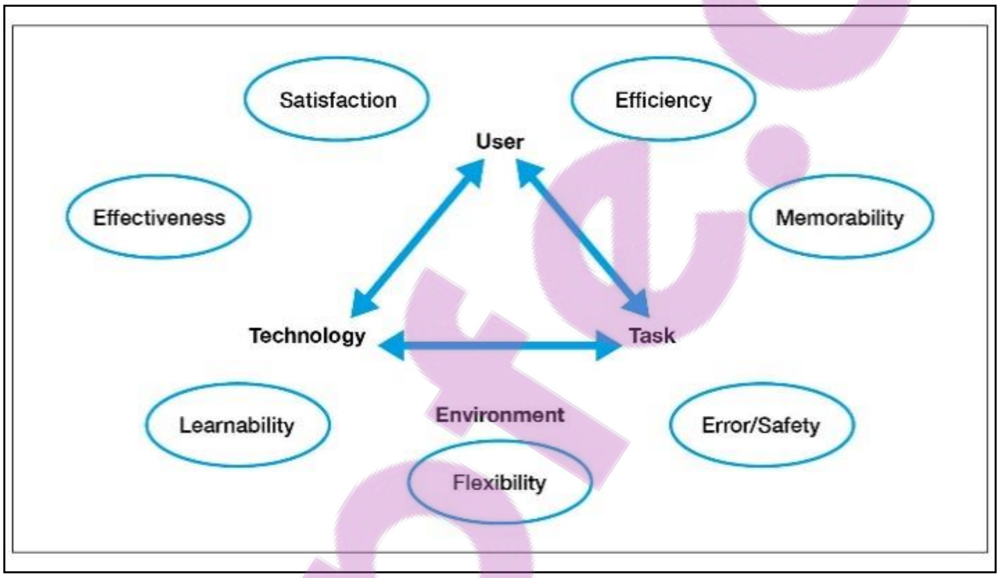

Figure 2.13: The user's role in the triangular relationship

Returning to the issue of tablet usability problems, with the introduction of the handheld system came a paradigm shift involving a radical change from a traditional computer system to a miniature handheld system. As a result, new HCI research must still be conducted (Birkhofer 2011:61).

Lazar et al. (2010:352) wrote:

> "Every time there was a shift in focus of research, there was a need to adapt or develop new research methods. HCI isn't a research area with 100-year history. So whenever a new research approach is needed, it tends to be adapted from existing research methods in other fields, primarily the social sciences and engineering. Research methods in HCI are always changing, developing, and improving."

When planning any form of computer interface, adequate tests must be conducted to ensure that all necessary navigation aspects are taken into consideration, or that strict and existing GUI methodologies are followed, always placing the user's needs at the centre of interaction development, as Figure 2.13 indicates (Birkhofer 2011:66). This does not only apply to GUI but also to the physical aspects of the device, therefore a new interactivity term was coined – "user-centred design". The major paradigm shift is a result of many technological phenomena around us, such as the fact that "the focus is not on workplace efficiency anymore, but about whether people 'like' an interface and want to use it" (Bootsma, Fernandez & Motted 2004:812).

All design principles must be taken into account regarding any computer interface; for example, ensuring that the output is legible or audible, avoiding absolute judgment limits, as well as other design principles such as top-down processing, redundancy gain, the use of discriminable elements, and the principle of pictorial realism (Birkhofer 2011:72). Other principles include the principle of the moving part, the reduction of information access cost, the proximity compatibility principle, the principle of multiple resource, the replacement of memory with visual information, the principle of predictive aiding and, finally, the principle of consistency (Smith-Atakan 2006:16).

Some of these guidelines are not followed or applied regarding many handheld systems' GUI design and could well be one of the reasons many users cannot fully take advantage of their handheld system (Birkhofer 2011:13). According to Lazar et al. (2010:355),

> "As the Internet and the Web gained wide acceptance, there was a need to research new types of interfaces and communication, such as web pages, e-mail, instant messaging, groupware, and handheld systems. This caused an increased number of research fields to be included under the umbrella of HCI, especially communication."

During the early days of HCI, evaluation and assessment were based on standards of human ability to perform tasks based on human factors and Internet psychology. During this time the important questions were: How long would it take for a human to complete a task? How many tasks were completed satisfactorily? How many errors were made? These are still important factors and still form the basic measurement of computer system usability (MacKenzie 2013:56).

Assessments today are based on a "task-centred" efficiency and effectiveness model, where a specific assessment can be singled out, quantified, and measured (Molina et al. 2010:410). These "metrics" can very well include task accuracy, performance time, error rate, the time it takes to learn, retention overtime, and, most importantly, US; to mention just a few (Baron & Byrne 2003:11). These are just some of the approaches that were included in the proposed research study but with specific focus on adult first-time users.

2.10 DIGITAL DIVIDE IN SOUTH AFRICA

This research study was conducted in South Africa and within the South African context, taking into account local reality. All the participants were located within the borders of South Africa and therefore it is important to explore its landscape to see what makes it so unique as to justify conducting an entire study.

South Africa is a country on the African continent, with a population of just over 55 million people, according to 2015 statistics. The country is the southernmost country in Africa and borders Botswana, Namibia, Zimbabwe, Lesotho, Swaziland, and Mozambique (Lester et al. 2010:1840).

Even though the country has a rich heritage, after nearly 24 years of the new political dispensation, the nation is still as divided as it was during racial segregation; this time not based on race but rather on the overall distribution of the country's internal wealth (Lester et al. 2010:1840). Those who "have", "get a lot", and those "without", are "left out" (Ballard & Linton 1997:39). The socio-economic status gap is also evident in other sections of the South African society, such as access to better and higher education, healthcare, better living conditions, housing, technology, and the labour market (Lester et al. 2010).

On the technological front, the country does not envy other developing or developed countries as it has access to the latest and most advanced technological infrastructure compared to developed countries (Lester et al. 2010:1841).

The more balanced socio-economical approach as promulgated by the current state leadership still falls short of eradicating the past social and economic imbalances (Maylam 1995:20). Or, one may also say that the more inclusive socio-economic systems implemented during the past couple of decades are still inadequate to eradicate the history of single-sided poverty. As a result, many are still living in impoverished conditions with very little to hope for (Maylam 1995:20).

The overall level index of development seems to be propelling the nation ahead of many other African nations but many of its citizens cannot catch up with its pace as valuable and life-changing information can increasingly only be found online in electronic format. Access to the Internet is almost becoming an obligation, but many cannot afford it, and those who can, may not use it properly as it may well be the first unique piece of technology for them (Maylam 1995:20). Those who for some reason missed the ICT education drive in their youth are now observing the latest developments from a distance and want to join in, but system usability prevents them from doing so (Naidoo 2010:170).

Educating the masses on the virtues of ICT and the link to improved living conditions is becoming a certainty, but the reality is that it seems easier to teach a first-time user who is under the age of 18 than a first-time user who is older than 18 (NEPAD 2014:4). In other words, the younger the first-time user, the better (World Bank 2015:3). It is even more difficult if the person has entered the informal labour market in search of living income without any computer literacy or formal education (NEPAD 2014:7).

The digital divide does not reflect solely on the digital side of the equation, but it starts from the economic side to reach the technological sphere of the other side of the equation. The first priority of people without money would be food and shelter and not technological gadgets (NEPAD 2014:6).

The next section discusses the negative aspects of the digital divide and explains how it originated.

2.10.1 The negative impact of the digital divide

Living in a society where almost all information is located on the Web brings new challenges for the people of that society. More often than not, policy makers may not fully understand the depth of difficulties ordinary citizens face regarding accessing this information. The digitisation initiative is highly applauded as it aims to limit the state budget and save the environment; however, it is unclear if this will help everyone (NEPAD 2014:7).

Many citizens still live in rural areas where they hardly have access to electricity and clean running water, and their local schools rarely have access to basic library facilities in a society where digital study material is becoming a reality (NEPAD 2014:7). The negative impact of the digital segregation on these poor and neglected segments of the population is immense to the extent that some learners may not even have access to their final examination results simply because they do not have access to the Internet (NEPAD 2014:7).

Many state agencies that provide services to the general public are avoiding printed application forms simply because it costs them money, and also because it helps them be, or appear, environmentally friendly. Unfortunately, they send all their clients to their online portal services without always thinking about those citizens who may not have access to the Internet (NEPAD 2014:7).

Many people are looking for better living conditions – striving almost every day to find any form of employment that may help alleviate their poor living conditions. However, nowadays even looking for employment is digitalised and only those with access to technology such as the Internet can apply for work opportunities online (NEPAD 2014:7).

The list of negative aspects that may hinder the self-expansion of individuals because of the lack of access to the Internet is vast and cannot all be mentioned in this research. People hold the importance of a computer system and its ability to improve their living condition close to their hearts (Molawa 2009:10).

Having established some of the negative aspects which may be associated with poor or lack of access to computing systems, it is important to note that providing computing systems only to those in need may not translate to the complete eradication of the digital gap; the gap does not exist simply because people do not have access to computing systems (Hill 2007:111). On some level it emanates from the ability of the recipient to acknowledge its usefulness and act on it (Molawa 2009:10).

Before anyone can address the existence of the digital gap in any society, analysing and understanding its root causes are equally important. Social inequality is clearly one of the root causes, but considering the high availability of low-cost mobile computing systems these days, this argument does not hold water (Molawa 2009:10).

Most people do not use these devices simply because they are afraid of technology or do not know how to use them, and regarding handheld systems such as tablets, people are even more uncertain about how they work (Molawa 2009:11).

2.11 ADULT FIRST-TIME USERS OF HANDHELD COMPUTING DEVICES

This study mainly focuses on adult first-time users; this includes mature users who for some reason are learning to use handheld computing systems such as a tablet for the first time, and, most importantly, are people who are bound by their current geographical area.

In this study, the researcher examined potential participants from the remote and impoverished rural areas of South Africa, as well as people who see the importance of computing systems and the Internet in their daily activities but for other reasons than not having access to computing systems, do not use them. Some of these reasons are a lack of knowledge, poor literacy and numeracy, low levels of education, and extremely low ICT penetration where they live (Sikhakhane et al. 2005:44).

When exploring overall computing usage and the closing of the digital gap, one may have to take many other parameters into account, such as the number of new users entering the existing pool; this number can be very high if a comprehensive ICT penetration study is conducted (Sikhakhane et al. 2005:44).

Further investments are needed in this new human development area in order to fast-track social and economic aspirations (Sikhakhane et al. 2005:43). The local population aged between three to 18 years old who are still attending school seem to be more computer literate than their older counterparts, who left school a few years ago while partially or not fully computer literate (Naidoo 2010:41).

First-time computer users in most developing nations such as South Africa are confronted with various complex issues which may not be directly connected to their ability to access a computer system. When one explores the social environmental aspects of potential first-time users, one should not overlook issues such as the high cost of some types of computing systems. As a matter of fact, many ordinary workers still cannot afford to purchase a standard handheld computing system for their children since many households only have a single breadwinner (Naidoo 2010:60). Some may not have any formal income at all (Tlagadi 2007:2) and rely on state grants for their day-to-day survival, and those who may be employed in the formal sector, such as mineworkers, may earn as little as R5 600 a month, which may not be enough given the fact that a commercialised tablet system may cost as much as R3 500 (Tlagadi 2007:2).

On the other hand, some may argue that the cost of a tablet system is subjective, as low-cost tablets are available, and while they may not be well-known brand names, they can still do all the tasks their more expensive counterparts do (Tlagadi 2007:2). While the cost of these devices is a major deterring factor regarding the access to these computing systems, having gained access to these gadgets, recipients must still be able to use them in the most effective and efficient manner (Tlagadi 2007:2).

The next big issue that one has to deal with regarding handheld computing systems and the digital divide, is the issue of Internet access. In this aspect, one has to examine issues such as the type of connection needed and the corresponding cost (Morris et al. 2001:150). Having access to the physical device only may not assist in producing, developing, and maintaining new users because the ability to connect to the Internet is also one of the reasons people want to become computer literate (Morris et al. 2001:150). Access to the Internet is still a luxury for many South Africans, and while the country may have access to many mobile network operators, all competing with one another, the cost of data bundles is still extremely high compared to the country's average household income (Morris et al. 2001:150).

The other aspect that is basically the essence of this research study and worth taking into account when assessing adult first-time users, is the aspect of poor computer literacy. Many who are discovering the importance of computing systems at a later stage of their life are doing so due to personal interest or are forced to do so. It was not part of their curriculum when they were still in school and their job description does not compel them to use any form of computing system (GDE 2016:1).

Amongst those who are most affected are people with social and economic setbacks. An example would be an adult first-time user who dropped out of school ten or more years ago and later became an auto mechanic to earn a living. After visiting the Department of Home Affairs to register the birth of his new-born child, he is told to access the application form online. Up until then computing systems and the Internet have not played a role in his life and the only mobile device he ever had was a cheap cell phone which was basically used to make and receive calls, but now he has to learn how to navigate the Web for administrative purposes (Naidoo 2010:70). One may assume that the only meaningful way to accomplish this task would be to use a tablet system but it could be more complicated if the mechanic does not even know how to navigate the device (Smith-Atakan 2006:124).

In the above example of obstacles that adult first-time users may encounter, one may also consider their geographical environments; some areas in South Africa are very remote and neglected regarding infrastructure development (Naidoo 2010:7). Tarred roads are rarely present, access to running water a far-fetched dream, and in most cases schools do not even have enough teachers for mainstream subjects, let alone computing subjects (Naidoo 2010:8).

People raised in these environments are mostly not predetermined to be computer literate unless steps are taken to address the imbalances. Still, only having access to the hardware is not enough; one also needs to educate people on how it works to fully equip them (Magubane 2015:6).

The challenges of adult first-time users are the essence of this study. How do we solve the issue of the vast majority of computer users who never had the opportunity to discover the world of computing systems (Magubane 2015:11), and how do we make them cross over to the other side of the equation?

2.12 LINK BETWEEN ADULT FIRST-TIME USERS, DIGITAL GAP, USABILITY, AND TABLET SYSTEMS

This research study mainly focuses on closing the digital gap for adult first-time users in South Africa, and while adults are the prime target of this investigation, the term "adult" is very wide since it refers to anyone older than 18 years. Focusing this study on adults in general may not help much since many adults in South Africa are very much computer literate and have their own computing systems or tablet, and sometimes even more than one set of computing system (Herselman & Briton 2010:101). As a matter of fact, most people who promote and drive computing exploration in South Africa are adults (Herselman & Briton 2010:101). The main target of this study was thus narrowed down further to only adult first-time users, who are over the age of 18 years old and are learning to use handheld computing systems for the first time. The keyword "handheld", as already defined, includes mobile computing systems, and "usability" here is a keyword that explores the ability of a particular user to conveniently manipulate computing systems in the most productive way with the aim of gaining full control (Smith-Atakan 2006:41).

To summarise, the connection between all these keywords creates the full picture that forms when one puts together the impacts of up-skilling those who for some reason were left out of the computing literacy drive.

People who are over the age of 18 constitute a large portion of the population. This portion is so large that it forms the significant gap that exists between the number of people who are digitalised and those who are not, also referred to as the un-digitalised (Sikhakhane et al. 2005:44). Bringing the un-digitalised people on board may not be as simple as providing them with computing systems, but also includes enabling them to effectively use the received device (NEPAD 2014:2). Doing so would mean undertaking a process of usability assessment (Dix et al. 2004:10), which is the connection that binds together all the keywords of this study and helps to see the full picture.

2.13 FITTS' LAW

Fitts's law, sometimes referred to as Fitts' model, is a description of human movement within its sphere of existence. It was originally developed to ascertain how humans and machinery interact with each other and explores in greater detail the relationship between humans and computer interaction, while paying attention to all types of ergonomics (MacKenzie 2013:71). It investigates human movement regarding moving from one targeted area to the next, while keeping a watchful eye on the space travel ratio (Plamondon & Alimi 1997:305).

Fitts' law is also used when one wants to measure the time it takes to move a pointing device from one specific area of the screen to another area. For many years, it was used to model the act of pointing or physically touching an object on the screen and therefore knowing what to expect next from the user (Plamondon & Alimi 1997:305). With the advent of other technology, such as eye tracking, Fitts' law can still be used; this time to assess the eye movement of the user and the time it takes for one person or user to move from one particular angle to the next (Zaal & Thelen 2005:1267). It examines and explains the speed versus accuracy trade-off regarding HCI (Huys et al. 2010:1180).

Even though it was first invented in 1954 by renowned researcher Paul Fitts, it is still applicable today. Over the years, the model assisted many generations of researchers to keep abreast with modern innovations. While the principle still remains the same, it was originally meant for heavy machinery; these days it seems to have adapted to the new world of digital electronics (Guiard 1993:140).

The essence of this particular research is mainly about exploring the speed and accuracy of an adult first-time user with a tablet system. The aim is to examine the time it takes any adult first-time user to identify a particular target and move to another target with the highest accuracy and precision. Fitts' law enables doing just that. It is important to note that it does not take into account any form of drawing or writing, and simply assesses the designated area (Huys et al. 2010:1180).

In numerous experiments, Fitts' law was used to particularly explore the time to move and point to a particular target of width (W) within a distance and using a logarithmic function of the special relative error (A/W). Zhao et al. (2002:1-10) published the following text about the law:

> "$MT = a + b \log_2 (2A/W + c)$
>
> where:
>
> - *MT* is the movement time.
> - *a* and *b* are empirically determined constants, which are device dependent.
> - *c* is a constant of 0, 0.5 or 1.
> - *A* is the distance (or amplitude) of movement from start to target centre.
> - *W* is the width of the target, which corresponds to accuracy.

The term $\log_2 (2A/W + c)$ is called the ID. It describes the difficulty of motor tasks. 1/b is also called the IP, and measures the information capacity of the human motor system."

Zhao et al. (2002:1-10) further indicated that

> "[m]athematically interpreted, Fitts' law is a linear regression model. The regression coefficients are:
>
> - a : intercept
> - b : slope (1/b is IP)
>
> $$\mathrm{MT} = a + b \cdot \mathrm{ID} = a + b \cdot \log_2 \left(\frac{2D}{W} \right)$$
>
> where:
>
> - *MT* is the average time to complete the movement.
> - *a* and *b* are model parameters.
> - *ID* is the index of difficulty.
> - *D* is the distance from the starting point to the centre of the target.

- *W* is the width of the target measured along the axis of motion. *W* can also be thought of as the allowed error tolerance in the final position, since the final point of the motion must fall within $\pm {}^{W}\!/_{2}$ of the target's centre."

Zhao et al. (2002:1-10) then used:

$$W_e = 4.133 \times SD_x$$

Which yields

$$\mathrm{ID}_e = \log_2\left(\frac{D}{W_e} + 1\right)$$

and hence

$$\mathrm{IP} = \left(\frac{ID_e}{MT}\right)$$

$$T = a + b_1 \log_2(D) + b_2 \log_2(W)$$

$$T = a + b_1 \log_2(D + W) + b_2 \log_2(W) = a + b \log_2\left(\frac{D + W}{W^k}\right)$$

2.14 CURRENT AND SIMILAR PROJECTS

The world of ICT research, development, and spectrum is wide and diverse. The importance and role of ICT in developing any nation is known and there are many examples of this happening. In any nation, rich or poor, when there are higher institutions of learning, chances are that there will be a field of study called ICT or related computer sciences. Considering this, it is very probable that someone may have had the intention of conducting research similar to this study.

Conducting academic or industry research to explain some phenomenon of our universe is important and applaudable, but conducting the same study over and over again is repetitive and a waste of resources in a world where there are many other inexplicable phenomena and very few researchers (Kiefer, Straub & Raubal 2012:313). It therefore becomes imperative that before any new research study is undertaken, that researchers conduct wide and thorough research to establish whether or not similar research has been conducted elsewhere (Franchak et al. 2010:33).

For this study, the researcher conducted significant research using all available legal sources to familiarise himself with other potential studies, either completed or ongoing. This research was not only conducted before the title of the research was selected and approved by the institution's statutory body, but it was also repeatedly conducted while the study was ongoing. A number of similar studies were discovered by the researcher, but they were not in any way identical to this study.

2.14.1 "Touchscreen mobile devices and older adults: A usability study"

The very first research that was discovered is titled "Touchscreen mobile devices and older adults: A usability study" by Tom Page. It was first published in 2014 by Loughborough Design School in the United Kingdom (UK).

The aforementioned study deals with the impact of the increasing use of technology on the older generation as compared to the younger generation of users. The main purpose of this study was to investigate whether touchscreen computing devices affected the usability of older consumers. It was conducted with adults to explore all the various usability challenges that they may face.

Page's study has some similarities to this research work as it also investigated adult users and system usability, but firstly, the study did not focus on handheld devices such as tablets. Secondly, the study was conducted in the UK only, therefore it did not cover enough scope to deal with the difference of the social and economic statuses between the two countries (i.e. UK and South Africa), hence there was a need to conduct similar research in South Africa to determine if the findings of the UK study correlate to the South African ones. Lastly, the UK study was for an article and was not as detailed and wide as this current study.

2.14.2 "A comparative study between tablet and laptop PCs: User satisfaction and preferences"

Another similar study was conducted in the USA and is titled "A comparative study between tablet and laptop PCs: User satisfaction and preferences". It was published in 2008 by Anthony F. Nocio in an international journal of HCI. It was also in the form of an article and discussed the impact of US and preferences.

The study was aimed at defining the level of US and preferences regarding comparing tablets and laptops, as it is no longer uncommon for most users to own both devices. The study was conducted in an experimental environment with 34 students as participants, and questionnaires were used to measure US.

The current study goes beyond Nocio's study; it discusses many other aspects that involve usability and US, and also investigates overall HCI and beyond. Here the participants' age was not mentioned, nor the physical location or level of education. While it did make reference to the country in which it was conducted, it did not provide details about the participants' background, and the sample size was reduced to a maximum number of 20.

2.14.3 "Using qualitative studies to improve the usability of an EMR"

The third similar research study discovered was an article published in a medical journal in 2004, titled "Using qualitative studies to improve the usability of an EMR", and the details of the author have not been released for unknown reasons.

This study deals with the adoption of electronic medical records (EMRs) and US regarding the usability of some computing systems. The aim was to improve the usability of results management within a hospital environment. The study included two focus groups and field study sessions, and the conclusion raised concern about the amount of information displayed on a screen, which could distract the user from understanding the outcome of some of the exercises.

The study did not make any specific reference to the type of computing device used, nor the level of understanding of the user. It may seem that the only real similarity lies in the title as the rest of the actual study was conducted in different environments.

2.14.4 "Tablets for seniors: An evaluation of the current model (iPad)"

The fourth similar study is titled "Tablets for seniors: An evaluation of the current model (iPad)", and was conducted in Austria by Franz Werner, Katharina Werner, and Johannes Oberzaucher in 2004. It deals with the dissimilar level of Internet access in Austria, where only 30% of people over the age of 60 have access to the Internet compared to the 100% of people aged between 14 and 30.

It discusses the existence of the digital divide that may still persist in Austria, mostly due to technical, social, and economic hurdles. The number of participants comprised only 11 senior citizens and the study targeted US and acceptance.

Yet again, there may be some similarities to the current study, but the study by Werner et al. was conducted in 2004, more than 12 years ago, and given the constant innovative nature of

ICT, any discovery older than five years is deemed obsolete. Other aspects are the low number of participants and that no mention was made of any form of observation of users.

It may be concluded that the current study still has its place, and as strange as it may sound, this is the first time this type of study has been conducted on the African continent. This study comes at a time when the absence of ICT penetration in South Africa is a hot topic for debate, and at a time when many see the fast rollout of ICT as an opportunity to fast-track the development of the continent.

2.15 THE ROLE OF METRICS

The aim of this research is to develop a usability assessment metric that will assist any researcher who wants to assess the level of usability of any handheld computing system such as a tablet system. Currently, none exists.

The structure of the metric is composed of a set of mathematical variables, which are computed as part of the individual assessment outcome, and the tally of these variables will globally form an expression that is unique to a particular user. It is important to also note that its usage is not only limited to adult first-time users as applicable in the current project but can be freely applied to anyone who wants to measure any handheld system's usability.

2.16 CONCEPTUAL FRAMEWORK

In order to equip the reader with a supporting graphical model that can assist in comprehending the research project, the researcher developed a conceptual framework (see Figure 2.14). Here the entire literature review is summarised into a single figure to demonstrate the researcher's deep comprehension of the topic.

The research project is about comprehending the continued presence of the digital gap in South Africa, regardless of the level of technological penetration or the presence of computing gadgets all over the nation.

One assertion that is very well understood and accepted is the presence of the missing middle group. These are people who are over the age of 18 years old, with no or little educational background, and who are unable to use a computing system. They contribute to the country's population and growth, yet they find themselves in the neglected corner of the digital drive. The other unknown that the researcher tested in this study is their ability to effectively and efficiently use a computing system without external assistance, hence the introduction of the usability study, which is part of HCI. The researcher tested these assertions using a mathematical tool called Fitts' model, which is a well-known equation to measure the adoption of objects in the workplace.

The conceptual model shows the important principles of HCI and links these with system usability, system ergonomics, user-centred approaches, and the role that is played by computing systems to address societal imbalances.

Figure 2.14 is the graphical model which led to the current study and the approach which was investigated.

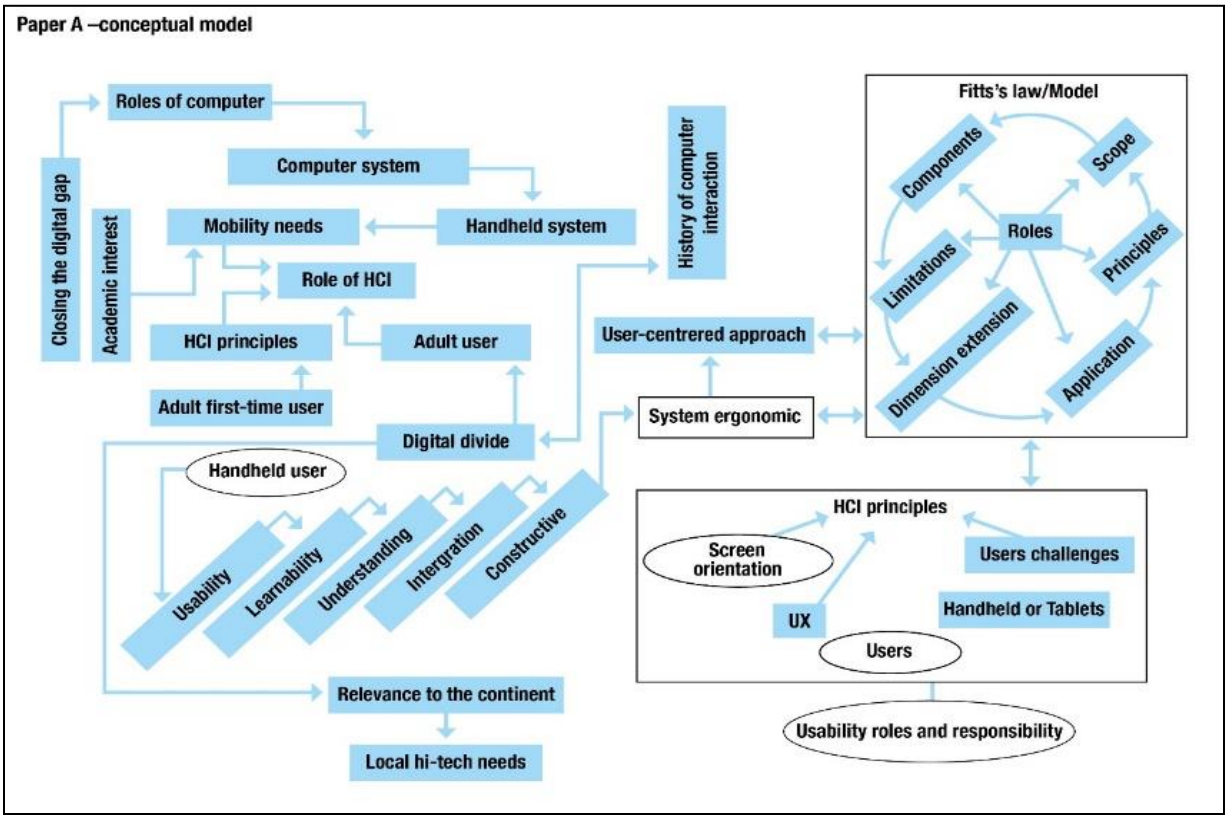

Figure 2.14: Conceptual model

The conceptual model as presented in Figure 2.14 depicts the process of system usability and adoption only; it does not in any way examine the issue of physical computing devices and solely capture the essence that is needed to move from the state of computer phobia to the stage of computer user or expert. In the process it needs to take into account issues such as the physical control of the physical computer device.

There are issues such as the impact of Fitts' law, the HCI principles, and the perceived impact of the handheld computing device; when brought together within an environment of interactivity and cognition, the impact might have various outcomes.

The role of an adult first-time user is explored next. First they need to deal with the cognitive ability to control their emotions as well as their line of thinking when dealing with computing systems, then the physical computing systems control comes into play. This is why a broad understanding of the role of Fitts' law is needed.

2.17 SUMMARY

HCI is the primary investigative field of system interactivity and will for many years be at the centre of numerous types of investigations and interest. Computer systems users are changing, and so are the types of computer systems around us.

The purpose of conducting this literature review was to unveil the essence and reasons of this research and to demonstrate that conducting this research would not be a waste of time or resources. The researcher explored the wide dynamics of the computing world, and explained the reason why people, here referred to as users, are attached to gadgets such as computer systems, and over and above that, the importance of these devices in society, as well as in our professional lives.

This chapter discussed users, and more specifically the type of users this study deals with. This study is meant for people who for some reason have not interacted with any form of computing system before encountering handheld devices. An exception may be made for users who have had smartphones. The most important selection criterion was to choose participants who are engaging with a handheld computing device for the first time, hence the reference to adult first-time users.

The study is based solely on the ICT side of HCI; other aspects of HCI such as psychology were not covered as they are outside the scope of this study, and the focus is mainly on system usability and interactivity. Some sections of the literature review helped to geographically locate the study, which was conducted in South Africa.

On the African continent, various issues linked to its importance were also discussed in greater detail to assist readers with absorbing the particularity of having to deal with socio-economic issues found on this continent.

The much publicised issue of the digital divide is at the centre of this research and is thoroughly debated and isolated to enable the reader to know what this subject entails. The importance of this study for the academic arena was to discuss and demonstrate the role systems usability plays**.**

Aspects related to the topic at hand were discussed, which were handheld computing systems and, more specifically, tablet systems, as they are part of the bigger family of handheld computing systems. This chapter also reviewed computing mobility and why many users are suddenly moving to this new platform.

The history of HCI also played a role in this chapter. It enabled the researcher to locate its origin and investigate its decade-long transformation, the interaction of computing systems, how people are accessing computing systems, and the various hurdles that may come with it. The chapter discussed the impact of HCI on handheld users, which enabled the researcher to focus on transformative interactions that may be caused by dealing with electronic machinery.

The word "user-centred" prominently features at various HCI colloquia where usability is discussed. People are fast becoming the centre of ICT research; people's needs are taken seriously when dealing with new computing systems development. This user-centred approach, as well as usability, was thoroughly investigated in this chapter.

This chapter also investigated UX and what it entails by exploring different hindrances that may limit the user's ability to fully utilise a computing system. The challenges that arise when users interact with computing systems were also discussed.

Fitts' law was introduced and demonstrated. It forms part of the general mathematical equations that were applied in this study.

The literature review concluded by thoroughly investigating similar studies, as it will not make sense if similar research under the same conditions was conducted elsewhere on the continent and the researcher went ahead without taking full knowledge of the outcomes, or learning from what may have transpired.

The next chapter is the research methodology and design chapter. It will give the reader an opportunity to understand how the data collection, analysis, and interpretation were conducted.

CHAPTER 3

METHODOLOGY AND DESIGN

3.1 INTRODUCTION

This chapter presents the research methodology and provides a detailed description or overview of how this research project was conducted. The application of the research objectives as described in Chapter 1 will be reviewed and the steps and processes that were undertaken will be described.

The reader will thus be led through the research process from the planning stage, through to the data-collection phase, then the data analysis and the development of the metric and what it means. Consequently, the conceptual model that the researcher developed in Chapter 1 will be clarified.

As expected in any research study such as this, the credibility of the findings, recommendations made, and framework developed are closely linked to the research design, data-collection techniques, and data analysis (Birkhofer 2011:17). Thus the research method and procedures that were used to obtain the analysed data will be described and closely examined to support the veracity of the findings (Birkhofer 2011:11).

This research study was conducted in a field where very little research has been conducted before, and consequently there is limited literature available locally (Babbie, Mouton, Payze, & Prozesky 2010:160). Research projects in the academic field or in industry could be a systematic endeavour to unearth answers to problems that may not easily be understood, defined, or demonstrated without intensive intellectual work (Simons 2009:10). That is how researchers see it and want to engage with it.

Before any scientific research project can be undertaken within the broader research community, the researcher should first identify the methodology that will be used in order to find answers to the research questions that were formulated (Babbie et al. 2010:161). The actual research can only begin once the methodology has been clearly disclosed, discussed, and agreed upon by all the stakeholders (Bwalya 2009:49).

3.2 GOALS AND PURPOSE OF THE METHODOLOGY

The purpose of the methodology chapter is to clarify the procedures before the study was conducted, and to describe the conditions under which the data were collected and analysed, and to explain the core of the research. The credibility of the results is linked to the research principles as stipulated in the methodology and data collection (Ridley 2009:19).

It is necessary to specify the population, sampling techniques, data-collection approach, research design, and any other element that may have an effect on the scientific authenticity of the manner in which the research was conducted (Ridley 2009:11).

3.3 RESEARCH APPROACH

Any research outcome that cannot be replicated is known as an isolated occurrence (Welman & Kruger 2003:41). The replication of a study is meant to ensure the scientific nature of the previous outcome; in other words, if correctly implemented, the outcome can be replicated by another researcher (Simons 2009:67).

In many instances, scientific researchers place great emphasis on the possible replication of the outcome whenever embarking on a new research venture, and this can only be irrefutable if the correct research methodology was followed and implemented (Ridley 2009:17).

3.3.1 Research types

Any research project can fall under a variety of categories, depending on the anticipated outcomes and expectations of the researcher. The approach taken by the researcher could help determine the classification of the research project (Ridley 2009:15).

In most academic environments, there are two distinctive types of research: basic and applied research. Although some researchers use these terms interchangeably, they should be seen and defined differently (Welman & Kruger 2003:15).

3.3.2 Applied research

Applied research is fundamentally built on systematic inquiry involving the practical application of the science that guides it. It pays attention to the research community, or mostly the academic research sector, by accumulating theories, knowledge, methods, and techniques for specific outcomes and deals with solving practical problems based on empirical methodologies (Krueger & Casey 2014:47).

Ridley (2009:305) stated, "Applied research refers to scientific study and research that seeks to solve practical problems. Applied research is used to find solutions to everyday problems, cure illness, and develop innovative technologies." Simply put, applied research is used to solve immediate and practical problems facing the scientific world.

3.3.3 Particularity

Based on the above knowledge of both approaches and the type of research expected, the researcher believes that applied research was appropriate for this study since the intention of this research project was to solve an existing problem by finding ways to explore computing usability problems for adult first-time users and thus narrowing the digital gap in the most remote and impoverished rural areas in South Africa (Mphidi 2011:51).

3.3.4 Exploratory study research approach

Generally speaking, a research approach may be defined as the process of developing new knowledge or re-evaluating the outcomes of existing ones. It enables the researcher to have a clear view or perspective of the whole project from the onset, and enables the reader to have a preview of what the outcome may be (Bauman 1991:31).

There are a few orientations, of which the most popular are exploratory, descriptive, and explanatory studies. The following paragraphs will elucidate the important facets of exploratory studies, why it is the most appropriate research approach, and also shed some light on its application.

Exploratory studies are conducted when insufficient research has been conducted in a certain area of interest. The main purpose of conducting an exploratory study is to help understand and determine the best manner in which to approach the problem emphasised in the research design (Bruyn 1966:41).

Data collection, methods, and the selection of the subjects will be thoroughly investigated during exploratory research (Buchanan et al. 2006). When choosing an exploratory research approach, the outcome could be contradictory when compared with the earlier assumptions made by the researcher. More often than not, exploratory research enables the researcher to rapidly unearth new meaning (Cheng, Ernesto & Truong 2008:77). Exploratory research may be a better alternative to gather preliminary information that will help the researcher to develop a hypothesis (Mehl et al. 1994:28).

3.3.5 Particularity of the current project

After having listed and defined the existing types of research approaches, the researcher was of the view that an exploratory research approach was most appropriate as it enabled the provision of an in-depth explanation of each sub-question. There are very few locally based research projects which identify the extent of the digital gap in HCI efficiency, effectiveness, adult first-time user preferences, and the negative usability impact on adult first-time users of handheld devices.

As a result of this lack of literature on the topic, a number of questions were raised; for example: What is a first-time computing user? What is good usability and what is not? What is system adaptability time, good and poor usability, speed of operation, eye-tracking processes, etc.?

Adult first-time users of handheld computing devices are the focus of this research study, and local users, like computing users in other underdeveloped nations, have their own particular needs which should be explored before being classified. Computing systems usability causes a variety of anxieties, as reported by many international studies; however, in South Africa, these aspects regarding frustration need to be investigated through exploratory research (Mphidi 2011:17).

3.4 RESEARCH METHODS

The research method describes the process of collecting and analysing data with the aim of making interpretations based on preliminary criteria as structured by the researcher. The goal of the research method is to define the analysis approach (Elmer-DeWitt 1996:7). In so doing, future researchers who may want to replicate the research will be able to understand what benchmarks were considered at the time (Morgan 1993:5).

There are many types of research methods that are used for scientific research. Quantitative data-collection methods involve numerical data, or any form of data that can be quantified (Fowler et al. 1999:61), while qualitative methods are mostly based on literary explanations of the phenomenon and give reasons, motivations, and opinions about a potential exploratory question (Fowler et al. 1999:111). Primarily, it helps to understand the research question as well as the answers to those questions (Gamson 1992:71).

The mixed-methods approach combines both quantitative and qualitative research methods, and aims to support each area and provide a deeper understanding of where there are shortfalls (Gill 2008:40).

The mixed-methods approach is used in this study based on the fact that where justification or substantiation is required for an answer to an open-ended question, this approach is used in order to fully comprehend the outcome of a numerical answer.

3.4.1 Research design

In any research project that involves more than one person, considerable resources are required (Groves 1990:41). There should be an agreed-upon blueprint that should stipulate the research process from the beginning of the study to the finalisation of the study (Grimes 1991:13).

Research design also helps to determine the type of data-collection design that will be implemented. There are three types of research design; namely experimental, quasi-experimental, and non-experimental (Parker 1992:67).

The researcher chose the quasi-experimental design for this study, as random sampling was applied when choosing the population but there was control to identify their place of origin and the characteristics for their selection.

3.4.2 Research population

The research was conducted in all nine provinces in South Africa. The purpose of defining the research population is to ensure that the researcher was clear about where and from whom data were collected. It also meant conducting a meaningful assessment of the potential participants, knowing who they were, where they were, and the exact number of participants in each group.

When dealing with a large population participating in a research study, it is important to group them in a cluster called a target population. A target population describes a group of individuals, objects, and aspects that may contribute to the meaningful and positive identification of the type of input they may provide (Kahane 1992:41). The target population for this research study are those who have neither been exposed to any form of meaningful ICT device nor any handheld computing device apart from cell phones. Because of the geographical location of the target population and their usability of handheld devices, selection criteria depended on those who may have been exposed to handheld computing devices despite not having owned one at the time of conducting this research.

The researcher approached all participants in their most natural environment, where questionnaires were administered. Usability demonstrations and observations before and after training were recorded on video. In order to access the most important participants in each province, age, gender, and education level were not considered as restrictions but rather as independent demographics aspect of the whole study.

3.4.3 Research sampling

The previous section described the population of the research project, but one also needs to be aware of the fact that the population as described did not at all times participate in the study, and therefore other means of selection were needed to help focus on those who are more likely to participate in the research. Sampling was used to specify the demographics of the participants who were expected to participate in the study (LeCompte & Preissle 1993:17).

The sample was selected from potential computing users from rural communities in all the South African provinces. To be eligible for selection, the participants had to be able to read and write in English and have an understanding of the importance of a computing device and its usefulness. A stratified sampling method was used to select the participants from whom data would be obtained for analysis (Lofland 1995:31).

3.5 DATA-COLLECTION PROCEDURE

Upon arrival at the identified venue, all participants received a brief description of the research study and what it entailed. After having completed the administrative procedures, which required the completion and signing of a waiver and ethical clearance documents, the participants were placed in a control location where they began interacting with the setup of computing devices. This was recorded on a fixed digital camera. All participants contributing to system usability were recorded on video. The testing device was installed at the venue in advance and the participants were informed that they were being recorded. All data collected in this process were analysed.

In this experiment, the first-time user participants demonstrated their usability of handheld devices. The researcher travelled around the community and explored aspects that could contribute to displaying technological limitations, user frustration, and system adaptation for that specific community. All aspects pertaining to the above were recorded on video for later analysis.

The researcher approached communities, churches, schools, and business leaders and administered questionnaires which consisted of open-ended questions to the participants. These questionnaires enabled participants to answer questions based on their own experience with a handheld computing system and the impact of system usability as a hurdle. The types of questions used in the questionnaire were meant to enable participants to air their views and opinions.

The questionnaires had blank spaces for written comments. Closed-ended questions were included and were structured in such a manner that participants could only answer them in a pre-defined section. These questions were mostly entry-level questions or questions that did not lead to long answers. The questionnaires are included in Annexure 2, 4 and 5.

At this stage, it is important to explain that not only surveys were used as a technique to collect data; other techniques were also used, which will be introduced as the process unfolds. These included experiments and interviews.

Lazar et al. (2010:68) stated,

> "One data-collection effort does not lead to a definitive answer on a question of research. In scientific communities, the goal is generally for multiple teams to examine the same research question from multiple angles over time. All of these efforts come up with same general findings over time, give evidence for the scientific truth of the findings; this is often known as triangulation."

The researcher attempted to apply this approach as closely as possible.

3.6 DATA ANALYSIS AND PRESENTATION OF FINDINGS

Once the data were collected, the researcher made use of QDA Miner to analyse the quantitative data. It features built-in capabilities that enable the analysis of both qualitative and quantitative data and is widely used in the fields of social sciences, medicine, sociology, political sciences, and psychology. This software is best used for coding, annotation, retrieving, and analysis of small and large documents.

3.6.1 Qualitative data analysis

The qualitative data were analysed using ATLAS.ti, which is a well-known commercial software system. The purpose was mostly to provide an explanation, understanding, or interpretation of what the respondents said during their interview. The researcher took some time to review the theories under investigation, which led to the main research question of this study.

The researcher then themed important points of interest to the responses that led to the question at hand; this was achieved by grouping lower-level data across the corresponding level. The researcher then identified the ideal characteristics, which are also known as single items or responses given by a single respondent.

Coding the data was one of the most time-consuming activities during this research. During this phase, the researcher attached important labels to lines of text for comparison purposes and later sorted them according to the lines of ideas; indexing was also conducted as part of the same process. Narrative analysis was systematically used, which is based more on transcribed data and which is an ideal method for the core activity of reformulating stories presented by participants in a manner that is better understood.

3.6.2 Quantitative data analysis

In this section, there were two separate sets of quantitative data, namely data obtained as the result of the experiments and computed using various mathematical formulas, and data collected before and after the experiment and analysed using the Statistical Package for the Social Sciences (SPSS), which is basically a quantitative data analysis software system. The results were all interpreted by the researcher and the report is presented in corresponding chapters for reader perusal.

3.6.3 Triangulation

This study used a variety of research methods which were independent in their own right and needed to be incorporated into a single research objective for global or broad analysis. For this reason, the research approaches were mixed to enable cross-completion of various sub-questions which were all part of the same main research question. For example, if the objective, which is the main research question of the chapter, contains three or four sub-questions which are answered using multiples methods or approaches, one method would then be used to support the other one and vice versa.

The researcher then introduced the quantitative report pertaining to the same main objective, which is based on the question under investigation, followed by the respondents' responses, then the quantitative data and analysis, as well as implementing a mixed interpretation in support of the quantitative data. The third section to complete the triangulation of the data is the result of the experiment where applicable; it is located at the end of the individual section.

3.7 PARTICIPANTS

The researcher obtained a number of participants for the study, from adult first-time users to ICT experts. Adult first-time users were the primary target population. They were selected solely based on the fact that they have never experienced or encountered computing systems before, were over the age of 18 years old, and were able to read and write in English about the new GUI and interactivity environment.

Making use of adult first-time user participants enabled the researcher to record their usability activities while interacting with the system. Besides the first-time users, the researcher also obtained some expert input that enabled him to deal with complex issues that required greater insight and technical demonstrations. Handheld computing systems, such as the tablet, which were mostly developed abroad and exported to South Africa, are also the outcome of intensive technological collaboration efforts and therefore the input of systems experts was a necessity.

This study had +/- 300 adult first-time participants from all the provinces and over 20 expert participants. At this stage of the study, the gender, disability status, and age of the participants were irrelevant.

3.8 EXPERIMENT

The experiment was solely based on the observation of what the participants were able to do once given a tablet system to use for the very first time. The researcher was interested in capturing their tacit knowledge about basic system usability and computing survival skills.

The environment was set up for the occasion and participants simply had to listen to the instructions given and execute them while they were recorded on video. The researcher was more inclined to observe their reaction to some of the questions asked as well as their actions on the computing system's screen. Close attention was paid to areas such as RT, the speed of their actions, the accuracy of their actions, and the CT per task and per activity.

The whole process was divided into phases. The pre-experiment phase determined their usability level at the time of their first encounter; the experiment phase; which was followed by usability training; and a post-experiment phase to measure how much knowledge was retained.

3.8.1 Testing process

The testing process of the participants took a more industrial or commercial approach, as opposed to a purely academic approach. The process was coupled with a training simulation, which was designed for the tasks and actions undertaken by the user participants. The initial phase was conducted solely on paper, using low-fidelity storyboarding.

Here we made use of papers and sketches which were prepared for the occasion. The researcher provided the participants with initial training on the tasks, and then moved to the second part of the assessment, which was purely based on high-level storyboarding. After each phase, a series of tests were completed by the participants to address issues lined to their ability to perform well.

During the first phase, the researcher tested the participants' ability to navigate around the system. The second phase was about error tracking, where the researcher explored and kept record of the erroneous activities of the users. The third phase assessed the task completion; where the researcher wanted to know whether tasks undertaken were successfully completed.

The fourth phase entailed the identification of the objects on the screen; the researcher wanted to determine if participants could remember some key critical points on the display without external assistance. The last phase was more about UX; the researcher focused on users' ability to enjoy their interaction with the system, and placed more emphasis on their vocal expression and feelings. All their activities were diverted into the global cognitive assessment approach, which, coupled with usability, helped to determine their task experience.

It is important to note that there was a diversion from the completion of the UX into a series of actions. When coupled together, it provided an assessment of the eye-tracking ability, learnability, memorability, and enjoyability during testing assessment, as shown in Figure 3.2.

3.8.2 Navigation

System navigation in the context of the study is the ability to move from one segment or corner of the computing screen sketches to the other. It does not in any way mean within the same application or object only, as navigation can take place amongst a set of unrelated applications. The participants were asked to show their ability to follow a particular scenario. An example can be an assessment of a scenario in which a user must move the cursor from the main menu or the menu of an application to a specific page of the browser or application system.

The researcher assessed and measured the completion rate of the action by determining if the user managed to gain access to the indicated point and the time it took them to get to that area. The number of errors made is important as it indicated whether the user understood the action or not.

The navigation testing process was conducted during the high-fidelity storyboarding process. Users were instructed on the tasks that they were required to complete. The whole process was captured on video and later analysed.

3.8.3 Error tracking

Error tracking during this phase of the experiment comprised a process of exploring and visualising the types of mistakes made by participants. During this phase, more emphasis was placed on the identification of what may be perceived as an erroneous operation from the user, which was then recorded. An example of an error is a task which was supposed to be completed, but instead the user did something else by mistake. Tracking errors means that the researcher keeps a record of all actions which are perceived as incorrect, which would later be counted and assessed.

The researcher believed that experienced users would make less mistakes when completing known tasks, and that they were well versed with the system and less prone to make mistakes; this approach was therefore used to see how good they were.

These exercises were completed in the same time as other activities and the participants were not pre-informed about the outcome of individual activities and could proceed without any problem to the next available task. In order to make the participants feel at ease, the controllers or data gatherers constantly emphasised the fact that they were not personally being assessed, but rather their usability.

3.8.4 Task completion

Not knowing the outcome of an accomplished task is supposed to enable participants to move forward without stress since it can be discouraging to know the outcome. The researcher wanted to know whether or not the participants completed their tasks as prescribed; this was perceived as the ultimate point and it helped to know if the participants understood their own actions, or if they were reaching the correct point.

Not successfully reaching the correct point simply means that the participants were not able to use the system effectively, or that the system was too complex for them. An example would be to know if a participant who was asked to tap into an area of the GUI could successfully do so. Some tasks were more complex than others and it was therefore imperative that the participants regarded the successful completion of a task as imperative and that the opposite would only be interpreted as incompetence.

These activities were done at the same time as the previous one; participants did not need to be notified about their completion status and could be asked to move to the next task from the same scenario.

3.8.5 Area identification

Area identification refers to the locations of points of interest. Here the researcher simply wanted to know if the users, without any assistance, could make a sound reference to their location within the system interface. This is an important part of the navigation process; the researcher wanted to know if a first-time user could develop the ability to reach the designated areas without any external help. In many cases, first-time users constantly asked for assistance and tips to move around, but measuring their ability to perform these tasks on their own was part of the assessment process.

3.8.6 UX

For many experienced system testers, this task can subsume the whole process. The researcher measured system usability to determine if participants got the best out of the systems; here the researcher wanted to know if participants could find their way around the interface with minimum frustration and thus have a pleasant experience regarding system learnability.

UX was measured by capturing the participants' vocal expression during the experiment. All the "indicated", "says", "do", "do not do", or "asked" were kept and later analysed to see if the participants were able to complete the process or simply bored or annoyed with the way it was done or conducted.

3.8.7 Learnability

Learnability is the ability to easily know what to do on a system after a short while. The researcher believes that testing system learnability is essential when assessing any computing system user. A system that is hard to learn will frustrate the user, who can later resist using the systems, or simply quit the learning process as a result of the system's complexity.

In the experiment, learnability was assessed through the vision and analysis of the flow of the screen which users interacted with; the ease of screen flow is a better indication of the user's ease of learnability.

3.8.8 Memorability

System memorability, also known as system recollection, is a recapitulation of all the steps that users can perform without having to pause and think. The flow of information is part of the whole process; when users move around easily without thinking, it indicates that the user easily memorised the task and therefore will be able to perform it the next time with little assistance.

This part was measured by analysing the flow of screen that the user performed.

3.8.9 Enjoyability

An adult first-time user is declared as having enjoyed the system when they feel good when interacting with the system. This experience can be visible, or by simple observation when users are demonstrating that the system with which they are interacting is providing them with a very rewarding feeling.

We measured the system enjoyability based on user expression and sentiment, during and after the assessment.

3.9 PROJECT APPLICATION FRAMEWORK

Figure 3.1 provides a single view of the entire experimentation and data-capturing process. The big picture can be seen here; it depicts what must be done and when it should be completed in order to meet the set criteria which are needed in order to have a sound and acceptable experiment. From the figure we can easily identify repeating sets of blocks, such as Phases 1, 2, and 3, which are observations or experiments, or simply training, as well as the stages where key critical components are executed.

Once the participant is willing to come forward and participate, the researcher asks the master question about their age. After they agreed to complete the ethical questionnaire, they are questioned about their experience with a tablet. This takes us to Phases 1 and 2 of the experiment, during which progress assessment is conducted. Other testing follows, such as cognitive testing, evaluation classification, and the exit questionnaire, which are all part of the assessment process.

The above description is part of the low-fidelity prototype experimentation, and summarises the whole process without going into individual tasks and testing assessment.

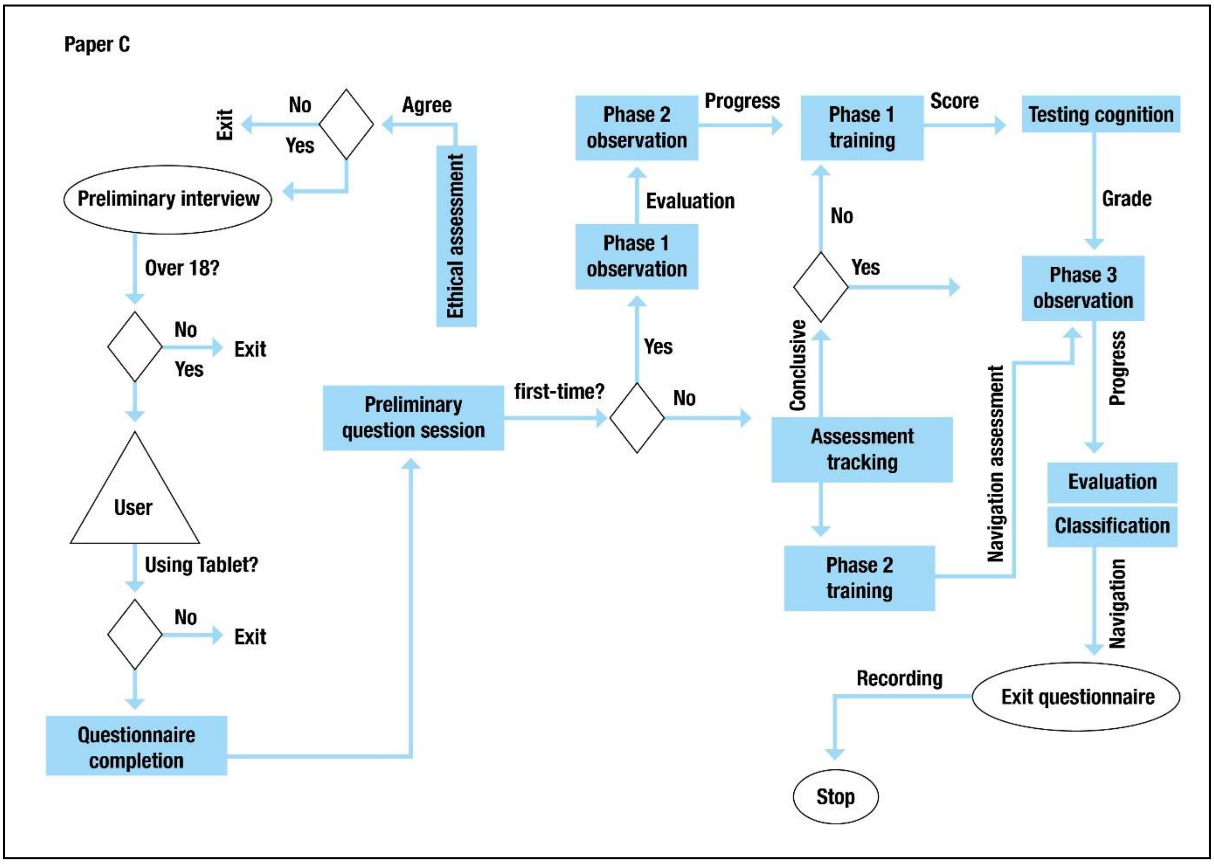

Figure 3.1: Experiment process

Figure 3.1 is a graphic representation of a single low- and high-fidelity prototype test and depicts all that happens within a single high-fidelity testing unit. It also provides information about the expectation and applicability of the questions and actions of the testing process. The five phases are all part of a single testing exploration. As high-fidelity testing equipment is automated, there are many assessment attributes which are meant to be tested and cross-examined to view the depth of the phenomenon.

The researcher started by conducting the experiment on system navigation, then error tracking, task completion, point identification, and finally UX. These are all individual phases which are part of the testing process. The outputs are all brought into a single cognitive analysis. The other testing sub-objectives are the participants' eye-tracking learnability – which was tested throughout multiple phases of training – memorability, and enjoyability levels, which are all part of the same testing philosophy.

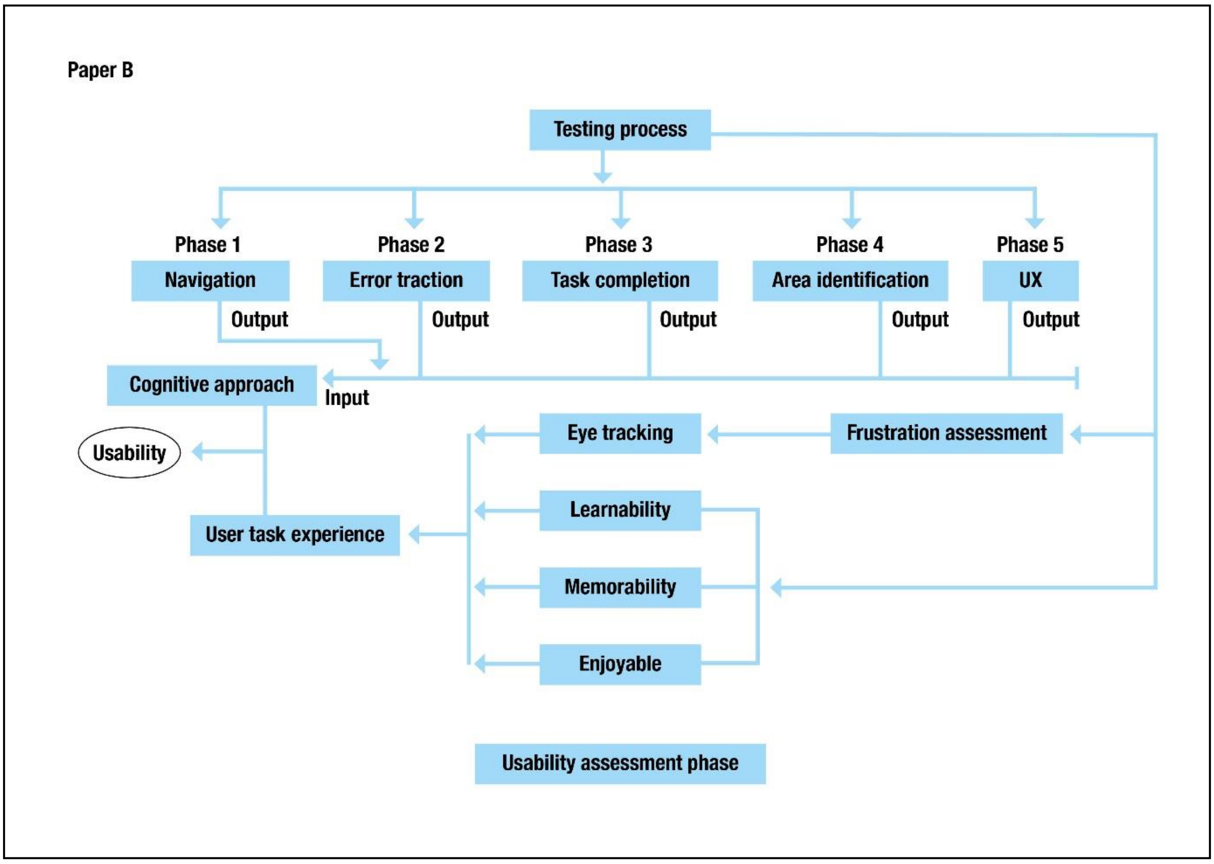

Figure 3.2: Testing approach for participants

Figure 3.2 illustrates the testing approach for participants as a simplified version of the tasks as they were completed on-site by willing participants. It is simplified to clearly elaborate on the level of engagement which took place at the testing sites from the preliminary encounter, where the conditions of participation are verified; to the stage where they are leaving the testing site; to the completion of questionnaire. The figure lists stages such as the ethical conditions and consideration, the pre-training assessment, the preliminary questionnaire completion, the training phase, the post-training assessment, the actual experiment, the post-experiment, and post-experiment questionnaire, before marking the closure.

3.10 EXPERIMENT AND LOGISTICS

This section discusses the conditions under which the experimental laboratory was set up and what constitutes the data captured and measured, which were used to obtain and assess the findings.

The experiment was solely conducted with individuals referred to here as participants, who voluntarily came forward to participate in the study. The experiment was conducted according to the university's rules and conditions. The tablet systems, the high-fidelity prototype, the low-fidelity prototype, the digital video cameras, and the platform that were used in this experiment were set up and assembled by the researcher after numerous failed attempts to gain access to a formal or industrial laboratory setup. A number of devices were used for the experiment; the following sections explain what they were and which role they played in the experiment.

3.10.1 Video recording

The researcher made use of three digital video cameras at the testing station; two were mounted on a tripod and the third was mounted on a laptop display. One camera recorded the action of the participants, the second one recorded the facial expression of the participants, and the third camera recorded the whole interaction. This provided a stream of videos which were then analysed.

3.10.2 Low-fidelity prototype

This set of paper-based sketches was developed by the researcher. The aim was to use a low-influential metaphor which would affect users less, and, most importantly, provide them with something that they may be familiar with, such as paper. Guidance was given as to how it was to be used and interpreted. The sketches were designed with the user in mind; the researcher simply drew what the participants may know or may have seen as part of the experiment. The flow of questions to be answered were structured based on the narrative and the flow of screens that they had in front of them.

3.10.3 High-fidelity prototype

Regarding the high-fidelity prototype used in this experiment, the researcher placed emphasis on the tablet system, which was not only less intimidating to the first-time user but also relatively usable. The system used was a 25 x 18 cm tablet; the brand cannot be disclosed, but it can be specified that it ran on Android and Mac operating systems. The tablets were purchased for experimental purposes and were solely set up for participant testing purposes.

3.10.4 Testing table and chairs

Tables and chairs were acquired and formed part of the equipment used to test the users. One of the fundamental issues with usability, as well as ergonomics, is the fact that users are not as comfortably seated as they are supposed to be and this is the reason for taking the seating arrangements into consideration. The table height was 720 cm and wide enough to accommodate resting arms, while the chair seating height was 420 cm and wide enough to provide the most comfort to the participants.

3.10.5 Systems setup

Every time the researcher moved to a different site and location across the various provinces, the equipment had to be set up again. This was time consuming and demanding from a logistical point of view. The researcher allocated sufficient time to address these challenges without compromising the participants' contributing time. The physical support and assistance received from travelling companions made it much easier.

3.10.6 Video decoding and transcription

Before, during, and after the experiment, the researcher ensured that the equipment functioned properly. There were instances when the researcher was under the impression that the cameras were recording only to find out that they were not, and the process had to be restarted. Therefore ensuring that the cameras were recording was one of the priorities for the research team. After recording, and once back home in Johannesburg, and after a resting period, the team then started the process of summarising what was on the videos. It was time consuming and labour intensive and it involved viewing what the users were doing based on the actions that were to be written down.

3.10.7 Recording sheet

The recording sheet recapitulated the individuals' actions. It was used during video transcription and later during interpretation. It contained the following important fields:

- Participant number: The researcher avoided referring to the individuals by name and instead used a number to refer to them.
- The overall starting and ending time: This time was taken for each participant and would later help to calculate the various times that formed part of the participants' performance.
- The points which are part of the target: Here the participants were told to perform the action based on the direction given. It is very important here and in liaison with the

positions which are organised in a particular alphabetical manner, for example A, B, C, D, or E.

The starting and ending time of each task were recorded and kept for the same reason as the previous one, which was basically the time it took them to complete the task. The distance to the centre of the device and the width of the device were also put to the test. The records of the video interpretation were also kept to decide if the users met the target or not as viewed on the video.

It is important to note that there would be other interpretations of the same target-reaching issue. The speed of the action is part of the sheet record, but can only be calculated by the researcher as part of the later mathematical processing. Samples of the recording sheet are available in Annexures 8A to 8J.

3.11 FORMULA EXPLORATION

In order to obtain an accurate balance of some of the arguments put forward in some sections of this thesis, it was necessary to support the findings using mathematical equations which are quantitative and easily verifiable.

This section provides an explanation of all the mathematical formulas that were used in this study. It will enable the reader to understand why some formulas and not others were used. The following sections will explain the formulas, which are all indicated in Table 3.1. It is important to note that nothing is invented here; these are all existing formulas which were exploited for the purpose of the research project.

Table 3.1: Mathematical formulas

Number	Activities/objectives	Formula used
1	MT	$MT = a + b.ID = a + b.\log_2\left(1 + \frac{D}{W}\right)$ D : Amplitude of movement (from the starting point to the centre of the target) W : Width of the target MT : Movement time for target selection
2	CT	$Task\ Time = End\ Time - Start\ Time$
3	Overall TBE	$Overall\ Relative\ Efficiency = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N} n_{ij}t_{ij}}{\sum_{j=1}^{R}\sum_{i=1}^{N} t_{ij}} \times 100$ where: n_{ij} is the result of i by user j t_{ij} is the time spent by user j to complete task i R : Total number of users N : Total number of tasks
4	Effectiveness = Success rate (SR)	$Effectiveness = \frac{Number\ of\ tasks completed\ successfully}{Total\ number\ of\ tasks undertaken} \times 100$
5	SR	It is similar to effectiveness
6	Task speed (TS)	$v_{ts} = \frac{D}{MT}$
7	AS	$\frac{Activity\ travelled\ distance}{Activity\ completion\ time}$
8	Horizontal overall relative efficiency	Cross excel horizontal efficiency addition
9	Vertical overall relative efficiency	Cross excel vertical efficiency addition
10	Usability for satisfaction	Determined using qualitative data
11	RT	a : Time required to click a button or widget (experimentally determined)
12	Completion rate per task	Only per set or group of tasks
13	Completion rate per activity	$Effectiveness = \frac{Number\ of\ tasks completed\ successfully}{Total\ number\ of\ tasks undertaken} \times 100$
14	CRP	$Effectiveness = \frac{Number\ of\ tasks completed\ successfully}{Total\ number\ of\ tasks undertaken} \times 100$

Number	Activities/objectives	Formula used
15	CRTA	$Effectiveness = \frac{Number\ of\ tasks completed\ successfully}{Total\ number\ of\ tasks undertaken} \times 100$
16	TBE	$TBE = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N}\frac{n_{ij}}{t_{ij}}}{NR}$
17	System ID	$ID = \log_2\left(1+\frac{D}{W}\right)$
18	IP	$IP = \frac{ID_e}{MT}$

3.11.1 Movement time (MT)

MT is the time it takes a particular participant to move from one point to another after instruction. In order to do this, certain variables are needed, such as the movement distance from the starting position to the target, the target width, some of the empirically determined constants, such as a and b, as well as a constant such as c, which is 0 or 0.5. The application of Fitts' model plays an important role in this section.

3.11.2 Completion time (CT)

CT is the time it takes to complete a task. A task here can be a single unit of action, for example from A to B. It can also be the CT of a set of tasks per unit, such as the completion of five tasks which are all part of the same unit, for example the first eight tasks of the same position. Position refers to a set of activities performed with a specific device. There are various types of CTs, which take into consideration the lapse time, which refers to the time a participant takes to start engaging with a task when told to do so. We have the users' starting and ending times.

3.11.3 Activities effectiveness (AE)

AE is one of the most important factors that needed to be assessed in this study. It refers to the effectiveness of a user's action during the assessment. To determine this, the number of tasks completed successfully is divided by the total number of tasks undertaken, which is then multiplied by 100% to determine its effectiveness.

3.11.4 Success rate (SR)

This formula determines the SR of all the tasks and activities performed during the experiment. In order to do this, the performance index has to be taken into account. It is important to note that there are various sets of SRs: the individual SR as well as the position, different participants across the same task, as well as horizontal and vertical comparison.

3.11.5 Task speed (TS)

The different types of speed of the participants were assessed, which included the single participant speed, vertical and horizontal speed per task, position, participant, and overall speed. To calculate this, the starting time and the constant are needed. This is basically the speed that is required to complete a task which would be calculated by calculating the time it takes to complete a single task and accumulated overall task time. The formula is presented in Table 3.1.

3.11.6 Activity speed (AS)

AS is the time that is needed in order to complete a single action. Like TS, AS is calculated by paying attention to the action which is needed to accomplish a single movement, such as moving from point A to B, and it is also measured in inches per second. It reflects the time it took a participant to move from one position to another and, like TS, it is vertically and horizontally applied and measured. As seen on the Microsoft Excel sheet which is attached, details such as the starting and ending point are all taken into consideration.

3.14.7 User satisfaction (US)

Here the researcher assessed the level of US. This was done by exploring the participants' efficiency performance versus the maximum percentage allocation for the task. By calculating the US in this manner, the researcher intended to assess the ability of adult first-time users versus system correlation, which can later determine the overall system satisfaction and adaptability.

3.14.8 Reaction time (RT)

RT is the time it takes a user to psychologically comprehend the activity to be completed, or the time a user takes before completing the requested activity. It is one of the fundamental principles that have an impact on the user. It not only involves the ability to complete a task but also the comprehension time that is needed for anyone to begin interacting with the task. RT is sometimes synonymous to real starting time, where the user actually engages with the action that is needed or demanded.

3.14.9 Completion rate per task and activity (CRTA)

CRTA is the user’s ability to complete a task and activity within the set spectrum and conditions. When an activity is requested, it may not always be completed as per the requirement, and the user cannot reach the set target, or simply missed the target. The aim was to assess how many of these targets were successfully completed or not, and the rate at which they were completed or reached as per activity and per task, both horizontally and vertically.

3.11.10 Completion rate (CR)

Like in the previous section, the CR of individual participants were assessed. The aim was to determine how fast participants were in terms of completing their tasks as individuals. The documents in Annexures 8A to 8J indicate that each participant had five tasks, which ran from position A to E. The research team calculated the time it took to complete these tasks in that particular order, although they were not completed during the same session.

3.14.11 Time-based efficiency (TBE)

TBE is basically the assessment of one’s computing efficiency per task and demonstrates the participant’s adaptation and systems accommodation. It is measured by summing the CT of all participants per task and per activity and dividing it by the base time, as indicated in Table 3.1.

3.11.12 System index of difficulty (ID)

The ability of a participant to master the usability of the system is based on the level of complexity of the system. Not all computing systems are the same. Some are more complex than others, some are more user friendly than others, and some are by their interaction development hard to master and use, therefore it was imperative to also pay attention to the GUI of all systems that were used as part of the system user assessment. Here Fitts’ model comes back into play and the research team used it, as well as the system width and move distance, to determine the ID.

3.11.13 Index of performance (IP)

The system performance index, which distinguished all participants and set up interactivity standards, is ultimately important regarding new and existing user-centric assessments. The IP and the ID are intertwined to establish overall system performance. In order to calculate this, the previously calculated ID and the MTs were used; since these were all already calculated, they were simply applied in the section.

3.11.14 Interaction rate (IR)

IR is the HCI rate which is at the heart of this study. The research team calculated the user participant IR, which is the overall interaction for all actions, both vertically and horizontally, per task, activity, and position, as per Table 3.1.

3.11.15 UX

By calculating and assessing the UX, the ability of the user to master and control the system is demonstrated. For that reason, access would first need to be gained to the interaction (i), which is calculated by multiplying the system degree of aesthetics (e) and communication (c), which are all part of the system description. Access to the purpose (p) is also needed, which is established by adding the benefits (b) and the system status (s), which are also known for various systems, and finally, the speed (v), which is obtained by summing the digital speed and the cognitive speed.

In order to avoid any confusion, it has to be stated that as newer computing systems are faster and constantly improved and seen here as a denominators, it may mislead the interpretation slightly. An example would be two or more computing devices with the various p and i, but with the same denominator (v). The formula may appear authentic, but if the denominator is different, and because one speed may be faster than the other, it may indicate that the UX is decreased, simply because the denominator in this case is bigger and therefore reduces what may be perceived as the UX in this case. Ideally, the testing and comparison must be done with the same device in order to maintain the validity of the formula.

3.12 PARTICIPANT TRAINING

As Figure 3.2 indicated, usability training was provided to participants to ensure that they performed better during the next phase of the experiment. This was done a day before the experiment in the same location where the recorded experiment was meant to take place. When the research team could not get there earlier, they would then provide the training a few hours before the experiment began.

The training was based on the activities that had to be completed during the actual experiment. It is important to note that the research team met each participant five times for various experiments and tested them each time on different tasks and activities.

The training was offered to groups of no more than five people, during which they all had access to the same set of testing equipment for the particular day so that they could familiarise themselves with these. The team told them what to do and when to perform the activities; the objective of this experiment was to assess their ability to cope with the equipment.

With the help of an assistant, participants were guided through the task; for example asking them to move from one point to another, showing them how to proceed, observing and guiding them whenever they made a mistake, and answering any questions they had. The average duration was 205 minutes for five people.

Since the training and experiments basically took place on the same day and since the research team dealt with the same people during these visits, it was not only important to keep track of who they were but also to bear in mind that their prime daily activities were their priority. For this reason the team planned their trips very carefully or cancelled them because some participants were simply not available.

3.13 EXPERIMENT PHASES

As indicated in Annexures 8A to 8J, there are five sets of positions that form part of the low-fidelity prototyping, which were identified as part of the process. Each set refers to one participant only, and the records were kept to accommodate that one person. During each site or field visit, the research team would take the correct file with them in order to keep track of the team's activities and simulations pertaining to a single participant and to facilitate the examination. Besides the first two activities of the experiment, others were conducted on separate days.

Some sections of the questionnaire were completed before others to enable the participants to interact with the system before completing the questions which were directly linked to the practical session.

Table 3.2 shows a single view of the whole set of testing phases with corresponding tasks and activities which were accomplished during these periods.

Table 3.2: Phase description

Task/activity	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Preliminary	x				
Position A	x				
Position B		x			
Position C			x		
Position D			x		
Position E				x	
HFP A	x	x	x	x	x
HFP B				x	x
HFP C					
Questionnaire A	x				
Questionnaire B		x			
Questionnaire C			x		
Questionnaire AA				x	
Questionnaire BB					x

The activities, tasks, and experiments' report sampling are all included in the Annexure of this thesis. Some of these activities were conducted using low-fidelity prototypes, high-fidelity prototypes, and questionnaires for ICT professionals and salespersons.

3.14 AREAS WHERE DATA WERE COLLECTED

This research project was conducted countrywide and data were collected from all provinces. The study did not focus on affluent communities or cities but rather on vulnerable and poor communities. The researcher and his team travelled to these areas to meet the primary participants.

At this stage it is important to note that the researcher is based in Johannesburg in the Gauteng province, and the distances indicated in Table 3.3 were calculated from the main residence of the researcher.

It is also important to note that in the nine provinces of South Africa, there are main commercial hubs and towns, but the areas indicated in Table 3.3 are the places where the researcher met the participants.

The durations indicated in the table are simply the time it took the data-collection team to conduct the research activities and do not in any way suggest the length of time spent on a journey.

Table 3.3 gives the full picture of all the locations that were visited by the team, the location within each province, the travelling distance from the researcher and his assistants, the time it took to collect the data, an indication of whether or not the team had to return to that location for any reason, and lastly, the number of participants who came forward to contribute to the research project.

Table 3.3: Townships visited

Province	Township community	Distance from JHB	Duration on the field (days)	Subsequent visit (Yes/No)	Number of participants
Western Cape	Nyanga	1 396 km	3	No	22
Eastern Cape	Adelaide	1 198 km	3	No	23
Limpopo	Bela Bela	150 km	3	yes	17
KwaZulu-Natal	Ulundi	408 km	3	No	16
Northern Cape	Sutherland	1 156 km	4	No	32
Mpumalanga	Delmas	70 km	2	Yes	31
Free State	Naledi	224 km	3	Yes	27
North West	Ventersdorp	148 km	3	Yes	27
Gauteng	Randfontein	40 km	2	Yes	29

The areas chosen for data collection were randomly selected; in other words, it means that the researcher simply explored a country map and picked a particular area in each province provided it was a township. No other specific criteria were taken into consideration besides the fact that they were all rural communities from all the provinces in South Africa. The researcher spent a minimum of three days in each area with the aim of obtaining the maximum input from the participants and sometimes had to return to the areas. The researcher used a rental car to freely move from one location to the next.

The decision to collect data countrywide was determined by both ethical considerations and the research project’s guidelines. The research project clearly defined the “digital divide” in South Africa as a whole and not in a specific town only.

3.15 APPLICATION OF THE METHODOLOGY IN EACH OBJECTIVE

This section discusses how each research objective was investigated; in other words, how the research process was conducted with each of the research objectives in order to draw conclusions. To achieve this, a set of predetermined methodologies were used.

1. To identify, analyse, and address usability hurdles of handheld systems

   a. Research method: Driven by the technical expertise that is expected in this section, it was appropriate to use a qualitative method of data collection to source the necessary information from expert participants.
   b. Data-collection techniques: Interviews and document analysis were used.
   c. Research population: The research population comprised tablet system developers and computing system specialists based in South Africa since they do not only know the market but also the system development process.
   d. Research sampling: Probability sampling was chosen to provide all potential participants with a chance to meaningfully contribute to the research project.
   e. Research design: A quasi-experimental approach was implemented.
   f. Research location/area: The participants were experts in the ICT field and were based in South Africa; the sites for data collection were their place of employment.

2. To calculate key systems usability measurement

   a. Research method: This area dealt with Fitts' law and other similar formulas which were tested by using current approaches and data collected in the field. For that reason it was appropriate to use a quantitative method.
   b. Data-collection techniques: Observation and documentation analysis.
   c. Research population: Adult first-time handheld users from all provinces participated in the research study.
   d. Research sampling: Probability sampling was used throughout the study.
   e. Research design: An experimental approach was used.
   f. Research location/area: Remote rural communities in all provinces participated.

3. **To develop, test, and implement a UXM**
   a. Research method: Not applicable here.
   b. Data-collection techniques: An analysis of all the existing relevant literature and supporting documents.
   c. Research population: The target population comprised adult first-time handheld users.
   d. Research sampling: Not applicable here.
   e. Research design: Not applicable here.
   f. Research location/area: Not applicable here.

3.16 QUESTIONNAIRES, ACTIVITIES, AND TASKS FOR EXPERIMENT

Each participant had to sign a waiver form (see Annexure 1) before participating in the survey or proceeding to the observation or training session. The next step involved providing the participants with a short training session during which they were observed. The survey questionnaire was completed after the observation (see Annexures 2, 4 and 5).

The observations that were captured on video and audio were answered by the participants. The expert participants completed the waiver form and questionnaire (see Annexure 2).

The series of tasks – basic, standard, and advanced computing usage activities – that adult first-time users completed before and after the training were compiled by the researcher (see Annexure 5). The completion of tasks highlighted the challenges experienced by the adult first-time users when exposed to handheld computing systems. During this process, the researcher monitored the amount of frustration, repetition of tasks, enjoyable experiences, and navigation.

3.17 ETHICAL CONSIDERATIONS

In any postmodern research project, and especially where humans are involved, there should be a way to protect those involved and the information they may divulge (Broome 1984:625). Research ethics involves the general principles and guidelines that are meant to guide any researcher during the compilation of a research project and also to hold together all that may exist and matter (Broome 1984:626).

For academic purposes, ethical considerations are grouped into sections to enable easy identification and interpretation. In many ways, research ethics encompasses field accountabilities, the research population, intellectual ownership, content editing, text reviewing, research sponsorship, policymaking, student research, etc. (Rosenblatt & Im 2015:1613). In many cases, and depending on the field of research, the academic or scientific field is strict about ethical considerations (Cooper 1990:44).

The researcher disclosed his full identification before, during, and after data collection. The waiver forms were signed by participants and each participant received a copy of the declaration of interest from the researcher. The waiver did not affect the rights of any participants in any situation. When a potential participant failed to complete and sign the waiver form, data were not collected. A copy of the ethics form is available in Annexure 6.

Jameson (2014) stated,

> "Confidentiality can be defined as an explicit or implied guarantee by the researching team to the respondent in social science research whereby the respondent is confident that any information provided to the researcher cannot be attributed back to the respondent."

The UNISA research ethics was observed at all times in terms of confidentiality. Research is built on a foundation of trust between participants and researchers, as well as the sound trust that the data collected at the end of the day will remain confidential. Most importantly, there should also be trust that the results of the research will reflect an honest attempt by the scientific community and other researchers to describe output accurately and without any form of bias (Orne 1962:776), and that the results would be well represented during analysis.

3.18 ACCURACY AND ERROR CHECKING

Most of the data that were used for this research were directly or indirectly collected from participants. Since erroneous data could be harmful to the outcome of this research project, the researcher introduced contradicting questions into the questionnaires and surveys to enable the verification of the accuracy of the statements made by the participants during interviews or in their responses to the survey questions.

3.19 SUMMARY

Conducting and concluding this research project was certainly fascinating because based on the research verification, specific research projects dealing with adult first-time computing users regarding system usability have not been conducted before in South Africa. The research locations were also interesting because very often, when similar types of research are conducted, they are done in developed nations where almost everything is present and taken for granted and few logistical and technological obstacles are encountered.

The research considered important aspects of research practice that make it unique. It paid attention to areas such as control, replication or verification, as well as systematic observation of the possible outcomes. The types of research that exist were also reviewed.

This chapter reviewed basic applied research and the particularity of the chosen approach and stated why it should proceed that way. It also considered the research approach which, to some extent, disclosed some details about the research approach types and motivation for the project. Exploratory, descriptive, and explanatory studies and some of the possible orientations that can be used to obtain results were reviewed.

The chosen research approach based on the uniqueness of the project as well as the research methods, which provide some evidence on how the research would be conducted, were also investigated. This chapter also paid attention to the research design, particularly the quasi-experimental and experimental design. The chapter discussed the research population in general, made some statements about the sampling method, the data-collection procedure, data analysis, the presentation of findings, and the application of the methodology in each research objective.

The chapter also paid attention to the ethical dimensions and considerations of the research, confidentiality and research ethics, as well as research accuracy of data that must be taken into consideration. As Lazar et al. (2010:150) stated, “Usability research requires both rigorous methods and relevance. It is often tempting to lean more heavily towards one or the other. Some fields of research do focus more on theoretical results than on relevance.”

CHAPTER 4

QUANTITATIVE AND QUALITATIVE DATA ANALYSIS

4.1 INTRODUCTION

Conducting this research in the most appropriate manner required that the research team take some time to assess the level and number of respondents. The validity of the work or output is to a great extent linked to the manner in which it was conducted, as well as the type, amount, and level of participation. The aim of this chapter is to explore the quantitative and qualitative data. The chapter is divided into multiple sections, which range from participants' details to topic-linked data.

The questions explored in this chapter were compiled after the initial testing phase and before the training. The quantitative data are exclusively from adult first-time users and the qualitative data were collected from interactive designers.

It is also vital to note that data were collected at various locations around the country and more specifically from low-income communities in all provinces.

4.2 PARTICIPANTS

At this stage of data analysis, it is essential to declare and define those who participated in the study. The participants were divided into two groups. The first group, known as adult first-time users, were contacted in their respective communities and approached by the researcher. They responded to quantitative questions only and were part of the observation section of the same study. The second group of participants were ICT and interactive designers, also known as ICT professionals. They responded to qualitative questions only. For this last group, questionnaires were sent and returned via email.

4.2.1 Preliminary or participant background analysis

This section explores all the related questions which are linked to the participants and provides information about the number of people who participated in each question. This simply forms part of the demographics; some in-depth questions will be included in other chapters. Tables 4.1 to 4.4 show the results of each question, each followed by an analysis of the results.

Table 4.1: Q1 – Please indicate your gender

	Frequency		%	Valid %	Cumulative %
Valid	Female	166	44.0	48.3	48.3
	Male	178	47.2	51.7	100.0
	Total	**344**	**91.2**	**100.0**	
Missing	System	33	8.8		
Total	**-**	**377**	**100.0**		

Table 4.1 shows the level of gender participation. There are many stereotypes that women are less prone to participate in any technology-related studies; however, this study witnessed a strong level of female participation. Of all 377 participants, 344 indicated their gender as follows: 166 (44%) were female and 178 (47%) were male. A total of 33 participants did not complete this section, which is 8.8% of the total. Reflecting on the number of participants, the researcher observed a high number of people willing to be part of the research project. The 33 missing responses are due to people who did not want to indicate their gender for some reason.

Table 4.2: Q2 – Please indicate your age group

	Frequency		%	Valid %	Cumulative %
	Age Range	Results			
Valid	5-10	3	.8	.8	.8
	11-13	17	4.5	4.6	5.4
	14-17	39	10.3	10.6	16.0
	18-24	237	62.9	64.2	80.2
	25-34	42	11.1	11.4	91.6
	35-44	21	5.6	5.7	97.3
	45-55	4	1.1	1.1	98.4
	Over 55	6	1.6	1.6	100.0
	Total	**369**	**97.9**	**100.0**	
Missing	System	8	2.1		
Total	**-**	**377**	**100.0**		

Table 4.2 shows the age group of the participants. The researcher wanted to know whether or not the participants were indeed the people he was expecting. It is important to note that this study specifically and explicitly targeted a particular group of people, i.e. adult first-time users, and here the researcher noticed that a considerable number of participants were within the target age group, which makes this study more reliable. As indicated in the table, 82.3% of the participants were over the age of 18 years. It is also important to note that during the fieldwork the researcher made it very clear to all the participants that the study was limited to adult first-time users and adults who have never experienced any form of computing in their life, with the

exception of those who have used cell phones before. By combining the number of all those who came forward and who were 18 years and older, the researcher had a good number of people who met the requirements.

Table 4.3: Q3 – Please indicate your level of education

	Frequency		%	Valid %	Cumulative %
Valid	None	31	8.2	8.6	8.6
	Primary	178	47.2	49.3	12.7
	Secondary	102	27.1	28.3	22.4
	High school	35	9.7	10.1	50.7
	Tertiary	15	4.2	4.3	100.0
	Total	**361**	**95.8**	**100.0**	
Missing	System	16	4.2		
Total	**-**	**377**	**100.0**		

Table 4.3 shows the level of education of the participants. Knowing the level of education of the participants is part and parcel of the set criteria for initiating this study as it enables classifying or identifying the possible link between literacy and computer literacy, and whether or not the lack of the former may lead to the poor performance of the latter. The details as indicated in the table are a clear sign of the possible conclusion that can be made about the link between general literacy and computer literacy. As indicated in the table, 82.5% of the participants only had primary, secondary, and high school education levels, 8.6% never had any form of education, and 4.2% had a form of tertiary education.

Table 4.4: Q4 – Please specify how long you have been living in this area

	Frequency		%	Valid %	Cumulative %
Valid	Less than 5 years	121	32.1	33.2	33.2
	Between 5 and 10 years	68	18.0	18.7	51.9
	More than 10 years	175	46.4	48.1	100.0
	Total	**364**	**96.6**	**100.0**	
Missing	System	13	3.4		
Total	**-**	**377**	**100.0**		

The study is very clear about the target group for the study. It clearly indicates that most, if not all, prospective participants must be people who are living in some impoverished community. Asking this question was important as it later corroborated the other details in this study. In most cases, some of the participants were born and raised in these communities and were still living there. As indicated in Table 4.4, 32.1% of the respondents indicated that they had been living there for less than five years, 18% indicated that they had been living there between five and ten years, and 46.4% indicated that they had been living there for more than ten years, which is a huge percentage. The researcher also noticed that in many of these communities, the level of migration is very high and that most people are moving to bigger cities.

4.2.2 Topic-linked questions

While the preliminary section was mostly meant to assist in comprehending the demographics of the participants, this section deals with questions which were meant to assist the researcher in comprehending the topic under discussion.

At this stage, it is vital to specify that two methods were used here, namely qualitative and quantitative methodologies, and when they were combined, triangulation was further used to enable better understanding of the issues under investigation.

Table 4.5: Q5 – Have you ever accessed the Internet?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	31	8.2	8.3	8.3
	No	341	90.5	91.7	100.0
	Total	**372**	**98.7**	**100.0**	
Missing	System	5	1.3		
Total	**-**	**377**	**100.0**		

As indicated in Table 4.5, 8.2% of the respondents indicated that they had accessed the Internet before, and 90.5% indicated that they had not. Only 1.3% did not respond to this question; which on its own shows the great importance of the Internet in rural communities. This question can also be classified under the preliminary questions as it enabled the researcher to identify the people who may have had contact with advanced ICT tools. These figures could easily be linked with the data from Table 4.2 and 4.3.

People are often driven to the Internet for various reasons. Although the question might not be about providing reasons here, one may wonder why people, who are mostly unemployed, are reaching out to the Internet in such large numbers.

Furthermore, one may also see the response of this question as a bit problematic, as these days one can easily gain access to the Internet from any smartphone, or by connecting devices with someone who has Internet access, even in rural areas.

Table 4.6: Q6 – Have you ever used a tablet system?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	40	10.6	10.7	10.7
	No	332	88.0	89.2	100.0
	Total	**372**	**98.6**	**100.0**	
Missing	System	5	1.3		
Total	**-**	**377**	**100.0**		

Table 4.6 shows the level of contact some participants may have had with handheld systems such as tablets.

To this question, 10.7% of the participants said that they had used a tablet before, 88.0% said they had not, and 1.3% did not respond to the question. In fact, if the response was the opposite, there would not be a reason to conduct this study, since it is aimed at people who had never had any meaningful contact with a tablet system.

The fact that the majority (88.0%) indicated that they have never used a handheld tablet system before warrants the purpose of this study, and the figure is big enough to deserve our full attention.

Table 4.7: Q7 – Did you feel frustrated because some actions could not be completed?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	170	45.1	49.4	49.4
	No	174	46.2	50.6	100.0
	Total	**344**	**91.2**	**100.0**	
Missing	System	33	8.8		
Total	**-**	**377**	**100.0**		

Based on the number of people who indicated in Table 4.6 that they have had prior contact with a tablet system, the researcher wanted to know more about the possible level of frustration they may or may not have experienced while operating one. Did they feel frustrated because some actions could not be completed, or were there other issues? Table 4.7 shows that 45.1% said yes, they felt frustrated, 46.2% said no, and 8.8% did not respond to this question. These responses can be used for further analysis as computing usability and frustration are often intertwined.

The researcher then used a qualitative question to help comprehend the issue, as indicated in Table 4.8.

Table 4.8: Qualitative question 1 – GUI design perspectives

Question	
From a GUI designing perspective, at what moment do you measure the level of user frustration?	
Number	**Responses**
1	During initial testing, yes, and after release of the product, it can be very difficult to assess.
2	Yes, we do, but only during the testing situation.
3	It can be helpful if we checked it before any user becomes frustrated with our product.
4	No, developers may simply ignore this call, and we need to be very aware of that by removing any hurdle that may lead to that type of user frustration.
5	User frustration is the leading cause of abandonment regarding computing systems and other related products, and therefore we need to be aware of that when designing user interaction in general and particularly usability and navigation.
6	Yes, it is important that we verify that aspect before releasing the system. If not, it can lead to clients not using our product.
7	We are aware of the phenomenon; that is the reason we always conduct user testing and analyse the level of frustration from their part before releasing the final product to the public.
8	It may help the developing team when testing their final version of the product as the users.

Some of the major themes from respondents were: during the initial phase of the development process; previewing user frustration during the development process; and before the release of the product.

The above statements from respondents mean the following:

- Early testing phases of the interaction.
- Testing user frustration during the overall testing process only.
- Before releasing the final product to the public.
- Testing user frustration during the overall assessment.

Based on the meaning of what the respondents indicated above, one may ask oneself what can be done to achieve the above.

It appears as if most interactive developers are not well aware of the importance of assessing the level of user frustration regarding the quality of any computing system. In some instances, it seems to be integrated into the overall systems testing, or not having the attention it may deserve. To achieve the above, one needs to assess and acknowledge the impact user frustration may have on any computing user. It is thus important to have an independent set of assessment tools to measure the level of user frustration during all phases of the systems development life cycle. As indicated in Response 5, "User frustration is the leading cause of abandonment regarding computing systems and other related products, and therefore we need to be aware of that when designing user interaction in general and particularly usability and navigation." Taking users' level of frustration into account during a usability assessment may have a positive impact, as indicated in Table 4.8.

This question was about understanding how a developing team approaches the issue of user frustration at the developmental stage. The answers varied widely. Some indicated that they conducted a pilot assessment to overcome the user frustration that may be attached to the usability of the device, while others indicated that they often included the user in all stages of system development, which enabled them to constantly assess the degree of user frustration and address it while they still could. It appears that all respondents were of the view that any form of user frustration needs to be dealt with as soon as possible.

Based on the quantitative data collected in Table 4.7, which shows that 45.1% of the respondents indicated that they were frustrated, and considering the qualitative responses from ICT professionals in Table 4.8, which indicates that ICT professionals do not pay enough attention to the needs of users during their initial analysis, it can be concluded that usability and user frustration may still be an issue if no clear attempt is made towards understanding users' needs, and it can be even worse if participants are adult first-time users.

Table 4.9: Q8 – Did you feel confident when using the tablet system for the very first time?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	92	24.4	26.4	26.4
	No	257	68.2	73.6	100.0
	Total	**349**	**92.6**	**100.0**	
Missing	System	28	7.4		
Total	**-**	**377**	**100.0**		

This question touches on the essence of this research study. It indicates how users felt when they operated a tablet system for the first time. Only 24.4% of the respondents indicated that they felt confident when using a tablet for the first time, and 68.2% said they were not confident at all.

The negative output of 68.2% here is very problematic because some users may opt out after such a negative experience, while it may also lead to other forms of reclusion. It is important to note at this stage that these preliminary questions were asked before the training session and therefore users responded to these questions after interacting with the device for the first time.

Table 4.10: Q9 – Was the tablet's usability complex?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	211	56.0	87.9	87.9
	No	29	7.7	12.1	100.0
	Total	**240**	**63.7**	**100.0**	
Missing	System	137	36.3		
Total	**-**	**377**	**100.0**		

Table 4.10 shows the limited knowledge participants may have had about computing systems. The researcher wanted to know if participants found the tablet's usability complex. Most (87.9%) indicated that they found it complex, while 12.1% indicated that they found it easy.

This may indicate that not much is being done to address the level of complexity of some handheld computing systems, which may cause some major problems down the line, as this figure is very high and needs to be explored in order to address it. The more complex a device is, the more frustrating it is for users.

To further explore the above answers, the researcher asked the second qualitative question to ICT interactive system designers (see Table 4.11).

Table 4.11: Qualitative question 2 – Usability and accountability

Question	
How are the needs of users taken into account when designing the GUI?	
Number	**Response**
1	They make it user friendly.
2	The use of applicable icons and organising the menu by grouping related features under same categories help the user to easily get accustomed to the graphical user interface.
3	One method that manufacturers use to cater for both new and experienced users is by having a variety of handheld devices where users can choose the one that best caters for their needs. Another way is by keeping the interface standard.
4	They design similar graphic user interfaces.
5	I think they are taken into account quite well, because tablet systems are user friendly; one would not have troubles trying to figure out or locate a certain feature.
6	The GUI should be user friendly.

Question	
How are the needs of users taken into account when designing the GUI?	
Number	**Response**
7	Their needs are taken into account in the fact that GUI devices can interact with multiple devices such as MP3 portable media players, gaming devices, and smaller household, office, and industrial equipment. Also, it can be manipulated with a mouse and by some extent a keyboard.
8	Brightly coloured and widely used icons that are consistent throughout devices help users use their tablets but there is still much to do in this regard.
9	Manufactures put the end user first.
10	They ask employees within the company how they would like it to be (survey).
11	Companies present their prototypes to children and adults to make an evaluation on it.
12	If users were able to buy more smartphones and get a positive market, then designing the tablet GUI should be similar to maintain that market.
13	The interface is simple to follow and understand. Applications icons are properly labelled and spaced to reduce through the grouping of similar functions and the graphic animations are to assist users and add better aesthetics.
14	The graphic user interface is taken into account because it operates with an understandable system which enables users to operate it without having issues or problems.
15	I think they are partly involved because most devices these days are touchscreen models; they help reduce the time of clicking buttons, and the flat surfaces of many devices are pleasing to many users.
16	They look at the users' needs by trying to improve the graphics, allowing people with visual difficulties to handle it in a normal manner.
17	Designers who understand how humans think are hired to come up with design ideas to make sure the product's looks are in line with the users' needs.
18	The designer master ensures that the tablet is user friendly, easy to use, portable, flexible, satisfies users, and it must not irritate users in any way.
19	They are well considered for people to understand and simply manipulate the tablet. In other words, they create a user-friendly interface.

In the above table, the respondents indicated that user needs were central, leading to user friendliness and US. Issues such as user friendliness and US were some of the keywords in the respondents' answers. From the responses, one can conclude the following:

- The systems must afford ease of use.
- The interface must be visually pleasing.
- The use of familiar icons is important.
- The size and label of icons must be clear enough for everyone.

- System instructions must be easy to understand.
- The interoperability of all platforms must be guaranteed.
- The systems must support users' needs.

Next, we need to examine what is required to achieve the above set of preferences.

Some of the key phrases in the responses include: design seems to be globalising all the above; through design, standard processes can be achieved, which takes into account the users' needs and aspirations; and the use of good and familiar graphics and having the most reliable set of system requirements are the key to deliver and address the understanding of users' needs.

Next, it appears as if system profiling and testing systems design can easily ensure that the needs of users are taken into account, as indicated in Table 4.11.

Based on the above, one response (number 1) indicated that "they make it user friendly" to a greater extent, which means that by fully integrating user friendliness into the system's development, one may understand users' needs.

The ICT professionals believe that it is very important to put users' needs at the centre of any form of design. Some believe that no success can be achieved unless users' needs are placed at the centre of the design. In order to make interactive designs more user friendly, it is very important that application icons should be familiar to the user. Some believe that designing a GUI is more stressful than any other design task, as designers always need to make sure that they reassess their priorities at all times.

By mixing both sets of answers, it can be seen that the majority of the respondents who were active mobile users indicated that they found tablet systems complex (although it was their very first encounter). Even though the majority of the system designers indicated that they do whatever they can to make tablet systems' interactivity as smooth as possible, from the participants' responses it appears quite the opposite. One way of understanding this could be that systems were not developed for adults first-time users, or that while considering their target group, the designers were not looking at the same user group.

Table 4.12: Q10 – Did you complete the first tasks (stipulated) on time?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	90	23.8	26.5	26.4
	No	250	66.3	73.5	100.0
	Total	**340**	**90.1**	**100.0**	
Missing	System	37	9.9		
Total	**-**	**377**	**100.0**		

Table 4.12 gives an indication of whether the tasks which were meant to be completed, were indeed completed by the participants. The researcher wanted to know if the tasks were completed within the specified timeframe. Only 23% indicated that they had completed the first task in the stipulated time, while 73.5% indicated that they had not. These figures are quite concerning.

The question was meant to address in detail the difficulty adult first-time users may have had operating a handheld system. Not completing the requested task within the specified time, or not completing it at all, is a sign that participants were struggling to complete them, or that they did not know what to do to complete them and as a result they fell behind and/or abandoned the activity.

Table 4.13: Q11 – Did you ask for help while doing the task?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	163	43.2	52.2	52.2
	No	149	39.5	47.8	100.0
	Total	**312**	**82.8**	100.0	
Missing	System	65	17.2		
Total	**-**	**377**	**100.0**		

Very often, when people are experiencing difficulties, they tend to ask for assistance. With this question, the researcher wanted to know whether participants felt they were unable to complete the tasks unless they sought any form of assistance, even though they were not supposed to do so. A total of 52% indicated that they asked for assistance during testing and 47% said they did not. It is a matter of concern that the majority of the respondents indicated that they found themselves in a situation where they had to seek external help to complete basic tasks.

This shows that the respondents needed help when interacting with a tablet system, and that they were stuck and needed help to overcome the difficulties.

Table 4.14: Q12 – Was the user interface well designed for the tasks you were executing?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	100	26.5	32.1	32.0
	No	200	53.0	67.9	100.0
	Total	**300**	**79.5**	**100.0**	
Missing	System	77	20.4		
Total	**-**	**377**	**100.0**		

With this question, the researcher wanted to know if the user interface had helped the participants in completing their tasks; only 32% said yes, while 67% said no. This is in line with the results of the previous question. Is there any link between the user interface and the difficulty of any given task on a computer system? The answer can be either way. Under normal conditions, an interactive GUI is based on possible tasks which can be executed or tasks which need to be executed and based on set criteria, the interaction is developed and implemented.

The participants indicated that they needed help when completing their tasks as their user interface was not suitable for their duties and tasks. A simple explanation can be lack of understanding of how the system is meant to operate or the task could not successfully be completed using such interaction, but the latter seems less realistic.

Table 4.15: Q13 – Was the system effective and efficient?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	90	23.8	26.4	26.4
	No	250	66.3	73.5	100.0
	Total	**340**	**90.1**	**100.0**	
Missing	System	30	9.8		
Total	**-**	**370**	**100.0**		

This question seeks to explore one of the main areas that was widely analysed in this study, especially in the observation section of the study. The researcher wanted to determine if the system the participants were using was to some extent effective and efficient. Only 26.4% said yes, while 73.5% said no. These figures support the output of the previous question. One may stipulate that the response is open for any form of interpretation, since one may need to clearly define what we understand as “effective” and “efficient”.

In this study, under “effective”, the researcher wanted to know if participants believed that the system enabled them to do what it was meant to do, and under “efficient”, the researcher wanted to know if it enabled them to speedily complete the tasks they were meant to complete.

Still in the same line as the output from the previous question, many believed that the system they were tested on was not as good as they expected it would be, which is also problematic – at least at this stage.

Table 4.16: Q14 – Was the system easy to learn?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	50	13.2	15.2	15.2
	No	277	73.4	84.7	100.0
	Total	**327**	**86.6**	**100.0**	
Missing	System	40	13.4		
Total	**-**	**367**	**100.0**		

As with the previous question, the researcher wanted to know if the participants, based on the limited contact they had with tablet systems, thought that it could easily be learned in terms of usability. Only 15.2% indicated that it was easy to learn, and 84.7% indicated that it was not. This is a clear sign that most were of the view that learning to use or control these devices needed either more time or that it was not at all possible.

The learnability of any system is what makes it worthy to invest in because when first-time users do not find it easy to use, it can easily be interpreted as not being user friendly.

Table 4.17: Q15 – Did you struggle to select a specific icon because your thumb felt too big for the device or GUI?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	65	17.2	18.6	18.6
	No	285	75.6	81.4	100.0
	Total	**350**	**92.8**	**100.0**	
Missing	System	27	7.2		
Total	**-**	**377**	**100.0**		

This question regarded the physical constraints which some adult tablet users complained about. It is obvious that questions such as this may come into play when discussing the issue of tablet usability. The researcher wanted to learn if the participants had a problem with the size of the icons while using the system. Regarding poor icon visibility, users sometimes find it difficult to access interactive icons, which may lead to them becoming frustrated. To this question, 17.2% indicated that they experienced such issues with the icons and 75.6% said no. This came as a bit of a surprise to the researcher.

Thumb problem is one of the reasons some people choose to use a stylus when using a handheld system, as some icons may be too small for their thumbs to select them. Here it seems as if that might not be the case.

Table 4.18: Q16 – How do you rate the tablet system's usability?

		Frequency	%	Valid %	Cumulative %
Valid	Impossible to use	137	36.3	39.6	68.2
	Hard to get used to, but then not bad	110	29.2	31.8	31.8
	Easy to use, but some problems persist	34	9.0	9.8	9.8
	Very easy to use	65	17.2	18.8	100.0
	Total	**346**	**91.8**	**100.0**	
Missing	System	31	8.2		
Total	-	**377**	**100.0**		

This was one of the most important questions that helped to understand the whole aim of the test. The researcher wanted to know how the participants rated the usability of the tablet system, to which 36.3% said it was impossible for them to use the system; 29.3% said it was hard to get used to, but then not bad; 9.0% said it was easy to use, but some problems persist; and 17.2% said it was very easy to use. If grouped into two distinctive sections, i.e. agreeing and disagreeing, it is evident that more people complained about the usability than those who found the systems easy to use, and that is the essence of the whole study.

Table 4.18 provides some very important information, which is that only 17.2% said it was very easy, and the rest said it was problematic, which raises concerns. It also means that most people experienced problems with the systems, even after attending the training session.

Table 4.19: Q17 – Were you able to locate key features and functionalities of the tablet without any help?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	101	26.7	29.4	29.4
	No	243	64.5	70.6	100.0
	Total	**344**	**91.2**	**100.0**	
Missing	System	33	8.8		
Total	-	**377**	**100.0**		

With this question, the researcher wanted to know if participants were able to at least locate the key functions and functionalities on the tablet without any external help. Only 26.8% said yes, 64.5% said no, and 8.8% did not respond to this question. If someone is unable to locate and access critical control functions, they would not be able to sufficiently interact with the system. However, this does not in any way mean that those controls are not in place or that they are missing; it simply means that the respondents were unable to identify or locate them. There can be other reasons than simply poorly designed interactivity, such as the participants' own visual abilities (which is beyond the scope of this study).

Table 4.20: Q18 – Do you understand the tablet's primary and secondary navigation techniques?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	121	32.1	35.0	35.0
	No	225	59.7	65.0	100.0
	Total	**346**	**91.8**	**100.0**	
Missing	System	31	8.2		
Total	**-**	**377**	**100.0**		

With this question, the researcher wanted to determine participants' ability to clearly understand the importance of some key functions regarding system navigation and if they were fully aware of the primary and secondary navigation techniques that come with the device. Here, 32.1% indicated that they understood the primary and secondary navigation techniques, 59.1% said that they did not, and 8.2% did not respond to this question. The primary navigation functions are commands that the user needs to gain access to before being able to locate the secondary navigation functions, which are mostly hidden. The aspect that was evaluated was whether participants could differentiate between these functions and whether they were able to follow their order of appearance.

The results to this question indicate that not everyone fully understood the importance of computing system navigation. Some tasks can be done in a number of ways and users must have the option of choosing which one is the most appropriate for them.

Table 4.21: Q19 – Did you feel that you have to remember too many things while using the system?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	182	48.2	52.4	52.4
	No	165	43.8	47.6	100.0
	Total	**347**	**92.0**	**100.0**	
Missing	System	30	8.0		
Total	**-**	**377**	**100.0**		

Here the researcher evaluated the participants' recollection of phases which were needed for efficient system navigation and control. The question was aimed at learning whether the participants felt that they had to recall too many steps during the process in order to complete some tasks at hand. Here, 48.3% said yes, 43.8% said no, and 8.0% did not complete this section. By not being able to remember the sequence of navigation, users spend a great deal of time finding ways to identify what to do next when asked to complete the next task or activity. As a matter of fact, most systems' navigation is nearly identical. The issue is when participants found it difficult to know or recall what they did previously.

This question is meant to assess the ability of the user to recall steps while using the system. Most participants struggled a little with the tasks before being able to complete them because their ability to recall previous steps was insufficient.

Table 4.22: Q20 – Were you satisfied with the tablet system's operation?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	80	21.2	23.2	6.0
	No	265	70.2	76.8	100.0
	Total	**345**	**91.4**	**100.0**	
Missing	System	32	8.6		
Total	**-**	**377**	**100.0**		

With this question, the researcher wanted to determine if the participants felt any sense of satisfaction after completing the experiment. Only 6.0% said that they felt satisfied, while 76.8% indicated that they did not, which is a very high percentage. This high percentage comes as no surprise after observing the results of the preceding questions, which were clear signs of dissatisfaction, and an indication that something needs to be done to address this dissatisfaction.

Table 4.23: Q21 – Did you make any errors during the test?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	277	73.4	84.7	84.7
	No	50	26.5	15.2	100.0
	Total	**327**	**86.7**	**100.0**	
Missing	System	50	13.3		
Total	**-**	**377**	**100.0**		

This question is basically a sub-question of the previous question in Table 4.22, and the answers are also very much in line with the previous answers. The researcher wanted to learn if the participants made any errors during the testing process. A total of 84.7% said yes, and 15.2% said no. Making mistakes during an experiment can be seen as obvious for first-time users since tasks and activities are recurrent and repetitive, but when it affects a large group of people, one can only wonder about the overall outcome. The task each participant was asked to complete can be seen as basic and in a linear function of execution, but when the masses seem to experience problems with its execution, it can mean that it is incomprehensible or its execution is problematic.

In conclusion, the fact that they made many mistakes can be justified – given the output in the previous table.

Table 4.24: Q22 – How many mistakes did you make?

	Variant	**Frequency**	**%**	**Valid %**	**Cumulative %**
Valid	Less than 5	139	36.9	57.4	57.4
	Less than 10	49	13.0	20.2	77.7
	less than 15	32	8.5	13.2	90.9
	Less than 20	7	1.9	2.9	93.8
	Less than 25	15	4.0	6.2	100.0
	Total	**242**	**64.2**	**100.0**	
Missing	System	135	35.8		
Total	**-**	**377**	**100.0**		

This question is a follow-up from the previous question. The researcher wanted to determine how often the participants made mistake or errors, as a way of classification of those mistakes. Table 4.24 supports the outcomes of the previous table and indicates the number of mistakes the participants may have committed, which is quite concerning. The researcher provided a set of groups under which to classify the mistakes and it seems that those who made five or less errors per activity were in the majority. It also needs to be specified that each activity consisted of five tasks, and if the majority indicated that they made approximately the same number of mistakes as there were tasks, then it means that at least one mistake per task was made, which is very high. It also means that no tasks were completed without mistakes.

Table 4.25: Q23 – Do you think the system design was consistent?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	67	17.8	19.3	19.3
	No	280	74.3	80.7	100.0
	Total	**347**	**92.1**	**100.0**	
Missing	System	30	8.0		
Total	**-**	**377**	**100.0**		

With this question, the researcher wanted to learn if participants were under the impression that issues or problems they experienced were based on the system they were using or within the testing interactivity. The question seeks to determine if they believed that the interaction design of the tablet system was consistent. Only 17.8% said yes, 74.3% said no, and 8.0% did not respond to this question. From these results, the researcher is under the impression that the respondents did not think that they were the problem, but rather the systems they were given. This is just an impression, but it can be observed in other fields as well. Whenever people are confronted with issues that are not within their control, or they are simply not able to control their own ability to achieve certain goals, they tend to blame others for their failure. As a productive system, the functionality is well and sound. Consistency or a lack of it becomes a problem when some actions are not the same throughout the development phase, and users are forced to relearn something each time they want to complete a new task or activity.

In this section, the researcher paid more attention to the percentage of people who responded that they did not find the system design consistent, which was 74.3%. This high percentage indicates that something must be done to bring it under control.

To better defend this argument, the following qualitative question was asked:

Table 4.26: Qualitative question 3 – Design consistencies

Question	
From your own experience, what is the importance of design consistencies?	
Number	**Responses**
1	In any serious development project, we remain consistent.
2	Consistency helps everyone, as it guides our overall designs.
3	Very important when doing projects like GUI.
4	Without that, it could be a disaster to all.
5	Any important interaction design must always be consistent with an agreed process; otherwise it would not help the project.
6	Lack of consistencies in any design project is bad and totally unacceptable.
7	That is one of our priorities when designing any interaction.
8	Yes, all the time, and always consistent.
9	To keep our project relevant, we must be consistent.

From the above answers, the researcher identified summative themes such as guideline, disaster prevention, and unacceptable lack of consistencies. This generally means the following:

- A means of guiding the overall design process.
- A mechanism that prevents losing control over the aim of design interactivity.
- Having it as a priority helps to control and prevent errors.

Based on the above, and having explored the overall meaning of those themes, it can be concluded that in order to address the question in Table 4.26, one needs to develop system prototypes that portray the needs and aspirations of both the designers and users by paying close attention to designing issues such as the navigation and flow of handheld systems, the order of processing during interaction, and maintaining a close sense of consistency when designing an interaction. As Respondent 5 indicated in Table 4.26, "Any important interaction design must always be consistent with an agreed process; otherwise it would not help the project."

From the output presented here, most respondents agreed that design consistencies constitute an important element that guides their overall approach for development. Design consistencies are mostly used as an approach in which the design team uses similar operations and similar elements for developing similar tasks, operations, processes, and pages. This rule has to be applied consistently and broadly to enable the user to easily identify similar operations based on previous experience. Some indicated that they do apply them as broadly as they can in order to prevent any form of confusion and promote easy memorability of the system.

From the quantitative responses from people who participated in the experiment, the majority (74.3%) said that the systems were not consistent, and when the researcher tried to back that up with responses from the interactive designers, they indicated that the incorporation of consistent design is a critical matter, and that without consistency it can be a disaster. Where does this lead us? It can well be that some participants were still trying to understand what it really meant, and what they understood as consistencies may not be what they thought or saw. This was indicated in Table 4.25 and later supported by Table 4.26.

Table 4.27: Q24 – Did your previous experience as mobile user help during the testing?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	283	75.1	81.1	81.1
	No	66	17.5	18.9	100.0
	Total	**349**	**92.6**	**100.0**	
Missing	System	28	7.4		
Total	**-**	**377**	**100.0**		

With this question, the researcher is of the view that most rural areas in South Africa have mobile network coverage, and it is also supported by the literature. This means that although people may not have access to other forms of computation, they may still have access to mobile connectivity. Here, the researcher wanted to determine if using this tacit knowledge, one is able to utilise it to better control a system such as a tablet. How does existing knowledge help develop better interaction? One may hope that users may still gain valuable experience based on their previous knowledge of mobile computing. To this question, 75.1% said yes, and 17.5% said no. This indicates that most participants were able to make use of their existing knowledge as mobile users to use their intuition when dealing with a completely new system.

From the following qualitative question, the researcher wanted to learn what the responses and statements are which enable us to fully comprehend the research question.

Table 4.28: Qualitative question 4 – Interactive designing

Question	
From an interactive and designing perspective, what mechanism enables you to guide any first-time user of a tablet system?	
Number	**Response**
1	From our developmental approach, we include an application wizard into our product, which can easily guide the developmental process of any first-time user. Of course we pay great attention to first-timer user needs and anyone that can be classified as such.
2	We may not be able to cater for all options, but we pay great attention to any first-time user.
3	That should be our priority.
4	It may not make sense if we simply ignore them.
5	It can be simple and complicated at the same time, but we do that.
6	Yes, we include user needs.

From these responses, the researcher identified the following key phrases: the inclusion of artefacts such as an application wizard into the operating system, and paying great attention to the needs of first-time users.

From the above, one can conclude that the respondents meant the following:

- The inclusion of an application that can guide first-time users.
- First-time users' needs.
- Paying attention to first-time users.
- Making first-time users a priority.
- Simply ignoring first-time users may not make sense.

The researcher investigated ways to achieve the above statements and declarations. This brings us to system analysis and design. Comprehending users' needs is just part of the process of elicitation, therefore better comprehension of the needs of users is essential. The specific needs of adult first-time users may not be part of the set priorities, but based on the responses, it seems to play a major role in the accomplishment of using a handheld computing system.

In Response 2 in Table 4.28, interactive developers acknowledged their role and responsibility regarding guiding any first-time user.

Judging by the responses in Table 4.28, users are treated as a group. At first it may sound as if little consideration is given to individual segments of the user community and most attention is directed towards providing an ultimate solution which may be ideal for any ordinary user; however, some designers indicated that in their approaches they consider the issue of a first-time user as part of their wider integration, and they explore the interaction regarding the various versions that they intend to release. In most cases, the designers start with the initial version, which is more user friendly, and later release a more advanced version. They tend to increase the usability burden and sophistication.

Table 4.29: Q25 – Did the interface provide some form of guidance?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	70	18.6	20.3	20.3
	No	275	72.9	79.7	100.0
	Total	**345**	**91.5**	**100.0**	
Missing	System	32	8.5		
Total	**-**	**377**	**100.0**		

With this question, the researcher wanted to determine whether or not the interactive interface gave participants any sort of guidance. This involves the system navigation, depending on the task and activity that one needs to complete. The GUI, when well developed, must provide the user with some sort of guidance, which ultimately guides their actions when interacting with the system. To this question, 18.6% said yes, 72.9% said no, and 8.5% did not answer the question. Although the answer is very much in line with previous responses, one needs to ask if they fully understood the question, or if they did understand the question, but just like in previous questions, they simply did not feel guided by the interaction.

GUI is the link between humans and computing systems. As such, it must provide all possible types of guidance that are needed in order to limit the number of errors that a user may make during the interaction process.

Table 4.30: Q26 – Was your experience enjoyable?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	43	11.4	12.3	12.3
	No	306	81.2	87.7	100.0
	Total	**349**	**92.6**	**100.0**	
Missing	System	28	7.4		
Total	**-**	**377**	**100.0**		

Based on the results of previous questions, the researcher wanted to determine if respondents, after all the difficulties they had faced, still felt like they achieved something positive; in other words, if they found the experiment enjoyable. This is one way of assessing whether participants liked the whole interactive journey. Only 11.4% indicated that they found it enjoyable, 81.2% indicated that they did not, and 7.4% did not respond to this question. The results are not too surprising and they are very much in line with the results from previous questions. Considering that, as indicated in previous questions, the majority of the respondents indicated that they were not guided by the interface, that it did not provide any form of consistency, that they made some errors, and that they were not able to locate key features and functions, it is not surprising that they did not enjoy the experiment.

To further defend this argument, the following qualitative question was asked:

Table 4.31: Qualitative question 5 – UX and emotion

Question	
What impact does “user experience” and “emotion” have when designing interaction?	
Number	**Responses**
1	User experience is what makes the whole testing process worth something, and user emotion is captured on camera and then analysed afterwards.
2	We are using these two aspects to check our products.
3	User experience and emotion are also tested and validated by the designing team.
4	We have our own internal standard when measuring user experience and level of emotion when they deal with our product. It is important to know how people/users feel about our product and the level of emotional connection with the interaction development during testing processes.
5	Yes, we also explore that aspect when development is taking place.
6	Yes, we do test that as well.
7	It helps to verify that process before moving the release of the final system.
8	Customer experience is what makes any product what it is. Customers are the users, and if users are not okay, then the product is useless; and from the emotion side of it, if the emotions of the user are not considered during the design process, the entire project can be in a poor state.

This question was aimed at knowing what impact user experience and emotions had on interactive designers when working on interaction. From the above responses, the researcher identified a few common keywords which may assist in generalising their responses, namely testing and validation of user emotion; creating an emotional link with users; and verifying due processes.

Based on the above statements, the respondents referred to the following:

- Capturing user emotion and dealing with them while possible.
- Testing user emotion before any release.
- Measuring the level of user emotion before releasing it.
- Understanding the degree of user engagement and emotion when designing.
- Assessing the final product before releasing it.

The researcher believes that the above can be achieved by progressively reviewing and evaluating user interaction and addressing shortfalls as soon as they are identified. The computing users in general developed and maintained some form of emotional connection with their devices, and, most importantly, new users or adult first-time users were prone to some forms of emotional distress if they were unable to control the systems the way they intended to. As indicated by Respondent 8, "Customer experience is what makes any product what it is. Customers are the users, and if users are not okay, then the product is useless; and from the emotion side of it, if the emotions of the user are not considered during the design process, the entire project can be in a poor state."

Regarding the roles that assessing the user experience and user emotions may play, many respondents were adamant that it constituted the key evaluation that each needed to comply with in order to be commercialised. According to the responses, the ultimate hurdle that all interactivity design processes must meet is using active participant users who are able to assess the system interactivities and measuring their responses to the task being tested, and only when successfully completed, can the next process be initiated.

In response to the quantitative question in Table 4.30, just over 81% of the participants indicated that they did not enjoy their interaction with the system or the experiment, possibly due to the continued usage of the system over time, as the researcher expected. However, what did the participants indicate from an interactive perspective? From their perspective, it does not make sense to develop a system that does not provide any form of enjoyment to its users since it is one of the main reasons why people should purchase them in the first place.

They believed that testing and ensuring that the system is enjoyable for its users should be met. From the above, one may simply conclude that many participants, as the result of facing many layers of frustration with the systems, felt that their needs were not taken into consideration, which contradicts the responses in Table 4.31.

Table 4.32: Q27 – Do you feel that your needs as an adult first-time user were taken into account by systems developers?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Yes	105	27.8	7.8	7.7
	No	245	64.9	92.2	100.0
	Total	**350**	**92.7**	**100.0**	
Missing	System	27	7.3		
Total	**-**	**377**	**100.0**		

With this question, the researcher wanted to learn if adult first-time users felt that their needs were taken into account. Only 7.7% said yes, while 92.2% indicated that they felt that their needs were not taken into account. While these responses are concerning, it is by no way surprising, and this is very much in line with the responses from previous questions.

The section enables better planning regarding developing systems for adult first-time users, by taking into consideration what may be perceived as their primary and secondary needs while designing standard interactions.

The interactive designers were given the opportunity to address these responses by answering the following qualitative question:

Table 4.33: Qualitative question 6 – Design processes

Question	
During the design process, how do you cater for both experienced and first-time adult users?	
Number	**Responses**
1	Instructions at the beginning of each device when it is being switched on for the first time.
2	Instructions on the package.
3	I don’t know what it meant by user friendly.
4	They make sure that there is a demo video that comes with the device. What it basically entails is the step-by-step procedures of performing tasks.
5	Manual instructions and software can be used to cater for all.

Question	
During the design process, how do you cater for both experienced and first-time adult users?	
Number	**Responses**
6	They make sure that the user experience becomes simple enough for anyone to grasp.
7	They cater by introducing new technologies and for the first time there are tutorials to help them understand the features.
8	They create multiple devices for experts and novices.
9	By having cheaper and simpler tablets.
10	For the experienced, by improving the performance and the quality of the devices; and for the first-time users, by providing some much-needed help through tutorials or simplified software.
11	They make the basic, everyday features of tablets easy to find or on the home screen for first-time users, but the devices include features for experienced users.
12	They do handheld devices; one for the first-time user and another one for the experienced.
13	They don't make the functionality totally different and new. They make new models by analysing how users have advanced in technology and how the previous handheld devices that they have made.
14	Making it simpler to use and handle.
15	They ensure that whatever device that has been innovated, is not difficult to use for first-time users and are also advanced enough to cater for the needs of experienced users.
16	They offer simple trials for those who would like to purchase the item and they also go the extra mile by handing out surveys with information of tablets on how to use it and they also make sure that they don't make dramatic changes in the new models.
17	The GUI doesn't undergo huge changes with every new model. Every model is built so that new users can easily understand and use the tablet easily.
18	Normally, when a user purchases a tablet, it comes with a basic operating system. This enables first-time users to get comfortable with, when they become experienced and they can update the operating system for more features to be added so that the usability increases, like the functions of the tablet system.
19	A balance is struck between innovation and expanding old features.
20	Provide good quality which is durable on the other hand. The durability of cheaper tablets with more features can be activated by user-efficient hardware components and increasing the processor speed while decreasing storage capacity. Also, provide long-lasting batteries.

To the above question, there were multiple repetitive answers which contained the following themes: developers must conduct frequent testing, and they must develop comprehensive handheld usability instructions such as graphical and text assistance.

By these responses, the respondents are referring to:

- clear user instructions;
- demo videos;
- step-by-step procedures;
- simplified user experience;
- developing tutorial materials;
- having systems that cater for both experienced and non-experienced users; and
- Avoiding the introduction of totally new systems.

The above can be achieved as follows:

It is very clear that having a good set of user requirements obtained during the elicitation process can easily shed light on some of the issues experienced by adult first-time users. It appears as if their needs are not well understood from the onset, or from the time the development process was initiated. It also appears essential that developing and releasing a comprehensive user training material may also assist in addressing the usability issue of adult first-time users. It is also important to progressively introduce new system features to enable slow learners to adapt easily.

Computing systems development and interactive systems development for South African users may not be as simple as one may want it to be because these systems are often developed in other regions of the world where the same social dimensions do not apply. One needs to be constantly reminded of what other consumers may be dealing with, as stated by Respondent 17: “The GUI doesn’t undergo huge changes with every new model. Every model is built so that new users can easily understand and use the tablet easily.” When the pace of systems development is too fast, some users get lost or confused in the process.

The best way to do so is to assess the needs of the users at the beginning of the design, to explore all avenues to fully understand the users’ needs, and to spend sufficient time reassessing their priorities. While respecting HCI principles in this manner, one may easily master what their needs are and address them in the most comprehensive manner.

Table 4.33 is meant to bring some supporting arguments to the answers which were already provided in Table 4.32, which clearly indicated that participants did not have an enjoyable interaction. However, from a designer perspective, the researcher noticed that they included user emotions and user experiments as part and parcel of whole system development. The designers further indicated that they included the testing and validation of user experience before, during, and after the development of any form of interaction they have developed and before releasing it.

4.3 SUMMARY

This chapter was meant to enable the reader to fully comprehend the level of participation of the primary target and source of input for this study, i.e. first-time users. This section elaborated on all these aspects before commencing any in-depth discussion.

This chapter provided a clear indication of the number of participants for each section, while specifying the link that may exist with other groups. It also investigated all the respondents of the questionnaire by providing biographical information such as the gender, race, age group, education level, etc. The chapter also provided participants' responses to multiple-response questions. Here the researcher provided the summaries of responses obtained from all the respondents. With this, the researcher hoped that it would be useful in assisting the reader and foster better comprehension of the overall study.

This chapter also combined the qualitative responses from ICT professionals who provided some insight into interactivity, as well as quantitative insight from participants who took part in the study as real adult first-time users.

By analysing the responses from the participants and cross-verifying the meaning of their responses by using qualitative responses from original developers, the researcher was able to understand what truly happened when people were tested using applications and handheld systems such as tablets for the very first time.

The researcher examined their responses when asked about their system frustration and their level of confidence when dealing with a new computing system. The researcher also explored what may be seen as system complexity from a user perspective. Regarding the task and activity completion and complexity, the researcher asked participants how they felt and why it took some of them so long to complete what some frequent users may see as routine tasks. Regarding system efficiency and effectiveness, the researcher questioned participants on their performance, and most responded how difficult it was to accommodate such a system.

The researcher investigated the issue of participants' own system usability and how they rated themselves. Their responses demonstrated a deep level of anxiety and frustration regarding all these aspects of computing.

The overall responses from participants showed that participants at this stage of development were very nervous and felt totally unable to cope with the systems presented to them. Although they understood some of the key functions and usefulness of the system, they struggled to operate them, which caused deep levels of frustration.

CHAPTER 5

EXPERIMENT DATA AND ANALYSIS

5.1 INTRODUCTION

In this chapter, the results of the experiment that was conducted in the field and countrywide will be presented. The experiment was a combination of preliminary assessment, training, and actual assessment of the participants, and was concluded with the completion of a questionnaire. The aim of the experiment was to measure the speed of user adaptation to handheld tablet systems by measuring the participants' usability.

The researcher is of the view that providing computing systems to people who may not know how to use them may not lead to adoption, and that closing the digital gap is a matter of enabling all users to understand the importance of computing systems and connectivity. The question the researcher asks in this chapter is whether users receiving computing systems would be able to use them. The main target is still adult first-time users, as the researcher believes that many were left out of the computing literacy drives in the new millennium. They are still counted as citizens and therefore their ability to adopt and adapt to computing systems is of major importance.

5.2 EXPERIMENT SITE SETUP

After identifying a group of potential respondents who met the criteria stipulated in the literature review and after a formal introduction and explanation of the purpose of the experiment, the researcher asked the participants to complete the ethics form.

The equipment consisted of two digital cameras that recorded the tablet interface as well as the participant's face. An additional camera was set up further away and recorded the whole process. The tablet system used an Android operating system.

A set of questions were prepared for the experiment. The research team started with initial calibration of the screen, which included the set of points participants had to identify when asked to do so by the research team. These points comprised five important points from A to E, and the point identification, also known as navigation, was recorded on camera. These points were not only limited to the low-fidelity prototype, but also touched on some high-fidelity prototype aspects.

The next step was to assess the participants' navigation ability; here the participants were asked to navigate from one screen layout to another. During these exercises, the research team paid attention to measureable factors such as CT, duration of task completion, accuracy, number of errors made, and memorability.

5.2.1 Outcomes benchmarking

At this stage, it is important to note that the research team made use of a standard benchmark to assess the outcome of the processes. These benchmarks were pre-compiled for the occasion and were meant to guide the researcher in the tasks or activities under investigation. Without this, it would be impossible to know if the outputs were indeed what the researcher expected. There would be a set of known benchmark outputs for the team to compare each and every variable computation.

5.2.2 Benchmarking and analysis comparison

The reliability of any data that may be presented here will only be valid if compared with what the researcher perceived and identified as normal or power users. The study targeted adult first-time users rather than youths or adult frequent users. The analysis is based on the fact that the researcher had a benchmark at hand and wanted to compare participant skills to determine the usability level of other groups of users vis-à-vis our own set perimeters.

Having a set standard at hand is important to compare the level of skills against the set benchmark; the researcher therefore took this into consideration before the experiment analysis started, or before writing the report. In many instances or sections within this chapter, the researcher would consult an expert or normal user to support the analysis.

It is also important to note that the experiment took place in numerous phases; the purpose of the initial phase was to assess the status of participants as is, and the purpose of the following phases was to assess the participants' level of knowledge retention and assimilation.

It is of paramount importance to classify here that the benchmark as presented in this study is a compilation of results obtained by conducting the same assessment on other adult users under the same condition, and they cannot be classified as novice users, power users, or experienced users.

5.3 PRE-TRAINING, EXPERIMENT FINDINGS, AND REPORT ANALYSIS

This section, known as the pre-training and experimentation phase, assisted in determining the usability status of participants. It enabled the researcher to determine where they stood and where they were before any form of intervention such as training took place. This section also assists the reader in getting to the depth of the computing usability problem that is prevalent in poor communities in South Africa by providing a clear understanding of what is expected in this phase. This section will not only indicate the type of intervention that is needed but also pre-establish the computing usability and experience scenario which would work best.

5.3.1 How to read the table

Table 5.1 displays the data that were collected during the pre-training phase, with the aim of providing a better understanding of the participants before commencing. The research team gave the participants tasks that were similar to the actual tasks used in the experiment. Since the research team dealt with adult first-time users in the experiment, getting to know them better was essential and less subjective.

The table shows the 13 sets of instruments that were used to assess the participants, and for each set, a few usability assessments were run and captured in the cell where they should be before moving to the next set.

The last column of the table shows the benchmarks against which participants were measured. This shows whether a user was experienced or not. The purpose of this table is to indicate the current level of computer usability. The instruments are listed in the first column, while the participants are listed on the right.

Table 5.1: Pre-experiment data

Instruments	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Pt. 7	Pt. 8	Pt. 9	Benchmark
SR	10%	10%	09%	07%	10%	04%	05%	03%	14%	80-100%
MT	12.1 min.	7.91 min.	11.2 min.	09.14 min.	10.3 min.	10.0 min.	08.1 min.	08.7 min.	08.5 min.	0.005-0.030 min.
AE	08%	CNC	CNC	08%	04%	CNC	11%	CNC	24%	80-100%
TS	10.2 cm/s	11.3 cm/s	0.9 cm/s	12.2 cm/s	13.1 cm/s	15.2 cm/s	16.2 cm/s	13.1 cm/s	11.0 cm/s	0.01-0.4 s
US	10%	12%	09%	05%	04%	12%	15%	06%	04%	80-100%
RT	CNC	CNC	230 s	254 s	142 s	CNC	210 s	CNC	210 s	09-12 s
CRA	08%	06%	CNC	12%	14%	CNC	09%	CNC	13%	80-100%
CT	900 s	562 s	561 s	452 s	352 s	451 s	540 s	652 s	532 s	300-700 s

Instruments	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Pt. 7	Pt. 8	Pt. 9	Benchmark
TBE	2.2 s	CNC	5.9 s	5.2 s	7.14 s	9.2 s	5.2 s	8.1 s	CNC	4.2 s
ID	8.231	9.123	5.512	6.231	6.245	8.235	6.235	4.123	4.258	0.001-0.09
IP	5.234	5.132	4.213	3.235	4.123	4.235	3.254	3.235	4.234	0.01-0.08
DF	90%	88%	91%	95%	96%	88%	85%	94%	96%	0-10%
AS	452 cm/s	532 cm/s	512 cm/s	411 cm/s	520 cm/s	565 cm/s	452 cm/s	658 cm/s	685 cm/s	0.001-0.97 cm/s

Pt. = Participant; CNC = Could Not Complete

5.3.2 Observation and analyses

Based on the available data from the pre-training assessment, it is clear that most participants had a low UX, or that their computing system usability was low to the extent that external intervention is needed if they were to become computer literate, or if they could one day use a computing system such as a tablet.

In most cases, answers were not provided, and where they were, they were very low or outside of the acceptable boundary compared with the set standards in the benchmark column. As most participants indicated, it was their first time interacting with a tablet system and for some it was their first time coming into contact with any form of computing system; one may therefore not exclude the possibility of any form of system intimidation or technophobia.

It was believed that completing the training would help participants to familiarise themselves with the systems and set the proper pace to address the fundamental challenge, which is the UX.

The selection or adoption of this form of template to present the results came as a result of having multiple sets of variables to assess. The ideal approach was to create something that would not only be easy to comprehend but also easy to relate to. The set of variables, which are populated into the table, are included based on their importance regarding the adaptation of an electronic device such as a tablet.

5.4 TRAINING AND TABLET SYSTEMS INDUCTION

This stage was meant to follow phases such as the preliminary interview, the preliminary questionnaire completion, and before the experiment. It was aimed at determining the usability problems and the users' UX.

This training stage for participants ensured that they had the basic knowledge and understanding of a tablet system in order to assess them once more and visualise the gap that may exist between the stage when they first came in and the stage after completing the training.

The training consisted of a set of activities and tasks that were in line with the study's objectives. Under no circumstances did the research team try to trick the participants or humiliate them. Most participants were experiencing tablet systems for the first time. It was both an amazing and challenging experience as many participants were under the impression that they would receive free tablets, even though the ethical document was very clear about the purpose of the study.

5.4.1 Training operation

The research team showed participants how to perform the following tasks, activities, and steps:

- How to identify a target.
- How to tap into a target and resize, reduce, and enlarge a target.
- How to scroll through the menu.
- How to navigate from one window to the next and to return to the initial window.
- How to open an Internet browser and insert a URL to open a page.
- How to create, save, close, and reopen a document.
- How to create an email account, and how to compose and send an email.
- How to modify the tablet system settings and update their online status.
- How to best navigate around a window.
- How to master the system interaction.
- How to undo an action.

5.4.2 Random activity

Tasks were grouped in sets of activities, which were randomly selected and applied to the testing process. The tasks did not have to be from the same low-fidelity or high-fidelity prototype, but could be mixed, such as a low-fidelity task asking to identify the point to a high-fidelity task asking to open a browser; as long as there were eight tasks, it constituted an activity.

Randomising these activities meant that the research team did not request their completion in any particular order, but rather in an order that was considered appropriate at the time. Practising this approach was part of the training as well.

5.4.3 Training process

The training was conducted in the same location and setting as the actual experiment, and the same tools and controls were used during the process.

The team excluded all preliminary stages and placed participants in the room where the equipment was set up. The team then interacted with the participants on a one-on-one basis and told them what they needed to know and do for the experiment. The team also assisted them with any questions they had. It was also important to ensure that they familiarised themselves with the testing tool in order to alleviate the amount of system intimidation.

5.5 EXPERIMENT

During the experiment, the research team tested and assessed the participants. It is important to note that the experiment was only conducted after the training phase was completed.

5.5.1 Findings and report analysis

This section deals with the application of the pre-selected mathematical equations which were exploited and tested for this study. The demonstration will be based on the facts that were collected, interpreted, transcribed. These are also attached in the Annexure for reader perusal.

The Annexure section contains critical transcriptions that will assist the reader in understanding the work this part of the study does, which is linked to the research objectives in Chapter 1 and the formula table (Table 3.1) in Chapter 3.

The computation process was automated using a Microsoft Excel spreadsheet; this assisted the researcher in obtaining the most relevant data, which were later transcribed.

The researcher is also of the view that in order to fast-track the reader’s ability to comprehend the work that is demonstrated here, it is necessary to provide a proper explanation for readers who may not be as familiar with the project as the researcher is. For this reason, the researcher provides explanations before any set of computation is done. The formulas are provided and explained to enable the reader to understand; thereafter the application is applied to the data.

5.5.2 Platform used for computation

The application of all the mathematical formulas was conducted using Microsoft Excel. It is important to note that this study was conducted as part of the Information Systems discipline, which is part of IT, and better knowledge and manipulation of ICT tools such as Excel is essential. For this reason the researcher made use of Microsoft Excel to compute and apply all formulas and the interpretations are defended here. It is also important to note that all the Excel outputs are attached in the Annexure of this thesis for reader perusal.

5.6 RESULTS INTERPRETATION

Each participant in the experiment had a number of five activities, which were all done in a series, and each activity had a series of tasks which had to be completed in chronological order. The pre-experimentation activities were known as Position A, B, and C, and the post-experiment activities were known as Position D, E, and F. In all cases, attention was paid to tasks within each activity to determine the overall performance of the participants, and the performance of all participants completing the same activities and tasks, whether horizontally or vertically.

5.6.1 SR

The aim of this calculation is to assess the SR of participants and to determine whether they completed their tasks as requested. This is one of the parameters that determined whether participants were capable to engage with the tablet system in the most productive manner.

The approach is to some extent similar to the assessment of the effectiveness as it employed almost the same set of criteria.

5.6.1.1 Application and results

Table 5.2 provides some critical information about the outcomes of the application of the measurement; it gives the researcher the opportunity to cross-verify with the known outcomes of a power user.

5.6.1.2 *Post-training-experiment analysis*

For a post-experimental exercise such as this, the researcher interpreted the results as a negative input whenever an action was not completed successfully and a positive when it was. Annexure 11A, which is the source of all the interpretations, provides a series of results in their respective column. The analysis here examines participants and activity ratio.

5.6.1.3 *Horizontal*

Horizontal refers to the arrangement of data as displayed in Annexure 11A, where the number of participants are listed from left to right, and is then followed by the activities of each participant. It is important to reiterate that each participant had five activities, and each activity came with eight tasks, which were all chosen and applied randomly.

Table 5.2: Participants' SR for activities

Activity	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Pt. 7	Pt. 8	Pt. 9
Activity A	62.5%	62.5%	50%	75%	100%	50%	62.5%	100%	100%
Activity B	65.5%	87.5%	50%	87.5%	62.5%	100%	87.5%	25%	62.5%
Activity C	12.5%	75%	37.5%	75%	75%	50%	12.5%	100%	50%
Activity D	37.5%	87.5%	25%	25%	87.5%	37.5%	62.5%	100%	37.5%
Activity E	0%	62.5%	65%	62.5%	62.5%	100%	0%	75%	62.5%
Overall	**35.6%**	**75%**	**45%**	**65%**	**77.5**	**67.5**	**45%**	**80%**	**62.5**

5.6.1.4 *Observed experiment discrepancies*

The output in Table 5.2 gives us an opportunity to view the progress of the participants. Initially they were not able to have any interaction with the systems; however, soon after completing a few exercises as part of their training, they were able to show positive results. One may see that there were seven activities with an SR of 100%, which was unthinkable when they were first approached to participate in the pre-experiment.

5.6.2 MT

Given the fact that there are identified points where users must get to, Fitts' model plays a role here. In many cases, inexperienced users may develop a huge amount of frustration here, as they tried to reach areas which were not very familiar to them. It is understood that all users or participants in this case had a full view of the whole screen, and all the important points were known with reference letters such as a, b, c, d, and e.

In order to determine the MT, we need to know what the amplitude of the movement is, here referred to as D, which represents the starting point to the centre of the target, here referred to as the width of the screen (W), which is known as well.

The MT was calculated using the following formula:

$$MT = a + b.ID = a + b.\log_2\left(1 + \frac{D}{W}\right)$$

MT : Movement time for target selection.

5.6.2.1 Post-training-experiment analysis

As indicated in Annexure 9A, the MT across all participants, tasks, and activities (see Table 5.3) are grouped from left to right. We captured the MT and the SR for each participant until the end. As stated previously, there were eight tasks per activity. For Position A (activity), the researcher noticed that the higher MT was about 45 seconds for Task 1 in Activity A, and the lowest MT was 20 seconds for the same participant for Task 7.

Table 5.3: Horizontal comparison of MT results

Activity	Result
Activity A	When the MT is compared horizontally, from left to right, it is evident that Participant 1 performed the fastest time record of 0.0192 minutes for all eight tasks for Activity A. The slowest was Participant 8 with 0.101 minutes. The activity average was 0.0864 minutes. Here the researcher noticed some imbalances.
Activity B	In this activity, Participant 2 was the fastest, with a time of 0.0258 minutes, compared to Participant 3, who spent 0.09807 minutes on the same activity. The overall average was 0.0619 minutes, and when compared to Activity A, the amount of time spent seems shorter.
Activity C	Participant 1 had an MT of 0.0001 minutes for all the activities, and Participant 5 had an MT of 0.8606 minutes, which was the slowest MT in this activity. When further compared with the average of 0.0511 minutes for the activity MT, it can be stated that the MT became faster as time progressed.
Activity D	Participant 3 had an MT of 0.017 minutes for Activity D, which was the fastest time for this activity, and Participant 5 was the slowest with an MT of 0.213 minutes. The average MT was 0.089 minutes for Activity D.

Activity	Result
Activity E	Due to various types of pressures and frustrations, Participant 1 and Participant 7 did not complete this activity, which leaves only seven participants. Participant 4 had an MT of 0.044 minutes. The average MT for this activity was 0.082 minutes.

5.6.2.2 *Vertical*

By conducting a vertical comparison, the data per participant for the task and activity are explored. As in the previous stage, all nine of the participants participated. The results from one activity to the next are indicated in Table 5.4.

Table 5.4: Vertical comparison of MT results

Participant	Fastest MT	Slowest MT	Average MT
Participant 1	0.0001 min	0.0436 min	0.0188 min
Participant 2	0.029 min	0.077 min	0.059 min
Participant 3	0.014 min	0.062 min	0.028 min
Participant 4	0.016 min	0.062 min	0.047 min
Participant 5	0.08606 min	0.225 min	0.1364 min
Participant 6	0.023 min	0.046 min	0.108 min
Participant 7	0.012 min	0.180 min	0.068 min
Participant 8	0.031 min	0.101 min	0.159 min
Participant 9	0.051 min	0.15 min	0.100 min

5.6.2.3 *Observed experiment discrepancies*

Based on the above analysis, there is a huge gap between the results of the post-training and brief sessions. It seems as if the participants have mastered and improved their MT to an overall horizontal cross-examination of about 0.04 minutes per activity and a vertical cross-examination of about 0.100 minutes per participant for this segment only.

5.6.3 AE

AE deals with how users perform the activity they are given. It is closely related to the SR. Here the researcher wanted to see how the participants interacted with the system. Many participants did not perform as expected, and when targets were reached, it came after much effort.

To determine the AE, the number of tasks completed successfully was divided by the number of tasks undertaken and then multiplied by 100, as indicated in the following formula:

$$Effectiveness = \frac{Number\ of\ tasks\ completed\ successfully}{Total\ number\ of\ tasks\ undertaken} \times 100$$

5.6.3.1 *Post-training experiment analysis*

As indicated in the formula section (Table 3.1), to calculate the effectiveness of the action undertaken by the participant, the number of tasks completed successfully is divided by the total number of tasks and then multiplied by 100. It is similar to the SR, but describes the overall effectiveness of the participants. Table 5.5 shows a summary of all the data. It is important to note that activities here are sets of tasks that were completed by all participants, and their selection is primarily based on the random selection during the experiment.

As the AE data are similar to the SR data, we will focus our attention on what is not stated previously.

Table 5.5: AE for each participant

Participant	AE
Participant 1	35%
Participant 2	42.5%
Participant 3	42.5%
Participant 4	62.5%
Participant 5	62.5%
Participant 6	100%
Participant 7	0%
Participant 8	75%
Participant 9	62.5%

5.6.3.2 *Observed experiment discrepancies*

It is a reason for concern that the AE may be as low as 0%, and the reason(s) for such underperformance needs to be investigated. However, it is evident that most participants adapted to the systems and some can be declared as competent at this stage as their performance was around 100%.

Table 5.6 is about the level of frustration based on their task SR. It indicates how participants felt when assessing the skills level.

Table 5.6: DF for participants

DF = 100 - Task SR																		
	Pt. 1		**Pt. 2**		**Pt. 3**		**Pt. 4**		**Pt. 5**		**Pt. 6**		**Pt. 7**		**Pt. 8**		**Pt. 9**	
	E.	**F**	E	**F**	E	**F**	E	**F**	E	**F**	E	**F**	E	**F**	E	**F**	E	**F**
P A	62.5	**37.5**	62.5	**37.5**	50	**50**	75	**25**	100	**0**	50	**50**	62.5	**37.5**	100	**0**	100	**0**
P B	62.5	**37.5**	87.5	**12.5**	50	**50**	87.5	**12.5**	62.5	**37.5**	100	**0**	87.5	**12.5**	25	**75**	62.5	**37.5**
P D	12.5	**87.5**	75	**25**	37.5	**62.5**	75	**25**	75	**25**	50	**50**	12.5	**87.5**	100	**0**	50	**50**
P C	25.5	**74.5**	87.5	**12.5**	25	**75**	25	**75**	87.5	**12.5**	37.5	**62.5**	62.5	**37.5**	100	**0**	37.5	**62.5**
P E	0	**100**	62.5	**37.5**	62.5	**37.5**	62.5	**37.5**	62.5	**37.5**	100	**0**	0	**100**	75	**25**	62.5	**37.5**
F/P	35	**65**	42.5	**57.5**	42.5	**57.5**	65	**35**	77.5	**22.5**	62.5	**37.5**	57.5	**42.5**	80	**20**	62.5	**37.5**

Pt: Participant; E: Effectiveness; F: Frustration

5.6.4 TS

The TS is another important variable in assessing the participants' performance. It is the time that it takes the user to complete specific tasks or a single action. The formula used to determine the TS makes use of Fitts' model because the MT and the distance (D) are taken into account. The following formula was used to determine the participants' TS:

$$v_{ts} = \frac{D}{MT}$$

5.6.4.1 Post-training experiment analysis

For this section, please refer to Annexures 10A to 10C. The results are given in centimetres per second (cm/s). The results are shown in Table 5.7.

Table 5.7: Vertical readings of participants' TS

Participant 1			
Activity	**Average TS**	**Fastest TS**	**Slowest TS**
Activity 1	0.2780 cm/s	0.35 cm/s	0.194 cm/s
Activity 2	0.935 cm/s	0.461 cm/s	2.833 cm/s
Activity 3	0.249 cm/s	0.01 cm/s	0.388 cm/s
Activity 4	0.7344 cm/s	0.189 cm/s	0.9444 cm/s
Activity 5	Not completed		
Participant 2			
Activity	**Average TS**	**Fastest TS**	**Slowest TS**
Activity 1	0.9216 cm/s	0.318 cm/s	0.705 cm/s

Activity 2	0.6913 cm/s	0.293 cm/s	0.705 cm/s
Activity 3	0.581 cm/s	0.304 cm/s	1 cm/s
Activity 4	0.564 cm/s	0.425 cm/s	0.85 cm/s
Activity 5	0.9705 cm/s	0.5 cm/s	0.857 cm/s
Participant 3			
Activity	**Average TS**	**Fastest TS**	**Slowest TS**
Activity 1	0.389 cm/s	0.233 cm/s	0.566 cm/s
Activity 2	0.455 cm/s	0.194 cm/s	0.7 cm/s
Activity 3	0.429 cm/s	0.283 cm/s	0.7 cm/s
Activity 4	0.515 cm/s	0.304 cm/s	0.85 cm/s
Activity 5	0.641 cm/s	0.269 cm/s	0.571 cm/s
Participant 4			
Activity	**Average TS**	**Fastest TS**	**Slowest TS**
Activity 1	0.608 cm/s	0.386 cm/s	0.923 cm/s
Activity 2	0.6109 cm/s	0.472 cm/s	0.705 cm/s
Activity 3	0.698 cm/s	0.32 cm/s	1.2 cm/s
Activity 4	0.9161 cm/s	0.35 cm/s	1.33 cm/s
Activity 5	0.641 cm/s	0.369 cm/s	0.857 cm/s
Participant 5			
Activity	**Average TS**	**Fastest TS**	**Slowest TS**
Activity 1	1.7511 cm/s	0.35 cm/s	2 cm/s
Activity 2	1.2299 cm/s	0.85 cm/s	2.335 cm/s
Activity 3	1.023 cm/s	0.708 cm/s	1.714 cm/s
Activity 4	1.829 cm/s	0.653 cm/s	7.77 cm/s
Activity 5	0.8296 cm/s	0.472 cm/s	1.333 cm/s
Participant 6			
Activity	**Average TS**	**Fastest TS**	**Slowest TS**
Activity 1	0.7021 cm/s	0.437 cm/s	1.416 cm/s
Activity 2	1.638 cm/s	0.437 cm/s	4.25 cm/s
Activity 3	0.841 cm/s	0.5 cm/s	1.09 cm/s
Activity 4	2.434 cm/s	0466 cm/s	8.5 cm/s
Activity 5	2.0185 cm/s	0.636 cm/s	8.5 cm/s
Participant 7			
Activity	**Average TS**	**Fastest TS**	**Slowest TS**
Activity 1	1.667 cm/s	0.4666 cm/s	7 cm/s
Activity 2	0.797 cm/s	0.653 cm/s	1.166 cm/s
Activity 3	0.963 cm/s	0.636 cm/s	1.5 cm/s
Activity 4	0.892 cm/s	0.607 cm/s	1.5 cm/s
Activity 5	Not completed		

Participant 8			
Activity	**Average TS**	**Fastest TS**	**Slowest TS**
Activity 1	0.896 cm/s	0.368 cm/s	1.71 cm/s
Activity 2	0.846 cm/s	0.583 cm/s	1.416 cm/s
Activity 3	1.347 cm/s	0.425 cm/s	6 cm/s
Activity 4	1.8501 cm/s	0.653 cm/s	1.33 cm/s
Activity 5	0.8531 cm/s	0.708 cm/s	1.090 cm/s
Participant 9			
Activity	**Average TS**	**Fastest TS**	**Slowest TS**
Activity 1	0.836 cm/s	0.538 cm/s	1.2 cm/s
Activity 2	1.097 cm/s	0.777 cm/s	2 cm/s
Activity 3	0.9432 cm/s	0.77 cm/s	1.33 cm/s
Activity 4	1.743 cm/s	0.607 cm/s	1.714 cm/s
Activity 5	1.3932 cm/s	0.653 cm/s	4.25 cm/s

5.6.4.2 Observed experiment discrepancies

The researcher observed that in some cases some participants were too slow or too fast when executing a task. Some TSs were as low as 0.10, while others were as high as 7. This indicates a potential usability problem; when a user takes too long to complete a task, the user may have some skill problems.

5.6.5 AS

In order to calculate the AS, many other variables need to explored, which may not always be the same as the previous application. Attention needs to be given to the activity travelled distance versus the activity CT of a particular participant; this was applied throughout the process and experiment.

$$AS = \frac{Activity\ travelled\ distance}{Activity\ completion\ time}$$

The AS is basically the time from the beginning of a task to the time the last task within the activity is completed. It has nothing to do with the activity average and everything to do with the time needed to complete the set of tasks for specific activities. Table 5.8 shows the AS of each participant.

Table 5.8: AS of participants

AS (Cm/S), Activity = Position										
Activities	**Travelled distance**	**Pt. 1**	**Pt. 2**	**Pt. 3**	**Pt. 4**	**Pt. 5**	**Pt. 6**	**Pt. 7**	**Pt. 8**	**Pt. 9**
P A	69	0.07	0.299	0.3	0.47	0.73	0.78	0.86	0.68	0.74
P B	72	0.43	0.375	0.34	0.51	0.84	0.83	0.55	0.71	0.87
P D	72	0.26	0.526	0.33	0.54	2.32	0.99	0.83	0.75	0.84
P C	72	0.37	0.375	0.33	0.48	0.94	0.84	0.77	0.89	1.07
P E	72		0.526	0.34	0.47	0.7	0.77		0.63	0.8
Overall speed/participant		0.07	0.389	0.32	0.48	0.9	0.81	0.71	0.7	0.82

5.6.5.1 Post-training-experiment analysis

Table 5.9 shows the details of each participant's performance in the activities. It represents the most important aspects that determine the ease of controlling a system. From the table the researcher can interpret and analyse some of the outputs while paying attention to the distance travelled.

Table 5.9: Vertical readings

Participant	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5
Participant 1	0.07 cm/s	0.43 cm/s	0.26 cm/s	0.37 cm/s	n/a
Participant 2	0.299 cm/s	0.375 cm/s,	0.526 cm/s	0.375 cm/s	0.526 cm/s
Participant 3	0.3 cm/s	0.34 cm/s	0.33 cm/s	0.33 cm/s	0.34 cm/s
Participant 4	0.47 cm/s	0.51 cm/s	0.54 cm/s	0.48 cm/s	0.47 cm/s
Participant 5	0.73 cm/s	0.84 cm/s	2.32 cm/s	0.94 cm/s	0.7 cm/s
Participant 6	0.78 cm/s	0.83 cm/s	0.99 cm/s	0.84 cm/s	0.77 cm/s
Participant 7	0.86 cm/s	0.55 cm/s	0.83 cm/s	0.77 cm/s	n/a
Participant 8	0.68 cm/s	0.71 cm/s	0.75 cm/s	0.89 cm/s	0.63 cm/s
Participant 9	0.74 cm/s	0.87 cm/s	0.84 cm/s	1.07 cm/s	0.8 cm/s

5.6.5.2 Observed experiment discrepancies

The researcher noticed that Participant 3 completed the tasks and activities very quickly, while Participant 6 was rather slow when it came to the same activities and took more time than the average participant.

5.6.6 US

US is one of the most important variables to determine if a particular user would continue using the computing device after testing it for the first time. Here, due to the severity and complexity of such technical issue, the researcher used a questionnaire to collect quantitative data to determine the US of participants. Based on Table 5.9, and as part of the post-testing and experiment process, 92% of all participants declared their satisfaction, which is a great improvement.

5.6.7 RT

The RT is the time it takes a user to start implementing the instruction after it was given. It differs from one person to the next; some are fast and others are slow. There are many factors that may interfere in the process; however, in general, users who knew what they had to do spent less time commencing their tasks as opposed to those who did not have a clue about the process.

RT is sometimes referred to as the time it takes to click a button or widget, or the time between no action and the state of action by a particular user. This is one of the most critical points in the comprehension of the user's ability to understand and manipulate computing systems; the faster a user is, the more effective he/she can be. This section explores what some may call the idle time during tasks and activities or after instructions and actions.

For this section, we are making use of Annexures 9A to 9E.

5.6.7.1 Post-training experiment analysis

The analysis is conducted per activity as tasks are grouped together to form one activity. The averages referred to here are the result of the summary of the set of individual RTs. The researcher then based the analysis on the single activity RT and not the individual task RT. It is also important to note that the units here are expressed in seconds (s).

Table 5.10: Cross-vertical readings

Participant	Avg. RT Act. 1	Avg. RT Act. 2	Avg. RT Act. 3	Avg. RT Act. 4	Avg. RT Act. 5
Participant 1	100 s	10.5 s	157 s	3 s	4.52 s
Participant 2	11.3 s	6.25 s	2.63 s	7.88 s	5.88 s
Participant 3	6 s	7 s	6 s	10 s	8 s
Participant 4	4 s	3 s	3 s	7 s	5 s
Participant 5	1 s	2 s	2 s	1 s	1 s
Participant 6	1 s	1 s	1 s	2 s	2 s
Participant 7	1.4 s	2 s	1.3 s	1.1 s	n/a
Participant 8	1.4 s	2 s	1.3 s	1.1 s	3.5 s
Participant 9	1.3 s	1.9 s	1.9 s	0.8 s	2.8 s

5.6.7.2 Observed experiment discrepancies

From Table 5.10 one can see that, in most cases, the average RT for participants was around one second or slightly above one second. The only figure under one second was 0.8, completed by Participant 9 for Activity 4, which is also an IP of 0.0088.

In addition, in most instances where the RT was high, it was usually in the first task. This could indicate a comprehension/listening/language problem, and further testing would be needed to determine that. In some cases, it was as high as 5.8 seconds. Overall, in most instances, users took approximately one second to start performing the tasks they were given.

5.6.8 Completion rate per activity (CRA)

The CRA is another way in which the action of a particular participant can be tracked. Here we examine the individual task and activity performances to determine the extent to which the participant responded to those activities only. What makes this section important is that it determines the number of tasks completed within a specified time period in order to determine the participants' completion rate, also referred to as their CRA.

5.6.8.1 Post-training experiment analysis

Table 5.11 shows the horizontal analysis of the CRA, which is based on task and activity only. Each CRA indicated in the table represents the total of all individual tasks and is the combined percentage for all participants interacting with the systems in that specific activity.

Table 5.11: Horizontal analysis of overall CRA

Activity	Overall CRA
Activity 1	71.01%
Activity 2	69.7%
Activity 3	77.9%
Activity 4	47.82%
Activity 5	64.18%

5.6.8.2 Observed experiment discrepancies

From Table 5.11, one notices that, apart from Activity 4, all the activities were over the 60% mark. Participants did far better than originally thought. The figure as shown here does not limit the internal observation regarding individual task completion rate.

5.6.9 Completion rate per participant (CRP)

The purpose of this section was to determine the rate at which participants completed their tasks, taking into account the time that was allocated for that purpose. It is a vertical interpretation of the actions that were assessed with the aim of knowing how a particular participant acted during the experiment. The CRP is not only a CT exercise where the starting and ending times are noted for differentiation, but also pays attention to the tasks and activities.

5.6.9.1 Post-training experiment analysis

Table 5.12 shows the vertical interpretation based on the performance of each individual user or participant.

Table 5.12: Vertical interpretation of participants' CRP

Participant	CRP
Participant 1	79.62%
Participant 2	76.93%
Participant 3	40.34%
Participant 4	67.08%
Participant 5	72.43%
Participant 6	72.80%
Participant 7	54.68%
Participant 8	78.77%
Participant 9	59.84%

5.6.9.2 Observed experiment discrepancies

From Table 5.12 one can see that even though Participant 1 and Participant 7 completed the same number of tasks, which was 32 out of 40 tasks, and even though both these participants did not complete the last activity, which consisted of eight tasks, there is a huge gap between their CRP, which is 79.62% and 54.68%. This gap of almost 25% can be explained when one takes into consideration the number of tasks successfully completed per participant.

Overall, the CRP of all participants was acceptable.

5.6.10 CT

This section deals with the time it takes a participant to complete a task/activity or a set of activities. Whenever a user started a task or activity, the time it takes to complete it was recorded for each task, each activity, and the overall CT for all tasks and activities. The purpose of this was to see if that means anything to the final assessment.

The approach is based on Table 6.1, in which the data are very explicit and self-explanatory.

5.6.10.1 Post-training experiment analysis

Table 5.13 shows the vertical interpretation of the CT of all activities for all participants and is expressed in seconds (s).

Table 5.13: CT of participants

Participant	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Total	CT per set
Participant 1	986 s	168 s	281 s	194 s	n/a	1629 s	4079 s
Participant 2	231 s	192 s	137 s	192 s	137 s	889 s	917 s
Participant 3	231 s	210 s	219 s	217 s	214 s	1091	1106
Participant 4	148 s	142 s	133 s	150 s	154 s	727 s	738 s
Participant 5	94 s	86 s	31 s	77 s	103 s	391 s	395 s
Participant 6	89 s	87 s	73 s	86 s	93 s	428 s	439 s
Participant 7	80 s	132 s	87 s	93 s	n/a	392 s	399 s
Participant 8	102 s	101 s	96 s	81 s	115 s	495 s	511 s
Participant 9	93 s	83 s	86 s	67 s	90	419 s	435 s

5.6.10.2 Observed experiment discrepancies

From Table 5.13 one can see that Participant 1 took a considerable amount of time to complete the set; in fact, the last activity was never completed. While Participant 7 also did not complete an activity, the overall time was low and within an acceptable range.

The time reference here is in seconds (s) and gives us an indication of the amount of work that a participant could complete within a specific timeframe. It can also be observed that the fastest time was 67 seconds, while the slowest was 986 seconds. The latter figure is of concern and the recorded times for this particular participant are somewhat concerning.

5.6.11 TBE

The TBE of a particular user compares the time a participant took to complete each activity against the efficiency of those tasks; this is one of the most fundamental characteristics that are important when considering the consistency of the user's system usability. The TBE is calculated by using the following formula:

$$TBE = \frac{\sum_{j=1}^{R}\sum_{i=1}^{N}\frac{n_{ij}}{t_{ij}}}{NR}$$

The purpose of this calculation is to know what the ratio between efficiency and the time of completion is. This would enable the researcher to re-evaluate the participant's ease and control regarding system usability and how effective they were in completing the activities, which at times may lead to the abandonment of tasks and activities.

5.6.11.1 Post-training experiment analysis

For this important set of values, the researcher took two important characteristics into account; the first is the orientation, which can be either vertical or horizontal, and the individual details, such as performance. Table 5.14 shows a horizontal cross-assessment of the participants' overall TBE per each of the eight tasks per activity. Each value represents the TBE in seconds.

Table 5.14: Horizontal cross-assessment of TBE

Activity	Task 1	Task 2	Task 3	Task 4	Task 5	Task 6	Task 7	Task 8	Min	Max
Activity 1	0.059	1.291	0.046	0.068	1.705	0.061	0.052	0.047	0.0462	1.705
Activity 2	0.072	0.052	0.061	0.132	0.051	0.106	0.053	0.079	0.052	0.106
Activity 3	0.098	0.025	0.022	0.046	0.033	0.047	0.070	0.065	0.025	0.098
Activity 4	0.045	0.178	0.174	0.045	0.151	0.042	0.037	0.039	0.037	0.178
Activity 5	0.043	0.035	0.054	0.0048	0.206	0.068	0.075	0.053	0.035	0.206

It is important to note that the lower the TBE, the better; it means that the participant is spending less time completing the same amount of work.

The other aspect of cross-participant is shown in Table 5.15.

Table 5.15: TBE of the participants

TBE/Position									
Activities	**Pt. 1**	**Pt. 2**	**Pt. 3**	**Pt. 4**	**Pt. 5**	**Pt. 6**	**Pt. 7**	**Pt. 8**	**Pt. 9**
P A	0.019	0.03	0.025	0.06	0.23	0.04	0.18	0.01	0.1
P B	0.044	0.08	0.026	0.06	0.1	0.19	0.08	0.03	0.08
P D	0.000	0.06	0.014	0.06	0.09	0.03	0.01	0.13	0.05
P C	0.312	0.06	0.018	0.02	0.21	0.03	0.07	0.21	0.17
PE	0.000	0.07	0.062	0.04	0.06	0.24	0	0.07	0.12
TBE/Participant									
Overall	0.01882	0.06	0.029	0.05	0.14	0.1	0.07	0.11	0.1

From the above table one can see that the participants' overall TBE for the entire set of tasks was very impressive.

5.6.11.2 Observed experiment discrepancies

The general observation is that the participants who did not complete all five activities seemed to have the lowest TBE. Regarding the results of Participant 1 and Participant 7, which were 0.018 s and 0.07 s respectively, may be a bit misleading, but in general, those who completed all the activities displayed a very significant improvement from the initial assessment and evaluation.

5.6.12 System ID

The ID determines which tasks participants found difficult and which they found easy. In order to determine the ID, the participants had to complete all the activities. Once again, Fitts' model comes into play here. To calculate the ID, the following formula is used:

$$ID = \log_2\left(1 + \frac{D}{W}\right)$$

This equation uses variables such as the distance travelled (D), the width of the platform (W), and the log application ($\log_2$). The purpose of this calculation is to assess the level of resistance that is faced by users when dealing with a system for the first time.

5.6.12.1 Post-training experiment analysis

A range of ID data were collected from individuals during their activities; the researcher targeted them as a set of tasks as the purposes were the same. It is important to note that the values as displayed here are the results of the application of the formula in Microsoft Excel, and that these are simply the outcomes. Table 5.16 shows the standard ID for each activity.

Table 5.16: Standard ID for participants

Activity	ID for participants
Activity 1	0.584
Activity 2	0.584
Activity 3	0.584
Activity 4	0.584
Activity 5	0.584

5.6.12.2 Observed experiment discrepancies

After completing the interpretation of the first activity, the researcher discovered that the outcome is the same for all participants as long as the values that were used were the same. The researcher therefore abstained from repeating the same details when it is not necessary.

5.6.13 System IP

The IP, unlike the ID, looks at the participants' process performance during the activities. Once again Fitts' model is applied to assess users' control and consistent usage of the device. To determine the IP, the following formula is used:

$$IP = \frac{ID_e}{MT}$$

This calculation takes the ID of the task and activity into account, as well as the MT of the task and activity, which were both already calculated. As with the previous section, the details from Annexures 9A to 9E are used.

5.6.13.1 Post-training-experiment analysis

Table 5.17 shows the vertical analysis of each participant's average IP (indicated as a positive or negative) during each activity, as well as the number of negative indicators.

Table 5.17: Vertical analysis of participants' IP

Participant 1		
Activity	**Average IP**	**No. of negative indicators**
Activity 1	-0.001	0
Activity 2	0.024	3
Activity 3	-0.00055	0
Activity 4	0.0039	1
Activity 5	n/a	0
Participant 2		
Activity	**Average IP**	**No. of negative indicators**
Activity 1	0.010	2
Activity 2	0.0056	1
Activity 3	0.0059	0
Activity 4	0.0086	2
Activity 5	0.0119	1
Participant 3		
Activity	**Average IP**	**No. of negative indicators**
Activity 1	0.004	0
Activity 2	0.0040	0
Activity 3	0.0042	0
Activity 4	0.0084	1
Activity 5	0.0065	0
Participant 4		
Activity	**Average IP**	**No. of negative indicators**
Activity 1	0.007	0
Activity 2	0.0062	0
Activity 3	0.0053	0
Activity 4	0.0124	0
Activity 5	0.0071	0
Participant 5		
Activity	**Average IP**	**No. of negative indicators**
Activity 1	0.0077	1
Activity 2	0.0086	0
Activity 3	0.0053	0
Activity 4	0.010	0
Activity 5	0.009	0

Participant 6		
Activity	**Average IP**	**No. of negative indicators**
Activity 1	0.008	0
Activity 2	0.0081	0
Activity 3	0.0073	0
Activity 4	0.011	0
Activity 5	0.012	0
Participant 7		
Activity	**Average IP**	**No. of negative indicators**
Activity 1	0.008	0
Activity 2	0.010	0
Activity 3	0.0053	0
Activity 4	0.007987	0
Activity 5	n/a	n/a
Participant 8		
Activity	**Average IP**	**No. of negative indicators**
Activity 1	0.0072	0
Activity 2	0.008	0
Activity 3	0.0067	0
Activity 4	0.0091	0
Activity 5	0.0100	0
Participant 9		
Activity	**Average IP**	**No. of negative indicators**
Activity 1	0	0
Activity 2	0	0
Activity 3	0	0
Activity 4	0	0
Activity 5	0	0

On the horizontal section, the researcher noticed figures that are crossed-participants. Here, the outputs from participants are compared with other participants in the same task. An example would be the output, which represents the IP of Activity 1 of all the participants. Table 5.18 shows the average IP for each activity.

Table 5.18: Average IP for each activity

Activity 1	Activity 2	Activity 3	Activity 4	Activity 5
0.007	0.008	0.0067	0.0091	0.0100

5.6.13.2 Observed experiment discrepancies

One of the most fundamental details worth mentioning here is the fact that an IP can be negative or positive. Given the standard benchmark of the task, some IPs can be as poor/under performing as the attitude observed when completing it.

Regarding the horizontal cross-comparison, the last activity had the highest IP simply because the of the fact that neither Participant 1 nor Participant 7 completed Activity 5.

Overall, the figures correspond or have some correlation in both orientations, which is vertical or horizontal.

5.6.14 Degree of frustration (DF)

Another set of variables that were essential in completing our task is the DF, which enabled the research team to assess the participants' DF and absorption. The literature indicates that when users are frustrated, they abandon their intent or look for something else to do. It also shows that when people are more comfortable with what they do, and do it often, chances are that they would carry on doing it in the future, with or without external support.

There is a strong correlation between the DF and the task/activity SR, and it can be used to determine the user's level or DF.

To determine the DF, the following formula is used:

$$DF=100-Task/Activity\ SR$$

Here, 100 represents the 100%, which is just like the full support that anyone may have on the need of ICT. The task/activity SR represents the rate of task or activities which were not completed by the user, or the portion of what he/she produced within the given timeframe.

5.6.14.1 Post-training experiment analysis

Table 5.19 shows the cross-horizontal analysis of the various degrees of frustration experienced by each participant.

Table 5.19: Participants' degrees of frustration

Activity	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Pt. 7	Pt. 8	Pt. 9
Activity 1	37.5%	37.5%	50%	25%	0%	50%	37.5%	0%	0%
Activity 2	37.5%	12.5%	50%	12.5%	37.5%	0%	12.5%	75%	37.5%
Activity 3	87.5%	25%	62.5%	25%	25%	50%	87.5%	0%	50%
Activity 4	74.5%	12.5%	75%	75%	12.5%	62.5%	37.5%	0%	62.5%
Activity 5	100%	37.5%	37.5%	37.5%	37.5%	0%	100%	25%	37.5%
Overall DF	67.4%	36.5%	55%	35%	22.5%	32.5%	55%	20%	37.5%

5.6.14.2 Observed experiment discrepancies

The principle here is that the lower the DF, the better. In some instances, some participants had a DF of 0% simply because the level of effectiveness was 100%. It means that for the DF to be low, which is the ultimate state, the user's TBE must be high. It can also be observed that Participant 8 scored the lowest overall DF because in three activities the DF was 0%.

5.6.15 UX

The UX is one of the most fundamental variables for this study since we needed to know what the user's experience is. In most cases, measuring the UX can be very difficult unless there are some fundamental ground rules. Determining the UX is fundamental and its application can lead and guide the full understanding of the research project. The researcher wanted to demonstrate how comfortable users are when dealing with the system. Any system comes with its own set of challenges and users are seen as the primary victim when their needs are not considered during design and application.

5.6.15.1 Calculation and computation analysis and reporting

All the calculations and analyses were done using a Microsoft Excel spreadsheet and the results were merely replicated in the chapters. It is important to note that given the power, flexibility, and the complexity of the exercises that were undertaken here, that the research team found more appropriate computing application tools that could automate the process. This study is still regarded as an information systems study and using electronic tools associated with the field may make the comprehension easier and more reliable.

5.6.15.2 Low-fidelity prototype process demonstration

Figure 5.1 is an example of the setup of the testing station that was used for the experiment process. It shows all the cameras used, the recording systems, and the low-fidelity prototype.

Figure 5.1: Low-fidelity testing station

The following five sets of activities were meant for a single participant. Upon receiving instructions, the participant needed to begin completing the individual tasks, which were recorded on a digital camera for later analysis.

Figure 5.2 represents Position A only. The research team asked participants to reach some point on the interface; for example, asking them to point or move from A to B, or from C to D. These actions are referred to as calibration of the user's eye.

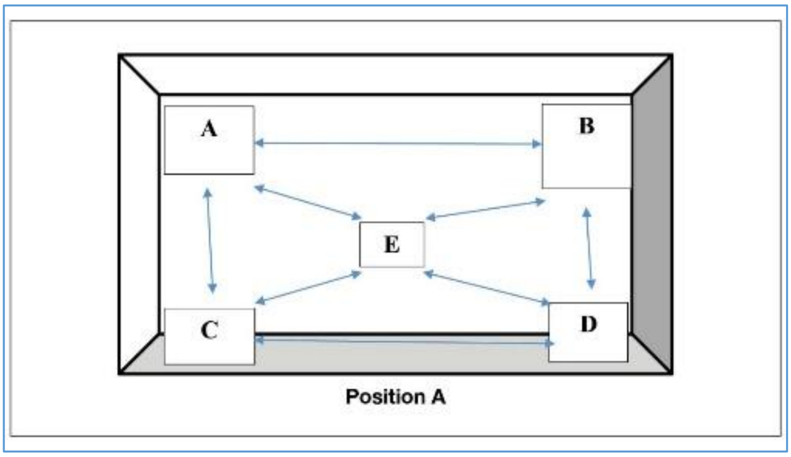

Figure 5.2: Position A

Figure 5.3 shows that the letter positions have changed in an attempt to confuse the participant and to make the process more complex to see how they would react to the difficulties.

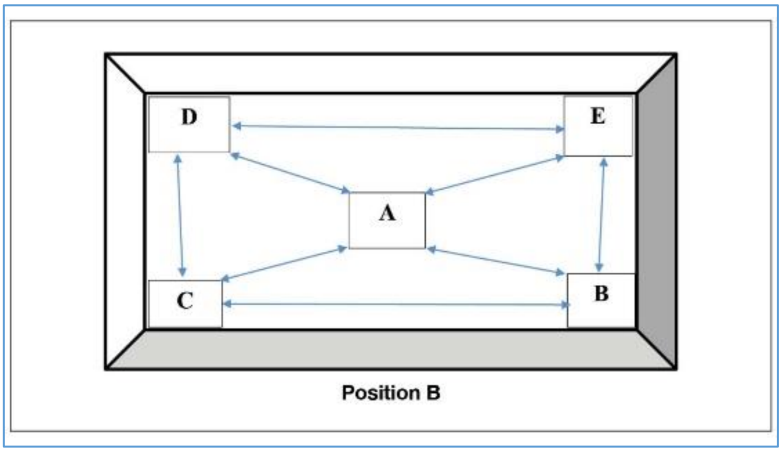

Figure 5.3: Position B

Figure 5.4 represents Position C and is the third activity that participants had to complete. They needed to see how they were being challenged and pushed by the tasks in front of them.

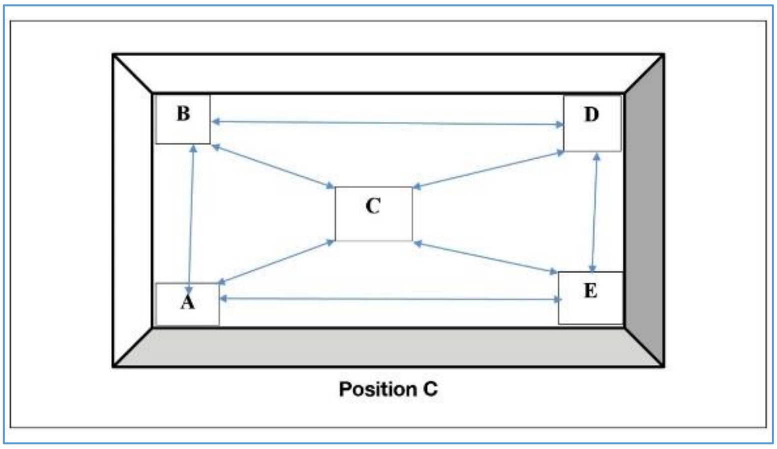

Figure 5.4: Position C

Figure 5.5, or Position D, is the fourth range of positions that participants had to complete. Some did not even get to this level simply because they were so challenged or frustrated that they decided not to continue. This is not ideal but one needs to be prepared for such eventualities.

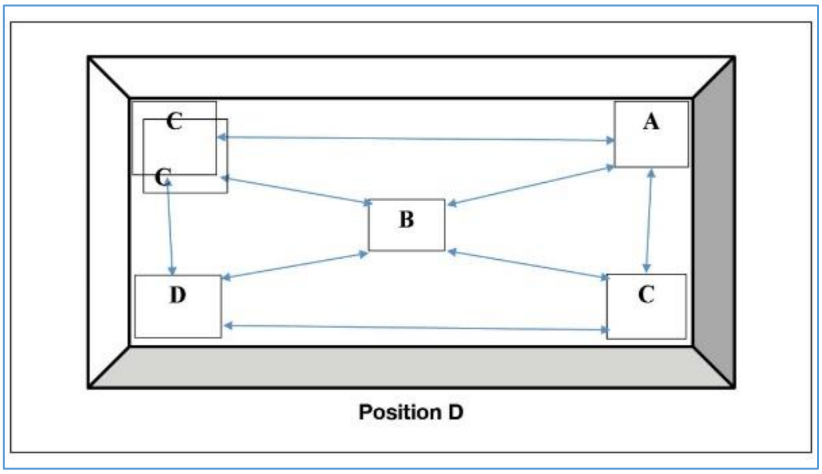

Figure 5.5: Position D

Figure 5.6, or Position E, is the last of the low-fidelity prototypes that were used to assess the participants. It is important to note that these sketches were designed for this purpose.

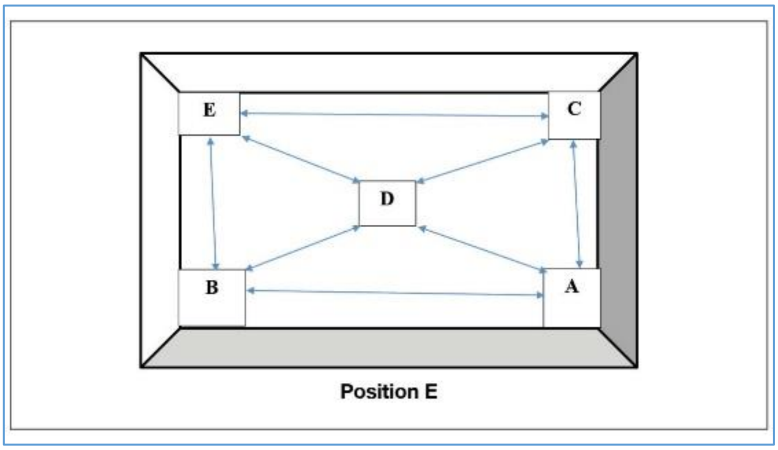

Figure 5.6: Position E

Since this section is situated at the end of the experiment, many participants, due to the challenges they may have faced, might not have progressed to or completed this level. After completing this section, the next section dealt with the high-fidelity prototype which was designed for these exercises.

5.6.15.3 High-fidelity prototype process demonstration

This section deals with how users interacted with the real computing system during testing. These sets of screenshots indicate the type of actions which were demanded and the responses obtained or provided. The assessment process was the same as in the low-fidelity prototype process.

Figure 5.7 shows just one of the testing stations where participants were asked to identify and complete some activities; some did and others did not. The aim was to evaluate their usability using a real computing system.

Figure 5.7: High-fidelity testing station

5.7 PRELIMINARY SUMMARY

The length and depth of this chapter require that, in order for the conclusion to answer all questions that are part of the study, the summary be divided into subsections that are aligned to the project.

5.7.1 Preliminary stage or pre-testing

When we explore the findings within the preliminary investigation and analysis that followed, and for each instrument used versus the known benchmark range, one may conclude that the results were very low from one end to the next, and compared with the benchmark, it makes even more sense that the level of UX was not up to standard.

From the SR to the AS, all nine participants selected for analysis performed very poorly. It is important to note that this study dealt with adult first-time users and in most cases their language level was not up to standard.

The inclusion of the benchmark in Table 6.1 enabled the researcher to determine where figures should have been if participants performed well, and later on those figures would also assist in measuring the same participants at the end of the experiment to determine whether or not the goals were achieved.

5.7.2 Pre-experiment: Training

During the preliminary phase it was obvious that without any external intervention or training, the participants' results during the actual experiment might not change, and therefore the training phase was included as part of the study to assess the participants' improvement.

As this study dealt with the "missing middle" who never had the opportunity to become computer literate, the training phase could assess their responses compared to their computer literate counterparts in the same conditions.

The tasks and activities listed in this chapter are self-explanatory and useful for this type of experiment.

5.7.3 Formulation model

The set of formulas that were used in this chapter were helpful in understanding the manner in which the outputs were attained. The application steps which are not manuals are not listed here since they are not essential, but an explanation of its computation is included, which enables the reader to understand how all the individual formulas were applied.

5.7.4 Experiment findings

Concluding this segment requires that attention is paid to each instrument that was used and that their performances are re-evaluated.

SR: The SR of each participant improved after the training phase. Participant 4 had an SR of 100% for Activity A; this is in line with the existing benchmark. When we compare this with the preliminary assessment, it appears that most participants improved from the poor performance initially observed.

MT: After the computation, it was evident that most participants improved. The benchmark here is between 0.005 and 0.030 minutes based on the activity completed and the results show that the participants were well within the set standard.

AE: Based on the benchmark, an action is considered effective when the execution is between 80% and 100%, which represents the number of tasks completed successfully divided by the number of tasks undertaken, and then multiplied by 100 to have the result as a percentage. Here we have a minimum of 42% and a maximum of 100%. This may not be ideal but it generates a positive outlook.

TS: Based on the known benchmark, which must be between 0.01 and 0.4 seconds, the calculation of the TS takes the distance travelled divided by the MT already calculated in the experiment. Most participants were still within the parameter, such as below 0.4, but many were well above the limit, which is an area of concern.

US: According to our set benchmark, the US must be between 80% and 100%. Here, there was an overall reading of 92%, which is very much in line with the researcher's prediction and also indicates that some drastic measures were taken to improve the figure.

RT: The RT is determined by the idle time that is wasted between the time an instruction was given and the time the action was started. The benchmark indicates that it must be between 9 and 12 seconds to be acceptable, otherwise it can be viewed as wasted time. Here the participants' RT was within the limit; however, there were some isolated cases where it was outside the expected limit. The researcher ascribes these late reactions to external distractions such as system intimidation.

CRA: The CRA is the amount of successful activities based on the number of activities available. The benchmark for this section is 80% to 100%. While the average CRA for some participants was below the 65% mark, in most cases it was within the set bracket.

CT: The CT is the time it takes to complete the whole series of activities, and also the set of individual tasks that constitute that activity. By calculating the overall time it takes to complete all these, one may have an estimate of the speed of the participants' actions. The benchmark for this section is 300 to 900 seconds. Some participants took more time but in most cases these boundaries were met. In very few cases the research team recorded times outside the upper limit of 900 seconds.

TBE: Its benchmark is between 0.001 to 0.18 seconds. Here, the participants were well within the limit, as the lowest TBE was 0.01 seconds and highest TBE was 0.17 seconds. However, there were isolated cases where it was slightly over 1.7 seconds.

System ID: The calculation of the ID takes into account the distance travelled, the width of the target, as well as the log. It is important to note at this stage that both low- and high-fidelity prototypes were the same sizes and therefore the width must be the same. This means that the output calculated for individual participants would be the same, and therefore we can use it as a mechanism to assess the validity of the outcomes. Here it stands at approximately 0.584, which is within the set benchmark of 0.001 to 0.9.

System IP: The calculation of this variable takes into account the ID, which is divided by the MT. The ID may be standard for all participants but the MT differs for each participant. The set benchmark is 0.01 to 0.08 and the results indicate that participants on average scored 0.004.

DF: The DF can be seen as the opposite of the task/activity SR. The set benchmark of 0% to 50% seems to be valid for any testing condition, or the lower the better in any condition. The figures here were a little high because some participants had a hard time completing the tasks. It therefore makes sense that the DF on average was approximately 44%.

5.8 SUMMARY

Conducting this set of exercises was not only rewarding but it was also an eye opener. The research team saw adult first-time users moving from a state of avoidance to the level of visibly improved interaction, and even though the end results were not always ideal, it was a work in progress.

Adult first-time users, as this study portrayed them, are people with no computing interaction experience, let alone any computing usability exposure, from the time they arrived on site and wanted to take part in our study until the time they left. Judging by their actions and enthusiasm, the impression is that the study changed something in them.

In most cases, the set of tasks that were undertaken were meticulously chosen and meant to achieve the assessment of the UX, but before getting to that stage, a set of other variables needed to be determined, such as the SR, the MT, the activity efficiency, the TS, the US, the RT, the CRPA, the CT, and the TBE.

The system ID, the system IP, the DF, and the AS are just a few variables that were combined to assist in determining the UX, which will be determined in the next chapter.

CHAPTER 6

UX METRIC (UXM), POST-EXPERIMENT, AND FRAMEWORK

6.1 INTRODUCTION

The UXM that is developed and presented here is the outcome of the application and exploitation of the previous chapters; it is not the overall conclusion of the study, but the step that leads to the end.

Clearer and better UX parameters mark the beginning of understanding computer usability challenges and the further explanation leads to the notion of HCI and the underlying interactivities which are constantly sought when humans interact with computing systems.

Comprehending and applying the principles of this section not only give us a model that is useful when assessing tablet users but also assist us in getting to know what it takes to operate a handheld computing system. The primary targets were adult first-time users, but the principles are the same if one needs to make a similar demonstration regarding other user groups.

All the variables used in this section were first defined, calculated, and demonstrated in one of the previous chapters, and this chapter is simply a conclusion of the previous sections. The issue of the digital gap assessment had not been addressed in the most constructive and academic manner so far. This chapter explores the digital gap issue by demonstrating how UX through the UXM assists in assessing the progression or narrowing of the digital gap within a community.

This chapter enables us to engage with the study output, which is the framework that is developed to demonstrate the approach that has to be followed if one wants to address the digital gap problem in South Africa.

This chapter also pays attention to the post-experiment questionnaire, which is crucial in obtaining the adult first-time user's opinion regarding the whole experimental study. This section gives us the opportunity to assess the user once more.

6.2 THE METRIC

Table 6.1 shows the UXM that represents all the most important characteristics that are vital to determine any potential user experience. It gives a holistic and numeric approach, which is essential in comprehending tablet system usability and adaptation. The UXM is the assessment measurement that this current study attempts to address. It was developed based on a number of factors that are essential regarding comprehending mitigating variables which can assist user adaptation and depict future interaction.

Table 6.1: UXM

Instrument	Benchmark	Pt. 1	Pt. 2	Pt. 3	Pt. 4	Pt. 5	Pt. 6	Pt. 7	Pt. 8	Pt. 9
SR (%)	90	35	75	42.5	65	77.5	62.5	57.5	80	62.5
DF (%)	25	65	25	57.5	35	22.5	37.5	42.5	20	37.5
ID (bits)	0.001	0.468	0.585	0.585	0.585	0.585	0.585	0.468	0.585	0.585
IP (bits)	0.005	0.005	0.009	0.005	0.008	0.009	0.01	0.007	0.008	0.01
TBE (goal/s)	0.02	0.019	0.059	0.029	0.047	0.136	0.108	0.069	0.16	0.1
US (%)	90	65	25	57	35	22	37	42	20	37
CT (s)	450	4079	917	1106	738	395	439	399	511	435
RT (s)	11	2450	28	15	11	4	11	7	16	16
MT (s)	500	1629	889	1091	727	391	428	392	495	419
TS (cm/s)	0.8	0.07	0.389	0.323	0.484	0.904	0.813	0.714	0.699	0.821

Figure 6.1 is an illustration of the data from Table 6.1. It gives us a graphical illustration of what one may perceive as a methodological approach, which can lead to the comprehension and exploitation of the UXM.

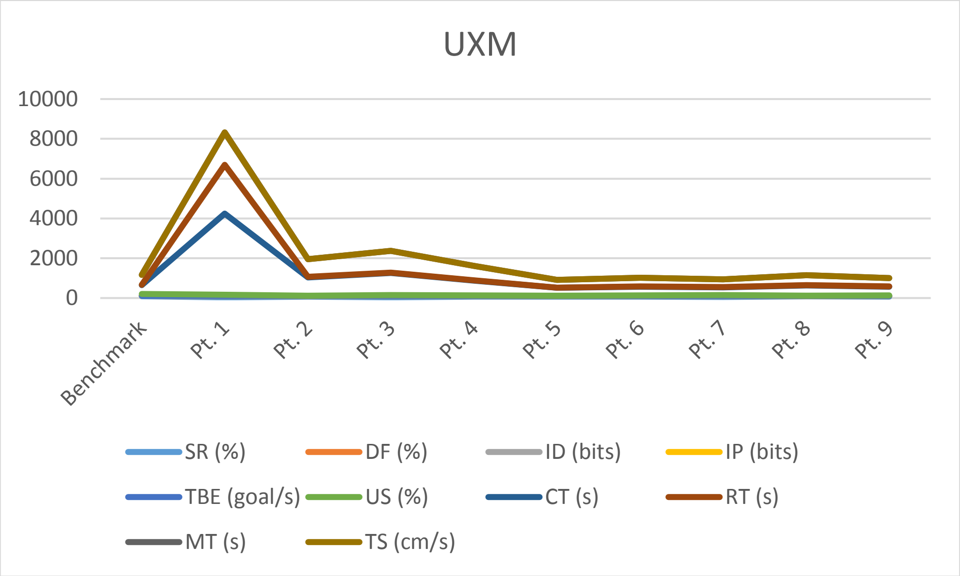

Figure 6.1: Graphic representation of the UXM outcome

6.2.1 Demonstration

The included variables are individually calculated and were included in Table 6.1. It also shows the standard benchmark on the right, which represents the standard that any adult first-time user needs to work toward. Any variations of other instruments are an indication of individual performance, which is as unique as the person whose capacity is being measured.

To get to this level, the researcher applied the set formulas, which are mostly existing mathematical formulas used in other fields and that were adapted for this study. Using a Microsoft Excel spreadsheet, the researcher computed all the data to obtain the results.

To repeat the demonstration or apply the output to other participants, one only needs to have the computed variables and insert them into the table and compare the result with the benchmark.

6.2.2 UXM definition

The UXM is an agglomeration of a multitude of instruments that are used in conjunction in order to determine the suitability and adaptability by a first-time user of a tablet system. It is a series of tools and methods adapted to uncover the ability, level of engagement, usability, and persistence of a potential user, which ultimately could lead to a conversion shift in the mind-set, or simply the likelihood to convert to ordinary-user status.

6.2.3 Application

The UXM takes into account all the independent instruments and variables, i.e. the user SR, the DF, the ID, the IP, the TBE, the CRTA, the RT, the MT in relation to the point of contact, the TS, the number of errors made, and the overall US.

The application is based on and pertains to a single participant only, who is being measured against the known and established standard, also known as the benchmark, which is the optimal level of computing usability. The metric measures participants against the benchmark, which is an innovative way to obtain an overview of their performances from a single snapshot.

6.3 THE LINK BETWEEN UX AND THE DIGITAL GAP

The digital gap is fundamentally the absence of broad digital computing systems within a community or group of potential users at the time and under the conditions when they need it (South African Government 2014). As stated previously, the digital gap is not merely the absence of computing systems (Smith-Atakan 2006), but a combination of interrelated factors that include computing system usability.

Any reference to computing system usability involves UX; the literature provided ample explanations of the existing connections. Here we are merely demonstrating and confirming our suspicions about the previously introduced link which may exist between these two important aspects – the user and the system.

The development of the UXM is fundamental in moving towards the assessment of the digital gap; one may not simply explore the existence of the digital gap without having full comprehension of the user experience.

From the onset of this study it was stated that the digital gap is not the mere absence of the ICT devices where they are needed, but a combination of several factors which include UX as the heart of the problem.

6.3.1 UXM exploitation

To better understand the UXM, one needs to consider its dimensions, especially regarding individuals who are mastering the overall exploration and exploitation with the GUI and HCI field.

The goal dimension, which can have a summative approach in the sense that it uniquely takes into account the final output, or a more formative goal that is closely intertwined with the process, can be achieved through the testing processes that are part of the systems evaluation.

The next dimension is the approach dimension. Depending on the user or user community, it can be seen either as objective, as it gives us a series of the tangible results that are based on the instruments and variables the researcher selected, or as subjective by those who may interpret the metric as being too biased toward the developed assumption as it takes into consideration the set benchmark as anything which is not untoward but is simply seen as inferior.

The next dimension is the data used. Here, various sources of data are taken into account, while most are computed before being exploited. Data are generally grouped as either being quantitative or qualitative.

The next dimension is the granularity as part of the exploitation of the metric; it gives the users of the metric an overall engagement philosophy. Conducting this form of testing can either be a momentary (a once-off event), episodic (gradually repeated or re-assessed, whether or not the previous data are still valid and defendable), or partial or overall UXM for a project.

The last dimension is rather logistically bound and is referred to as the setup. It solely depends on the user of the metric. Do we conduct this type of assessment while conducting fieldwork, or is it best while conducting lab interpretation, that is left open to anyone who may wish to explore it further?

6.3.2 How the UXM guides the digital gap assessment

The UXM is an assessment tool that was developed with users in mind, and its aim is to assess user performance against a series of instruments that are essential in mastering computing devices. The successful control has become the main factor that enables users to move to the next level, as demonstrated in the post-experimentation questionnaire later in the chapter.

A poor metric assessment output can only lead to low engagement and dissatisfaction, and can maintain the existence of the digital gap.

Figure 6.2 is an illustration of the UXM within the UX framework and shows how the interpretation and exploitation of the metric may have an impact on other critical interactions with the computing systems, and most importantly the various aforementioned dimensions.

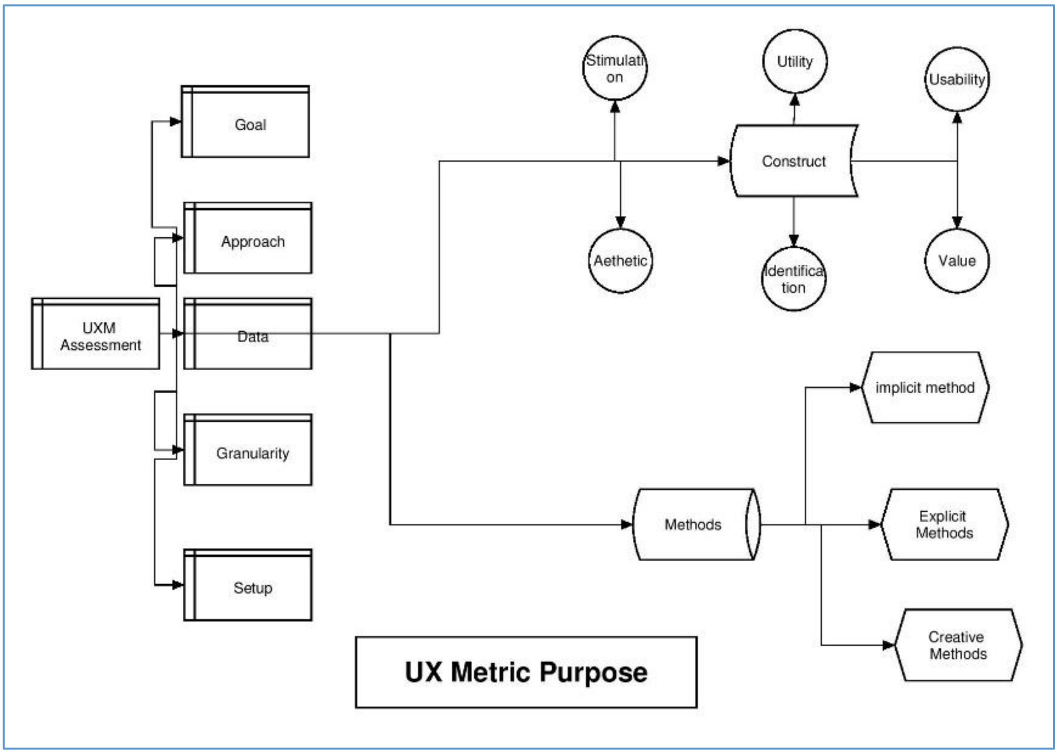

Figure 6.2: UXM usage diagram

6.3.3 Factors that contribute to the digital gap

Without sound UX, potential users are less likely to pursue the interactivity of computing systems. Poor usability can lead to frustration and abandonment, as indicated in Table 4.7 in Chapter 4. Resentment of systems is functionally the main driver of systems discontinuation and disengagement, which lead to the maintenance of the digital gap.

Other important digital drivers that are not explored here are socioeconomic factors. The literature review provided a broad perspective of the factors that contribute to poor usability, and Chapter 4, Table 4.29 gave us a clear indication of the scalability of the interface guideline dilemma.

The psychological impact and other psychological factors, which are not broadly covered in this study, are other factors that cause the digital divide as they influence the state of the user's mind.

This study examined interaction, HCI, and GUI as individual components of information systems that form the focus of this research and are the most dominant denominators of the project under scrutiny. The preliminary investigation indicates that many adult users are included in the digital divide for various reasons, including lack of education, poor understanding of the role of computing, and especially very poor UX (see Figure 6.3). Therefore, the unity between UX and the digital gap becomes irreversible, meaning the better the UX, the narrower the digital gap.

6.4 POST-EXPERIMENT QUESTIONNAIRE AND REPORT

This section deals with the views of participants after completing the experiment. The aim was to obtain their opinions after completing the experiment – known as the post-experiment questionnaire – and to help obtain other perspectives that would not have been possible during the pre-experiment or experiment phases.

This section also aims to ensure that experiment outputs are in line with the participants' opinions, as things said here would either support the experiment findings or dismiss them.

6.4.1 Researcher post-experiment observation

This section deals with the unspoken and unwritten non-verbal observations that are essential regarding conducting a study involving human subjects. This essentially comprises a series of notes made by the researcher before, during, and after the actual experiment.

Humans in their natural environment are subjected to various influences, which may at times prevent them from making remarks that are explicitly interpreted and understood. The experiment process in this study exposed participants to technological challenges and most of them were not prepared to interact with the systems. Nonetheless, they participated in the testing process.

After the completion of the actual experiment, this reluctance was observed in almost 82% of all participants. Even though there was a form of user frustration in most participants, the research team had difficulty stopping them after their interactive time was over.

Without knowing their background and income level, one could easily conclude that they lived in very difficult conditions and could hardly afford to purchase their own devices, but the impression was that most wanted to buy one as soon as possible after the experiment.

Although the research team explained the study to the participants on numerous occasions, most participants could hardly understand the purpose of the study. Many understood it as a preliminary assessment to later provide them with state-sponsored tablet systems, which the researcher refuted on numerous occasions.

The transition was rather easy for many after training was provided; by the time the experiment was finished, many, if not most, of the participants gave the impression that they were ready to own their own tablet system.

The main interpretation of their body language during the experiment was that many had the instinct of how to complete the tasks; the difficulty was just how they should be started.

The research team observed a lot of unpleasant language and swearing from participants during the experiment as they expressed their frustration with thinking they could execute the tasks, but failing to do so.

Female participants were more inclined to ask for assistance than males, and they were also more polite and respectful of the instructions and recommendations given to them.

6.4.2 Post-questionnaire reviews

This section deals with post-questionnaire reviews that were sent to ICT professionals and sales agents. Their input was very important in comprehending research aspects that could not be provided by our primary target, namely the adult first-time users.

Availability and time were particular hurdles, and very few responded to our questions compared with the number of questionnaires sent out, and when they did, most wrote the minimum number of sentences and provided limited insight. It was easy for many to simply choose options, but when they were asked to write their own replies, most chose either not to do so or simply wrote too little.

In most cases the research team had to make several follow-up phone calls in order to remind people to complete the questionnaire and that was mostly at their place of work and during their lunch period. In some instances, the questionnaires were completed in our presence after several requests to complete the questionnaire had failed.

In the case of ICT professionals participating in the research, their job description was one important factor that was used to select them, and luckily for the researcher most were situated in the same province as the researcher.

Most respondents avoided using technical jargon and provided easy-to-understand responses as if the researcher was from a different field.

6.4.3 Quantitative data responses

This section only deals with the quantitative questions of the post-experiment questionnaire. It examines numerical explanations to support the findings within the literature and is organised according to the opinions expressed, based on the question and the response and the analysis thereafter.

As per previous chapters, the researcher conducted an analysis of the answers to determine if there was any form of correlation with the experiment output. Tables 6.2 to 6.20 show the responses to the individual questions.

Table 6.2: Q1 –How did you experience the experiment?

	Frequency		**%**	**Valid %**	**Cumulative %**
Valid	Good	312	88.3	89.6	89.6
	Bad	31	11.6	10.3	100.0
	Total	**348**	**98.5**	**100.0**	
Missing	System	5	1.4		
Total	**-**	**353**	**100.0**		

This question assisted in knowing how the respondents reacted after completing the questionnaire, training, and experiment. The researcher wanted to know how they felt after all the stages they went through. The responses were to a large extent the opposite of the responses in the preliminary phase.

Here, 88.3% indicated that they felt very good and excited about the process and only 11.6% indicated the opposite. This makes the researcher believe that the whole approach helped the majority to change their minds about the whole interactivity issue.

Table 6.3: Q2 – Did you struggle to complete some tasks?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	70	32.0	32.0	32.0
	No	216	67.9	67.9	100.0
	Total	**286**	**89.9**	**100.0**	
Missing	System	32	10.0		
Total	**-**	**318**	**100.0**		

A similar question in the preliminary phase indicated that most participants had issues with the completion of tasks, and that was the reason why they indicated reluctance to have any future interaction with computing systems.

Here, as a post-experiment question, 32.0% indicated that they had issues with the completion of tasks, while 67.9% indicated the opposite; which is a sharp contrast to what the researcher experienced during the initial phase.

Table 6.4: Q3 – Did the training you received help you?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	280	94.9	96.2	96.2
	No	11	5.0	3.7	100.0
	Total	**291**	**98.6**	**100.0**	
Missing	System	4	1.3		
Total	**-**	**295**	**100.0**		

This question sought to assess if the training provided was useful and if it improved their abilities. This training stage was very important and provided an important delimitation of what was accepted and what was not.

Here, 94.9% indicated that it was helpful, while only 5% indicated the opposite. It shows that, to a large extent, participants liked these types of exercises or that the actual training helped them improve their user experience.

Table 6.5: Q4 – Were the tablet systems intimidating during the experiment phase?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	17	5.5	4.9	4.9
	No	291	94.4	95.0	100.0
	Total	**306**	**99.3**	**100.0**	
Missing	System	2	0.6		
Total	**-**	**308**	**100.0**		

Here the researcher wanted to know if the tablet systems were to any extent intimidating during the experiment (actual, not preliminary) phase. Only 5.5% indicated that they were intimidating, and 94.4% indicated that they were not. This is very positive and could be due to the fact that many became very familiar with the systems through training.

Table 6.6: Q5 – Do you think your action was effective and efficient enough?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	280	93.6	95.2	95.2
	No	14	6.3	4.7	100.0
	Total	**294**	**98.3**	**100.0**	
Missing	System	5	1.6		
Total	**-**	**299**	**100.0**		

Measuring the effectiveness and efficiency of tablet systems was very important for one to know the user experience and usability of the systems after completing the preliminary experiment. Here, 93.6% indicated that their actions were effective and efficient, while 6.3% indicated the opposite.

Table 6.7: Q6 – Would you do these exercises again in the future without supervision?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	292	92.9	95.1	95.1
	No	15	7.0	4.8	100.0
	Total	**307**	**97.7**	**100.0**	
Missing	System	7	2.2		
Total	**-**	**314**	**100.0**		

If participants cannot take the initiative on their own to complete similar tasks than those during the experiment, then it means that the training and experiment were not good enough to stimulate the need to have these types of exercises.

Here, 92.9% indicated that they would like to complete similar tasks, while 7.0% indicated otherwise.

Table 6.8: Q7 – Do you feel ready to use tablet systems in the future?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	288	92.6	96.9	96.9
	No	9	7.3	3.0	100.0
	Total	**297**	**95.4**	**100.0**	
Missing	System	14	4.5		
Total	**-**	**311**	**100.0**		

Being able to own a tablet system in the future means that one is gradually crossing the digital divide. It is also an indication that some adult first-time users are ready to start using computing systems such as tablets. Here, 92.6% indicated that they would use the system in the future, while 7.3% indicated otherwise.

Table 6.9: Q8 – Was your level of anxiety high when completing the experiment?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	277	95.8	97.8	97.8
	No	13	4.1	2.1	100.0
	Total	**283**	**97.9**	**100.0**	
Missing	System	6	2.0		
Total	**-**	**289**	**100.0**		

The level of anxiety here may also mean the degree of fear that one experiences when dealing with something new. Here, 95.8% said they had some form of anxiety during the experiment, while 4.1% indicated the opposite. Most participants were unsure about what to expect from the experiment, hence the high levels of anxiety.

Table 6.10: Q9 – Was the prototype used for experiment appropriate for the task?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	288	90.8	95.3	95.3
	No	14	9.1	4.6	100.0
	Total	**302**	**95.2**	**100.0**	
Missing	System	15	4.7		
Total	**-**	**317**	**100.0**		

The prototype is the instrument used to conduct all demonstrations. Both low- and high-fidelity prototypes were used throughout the experiment. The researcher wanted to know whether the instrument posed challenges in the completion of the tasks. Here, 90.8% indicated that it was appropriate, while 9.1% indicated otherwise.

Table 6.11: Q10 – Was the system difficult to use?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	30	9.5	9.5	9.5
	No	259	82.4	82.4	100.0
	Total	**289**	**92.0**	**100.0**	
Missing	System	25	7.9		
Total	**-**	**314**	**100.0**		

This question was helpful in comprehending whether or not the tablet systems used for the experiment were in any way complex or difficult to use, with the aim of ensuring that the aspects underlining the experiment were fully covered before the assessment. Here, only 9.5% indicated that it was difficult, while 82.5% indicated that it was not.

Table 6.12: Q11 – Do you think the tablet system is useful?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	288	90.8	95.3	95.3
	No	14	9.1	4.6	100.0
	Total	**302**	**95.2**	**100.0**	
Missing	System	15	4.7		
Total	-	**317**	**100.0**		

This question is very important because it may determine the future usefulness of the computing system after the completion of the study. The researcher wanted to determine if participants could still see the importance of these tools after the experiment. Here, 84.7% indicated that the tablet systems were useful, while 15.2% indicated otherwise.

Table 6.13: Q12 – Were your experiment actions fast enough when completing tasks?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	280	86.4	94.5	94.5
	No	16	13.5	5.4	100.0
	Total	**296**	**91.3**	**100.0**	
Missing	System	28	8.6		
Total	-	**324**	**100.0**		

During the actual experiment, the research team took time- and action-based tasks into consideration. Knowing whether and how these tasks were hindered may help to determine how to address some aspects of the findings. Here, 86.4% indicated that their experiment actions were fast enough, while 13.4% indicated the opposite.

Table 6.14: Q13 – Did you take a while to react when instructed to complete a task?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	261	16.0	9.0	9.0
	No	26	83.9	90.9	100.0
	Total	**287**	**92.2**	**100.0**	
Missing	System	24	7.7		
Total	-	**311**	**100.0**		

Idle time calculation was taken into account when assessing the UX, and in many cases, some participants experienced difficulties understanding the instructions, therefore this question was asked. Here, 16.0% indicated that they had idle time between the time the instruction was given and the time they started completing the action, while 83.9% indicated that they did not.

Table 6.15: Q14 – Would you advise someone you know to purchase a tablet system?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	265	86.0	91.3	91.3
	No	25	13.9	8.6	100.0
	Total	**290**	**94.1**	**100.0**	
Missing	System	18	5.8		
Total	**-**	**308**	**100.0**		

The researcher wanted to know whether participants would advise anyone they knew to use a tablet. The researcher believes that the more tablet users there are, the better; or the narrower the digital gap. Here, 86.0% indicated that they would, while 13.9% indicated otherwise.

Table 6.16: Q15 – If affordable, would you buy one for yourself?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	264	83.8	91.6	91.6
	No	24	16.1	8.3	100.0
	Total	**288**	**91.4**	**100.0**	
Missing	System	27	8.5		
Total	**-**	**315**	**100.0**		

Closing the digital gap requires computer literate users to acquire computing systems of their own and using them effectively. It may assist in getting to know if they were willing to become more prone to frequent computing usage, which is the power of computing. Here, 83.6% indicated they would purchase a tablet if they were affordable, while 16.1% indicated otherwise.

Table 6.17: Q16 – How soon could you purchase your own tablet?

	Frequency		%	Valid %	Cumulative %
Valid	Less than 1 month	150	49.8	62.5	62.5
	More than 3 months	50	16.6	20.8	20.8
	More than 4 months	25	8.3	10.4	10.4
	More than 1 year	10	3.3	4.1	4.0
	Other	5	1.6	2.0	100.0
	Total	**240**	**79.7**	**100.0**	
Missing	System	61	20.2		
Total	-	**301**	**100.0**		

Having completed the experiment, and having participants indicating their willingness to gain access to their own computing systems, the researcher wanted to know how long it would take them to purchase one. Here, 49.8% indicated that it would be less than a month, 16.6% indicated that it would be less than three months, 8.3% indicated that it would be less than four months, 3.3% indicated that it would be less than one year, and 1.6% indicated "other", which may mean that it might take longer than a year before they could purchase a tablet.

Table 6.18: Q17 – What would be the purpose of buying the tablet?

	Frequency		%	Valid %	Cumulative %
Valid	For web surfing	40	14.2	16.1	16.1
	For education	85	30.3	34.2	34.2
	For information	69	24.6	27.8	27.8
	For entertainment	34	12.1	13.7	13.7
	Unknown or other	20	7.1	8.0	100.0
	Total	**248**	**88.5**	**100.0**	
Missing	System	32	11.4		
Total	**-**	**280**	**100.0**		

This question is a follow-up question to the previous one. The researcher wanted to know what the main purpose of purchasing a tablet system would be. This question assists in determining the purpose of purchasing a tablet. Here, 14.2% indicated that it would be for surfing the Web, 30.3% indicated that it would be for educational purposes, 25.6% indicated that it would be for information seeking, 12.1% for entertainment, and 7.1% for unknown or other purposes.

Table 6.19: Q18 – Does it need to be a brand name or any functional tablet?

	Frequency		%	Valid %	Cumulative %
Valid	Brand name	65	25.7	28.7	28.7
	Any tablet	150	55.3	66.3	66.3
	Undecided	11	4.0	4.8	4.8
	Total	**226**	**83.3**	**100.0**	**100**
Missing	System	45	16.6		
Total	**-**	**271**	**100.0**		

When purchasing a tablet system, the researcher wanted to know which type they would prefer, as many participants may not be in the position to afford more expensive tablets. Here, 25.7% indicated that they would prefer a brand name, or a more expensive type of tablet, 55.3% indicated that they did not mind, as long as it worked, and 4.0% were undecided.

Table 6.20: Q19 – Are you satisfied with your user experience?

	Frequency		%	Valid %	Cumulative %
Valid	Yes	277	92.0	92.0	92.0
	No	13	7.9	7.9	100.0
	Total	**301**	**98.0**	**100.0**	
Missing	System	6	1.9		
Total	**-**	**307**	**100.0**		

This question is fundamental in comprehending the UX dilemma, although the responses here were generic. The researcher wanted to know how participants felt about their own UX after completing the experiment. Here, 92.0% indicated that they are very satisfied with their user experience, while 7.9% indicated otherwise.

6.4.4 Post-experiment multiple-response questions

The multiple-response questions that form part of Chapter 4 provided us with a new dimension of the post-experiment section. The researcher observed a transformation from the participants' initial state of mind and application to the positive state of mind and embracement of technology. These responses illustrate the transformation that took place during the training and experimentation phases. Participants discovered the power of ICT and the related benefits that can come from being able to operate a computing device.

6.5 DIGITAL CLOSURE FRAMEWORK

Figure 6.3 is a depiction of an approach that can lead to the closure of the digital divide we are currently experiencing in the most impoverished communities in South Africa. At the heart of this dilemma is the UX, without which any effort to accomplish the intended outcome is futile.

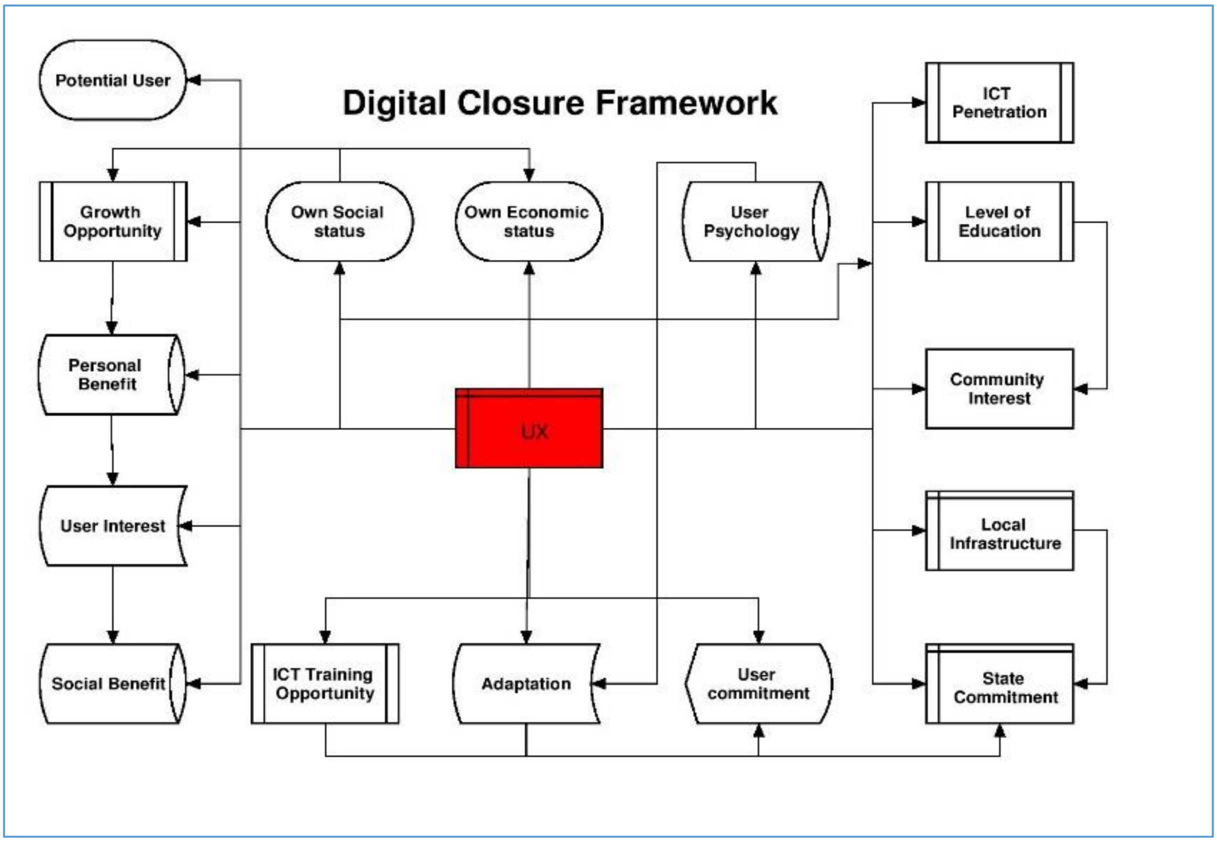

Figure 6.3: Digital closure framework process

Figure 6.3 provides a holistic view on all the parameters that are individually and globally responsible for keeping the digital divide wide open. The issue of the digital gap cannot be addressed without paying attention to the individual aspects of the framework, and the aspect that is most valuable and which falls under the jurisdiction of this study is the UX.

As demonstrated in the theoretical framework, UX is the single most critical aspect that can assist in determining whether a user who is using a computing system for the first time would be able to continue doing so in the future. This study gives us an indication of the degree of engagement when personal anxiety ceases to exist.

Closing the digital gap in any developing nation such as South Africa may not be addressed at all if some fundamental issues are not addressed beforehand. Figure 6.3 provides a series of actions and prerequisites that must be taken into account if any form of digital closure can be expected. At the centre of it all is the UX, without which no first-time user will ever take the opportunity to engage with any computing system.

Then we investigate issues such as user social status, own economic status, and user psychology, which are all essential regarding exploring the way humans interact with computing systems. These can be classified as enabling factors which could easily foster the adaptability of any systems.

At the bottom of Figure 6.3 there are elements such as ICT opportunity, adaptation, and user commitment. These elements are meant to create an enabling environment which users can navigate around to gain access to the UX world. It can also prevent any potential user from crossing to the other side of the same spectrum. An example is "user commitment", without which no one can comprehend how any system works.

6.6 SUMMARY

The researcher is of the view that the UXM that was presented in this chapter would be extremely useful to the ICT community in general and HCI in particular, especially for those who are in the information systems field. This new ICT tool has not been used before and was conceptualised, demonstrated, and applied by the author for this research project. The tool seeks to address one of the most discussed issues of less developed nations such as South Africa, where the closure of the digital gap has been addressed by various authors but solutions to it have not been addressed sufficiently.

This chapter did not address how to close the digital gap, but rather how to determine what keeps it so wide and constantly present. The chapter also addressed the fundamental issue of the lack of computing knowledge acquisition and transfer.

This chapter brings to the fore a number of variables that were previously used in other chapters. The exploitation of these variables is seen as the process of binding them all together to view what they may provide as a result. The UXM, which is the fundamental missing variable that was created, has not been presented or discussed by any other researcher before.

This chapter paid attention to the issue of the interpretation and application of the metric, while also exploring the post-experiment questions that shed light on the usability issue, and also enabled the researcher to assess participants' opinions, which were very essential to the comprehension of UX.

Finally, the chapter demonstrated and unveiled the digital gap closure framework, which gave the researcher the opportunity to visualise the whole study and how it came to be an important topic worth addressing.

CHAPTER 7

CONCLUSION

7.1 INTRODUCTION

This chapter marks the end of the investigative process regarding the issue of adult first-time users' adaptation to and adoption of handheld computing systems where usability is concerned. It also enables the researcher to provide a summary of all the work that was covered in the rest of the study. This chapter gives the researcher the opportunity to discuss what he has observed and learned during the whole process to ensure that his point is put across.

From the onset of this study, the solution to the problem of the digital gap sounds as simple as providing digital computing systems to those who need them in order to reverse the situation, but the researcher then examined the issue of usability to determine who can actually utilise the systems if provided to them, and, most importantly, how many people knew about the existence of computing devices such as tablet systems.

The level of poverty in some of the areas the researcher and his team visited was very disturbing. The poor literacy rate, unemployment, and dependency on state social grants were also alarming, but remarkably enough, most, if not all, potential users who were approached had a cell phone and some even had smartphones. This led to some confusion when the researcher asked them about their understanding of handheld computer systems and how they can adapt to them.

7.2 REFLECTING ON THE JOURNEY

Adult first-time users were the primary target of this investigation. They are sometimes referred to as the "missing middle", with reference to the fact that they missed the ICT drive of the 1990s and 2000s, and found themselves computer illiterate; this time not as desktop or laptop computer users, but as handheld computer users.

The participants were recruited across the country, and their level of knowledge of computing systems was as wide as any other social phenomenon that can be observed in a free society – some were well informed about these types of devices but had no contact with it, while others were simply out of touch with ICT developments.

Some of the participants understood that they could gain something positive from engaging with the handheld systems, while others who had previously engaged with such systems considered the exercises in which they participated as a life-changing experience, an eye opener, or simply as a study being conducted.

7.3 RESEARCH AIMS

From the onset of the study, and based on the primary aim of the research, the researcher wanted to learn how long it would take someone who has never used a computing system to complete a basic activity, and how efficient and effective they would be in completing several tasks and activities.

The formulas used in this study were all calculated in a Microsoft Excel spreadsheet (experiment data included on the accompanying CD) and enabled the researcher to visualise all the applications of those formulas and how the results were obtained.

In order to effectively fulfil the research obligations of this section, it is important to reiterate the objectives of the aim to ensure that they are fully understood before providing any answers.

The main objective of this study was to develop a UXM which would enable the assessment of individual users based on a number of variables and instruments, and the assessment of participants from the primary introduction through to the completion of the post-experiment questionnaire.

The researcher approached and interacted with ICT interactive designers, who are people entrusted with the development and deployment of the GUI of computing systems, which was used to test adult first-time users. The researcher acquired the input of computer salespersons, whose job it is to engage with people who are looking to buy a computing system. Their views and opinions proved to be vital in understanding the issues anyone faces when they want to interact with a computing system.

Lastly, the researcher also interacted with adult first-time users, who were the primary target of this study. Any interaction with them was guided by the UNISA code of ethics (see Annexure 6). The researcher's engagement with stakeholders was subdivided into various levels (see Figure 3.1) in order to determine the suitability of the participants at each phase of the data-capturing process. It was vital to conduct a pre-assessment to evaluate the participants, using a low-fidelity prototype, as shown in Annexure 7.

The researcher initially made some assessments on well-versed users – also known as standard or experienced users – who commented on their level of interaction with the same systems used to test the participants. This is referred to as the benchmark, as discussed in Chapter 5.

When one looks at the pre-experiment data, as displayed in Table 5.1 and also in Table 6.1, the researcher had an idea of the standard of adult first-time users in this study, how long it took them to complete an activity, and what the rate of success was when it came to the same set of tasks they were asked to complete. These were some of the aspects that the researcher considered when starting this research process.

After making an in-depth comparison between Table 5.1 and 6.1, if one takes only one variable such as the SR into account, the benchmark in Table 6.1 shows that it should be around 90%. The data for Participant 1, for example, showed that during the pre-experiment the SR was around 10%, and during the post-training experiment (see Table 6.1) it increased to around 35%.

The same can be said about the level of difficulty of the task, the ID, the IP, the TBE, the US, etc. when comparing the two tables. By further exploring Table 6.1, the researcher discovered details that were much more positive than they initially were in Table 5.1, and by considering the frustrations experienced by the participants, as indicated in this table, the researcher can see how important those data are regarding assessing the level of system usability of any user.

The researcher collected two sets of data using questionnaires at two separate levels during the experiment. In the first set, the participants qualified to participate in the pre-experiment, and the second set was collected after the experiment and post-experiment (see Annexure 4 and 6), and the data output was far apart. If we consider a question such as systems efficiency and effectiveness before and after the experiment, the output was very negative in Table 4.15 and then very positive in Table 6.6.

Taking into account the overall data as displayed in Chapter 4, which is the reflection of the participants when they were initially considered for the research, there seem to be some trends such as user frustration (see Table 4.7) and confidence (see Table 4.9), as well as the perceived complexity of tasks, completion of tasks, and asking assistance because the tasks could not be completed without external assistance, which was due to their complexity and accountability, as demonstrated in Tables 4.10, 4.11, and 4.13 respectively.

When observing the MT, which was measured in seconds, and having a benchmark of about 500 seconds, which can only be successfully achieved if users had good system learning ability, the researcher noticed that Table 4.18 painted a very negative picture of the system rating, which later had an impact on the user's functionality (see Table 4.19), system navigation (see Table 4.20), and satisfaction (see Table 4.22). The formula to calculate the MT is shown in Table 3.1.

When users struggled to execute tasks, and after failing to do so, as indicated by the number of participants who made errors (see Table 4.23) and the frequency of those errors (see Table 4.24), they tend to blame it on other external phenomena such as the system design (see Table 4.26) and consistencies (see Table 4.26). Table 4.27 provides the most important aspect the researcher has explored regarding user usability. Here one can see that although some participants had previous exposure to mobile devices, it played a very small role in inspiring tablet systems migration and usability.

The data in Table 4.30 and 4.31 painted a negative picture of system usability and interaction. The researcher has the distinctive impression that the participants believed that the problem did not lie with them but rather with the systems they interacted with.

7.4 RESEARCH QUESTIONS

The researcher cannot conclude this study without ensuring that the questions that were asked in Chapter 1 are answered. The following sub-sections will explore each question that was asked in Chapter 1 and provide some answers.

7.4.1 To measure key systems usability

Using the formula introduced in Table 3.1 as the set mechanism to determine the level of frustration with the level of usability, as seen in Chapter 6, and shown on the accompanying CD on the Excel sheet called Experiment Data, the researcher demonstrated how variables, such as the SR (see Table 5.3), both in the horizontal and vertical approach, were calculated.

The researcher calculated the MT (see Table 5.4 and Annexure 10A to 10C), where one can see the impact it had on activity completion as well as the discrepancies with the benchmark and how participants performed during both pre- and post-training.

The researcher examined the AE formula and applied it to the collected data. While some participants achieved a 100% rate, most were as low as 0%, which again provided an indication of the level of involvement of adult first-time users, as indicated in Table 5.6.

The researcher calculated the ST, which was basically derived from the MT formula. This formula enabled the researcher to determine the amount of time a particular user took to complete a single task (see Table 5.8 and Annexures 10A to 10C).

The AS was used to calculate how long it took participants to complete an activity, which was basically a set of multiple tasks put together, in order to determine how they behaved once grouped in a single unit (see Table 5.9). The RT was also calculated (see Table 5.10), which basically indicated the time between an action being requested and the time the participant started with the task (see Table 5.11).

The researcher examined the CRP where all tasks and activities to be completed by a single participant were grouped into a single block to assess how the data would behave (see Table 5.13). The CT was also calculated, which is demonstrated in Table 5.14.

The researcher also calculated the TBE of each participant, which indicated how precise participants were in terms of meeting their prescribed target (see Table 5.15). The researcher investigated the ID and IP, which are indicated in Tables 5.17 and 5.18 respectively. Lastly, the researcher examined the DF of each participant, which is shown in Table 5.20.

7.4.2 To identify, analyse, and address usability hurdles of handheld systems

In this section, the researcher explored the perceived root causes of poor system usability. By exploring some of the answers obtained in Chapter 4, the researcher observed some correlation between the use of tablet systems, where about 88% indicated that they have never used one (see Table 4.6), and the participants' level of frustration when they performed the tasks, where 45% indicated that they experienced some level of frustration because some actions could not be completed (see Table 4.7). This implies that users, who for some reason were not exposed to computing systems early enough, may feel some form of resentment as they may be under the impression that some of their actions could not be completed for various reasons which are out of their control.

In Tables 4.14 and 4.15, which dealt with the user interface of handheld electronic devices such as tablets and what users see as system efficiency and effectiveness, the researcher observed that 53% of the participants disagreed that the tasks they were asked to complete were not in line with the built-in interface that they were tested on. This is in line with the 66% who indicated that the system they were tested on was not effective and efficient from their point of view. This is one of the explanations for the major obstacle one has to deal with regarding system development. What these two questions have in common is that they were both asked prior to the training.

When the researcher conducted a cross-verification with data from the post-experiment and training phase, 88.3% of the participants indicated that they had a pleasant experience (see Table 6.2), which is in stark contrast with their earlier answer and an indication of what may truly constitute systems adaptation.

In Table 6.3, the researcher observed that 67.9% of the participants indicated that they did not have any problems completing the tasks and activities they were asked to complete, while also acknowledging that the training phase assisted them in mastering the tasks, as indicated in Table 6.4.

From all these data, it seems obvious that handheld system usability, as identified in the pre-experiment section of this study, is basically a training issue. This means that with good and effective training, most users will be able to embrace handheld systems and adopt them.

7.4.3 To develop a UXM

The ultimate goal of this study was to develop a UXM (see Table 6.1). This UXM, which is explained in Chapter 6, gives any other potential systems developer a tool that they can utilise any time they want to measure how the user's knowledge of any system will affect its effectiveness and efficiency. The metric also provides multiple variables that can be used to monitor the progress of any user who wants to master a handheld system such as a tablet.

7.5 CONTRIBUTION MADE TOWARDS THE BODY OF KNOWLEDGE

While this research project provides an idea of the role and importance of computing systems in local communities in terms of people, challenges, and the ability to become computer literate, as indicated in Table 4.1, it might not be seen as a direct contributing factor towards information systems in general and the HCI field in particular.

Knowing which social and technological aspects contribute towards the maintenance or closure of the digital gap in Africa is vital in indicating to ICT leaders what their next move must be and how it must be conducted. Exploring some of the underlying aspects, the researcher came across some simple and logical trends that one must consider when any form of new technological innovation is considered, such as not to always assume that all users are the same, and not to assume that system usability is universal.

Tables 5.1 and 6.1 may be nearly identical, but they show different data collected from the same people; the only difference is that the data were collected before and after the training, and the question the researcher asks himself is how we can ensure that new ICT products are integrating user training and considering each user's strengths and weaknesses. The researcher strongly believes that conducting further analysis on user TBE and handheld MT is essential in comprehending the user's mindset and speed of adaptation. This study contributes towards creating an important set of knowledge about what the "missing middle" users are going through and what can be done to address or redress their issues in the short and long term.

This study also enabled the researcher to uncover or create a unique technique that any interactive developer may use when testing new or existing systems in terms of the level of adaptation, adoption, and usability. This was called the UXM, and it may well be as unique as it sounds. It is this contribution that the researcher is looking forward to introducing into the body of knowledge of the HCI field.

7.5.1 Specific contributions of this study

The above section elaborated on the potential contribution which may be made by this study to the body of knowledge in general and to the information systems and HCI subfields. This section will further explore these contributions.

7.5.1.1 UXM

(a) Literature

- From a theoretical perspective, it enables any potential developer of any handheld computing device to fully understand what the major areas of system usability are which will need closer attention.

- Knowing the average TBE of a first-time user is a stepping stone towards understanding the average speed of a user when using an interactive application, which is especially important when those applications must be used by all types of users.
- Most game applications developed these days are meant for handheld systems, where the user is constantly on the move and has to pay attention to their physical surroundings. Here, it is essential to comprehend the importance of outcomes of formulas such as MT. Theoretically, it will enable any interactive system designer to understand how long it may take a user to navigate from one corner of the system's screen to any other point while providing the possibility of positively reaching the set target.
- Not always assuming that all users are the same, or that system usability is universally applicable.
- The digital gap is not simply the absence of computing systems for those who need them but is also the inability of those who have access to computing systems to effectively use them.

(b) Application

- From an interactive system perspective, the UXM, as developed and structured in this study, will contribute immensely to the handheld systems community because now one can visualise in a single table all the variables which have an impact on the way humans interact with handheld systems.
- From a systems design perspective, having a clear understanding of the average RT, the efficiency, and the speed of completion of a user can guide development teams when exploring any form of innovation, while understanding what the DF for an average user may be.
- This study will enable interactive designers to measure user interaction in the future in terms of their CT, MT, activity efficiency, time needed to complete a task, US, RT, and time needed to complete a task, as well as knowing the level of difficulty and what their speed and DF are. None of these were known previously.

7.5.1.2 Adult first-time users

(a) Literature

- This study enables the research community to identify and classify those we see as the adult computer users' community. It enables us to have an idea of who they are and how the issue of the digital gap affects them.
- This study made a correlation between levels of education, access to computing systems, and computing systems usability, which may become an area of research in the future.
- One of the most obvious theories this study seemed to develop is that anyone who has access to the most effective educational ICT tools, may become an effective user. This study showed what the participants' approach to the experiment was, from early testing and after the training process and pre-experimentation.

(b) Application

- It may not be technically possible to design all systems with adult first-time users in mind, more specifically African adult first-time users, but designers can include training material in the package to enable those who may have difficulties using the system to teach themselves how to progress whenever faced with obstacles.
- The development of the interface must be as universal as possible in order to enable easy adaptation to existing ICT tools.
- Including navigation guidelines in any common computing system can be vital in assisting learner users.

(c) Mathematical variables

- One of the most significant contributions of this study is the fact that it brings together numerous mathematical formulas which at first glance may not have much in common, but when placed in the same box and structured to accept similar variables, one starts seeing them from a different perspective, and the outcomes start making sense. In this way the researcher discovered the UXM that was developed in this study.
- The application of formulas in a Microsoft Excel spreadsheet was also covered in this study, as well as how the computed data enabled some usability analyses and reflections.

- Thanks to this study, we can now calculate the SR, MT, activity efficiency, TS, US, RT, CRPA, CT for any activity, TBE, system ID, degree of performance, and the speed at which an interactive activity can be completed.

7.5.1.3 Motivation

The researcher believes that the above are important contributions because this type of study has not been conducted before on the African continent. The proliferation of handheld computing is a reality, and therefore the need to have computing systems that enable their users to gain access to life-changing content is immense, as many people within our communities are still unable to use the device due to their lack of computing education.

Most of the computing devices sold and used on the continent are developed elsewhere, with very little knowledge about the African continent and our social and economic realities. Interactive developers will need to read and understand this research to understand the reality of system usability in Africa.

The ultimate outcome of this research project, the UXM, will give the rest of the information systems community a tool that is vital in shaping their view of computing systems, especially if the outcome of their production is to be used on the continent.

7.6 FUTURE RESEARCH CONTRIBUTION

After concluding this research project as based on the identified objectives, and after the field interaction, there are still some areas that can be explored, as some of the uncovered data indicated. The following are some of the areas that may need further exploration.

By holistically exploring this particular research in terms of what was covered and what can still be covered, one can easily identify many trends that may later form part of other broad research projects, such as a study into adult first-time users' TBE in terms of task completion and what restrains their performance. The researcher also suggests a study on the impact of the degree of user frustration on task CT, as well as a study on user task RT and its impact on TBE. Lastly, further exploration of the UXM that takes into account all the variables as identified in this study, and more precisely in Table 3.1, can be undertaken.

7.7 SUMMARY

Concluding this research project after being involved with it for the past five years is both emotional and rewarding. The researcher has learned a lot, not only about the subject matter but also about the people and places visited for data collection.

Having had prior access to some statistics on most of these communities did not sufficiently prepare the researcher for what he was to discover when visiting the communities, such as the high level of youth unemployment; early pregnancy; youth alcohol consumption; poor literacy; difficulties in communicating in English; no access to libraries, community halls, supermarkets or shops, and administration buildings; and no access to local infrastructure such as tarred roads, electricity, and landline telephones.

The participants, who were described in the literature review as adult first-time users or the "missing middle", i.e. people who missed the ICT drive in the 1990s and 2000s, saw the study as an enabler. Completing the pre-questionnaire and pre-experiment was challenging for most adult first-time users, but after completing the training, it became easier to do other activities which followed, such as the completion of the experiment and the post-experiment questionnaire.

During this study, the researcher observed, lived, and visualised the struggle of anyone who wishes to educate themselves about what to do when given the opportunity to learn something new, which in this case was an interactive system; a technological tool that could change the way they interact with the rest of the world and benefit from it.

System usability is an issue, as demonstrated in Table 4.10, which is backed up by Table 4.11, and further supported by the data obtained regarding TBE. Users with less support have major difficulties adapting to the computing system they want to engage with, especially when it is a handheld system such as a tablet.

The literature review made some references to the depth of the digital divide and the negative impact it may have on social cohesion and access to basic needs. When one looks at the impact that improved access to computing systems may have, especially regarding uplifting the general population and, more importantly, those who never had access to a computing system before, one also needs to elaborate whether or not they are able to master and adopt a computing system and if their educational background enables them to do so. Table 4.3 indicated that most of the participants in this study did not have more than a secondary education; could this have been the reason why they could not learn on their own?

Throughout the literature review, the researcher described the digital gap as not simply the absence of computing systems but also the inability of potential users to rise to the usability standard and control the device at hand. The cost of computing systems is becoming more affordable; however, the issue is that those who may need them do not want to use them because of their own restraints, which is a lack of usability skills.

The UXM, which was developed in this study, is the ultimate output that anyone who is reading this material can use. Never before did we see a set of over 13 unique mathematical expressions for usability being put together to assist in comprehending user action and also comparing it with best practice, which is also built into the metric and the benchmark.

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ANNEXURES

ANNEXURE 1: RESEARCH PARTICIPANT CONSENT FORM

Closing the digital gap: handheld computing, adult first-time user and user experiment model

Participant consent form

This is to get consent for your participation in the research conducted by Guy Toko. The research is for a PhD at Unisa, under the supervision of Professor Ernest Mnkandla (Email: mnkane@unisa.ac.za. The purpose of this research is to assess the current level of usability of handheld computing in general, taking into account the ergonomic system, the relationship between human beings and computing, low-cost handheld usability assessment in terms of its user-friendliness, user-centred design, usability, features versus usability, and control.

The questionnaire will require approximately 25 minutes of your time. It is divided into three sections, namely Section A, B, and C (Section A: Demography and knowledge and understanding of handheld tablet systems, here referred to as AA Questionnaire 1; Section B: Advanced knowledge and testing of tablet usability, here referred to as AA Questionnaire 2; and Section C: measurement of the level of user frustration, enjoyment, manipulation, and overall approach, also known as AA Observation (participants would be responding to the research request as listed in the AA Observation file). Each section and question is aimed at gathering specific information about users, usability, efficiency, and effectiveness of first-time handheld tablet system users. You will be required to complete Section A and B alone without the help of the researcher. For Section C, a tablet system will be provided during the encounter, the researcher will observe you manipulating the device, you will be asked to perform a set of tasks that will be recorded by the researcher using a digital camera installed in full view, and at any time any participant can ask to withdraw or stop the recording or even request the deletion of existing recordings.

A recorded face-to-face interview will be conducted with ICT specialists using the form known as AA interview questions for ICT prof. The same would be done with sales agent participants using the form AA interview questions for sales agents. The ICT professional and sales agent interviews would ideally be done at their place of work or any convenient area they may suggest and the rules concerning participants' confidentiality would be applied.

The input you provide will be treated with confidentiality in accordance with the UNISA ethics policy and will only be used towards the completion of the aforementioned qualification. All data will be used anonymously in summary form without reference to any individual.

Participation in this research study is voluntary, and you have the right to, at any time, withdraw or refuse to participate or continue participating. Participants' anonymity will be respected and enforced before, during, and after data collection and the compilation of the research report. There are no risks or discomfort associated with your participation. All answers from you and other participants will be analysed collectively. Individual answers will therefore not be linked to any names of participants.

Participant consent

I have read and understood all of the above. I willingly choose to participate in this study.

Full name (optional) ____

Date: ____________________ **Signature:** __________________________

ANNEXURE 2: ICT PROFESSIONAL QUESTIONS

ICT professional questions:

1. From a GUI designing perspective, at what moment do you measure the level of user frustration?
2. How are the needs of users taken into account when designing the GUI?
3. From your experience, what is the importance of design consistencies?
4. From an interactive and designing perspective, what mechanism enables you to guide any first-time user of a tablet system?
5. What impact does “user experience” and “emotion” have when designing interaction?
6. During the design process, how do you cater for both experienced and first-time adult users?

ANNEXURE 3: EXPERIMENT QUESTIONS

Groups

There would be two distinct groups of participants who would be observed – Those who have never used handheld computing systems before, and those who (after training) have limited knowledge and experience in the use of handheld tablets.

Place

The observation will be conducted in an area very familiar to participants. It could be in their own classrooms, in the city hall, homes, or any public place.

Equipment

- Handheld computing system (tablet)
- Digital camera with voice-recording capability
- Tripod (mounting device)
- Laptop

Installed applications

- Word processor
- Spreadsheet
- Games
- Email
- Browser
- Digital study material (for students)

Tasks to be completed by participants

- Starting any application
- Navigating between applications
- Editing a Word document
- Opening a website
- Replying to an email
- Composing an email
- Accessing the settings function
- Downloading an application

What would be observed?

- Time taken to complete the task
- Elapsed time between tasks
- Completion status
- Difficulties encountered when completing the task
- Understanding of the tasks
- Frustrations
- Enjoyment

Questions

- Initial low-fidelity questions
    - Pointing area A, B, C, D, and E
    - Pointing area B, C, D, E, and A
    - Pointing area C, D, E, A, and B
    - Pointing area D, E, A, B, and C
    - Pointing area E, A, B, C, and D
- Training and testing
    - Repeat of the previous set of questions
- High-fidelity questions
    - Navigate to email
        - Compile an email
        - Open an email
        - Delete an email
    - Navigate to a browser
        - Open a website
        - Open a link
        - Return to the welcome page
        - Close the browser
    - Navigate to the digital camera
        - Take a picture
        - View the picture
        - Save the picture
    - Navigate to the tablet setting
        - Access the menu
        - Access the Wi-Fi setting
        - View the wireless availability
        - Pick a network and connect to it
        - Delete an app
        - Update an app
        - View the details of an app
        - Download an app

- Navigate to any word-processing application
  - Compile a document
  - Save it
  - Close it
  - Find the saving location
  - Re-open it
  - Change the document name

- All questions to participants will be linked to the tasks to be completed, such as opening an application, browsing, etc.
- All questions are directly linked to the research aim.

ANNEXURE 4: PRE-EXPERIMENT QUESTIONNAIRE

Demographic information and entry-level questionnaire

(Please note, your information will ***not*** *be shared or given to outside entities. It is for internal use only.)*

[Optional]

Initial and surname: ____________________________________

Province: ____

Location: ____

Section A: Demography questionnaire

Questions	Answers	
Gender	Female	Male
Age group	5-10 | 11-13 | 14-17 | 18-24 | 25-34 | 35-44 | 45-55 | Over 55	
Education level	None | Primary | Secondary | High School | Tertiary	
How long you have been living in the area	less than 5 | between 5 and 10 | more than 10 years	

Section B: Entry-level questionnaire

Questions	Answers	
Have you ever accessed the Internet?	Yes	No
Have you ever used tablet systems?	Yes	No

Section C: Exit questionnaire, after training

Questions	Answers	
How do you rate the tablet usability?	a. Impossible to use b. Hard to get used to, but then not bad c. Easy to use, but some questions persist d. Very easy to use	
Did you feel frustrated because some actions could not be completed?	Yes	No
Do you understand the tablet's primary and secondary navigation techniques?	Yes	No
Did you feel confident when using the tablet system for the first time?	Yes	No
Do you think the system design was consistent?	Yes	No
Does your previous experience as mobile user help during the testing?	Yes	No

Did you feel like having to remember too many things when using the system?	Yes	No
Did the interface provide some form of guidance?	Yes	No
Was the tablet's usability complex?	Yes	No
Did you complete the first task (as stipulated) on time?	Yes	No
Did you ask for help while doing the task?	Yes	No
Was the user interface well designed for the task you were executing?	Yes	No
Was the system effective and efficient?	Yes	No
Was the system easy to learn?	Yes	No
Did you struggle to select a specific icon because your thumb felt too big for the device or GUI?	Yes	No
Were you able to locate key features and functionalities of the tablet without any help?	Yes	No
Were you satisfied with the tablet's operation?	Yes	No
Did you make any errors during the test?	Yes	No
Did you make mistakes?	Yes	No
Do you feel that your needs as adult first-time user were taken into account by the system developers?	Yes	No
Was your experience enjoyable?	Yes	No

ANNEXURE 5: POST-EXPERIMENT QUESTIONNAIRE

Questions	Answers	
How did you experience the experiment?	Good	Bad
Did you struggle to complete some tasks?	Yes	No
Did the training you received help you?	Yes	No
Was the tablet system intimidating during the experiment phase?	Yes	No
Do you think your action was effective and efficient enough?	Yes	No
Would you be able to do these exercises again in the future without supervision?	Yes	No
Do you feel ready to use tablet system in the future?	Yes	No
Was your level of anxiety too high when completing the experiment?	Yes	No
Was the prototype used for the experiment appropriate for the task?	Yes	No
Was the system difficult to use?	Yes	No
Do you think the tablet system is useful?	Yes	No
Were your experiment actions fast enough when completing tasks?	Yes	No
Did you take a while to react when instructed to complete a task?	Yes	No
Would you advise someone you know to purchase a tablet system?	Yes	No
If affordable, would you buy one for yourself?	Yes	No
How soon could you be purchasing your own tablet?	Less than 1 month More than 3 months More than 4 months More than 1 year Other	
What would be the purpose of buying the tablet system?	For web surfing For education For information For entertainment Unknown or other	
Does it need to be a brand name or any functional tablet?	Brand name any tablet Undecided	
Are you satisfied with your own user experience?		

ANNEXURE 6: ETHICS CERTIFICATE

UNISA | college of science, engineering and technology

Dear Mr Guy Roger Toko (39151468)

Date: 2015-02-25

Application number: 018/GRT/2015

REQUEST FOR ETHICAL CLEARANCE: (Bridging the digital gap in South Africa using low-cost handheld Tablet computing: Fitts' model impact on computing usability)

The College of Science, Engineering and Technology's (CSET) Research and Ethics Committee has considered the relevant parts of the studies relating to the abovementioned research project and research methodology and is pleased to inform you that ethical clearance is granted for your research study as set out in your proposal and application for ethical clearance.

Therefore, involved parties may also consider ethics approval as granted. However, the permission granted must not be misconstrued as constituting an instruction from the CSET Executive or the CSET CRIC that sampled interviewees (if applicable) are compelled to take part in the research project. All interviewees retain their individual right to decide whether to participate or not.

We trust that the research will be undertaken in a manner that is respectful of the rights and integrity of those who volunteer to participate, as stipulated in the UNISA Research Ethics policy. The policy can be found at the following URL:
http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Please note that the ethical clearance is granted for the duration of this project and if you subsequently do a follow-up study that requires the use of a different research instrument, you will have to submit an addendum to this application, explaining the purpose of the follow-up study and attach the new instrument along with a comprehensive information document and consent form.

Yours sincerely

Prof Ernest Mnkandla
Chair: College of Science, Engineering and Technology Ethics Sub-Committee

Prof IOG Moche
Executive Dean: College of Science, Engineering and Technology

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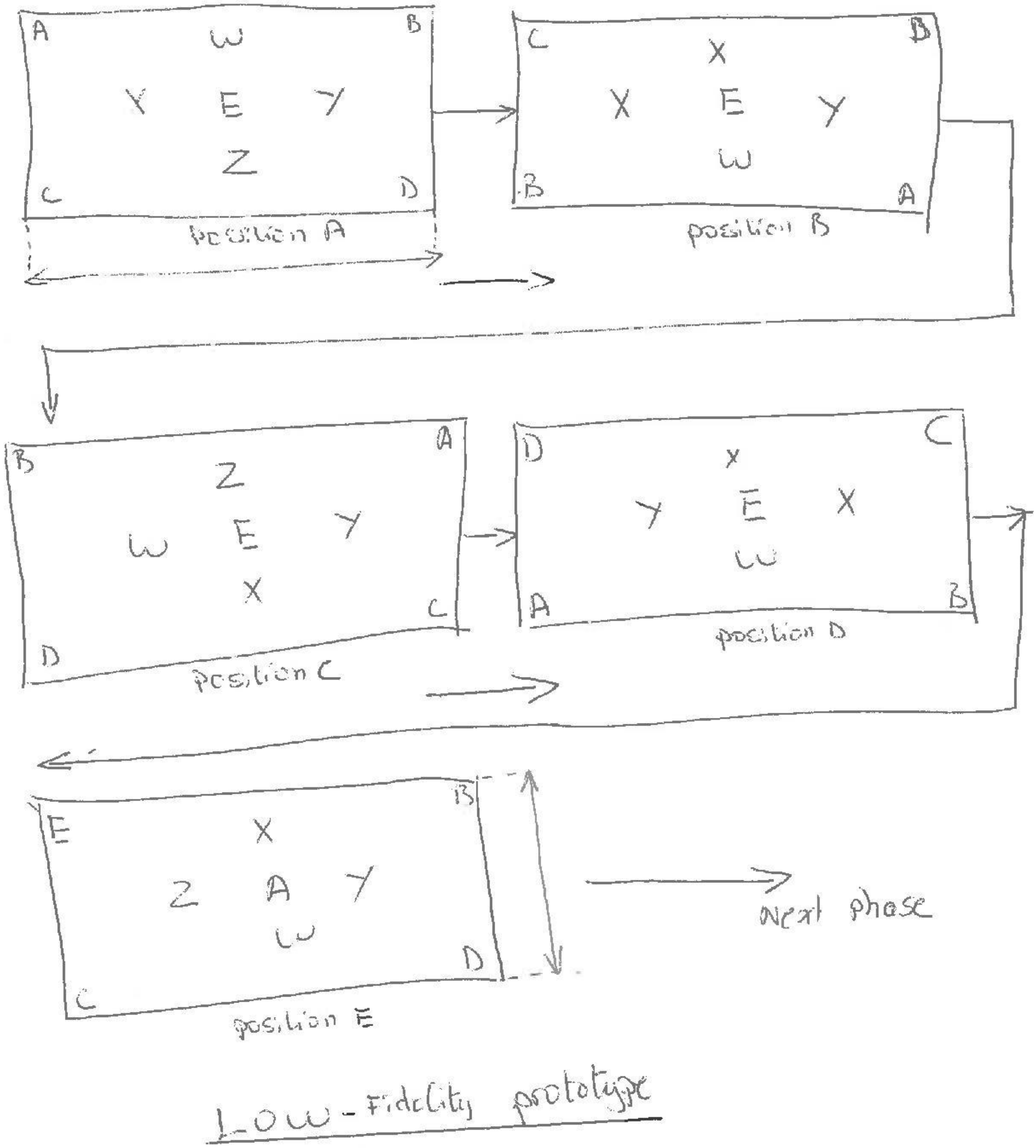
ANNEXURE 7: LOW-FIDELITY PROTOTYPE



ANNEXURE 8A: PARTICIPANT 1 USABILITY EXPERIMENT TRANSCRIPTION

Participant 1						
Overall starting time:		10:00	overall ending time:			11:07:59
Position A						
A to B						
start	stop	distance centre	width	speed	successful	number of errors
10:01:10 AM	10:00:50 AM	12 cm	24 cm		y	3
C To D						
start	stop	distance centre	width	speed	successful	number of errors
10:02:00 AM	10:02:45 AM	12 cm	24 cm		y	2
A to C						
start	stop	distance centre	width	speed	successful	number of errors
10:04:00 AM	10:04:35 AM	8.5 cm	17 cm		y	4
D To B						
start	stop	distance centre	width	speed	successful	number of errors
10:08:00 AM	10:08:28 AM	8.5 cm	17 cm		n	1
E to D						
start	stop	distance centre	width	speed	successful	number of errors
10:12:00 AM	10:12:30 AM	7 cm	14 cm		n	2
A to E						
start	stop	distance centre	width	speed	successful	number of errors
10:15:00 AM	10:15:21 AM	7 cm	14 cm		n	4
B to E						
start	stop	distance centre	width	speed	successful	number of errors
10:16:00 AM	10:16:20 AM	7 cm	14 cm		y	5
C to E						
start	stop	distance centre	width	speed	successful	number of errors
10:17:00 AM	10:17:36 AM	7 cm	14 cm		y	3

Position B						
D to E						
start	stop	distance centre	width	speed	successful	number of errors
10:18:00 AM	10:18:15 AM	12 cm	24 cm		y	4
C to B						
start	stop	distance centre	width	speed	successful	number of errors
10:20:00 AM	10:20:18 AM	12 cm	24 cm		y	5
B to E						
start	stop	distance centre	width	speed	successful	number of errors
10:18:22 AM	10:18:48 AM	7 cm	14 cm		n	3
D to C						
start	stop	distance centre	width	speed	successful	number of errors
10:18:59 AM	10:19:09 AM	7 cm	14 cm		y	5
D to A						
start	stop	distance centre	width	speed	successful	number of errors

10:19:15 AM	10:19:25 AM	8.5 cm	17 cm		y	5
A to B						
start	stop	distance centre	width	speed	successful	number of errors
10:19:35 AM	10:19:58 AM	8.5 cm	17 cm		n	2
A to E						
start	stop	distance centre	width	speed	successful	number of errors
10:20:03 AM	10:20:29 AM	8.5 cm	17 cm		n	3
C to C						
start	stop	distance centre	width	speed	successful	number of errors
10:20:38 AM	10:20:48 AM	8.5 cm	17 cm		y	3

Position C						
C to A						
start	stop	distance centre	width	speed	successful	number of errors
11:00:01	11:00:45	12 cm	24 cm		y	2
D to C						
start	stop	distance centre	width	speed	successful	number of errors
11:01:02	11:01:59	12 cm	24 cm		n	2
A to C						
start	stop	distance centre	width	speed	successful	number of errors
11:02:02	11:02:20	7 cm	14 cm		n	4
C to D						
start	stop	distance centre	width	speed	successful	number of errors
11:02:40	11:02:58	7 cm	14 cm		n	2
B to C						
start	stop	distance centre	width	speed	successful	number of errors
11:03:05	11:03:15	8.5 cm	17 cm		n	3
C to B						
start	stop	distance centre	width	speed	successful	number of errors
11:03:20	11:03:45	8.5 cm	17 cm		n	2
C to D						
start	stop	distance centre	width	speed	successful	number of errors
11:03:50	11:03:57	8.5 cm	17 cm		n	1
D to B						
start	stop	distance centre	width	speed	successful	number of errors
11:04:20	11:04:42	8.5 cm	17 cm		n	1

Position D						
A to E						
start	stop	distance centre	width	speed	successful	number of errors
11:04:45	11:04:55	12 cm	24 cm		y	2
E to D						
start	stop	distance centre	width	speed	successful	number of errors
11:04:55	11:05:21	7 cm	14 cm		y	2
B to A						

start	stop	distance centre	width	speed	successful	number of errors
11:05:22	11:05:59	7 cm	14 cm		n	2
D to B						
start	stop	distance centre	width	speed	successful	number of errors
11:06:02	11:06:21	12 cm	24 cm		n	2
C to D						
start	stop	distance centre	width	speed	successful	number of errors
11:06:22	11:06:26	8.5 cm	17 cm		n	1
C to E						
start	stop	distance centre	width	speed	successful	number of errors
11:06:30	11:06:58	8.5 cm	17 cm		n	2
B to C						
start	stop	distance centre	width	speed	successful	number of errors
11:07:02	11:07:42	8.5 cm	17 cm		n	2
A to C						
start	stop	distance centre	width	speed	successful	number of errors
11:07:50	11:07:59	8.5 cm	17 cm		y	2
Position E						
E to B						
start	stop	distance centre	width	speed	successful	number of errors
		7 cm	14 cm			
C to A						
start	stop	distance centre	width	speed	successful	number of errors
		7 cm	14 cm			
C to E						
start	stop	distance centre	width	speed	successful	number of errors
		12 cm	24 cm			
A to B						
start	stop	distance centre	width	speed	successful	number of errors
		12 cm	24 cm			
D to A						
start	stop	distance centre	width	speed	successful	number of errors
		8.5 cm	17 cm			
D to E						
start	stop	distance centre	width	speed	successful	number of errors
		8.5 cm	17 cm			
C to D						
start	stop	distance centre	width	speed	successful	number of errors
		8.5 cm	17 cm			
B to D						
start	stop	distance centre	width	speed	successful	number of errors
		8.5 cm	17 cm			

ANNEXURE 8B: PARTICIPANT 2 USABILITY EXPERIMENT TRANSCRIPTION

Participant 2						
Overall starting time:		14:30:05	overall ending time:		14:45:22	
Position A						
A to B						
start	stop	distance centre	width	speed	successful	number of errors
14:30:10	14:30:35	12 cm	24 cm		y	0
C To D						
start	stop	distance centre	width	speed	successful	number of errors
14:30:40	14:30:57	12 cm	24 cm		n	1
A to C						
start	stop	distance centre	width	speed	successful	number of errors
14:30:59	14:31:30	8.5 cm	17 cm		y	0
D To B						
start	stop	distance centre	width	speed	successful	number of errors
14:31:57	14:31:59	8.5 cm	17 cm		n	2
E to D						
start	stop	distance centre	width	speed	successful	number of errors
14:32:10	14:32:32	7 cm	14 cm		n	1
A to E						
start	stop	distance centre	width	speed	successful	number of errors
14:32:35	14:32:47	7 cm	14 cm		y	0
B to E						
start	stop	distance centre	width	speed	successful	number of errors
14:32:55	14:33:12	7 cm	14 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
14:33:41	14:34:01	7 cm	14 cm		y	0
Position B						
D to E						
start	stop	distance centre	width	speed	successful	number of errors
14:34:12	14:34:40	12 cm	24 cm		y	0
C to B						
start	stop	distance centre	width	speed	successful	number of errors
14:34:41	14:34:58	12 cm	24 cm		n	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
14:35:08	14:35:32	7 cm	14 cm		y	1
D to C						
start	stop	distance centre	width	speed	successful	number of errors
14:35:42	14:35:45	7 cm	14 cm		y	1
D to A						
start	stop	distance centre	width	speed	successful	number of errors

14:35:50	14:36:06	8.5 cm	17 cm		y	0
A to B						
start	stop	distance centre	width	speed	successful	number of errors
14:36:10	14:36:39	8.5 cm	17 cm		y	0
A to E						
start	stop	distance centre	width	speed	successful	number of errors
14:36:42	14:36:59	8.5 cm	17 cm		y	0
C to C						
start	stop	distance centre	width	speed	successful	number of errors
14:37:05	14:37:24	8.5 cm	17 cm		y	0
Position C						
C to A						
start	stop	distance centre	width	speed	successful	number of errors
14:37:28	14:37:40	12 cm	24 cm		y	0
D to C						
start	stop	distance centre	width	speed	successful	number of errors
14:37:41	14:38:04	12 cm	24 cm		y	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
14:38:06	14:38:29	7 cm	14 cm		n	1
C to D						
start	stop	distance centre	width	speed	successful	number of errors
14:38:31	14:38:45	7 cm	14 cm		n	1
B to C						
start	stop	distance centre	width	speed	successful	number of errors
14:38:47	14:38:58	8.5 cm	17 cm		y	1
C to B						
start	stop	distance centre	width	speed	successful	number of errors
14:39:02	14:39:15	8.5 cm	17 cm		y	1
C to D						
start	stop	distance centre	width	speed	successful	number of errors
14:39:18	14:39:35	8.5 cm	17 cm		y	1
D to B						
start	stop	distance centre	width	speed	successful	number of errors
14:39:38	14:39:45	8.5 cm	17 cm		y	1
Position D						
A to E						
start	stop	distance centre	width	speed	successful	number of errors
14:39:47	14:40:05	12 cm	24 cm		n	1
E to D						
start	stop	distance centre	width	speed	successful	number of errors
14:40:10	14:40:25	7 cm	14 cm		y	1
B to A						

start	stop	distance centre	width	speed	successful	number of errors
14:40:28	14:40:41	7 cm	14 cm		y	2
D to B						
start	stop	distance centre	width	speed	successful	number of errors
14:40:45	14:41:05	12 cm	24 cm		y	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
14:41:25	14:41:35	8.5 cm	17 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
14:41:38	14:41:58	8.5 cm	17 cm		y	0
B to C						
start	stop	distance centre	width	speed	successful	number of errors
14:42:06	14:42:24	8.5 cm	17 cm		y	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
14:42:42	14:42:59	8.5 cm	17 cm		y	0
Position E						
E to B						
start	stop	distance centre	width	speed	successful	number of errors
14:43:05	14:43:19	7 cm	14 cm		n	1
C to A						
start	stop	distance centre	width	speed	successful	number of errors
14:43:42	14:43:55	7 cm	14 cm		y	2
C to E						
start	stop	distance centre	width	speed	successful	number of errors
14:43:58	14:44:02	12 cm	24 cm		y	2
A to B						
start	stop	distance centre	width	speed	successful	number of errors
14:44:05	14:44:19	12 cm	24 cm		n	1
D to A						
start	stop	distance centre	width	speed	successful	number of errors
14:44:22	14:44:38	8.5 cm	17 cm		y	0
D to E						
start	stop	distance centre	width	speed	successful	number of errors
14:44:42	14:44:57	8.5 cm	17 cm		y	1
C to D						
start	stop	distance centre	width	speed	successful	number of errors
14:44:59	14:45:07	8.5 cm	17 cm		n	0
B to D						
start	stop	distance centre	width	speed	successful	number of errors
14:45:10	14:45:22	8.5 cm	17 cm		y	0

ANNEXURE 8C: PARTICIPANT 3 USABILITY EXPERIMENT TRANSCRIPTION

Participant 3						
Overall starting time:		09:00:10	overall ending time:		09:18:36	
Position A						
A to B						
start	stop	distance centre	width	speed	successful	number of errors
09:00:10	09:00:40	12 cm	24 cm		n	1
C To D						
start	stop	distance centre	width	speed	successful	number of errors
09:00:42	09:01:15	12 cm	24 cm		n	1
A to C						
start	stop	distance centre	width	speed	successful	number of errors
09:01:20	09:01:35	8.5 cm	17 cm		n	2
D To B						
start	stop	distance centre	width	speed	successful	number of errors
09:01:45	09:02:05	8.5 cm	17 cm		y	2
E to D						
start	stop	distance centre	width	speed	successful	number of errors
09:02:09	09:02:35	7 cm	14 cm		y	3
A to E						
start	stop	distance centre	width	speed	successful	number of errors
09:02:45	09:02:59	7 cm	14 cm		y	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
09:03:05	09:03:35	7 cm	14 cm		y	1
C to E						
start	stop	distance centre	width	speed	successful	number of errors
09:03:45	09:04:01	7 cm	14 cm		n	0
Position B						
D to E						
start	stop	distance centre	width	speed	successful	number of errors
09:04:05	09:04:30	12 cm	24 cm		y	0
C to B						
start	stop	distance centre	width	speed	successful	number of errors
09:04:35	09:04:55	12 cm	24 cm		n	0
B to E						
start	stop	distance centre	width	speed	successful	number of errors
09:04:59	09:05:35	7 cm	14 cm		y	0
D to C						
start	stop	distance centre	width	speed	successful	number of errors
09:05:45	09:05:55	7 cm	14 cm		y	1
D to A						
start	stop	distance centre	width	speed	successful	number of errors

09:05:59	09:06:25	8.5 cm	17 cm		y	1
A to B						
start	stop	distance centre	width	speed	successful	number of errors
09:06:35	09:06:45	8.5 cm	17 cm		n	0
A to E						
start	stop	distance centre	width	speed	successful	number of errors
09:06:55	09:06:59	8.5 cm	17 cm		n	0
C to C						
start	stop	distance centre	width	speed	successful	number of errors
09:07:05	09:07:35	8.5 cm	17 cm		n	0
Position C						
C to A						
start	stop	distance centre	width	speed	successful	number of errors
09:07:45	09:08:05	12 cm	24 cm		n	1
D to C						
start	stop	distance centre	width	speed	successful	number of errors
09:08:09	09:08:19	12 cm	24 cm		n	1
A to C						
start	stop	distance centre	width	speed	successful	number of errors
09:08:24	09:08:45	7 cm	14 cm		n	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
09:08:49	09:09:12	7 cm	14 cm		n	0
B to C						
start	stop	distance centre	width	speed	successful	number of errors
09:09:15	09:09:45	8.5 cm	17 cm		n	0
C to B						
start	stop	distance centre	width	speed	successful	number of errors
09:09:49	09:10:10	8.5 cm	17 cm		y	1
C to D						
start	stop	distance centre	width	speed	successful	number of errors
09:10:15	09:10:45	8.5 cm	17 cm		y	1
D to B						
start	stop	distance centre	width	speed	successful	number of errors
09:10:55	09:11	8.5 cm	17 cm		y	1
Position D						
A to E						
start	stop	distance centre	width	speed	successful	number of errors
09:11:18	09:11:40	12 cm	24 cm		n	1
E to D						
start	stop	distance centre	width	speed	successful	number of errors
09:11:42	09:12:05	7 cm	14 cm		n	0
B to A						

start	stop	distance centre	width	speed	successful	number of errors
09:12:35	09:12:58	7 cm	14 cm		n	0
D to B						
start	stop	distance centre	width	speed	successful	number of errors
09:13:09	09:13:39	12 cm	24 cm		n	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
09:13:45	09:13:55	8.5 cm	17 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
09:13:59	09:14:09	8.5 cm	17 cm		n	0
B to C						
start	stop	distance centre	width	speed	successful	number of errors
09:14:12	09:14:36	8.5 cm	17 cm		y	1
A to C						
start	stop	distance centre	width	speed	successful	number of errors
09:14:45	09:14:55	8.5 cm	17 cm		n	1
Position E						
E to B						
start	stop	distance centre	width	speed	successful	number of errors
09:15:02	09:15:18	7 cm	14 cm		y	0
C to A						
start	stop	distance centre	width	speed	successful	number of errors
09:15:22	09:15:48	7 cm	14 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
09:15:59	09:16:20	12 cm	24 cm		n	1
A to B						
start	stop	distance centre	width	speed	successful	number of errors
09:16:30	09:16:52	12 cm	24 cm		y	0
D to A						
start	stop	distance centre	width	speed	successful	number of errors
09:17:02	09:17:32	8.5 cm	17 cm		n	1
D to E						
start	stop	distance centre	width	speed	successful	number of errors
09:17:42	09:17:52	8.5 cm	17 cm		y	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
09:17:58	09:18:02	8.5 cm	17 cm		y	0
B to D						
start	stop	distance centre	width	speed	successful	number of errors
19:18:10	09:18:36	8.5 cm	17 cm		n	1

ANNEXURE 8D: PARTICIPANT 4 USABILITY EXPERIMENT TRANSCRIPTION

Participant 4						
Overall starting time:		11:50:20	overall ending time:		12:02:38	
Position A						
A to B						
start	stop	distance centre	width	speed	successful	number of errors
11:50:21	11:50:34	12 cm	24 cm		y	0
C To D						
start	stop	distance centre	width	speed	successful	number of errors
11:50:38	11:50:55	12 cm	24 cm		y	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
11:51:05	11:51:27	8.5 cm	17 cm		n	2
D To B						
start	stop	distance centre	width	speed	successful	number of errors
11:51:28	11:51:42	8.5 cm	17 cm			1
E to D						
start	stop	distance centre	width	speed	successful	number of errors
11:51:43	11:51:57	7 cm	14 cm		y	1
A to E						
start	stop	distance centre	width	speed	successful	number of errors
11:51:59	11:52:14	7 cm	14 cm		y	0
B to E						
start	stop	distance centre	width	speed	successful	number of errors
11:52:16	11:52:25	7 cm	14 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
11:52:35	11:52:49	7 cm	14 cm		y	1
Position B						
D to E						
start	stop	distance centre	width	speed	successful	number of errors
11:52:52	11:53:09	12 cm	24 cm		y	1
C to B						
start	stop	distance centre	width	speed	successful	number of errors
11:53:11	11:53:28	12 cm	24 cm		y	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
11:53:38 AM	11:53:48 AM	7 cm	14 cm		n	1
D to C						
start	stop	distance centre	width	speed	successful	number of errors
11:53:50	11:54:02	7 cm	14 cm		y	1
D to A						
start	stop	distance centre	width	speed	successful	number of errors

11:54:04	11:54:21	8.5 cm	17 cm		y	0
A to B						
start	stop	distance centre	width	speed	successful	number of errors
11:54:24	11:54:37	8.5 cm	17 cm		y	0
A to E						
start	stop	distance centre	width	speed	successful	number of errors
11:54:40	11:54:58	8.5 cm	17 cm		y	0
C to C						
start	stop	distance centre	width	speed	successful	number of errors
11:54:59	11:55:14	8.5 cm	17 cm		y	1
Position C						
C to A						
start	stop	distance centre	width	speed	successful	number of errors
11:55:16	11:55:31	12 cm	24 cm		y	1
D to C						
start	stop	distance centre	width	speed	successful	number of errors
11:55:33	11:55:43	12 cm	24 cm		n	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
11:55:45	11:55:58	7 cm	14 cm		n	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
11:56:02	11:56:12	7 cm	14 cm		y	0
B to C						
start	stop	distance centre	width	speed	successful	number of errors
11:56:15	11:56:29	8.5 cm	17 cm		y	0
C to B						
start	stop	distance centre	width	speed	successful	number of errors
11:56:33	11:56:45	8.5 cm	17 cm		y	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
11:56:47 AM	11:56:59 AM	8.5 cm	17 cm		y	1
D to B						
start	stop	distance centre	width	speed	successful	number of errors
11:57:03	11:57:29	8.5 cm	17 cm		y	1
Position D						
A to E						
start	stop	distance centre	width	speed	successful	number of errors
11:57:32	11:57:41	12 cm	24 cm		n	1
E to D						
start	stop	distance centre	width	speed	successful	number of errors
11:57:45	11:57:59	7 cm	14 cm		n	1
B to A						

start	stop	distance centre	width	speed	successful	number of errors
11:58:01	11:58:21	7 cm	14 cm		y	0
D to B						
start	stop	distance centre	width	speed	successful	number of errors
11:58:23	11:58:39	12 cm	24 cm		n	1
C to D						
start	stop	distance centre	width	speed	successful	number of errors
11:58:41	11:58:58	8.5 cm	17 cm		n	1
C to E						
start	stop	distance centre	width	speed	successful	number of errors
11:59:03	11:59:15	8.5 cm	17 cm		y	0
B to C						
start	stop	distance centre	width	speed	successful	number of errors
11:59:17	11:59:25	8.5 cm	17 cm		n	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
11:59:58	00:00:02	8.5 cm	17 cm		n	0
Position E						
E to B						
start	stop	distance centre	width	speed	successful	number of errors
12:00:04	12:00:21	7 cm	14 cm		n	1
C to A						
start	stop	distance centre	width	speed	successful	number of errors
12:00:24	12:00:39	7 cm	14 cm		n	1
C to E						
start	stop	distance centre	width	speed	successful	number of errors
12:00:41	12:00:57	12 cm	24 cm		y	1
A to B						
start	stop	distance centre	width	speed	successful	number of errors
12:00:59	12:01:13	12 cm	24 cm		y	1
D to A						
start	stop	distance centre	width	speed	successful	number of errors
12:01:28	12:01:38	8.5 cm	17 cm		y	1
D to E						
start	stop	distance centre	width	speed	successful	number of errors
12:01:48	12:01:59	8.5 cm	17 cm		n	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
12:02:01	12:02:24	8.5 cm	17 cm		y	0
B to D						
start	stop	distance centre	width	speed	successful	number of errors
12:02:25	12:02:38	8.5 cm	17 cm		y	0

ANNEXURE 8E: PARTICIPANT 5 USABILITY EXPERIMENT TRANSCRIPTION

Participant 5						
Overall starting time:		13:30:00	overall ending time:		13:36:35	
Position A						
A to B						
start	stop	distance centre	width	speed	successful	number of errors
13:30:01	13:30:17	12 cm	24 cm		y	0
C To D						
start	stop	distance centre	width	speed	successful	number of errors
13:30:18	13:30:24	12 cm	24 cm		y	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
13:30:25	13:30:38	8.5 cm	17 cm		y	0
D To B						
start	stop	distance centre	width	speed	successful	number of errors
13:30:40	13:30:51	8.5 cm	17 cm		y	0
E to D						
start	stop	distance centre	width	speed	successful	number of errors
13:30:52	13:30:52	7 cm	14 cm		y	1
A to E						
start	stop	distance centre	width	speed	successful	number of errors
13:30:53	13:30:59	7 cm	14 cm		y	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
13:31:01	13:31:14	7 cm	14 cm		y	1
C to E						
start	stop	distance centre	width	speed	successful	number of errors
13:31:15	13:31:35	7 cm	14 cm		y	1
Position B						
D to E						
start	stop	distance centre	width	speed	successful	number of errors
13:31:36	13:31:43	12 cm	24 cm		y	1
C to B						
start	stop	distance centre	width	speed	successful	number of errors
13:31:44	13:31:52	12 cm	24 cm		y	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
13:31:54	13:32:08	7 cm	14 cm		y	0
D to C						
start	stop	distance centre	width	speed	successful	number of errors
13:32:09	13:32:21	7 cm	14 cm		y	0
D to A						
start	stop	distance centre	width	speed	successful	number of errors

13:32:12	13:32:31	8.5 cm	17 cm		y	1
			A to B			
start	stop	distance centre	width	speed	successful	number of errors
13:32:33	13:32:42	8.5 cm	17 cm		n	2
			A to E			
start	stop	distance centre	width	speed	successful	number of errors
13:32:43	13:32:51	8.5 cm	17 cm		n	1
			C to C			
start	stop	distance centre	width	speed	successful	number of errors
13:32:52	13:33:02	8.5 cm	17 cm		n	0
			Position C			
			C to A			
start	stop	distance centre	width	speed	successful	number of errors
13:33:03	13:33:15	12 cm	24 cm		n	0
			D to C			
start	stop	distance centre	width	speed	successful	number of errors
13:33:16	13:33:23	12 cm	24 cm		n	0
			A to C			
start	stop	distance centre	width	speed	successful	number of errors
13:33:34	13:33:43	7 cm	14 cm		y	1
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
13:33:44	13:33:51	7 cm	14 cm		y	1
			B to C			
start	stop	distance centre	width	speed	successful	number of errors
13:33:52	13:34:04	8.5 cm	17 cm		y	1
			C to B			
start	stop	distance centre	width	speed	successful	number of errors
13:33:05	13:33:13	8.5 cm	17 cm		y	0
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
13:33:14	13:33:21	8.5 cm	17 cm		y	0
			D to B			
start	stop	distance centre	width	speed	successful	number of errors
13:33:22	13:33:34	8.5 cm	17 cm		y	0
			Position D			
			A to E			
start	stop	distance centre	width	speed	successful	number of errors
13:33:34	13:33:42	12 cm	24 cm		n	1
			E to D			
start	stop	distance centre	width	speed	successful	number of errors
13:33:43	13:33:43	7 cm	14 cm		y	1

			B to A			
start	stop	distance centre	width	speed	successful	number of errors
13:33:44	13:33:53	7 cm	14 cm		y	1
			D to B			
start	stop	distance centre	width	speed	successful	number of errors
13:33:54	13:34:02	12 cm	24 cm		y	0
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
13:34:03	13:34:15	8.5 cm	17 cm		y	0
			C to E			
start	stop	distance centre	width	speed	successful	number of errors
13:34:16	13:34:29	8.5 cm	17 cm		y	0
			B to C			
start	stop	distance centre	width	speed	successful	number of errors
13:34:30	13:34:39	8.5 cm	17 cm		y	0
			A to C			
start	stop	distance centre	width	speed	successful	number of errors
13:34:40	13:34:51	8.5 cm	17 cm		y	1
			Position E			
			E to B			
start	stop	distance centre	width	speed	successful	number of errors
13:34:52	13:34:59	7 cm	14 cm		n	1
			C to A			
start	stop	distance centre	width	speed	successful	number of errors
13:35:01	13:35:14	7 cm	14 cm		n	1
			C to E			
start	stop	distance centre	width	speed	successful	number of errors
13:35:15	13:35:31	12 cm	24 cm		y	0
			A to B			
start	stop	distance centre	width	speed	successful	number of errors
13:35:32	13:35:41	12 cm	24 cm		y	0
			D to A			
start	stop	distance centre	width	speed	successful	number of errors
13:35:43	13:35:55	8.5 cm	17 cm		y	0
			D to E			
start	stop	distance centre	width	speed	successful	number of errors
13:35:56	13:36:04	8.5 cm	17 cm		y	0
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
13:36:05	13:36:16	8.5 cm	17 cm		y	1
			B to D			
start	stop	distance centre	width	speed	successful	number of errors
13:36:17	13:36:35	8.5 cm	17 cm		n	0

ANNEXURE 8F: PARTICIPANT 6 USABILITY EXPERIMENT TRANSCRIPTION

Participant 6						
Overall starting time:		08:13:00	overall ending time:		08:20:19	
Position A						
A to B						
start	stop	distance centre	width	speed	successful	number of errors
08:13:01	08:13:13	12 cm	24 cm		y	0
C To D						
start	stop	distance centre	width	speed	successful	number of errors
08:13:14	08:13:25	12 cm	24 cm		y	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
08:13:26	08:13:32	8.5 cm	17 cm		n	1
D To B						
start	stop	distance centre	width	speed	successful	number of errors
08:13:33	08:13:42	8.5 cm	17 cm			1
E to D						
start	stop	distance centre	width	speed	successful	number of errors
08:13:43	08:13:52	7 cm	14 cm		n	1
A to E						
start	stop	distance centre	width	speed	successful	number of errors
08:13:53	08:14:02	7 cm	14 cm		n	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
08:14:03	08:14:12	7 cm	14 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
08:14:14	08:14:30	7 cm	14 cm		y	0
Position B						
D to E						
start	stop	distance centre	width	speed	successful	number of errors
08:14:31	08:14:41	12 cm	24 cm		y	1
C to B						
start	stop	distance centre	width	speed	successful	number of errors
08:14:42	08:14:53	12 cm	24 cm		y	0
B to E						
start	stop	distance centre	width	speed	successful	number of errors
08:14:54	08:15:10	7 cm	14 cm		y	0
D to C						
start	stop	distance centre	width	speed	successful	number of errors
08:15:11	08:15:25	7 cm	14 cm		y	1
D to A						
start	stop	distance centre	width	speed	successful	number of errors

08:15:26	08:15:37	8.5 cm	17 cm		y	1
			A to B			
start	stop	distance centre	width	speed	successful	number of errors
08:15:38	08:15:40	8.5 cm	17 cm		y	1
			A to E			
start	stop	distance centre	width	speed	successful	number of errors
08:15:41	08:15:55	8.5 cm	17 cm		y	1
			C to C			
start	stop	distance centre	width	speed	successful	number of errors
08:15:56	08:15:58	8.5 cm	17 cm		y	1
			Position C			
			C to A			
start	stop	distance centre	width	speed	successful	number of errors
08:15:59	08:16:12	12 cm	24 cm		n	1
			D to C			
start	stop	distance centre	width	speed	successful	number of errors
08:16:13	08:16:24	12 cm	24 cm		n	1
			A to C			
start	stop	distance centre	width	speed	successful	number of errors
08:16:23	08:16:32	7 cm	14 cm		n	0
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
08:16:33	08:16:42	7 cm	14 cm		n	0
			B to C			
start	stop	distance centre	width	speed	successful	number of errors
08:16:43	08:16:52	8.5 cm	17 cm		n	0
			C to B			
start	stop	distance centre	width	speed	successful	number of errors
08:16:53	08:17:10	8.5 cm	17 cm		n	0
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
08:17:11	08:17:22	8.5 cm	17 cm		y	0
			D to B			
start	stop	distance centre	width	speed	successful	number of errors
08:17:23	08:17:32	8.5 cm	17 cm		y	0
			Position D			
			A to E			
start	stop	distance centre	width	speed	successful	number of errors
08:17:33	08:17:42	12 cm	24 cm		y	1
			E to D			
start	stop	distance centre	width	speed	successful	number of errors
08:17:43	08:17:58	7 cm	14 cm		y	1

B to A						
start	stop	distance centre	width	speed	successful	number of errors
08:18:02	08:18:15	7 cm	14 cm		y	1
D to B						
start	stop	distance centre	width	speed	successful	number of errors
08:18:17	08:18:27	12 cm	24 cm		n	1
C to D						
start	stop	distance centre	width	speed	successful	number of errors
08:18:28	08:18:36	8.5 cm	17 cm		n	1
C to E						
start	stop	distance centre	width	speed	successful	number of errors
08:18:37	08:18:41	8.5 cm	17 cm		n	1
B to C						
start	stop	distance centre	width	speed	successful	number of errors
08:18:42	08:18:44	8.5 cm	17 cm		n	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
08:18:45	08:18:55	8.5 cm	17 cm		n	0
Position E						
E to B						
start	stop	distance centre	width	speed	successful	number of errors
08:18:46	08:18:59	7 cm	14 cm		y	0
C to A						
start	stop	distance centre	width	speed	successful	number of errors
08:19:01	08:19:12	7 cm	14 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
08:19:13	08:19:32	12 cm	24 cm		y	0
A to B						
start	stop	distance centre	width	speed	successful	number of errors
08:19:33	08:19:45	12 cm	24 cm		y	0
D to A						
start	stop	distance centre	width	speed	successful	number of errors
08:19:46	08:19:47	8.5 cm	17 cm		y	0
D to E						
start	stop	distance centre	width	speed	successful	number of errors
08:19:48	08:19:55	8.5 cm	17 cm		y	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
08:19:58	08:20:09	8.5 cm	17 cm		y	0
B to D						
start	stop	distance centre	width	speed	successful	number of errors
08:20:10	08:20:19	8.5 cm	17 cm		y	0

ANNEXURE 8G: PARTICIPANT 7 USABILITY EXPERIMENT TRANSCRIPTION

Participant 7						
Overall starting time:		14:12:00	overall ending time:		14:18:39	
Position A						
A to B						
start	stop	distance centre	width	speed	successful	number of errors
14:12:01	14:12:13	12 cm	24 cm		y	0
C To D						
start	stop	distance centre	width	speed	successful	number of errors
14:12:14	14:12:26	12 cm	24 cm		y	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
14:12:27	14:12:36	8.5 cm	17 cm		y	0
D To B						
start	stop	distance centre	width	speed	successful	number of errors
14:12:37	14:12:45	8.5 cm	17 cm		y	0
E to D						
start	stop	distance centre	width	speed	successful	number of errors
14:12:46	14:12:43	7 cm	14 cm		y	0
A to E						
start	stop	distance centre	width	speed	successful	number of errors
14:12:44	14:12:53	7 cm	14 cm		n	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
14:12:54	14:13:09	7 cm	14 cm		n	1
C to E						
start	stop	distance centre	width	speed	successful	number of errors
14:13:10	14:13:21	7 cm	14 cm		n	0
Position B						
D to E						
start	stop	distance centre	width	speed	successful	number of errors
14:13:24	14:13:36	12 cm	24 cm		y	1
C to B						
start	stop	distance centre	width	speed	successful	number of errors
14:14:07	14:14:25	12 cm	24 cm		y	0
B to E						
start	stop	distance centre	width	speed	successful	number of errors
14:14:26	14:14:35	7 cm	14 cm		y	0
D to C						
start	stop	distance centre	width	speed	successful	number of errors
14:14:36	14:14:42	7 cm	14 cm		y	0
D to A						
start	stop	distance centre	width	speed	successful	number of errors

14:14:43	14:14:58	8.5 cm	17 cm		y	0
A to B						
start	stop	distance centre	width	speed	successful	number of errors
14:14:59	14:15:12	8.5 cm	17 cm		y	0
A to E						
start	stop	distance centre	width	speed	successful	number of errors
14:15:13	14:15:24	8.5 cm	17 cm		y	0
C to C						
start	stop	distance centre	width	speed	successful	number of errors
14:15:25	14:15:36	8.5 cm	17 cm		n	1
Position C						
C to A						
start	stop	distance centre	width	speed	successful	number of errors
14:15:38	14:15:46	12 cm	24 cm		n	0
D to C						
start	stop	distance centre	width	speed	successful	number of errors
14:15:47	14:15:58	12 cm	24 cm		n	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
14:15:59	14:16:10	7 cm	14 cm		n	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
14:16:11	14:16:21	7 cm	14 cm		y	1
B to C						
start	stop	distance centre	width	speed	successful	number of errors
14:16:22	14:16:35	8.5 cm	17 cm		n	0
C to B						
start	stop	distance centre	width	speed	successful	number of errors
14:16:37	14:16:47	8.5 cm	17 cm		n	1
C to D						
start	stop	distance centre	width	speed	successful	number of errors
14:16:48	14:16:55	8.5 cm	17 cm		n	1
D to B						
start	stop	distance centre	width	speed	successful	number of errors
14:16:57	14:17:05	8.5 cm	17 cm		n	1
Position D						
A to E						
start	stop	distance centre	width	speed	successful	number of errors
14:17:06	14:17:18	12 cm	24 cm		n	0
E to D						
start	stop	distance centre	width	speed	successful	number of errors
14:17:19	14:17:28	7 cm	14 cm		y	0

			B to A			
start	stop	distance centre	width	speed	successful	number of errors
14:17:29	14:17:36	7 cm	14 cm		y	0
			D to B			
start	stop	distance centre	width	speed	successful	number of errors
14:17:38	14:17:46	12 cm	24 cm		y	0
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
14:17:47	14:17:59	8.5 cm	17 cm		y	0
			C to E			
start	stop	distance centre	width	speed	successful	number of errors
14:18:01	14:18:12	8.5 cm	17 cm		y	0
			B to C			
start	stop	distance centre	width	speed	successful	number of errors
14:18:13	14:18:24	8.5 cm	17 cm		n	1
			A to C			
start	stop	distance centre	width	speed	successful	number of errors
14:18:25	14:18:39	8.5 cm	17 cm		n	0
			Position E			
			E to B			
start	stop	distance centre	width	speed	successful	number of errors
		7 cm	14 cm		y	1
			C to A			
start	stop	distance centre	width	speed	successful	number of errors
		7 cm	14 cm		y	1
			C to E			
start	stop	distance centre	width	speed	successful	number of errors
		12 cm	24 cm		y	1
			A to B			
start	stop	distance centre	width	speed	successful	number of errors
		12 cm	24 cm		y	1
			D to A			
start	stop	distance centre	width	speed	successful	number of errors
		8.5 cm	17 cm		y	1
			D to E			
start	stop	distance centre	width	speed	successful	number of errors
		8.5 cm	17 cm		n	0
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
		8.5 cm	17 cm		n	1
			B to D			
start	stop	distance centre	width	speed	successful	number of errors
		8.5 cm	17 cm		n	1

ANNEXURE 8H: PARTICIPANT 8 USABILITY EXPERIMENT TRANSCRIPTION

Participant 8						
Overall starting time:		15:35:00	overall ending time:		15:43:31	
Position A						
A to B						
start	stop	distance centre	width	speed	successful	number of errors
15:35:01	15:35:14	12 cm	24 cm		y	0
C To D						
start	stop	distance centre	width	speed	successful	number of errors
15:35:15	15:35:22	12 cm	24 cm		y	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
15:35:23	15:35:36	8.5 cm	17 cm		y	0
D To B						
start	stop	distance centre	width	speed	successful	number of errors
15:35:37	15:35:42	8.5 cm	17 cm		y	0
E to D						
start	stop	distance centre	width	speed	successful	number of errors
15:35:45	15:35:58	7 cm	14 cm		y	1
A to E						
start	stop	distance centre	width	speed	successful	number of errors
15:35:59	15:36:10	7 cm	14 cm		y	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
15:36:12	15:36:23	7 cm	14 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
15:36:24	15:36:43	7 cm	14 cm		y	0
Position B						
D to E						
start	stop	distance centre	width	speed	successful	number of errors
15:36:45	15:36:56	12 cm	24 cm		n	1
C to B						
start	stop	distance centre	width	speed	successful	number of errors
15:36:57	15:37:10	12 cm	24 cm		n	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
15:37:11	15:37:23	7 cm	14 cm		n	2
D to C						
start	stop	distance centre	width	speed	successful	number of errors
15:37:30	15:37:41	7 cm	14 cm		n	0
D to A						
start	stop	distance centre	width	speed	successful	number of errors

15:37:42	15:37:52	8.5 cm	17 cm		n	0
A to B						
start	stop	distance centre	width	speed	successful	number of errors
15:37:53	15:37:59	8.5 cm	17 cm		y	1
A to E						
start	stop	distance centre	width	speed	successful	number of errors
15:38:01	15:38:13	8.5 cm	17 cm		y	1
C to C						
start	stop	distance centre	width	speed	successful	number of errors
15:38:14	15:38:26	8.5 cm	17 cm		n	0
Position C						
C to A						
start	stop	distance centre	width	speed	successful	number of errors
15:38:27	15:38:29	12 cm	24 cm		y	0
D to C						
start	stop	distance centre	width	speed	successful	number of errors
15:38:30	15:38:41	12 cm	24 cm		y	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
15:38:43	15:38:54	7 cm	14 cm		y	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
15:38:55	15:39:09	7 cm	14 cm		y	0
B to C						
start	stop	distance centre	width	speed	successful	number of errors
15:39:10	15:39:28	8.5 cm	17 cm		y	0
C to B						
start	stop	distance centre	width	speed	successful	number of errors
15:39:29	15:39:49	8.5 cm	17 cm		y	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
15:39:50	15:39:59	8.5 cm	17 cm		y	1
D to B						
start	stop	distance centre	width	speed	successful	number of errors
15:40:01	15:40:13	8.5 cm	17 cm		y	0
Position D						
A to E						
start	stop	distance centre	width	speed	successful	number of errors
15:40:14	15:40:27	12 cm	24 cm		y	1
E to D						
start	stop	distance centre	width	speed	successful	number of errors
15:40:28	15:40:37	7 cm	14 cm		y	1
B to A						

start	stop	distance centre	width	speed	successful	number of errors
15:40:39	15:40:48	7 cm	14 cm		y	0
D to B						
start	stop	distance centre	width	speed	successful	number of errors
15:40:49	15:40:58	12 cm	24 cm		y	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
15:40:59	15:41:00	8.5 cm	17 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
15:41:01	15:41:14	8.5 cm	17 cm		y	0
B to C						
start	stop	distance centre	width	speed	successful	number of errors
15:41:15	15:41:23	8.5 cm	17 cm		y	1
A to C						
start	stop	distance centre	width	speed	successful	number of errors
15:41:24	15:41:35	8.5 cm	17 cm		y	1
Position E						
E to B						
start	stop	distance centre	width	speed	successful	number of errors
15:41:36	15:41:48	7 cm	14 cm		y	0
C to A						
start	stop	distance centre	width	speed	successful	number of errors
15:41:49	15:41:58	7 cm	14 cm		y	0
C to E						
start	stop	distance centre	width	speed	successful	number of errors
15:41:59	15:42:10	12 cm	24 cm		n	0
A to B						
start	stop	distance centre	width	speed	successful	number of errors
15:42:19	15:42:30	12 cm	24 cm		n	0
D to A						
start	stop	distance centre	width	speed	successful	number of errors
15:42:43	15:42:52	8.5 cm	17 cm		y	0
D to E						
start	stop	distance centre	width	speed	successful	number of errors
15:42:53	15:43:05	8.5 cm	17 cm		y	1
C to D						
start	stop	distance centre	width	speed	successful	number of errors
15:43:06	15:43:14	8.5 cm	17 cm		y	1
B to D						
start	stop	distance centre	width	speed	successful	number of errors
15:43:16	15:43:31	8.5 cm	17 cm		y	0

ANNEXURE 8I: PARTICIPANT 9 USABILITY EXPERIMENT TRANSCRIPTION

Participant 9						
Overall starting time:		10:10:00	overall ending time:		10:17:15	
Position A						
A to B						
start	stop	distance centre	width	speed	successful	number of errors
10:10:01	10:10:13	12 cm	24 cm		y	0
C To D						
start	stop	distance centre	width	speed	successful	number of errors
10:10:14	10:10:24	12 cm	24 cm		y	0
A to C						
start	stop	distance centre	width	speed	successful	number of errors
10:10:25	10:10:36	8.5 cm	17 cm		y	0
D To B						
start	stop	distance centre	width	speed	successful	number of errors
10:10:37	10:10:46	8.5 cm	17 cm		y	1
E to D						
start	stop	distance centre	width	speed	successful	number of errors
10:10:47	10:10:55	7 cm	14 cm		y	1
A to E						
start	stop	distance centre	width	speed	successful	number of errors
10:10:56	10:11:09	7 cm	14 cm		y	1
B to E						
start	stop	distance centre	width	speed	successful	number of errors
10:11:11	10:11:23	7 cm	14 cm		y	1
C to E						
start	stop	distance centre	width	speed	successful	number of errors
10:11:25	10:11:34	7 cm	14 cm		y	1
Position B						
D to E						
start	stop	distance centre	width	speed	successful	number of errors
10:11:35	10:11:43	12 cm	24 cm		y	1
C to B						
start	stop	distance centre	width	speed	successful	number of errors
10:11:44	10:11:50	12 cm	24 cm		y	0
B to E						
start	stop	distance centre	width	speed	successful	number of errors
10:11:51	10:11:59	7 cm	14 cm		y	2
D to C						
start	stop	distance centre	width	speed	successful	number of errors
10:12:00	10:12:09	7 cm	14 cm		n	3
D to A						
start	stop	distance centre	width	speed	successful	number of errors

10:12:10	10:12:21	8.5 cm	17 cm		n	1
A to B						
start	stop	distance centre	width	speed	successful	number of errors
10:12:23	10:12:33	8.5 cm	17 cm		y	0
A to E						
start	stop	distance centre	width	speed	successful	number of errors
10:12:40	10:12:48	8.5 cm	17 cm		y	0
C to C						
start	stop	distance centre	width	speed	successful	number of errors
10:12:49	10:12:58	8.5 cm	17 cm		n	0
Position C						
C to A						
start	stop	distance centre	width	speed	successful	number of errors
10:13:00	10:13:09	12 cm	24 cm		y	0
D to C						
start	stop	distance centre	width	speed	successful	number of errors
10:13:10	10:13:23	12 cm	24 cm		n	1
A to C						
start	stop	distance centre	width	speed	successful	number of errors
10:13:24	10:13:33	7 cm	14 cm		n	1
C to D						
start	stop	distance centre	width	speed	successful	number of errors
10:13:35	10:13:42	7 cm	14 cm		n	1
B to C						
start	stop	distance centre	width	speed	successful	number of errors
10:13:43	10:13:52	8.5 cm	17 cm		n	1
C to B						
start	stop	distance centre	width	speed	successful	number of errors
10:13:54	10:14:05	8.5 cm	17 cm		y	0
C to D						
start	stop	distance centre	width	speed	successful	number of errors
10:14:06	10:14:15	8.5 cm	17 cm		y	0
D to B						
start	stop	distance centre	width	speed	successful	number of errors
10:14:16	10:14:26	8.5 cm	17 cm		y	0
Position D						
A to E						
start	stop	distance centre	width	speed	successful	number of errors
10:14:27	10:14:35	12 cm	24 cm		y	0
E to D						
start	stop	distance centre	width	speed	successful	number of errors
10:14:35	10:14:45	7 cm	14 cm		y	1
B to A						

start	stop	distance centre	width	speed	successful	number of errors
10:14:46	10:14:47	7 cm	14 cm		y	1
			D to B			
start	stop	distance centre	width	speed	successful	number of errors
10:14:48	10:14:55	12 cm	24 cm		n	1
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
10:14:56	10:15:08	8.5 cm	17 cm		n	1
			C to E			
start	stop	distance centre	width	speed	successful	number of errors
10:15:09	10:15:20	8.5 cm	17 cm		n	0
			B to C			
start	stop	distance centre	width	speed	successful	number of errors
10:15:21	10:15:35	8.5 cm	17 cm		n	0
			A to C			
start	stop	distance centre	width	speed	successful	number of errors
10:15:35	10:15:44	8.5 cm	17 cm		n	0
			Position E			
			E to B			
start	stop	distance centre	width	speed	successful	number of errors
10:15:45	10:15:55	7 cm	14 cm		n	0
			C to A			
start	stop	distance centre	width	speed	successful	number of errors
10:15:56	10:16:05	7 cm	14 cm		n	1
			C to E			
start	stop	distance centre	width	speed	successful	number of errors
10:16:18	10:16:28	12 cm	24 cm		n	1
			A to B			
start	stop	distance centre	width	speed	successful	number of errors
10:16:29	10:16:37	12 cm	24 cm		y	1
			D to A			
start	stop	distance centre	width	speed	successful	number of errors
10:16:39	10:16:41	8.5 cm	17 cm		y	0
			D to E			
start	stop	distance centre	width	speed	successful	number of errors
10:16:42	10:16:52	8.5 cm	17 cm		y	0
			C to D			
start	stop	distance centre	width	speed	successful	number of errors
10:16:53	10:17:06	8.5 cm	17 cm		y	0
			B to D			
start	stop	distance centre	width	speed	successful	number of errors
10:17:08	10:17:15	8.5 cm	17 cm		y	0

ANNEXURE 9A: PARTICIPANT 1 AND 2 ONLY

Participant 1							Participant 2						
Position A							Position A	Position A					
MTime	Result	D	W	RT	ID	IP	MT	Result	D	W	RT	ID	IP
40	1	12	24	70	0.585	-0.019	25	1	12	24	5	0.58496	0.02925
45	1	12	24	10	0.585	0.0167	17	0	12	24	5	0.58496	0.04875
35	1	8.5	17	75	0.585	-0.015	31	1	9	17	2	0.58496	0.02017
28	0	8.5	17	205	0.585	-0.003	2	0	9	17	27	0.58496	-0.0234
30	0	7	14	212	0.585	-0.003	22	0	7	14	11	0.58496	0.05318
21	0	7	14	150	0.585	-0.005	12	1	7	14	3	0.58496	0.065
20	1	7	14	39	0.585	-0.031	17	1	7	14	8	0.58496	0.065
36	1	7	14	40	0.585	-0.146	20	1	7	14	29	0.58496	-0.065
					0.585	-0.001						0.58496	0.01045
Position B							Position B	Position B					
15	1	12	24	24	0.585	-0.065	28	1	12	24	11	0.58496	0.03441
26	1	12	24	7	0.585	0.0308	17	0	12	24	1	0.58496	0.03656
10	0	7	14	11	0.585	-0.585	24	1	7	14	10	0.58496	0.04178
10	1	7	14	6	0.585	0.1462	3	1	7	14	10	0.58496	-0.0836
23	1	8.5	17	10	0.585	0.045	16	1	9	17	5	0.58496	0.05318
3	0	8.5	17	2	0.585	0.585	29	1	9	17	4	0.58496	0.0234
11	0	8.5	17	15	0.585	-0.146	17	1	9	17	3	0.58496	0.04178
10	1	8.5	17	9	0.585	0.585	19	1	9	17	6	0.58496	0.045
					0.585	0.0244						0.58496	0.00568
Position D							Position D	Position D					
44	1	12	24	1152	0.585	-5E-04	12	1	12	24	4	0.58496	0.07312
57	0	12	24	17	0.585	0.0146	23	1	12	24	1	0.58496	0.02659
18	0	7	14	3	0.585	0.039	23	0	7	14	2	0.58496	0.02786

18	0	7	14	40	0.585	-0.027	14	0	7	14	2	0.58496	0.04875
10	0	8.5	17	7	0.585	0.195	11	1	9	17	2	0.58496	0.065
25	0	8.5	17	5	0.585	0.0292	13	1	9	17	4	0.58496	0.065
7	0	8.5	17	5	0.585	0.2925	17	1	9	17	3	0.58496	0.04178
22	0	8.5	17	23	0.585	-0.585	7	1	9	17	3	0.58496	0.14624
					0.585	-6E-04						0.58496	0.00591
Position C													
10	1	12	24	3	0.585	0.0836	18	0	12	24	2	0.58496	0.03656
26	1	7	14	0	0.585	0.0225	15	1	7	14	5	0.58496	0.0585
37	0	7	14	1	0.585	0.0162	13	1	7	14	3	0.58496	0.0585
19	0	12	24	3	0.585	0.0366	20	1	12	24	4	0.58496	0.03656
4	0	8.5	17	1	0.585	0.195	10	1	9	17	20	0.58496	-0.0585
28	0	8.5	17	4	0.585	0.0244	20	1	9	17	3	0.58496	0.03441
40	0	8.5	17	4	0.585	0.0162	18	1	9	17	8	0.58496	0.0585
9	1	8.5	17	8	0.585	0.585	17	1	9	17	18	0.58496	-0.585
					0.585	0.0039						0.58496	0.0086
Position E													
							14	0	7	14	6	0.58496	0.07312
							13	1	7	14	23	0.58496	-0.0585
							4	1	12	24	3	0.58496	0.58496
							14	0	12	24	3	0.58496	0.05318
							16	1	9	17	3	0.58496	0.045
							15	1	9	17	4	0.58496	0.05318
							8	0	9	17	2	0.58496	0.09749
							12	1	9	17	3	0.58496	0.065
												0.58496	0.01194

ANNEXURE 9B: PARTICIPANT 3 AND 4

Participant 3							Participant 4						
Position A							Position A						
MTime	Result	D	W	RT	ID	IP	MT	Result	D	W	RT	ID	IP
40	0	12	24	0	0.584963	0.0146241	13	1	12	24	1	0.584963	0.048747
33	0	12	24	2	0.584963	0.0188698	17	1	12	24	8	0.584963	0.064996
15	0	8.5	17	5	0.584963	0.0584963	22	0	8.5	17	10	0.584963	0.048747
20	1	8.5	17	10	0.584963	0.0584963	14		8.5	17	1	0.584963	0.044997
24	1	7	14	4	0.584963	0.0292481	14	1	7	14	1	0.584963	0.044997
14	1	7	14	10	0.584963	0.1462406	15	1	7	14	2	0.584963	0.044997
30	1	7	14	6	0.584963	0.0243734	9	1	7	14	2	0.584963	0.083566
16	0	7	14	10	0.584963	0.0974938	14	1	7	14	10	0.584963	0.146241
					0.584963	0.0040342						0.584963	0.007048
Position B							Position B						
25	1	12	24	4	0.584963	0.0278554	17	1	12	24	3	0.584963	0.041783
20	0	12	24	5	0.584963	0.0389975	17	0	12	24	2	0.584963	0.038998
36	1	7	14	4	0.584963	0.0182801	10	1	7	14	10	0.584963	#DIV/0!
10	1	7	14	10	0.584963	#DIV/0!	12	1	7	14	2	0.584963	0.058496
26	1	8.5	17	4	0.584963	0.0265892	17	1	8.5	17	2	0.584963	0.038998
10	0	8.5	17	10	0.584963	#DIV/0!	13	1	8.5	17	3	0.584963	0.058496
40	0	8.5	17	10	0.584963	0.0194988	18	1	8.5	17	3	0.584963	0.038998
30	0	8.5	17	6	0.584963	0.0243734	15	1	8.5	17	1	0.584963	0.041783
					0.584963	0.0040622						0.584963	0.00629
Position D							Position D						
21	1	12	24	10	0.584963	0.0531784	15	1	12	24	2	0.584963	0.044997
20	0	12	24	4	0.584963	0.0365602	10	0	12	24	2	0.584963	0.07312
10	0	7	14	5	0.584963	0.1169925	13	0	7	14	2	0.584963	0.053178

21	0	7	14	4	0.584963	0.0344096	10	1	7	14	4	0.584963	0.097494
23	0	8.5	17	3	0.584963	0.0292481	14	1	8.5	17	3	0.584963	0.053178
30	0	8.5	17	4	0.584963	0.0224986	12	1	8.5	17	4	0.584963	0.07312
30	1	8.5	17	5	0.584963	0.0233985	12	1	8.5	17	2	0.584963	0.058496
29	1	8.5	17	10	0.584963	0.0307875	26	1	8.5	17	4	0.584963	0.026589
					0.584963	0.0042084						0.584963	0.005318
Position C							Position C						
22	0	12	24	18	0.584963	0.1462406	9	0	12	24	3	0.584963	0.097494
23	0	7	14	2	0.584963	0.0278554	14	0	7	14	4	0.584963	0.058496
23	0	7	14	30	0.584963	-0.083566	20	1	7	14	2	0.584963	0.032498
30	0	12	24	11	0.584963	0.0307875	16	0	12	24	2	0.584963	0.041783
10	1	8.5	17	6	0.584963	0.1462406	17	0	8.5	17	2	0.584963	0.038998
10	0	8.5	17	4	0.584963	0.0974938	12	1	8.5	17	5	0.584963	0.083566
24	1	8.5	17	3	0.584963	0.0278554	8	0	8.5	17	2	0.584963	0.097494
10	0	8.5	17	9	0.584963	0.5849625	4	0	8.5	17	33	0.584963	-0.02017
					0.584963	0.0084777						0.584963	0.012446
Position E							Position E						
16	1	7	14	7	0.584963	0.0649958	17	0	7	14	2	0.584963	0.038998
26	1	7	14	4	0.584963	0.0265892	15	0	7	14	3	0.584963	0.048747
21	0	12	24	11	0.584963	0.0584963	16	1	12	24	2	0.584963	0.041783
22	1	12	24	10	0.584963	0.0487469	14	1	12	24	2	0.584963	0.048747
30	0	8.5	17	10	0.584963	0.0292481	10	1	8.5	17	15	0.584963	-0.11699
10	1	8.5	17	10	0.584963	#DIV/0!	11	0	8.5	17	10	0.584963	0.584963
4	1	8.5	17	6	0.584963	-0.292481	23	1	8.5	17	2	0.584963	0.027855
26	0	8.5	17	8	0.584963	0.0324979	13	1	8.5	17	1	0.584963	0.048747
					0.584963	0.0065726						0.584963	0.007134

ANNEXURE 9C: PARTICIPANT 5 AND 6

Participant 5							Participant 6						
Position A							Position A						
MT	Result	D	W	RT	ID	IP	MT	Result	D	W	RT	ID	IP
16	1	12	24	1	0.584963	0.038998	12	1	12	24	1	0.584963	0.053178
6	1	12	24	1	0.584963	0.116993	11	1	12	24	1	0.584963	0.058496
13	1	9	17	1	0.584963	0.048747	6	0	9	17	1	0.584963	0.116993
11	1	9	17	2	0.584963	0.064996	9		9	17	1	0.584963	0.07312
0.9	1	7	14	1	0.584963	-5.84963	9	0	7	14	1	0.584963	0.07312
6	1	7	14	1	0.584963	0.116993	9	0	7	14	1	0.584963	0.07312
13	1	7	14	2	0.584963	0.053178	9	1	7	14	1	0.584963	0.07312
20	1	7	14	1	0.584963	0.030788	16	1	7	14	2	0.584963	0.041783
					0.584963	0.007707						0.584963	0.008124
Position B							Position B						
7	1	12	24	1	0.584963	0.097494	10	1	12	24	1	0.584963	0.064996
8	1	12	24	1	0.584963	0.083566	11	1	12	24	1	0.584963	0.058496
12	1	7	14	2	0.584963	0.058496	16	1	7	14	1	0.584963	0.038998
12	1	7	14	1	0.584963	0.053178	14	1	7	14	1	0.584963	0.044997
19	1	9	17	9	0.584963	0.058496	11	1	9	17	1	0.584963	0.058496
9	0	9	17	1	0.584963	0.07312	2	1	9	17	1	0.584963	0.584963
8	0	9	17	1	0.584963	0.083566	14	1	9	17	1	0.584963	0.044997
10	0	9	17	1	0.584963	0.064996	2	1	9	17	1	0.584963	0.584963
					0.584963	0.008602						0.584963	0.008124
Position D							Position D						
12	0	12	24	1	0.584963	0.053178	13	1	12	24	1	0.584963	0.048747
7	0	12	24	1	0.584963	0.097494	11	1	12	24	1	0.584963	0.058496
9	1	7	14	11	0.584963	-0.29248	9	0	7	14	1	0.584963	0.07312
7	1	7	14	1	0.584963	0.097494	9	0	7	14	1	0.584963	0.07312
12	1	9	17	1	0.584963	0.053178	9	0	9	17	1	0.584963	0.07312
8	1	9	17	1	0.584963	0.083566	17	0	9	17	1	0.584963	0.03656
7	1	9	17	1	0.584963	0.097494	11	1	9	17	1	0.584963	0.058496
12	1	9	17	1	0.584963	0.053178	9	1	9	17	1	0.584963	0.07312
					0.584963	0.010446						0.584963	0.007312
Position C							Position C						
8	0	12	24	0	0.584963	0.07312	9	1	12	24	1	0.584963	0.07312
0.9	1	7	14	1	0.584963	-5.84963	15	1	7	14	1	0.584963	0.041783
9	1	7	14	1	0.584963	0.07312	13	1	7	14	4	0.584963	0.064996
8	1	12	24	1	0.584963	0.083566	10	0	12	24	2	0.584963	0.07312
12	1	9	17	1	0.584963	0.053178	8	0	9	17	1	0.584963	0.083566
13	1	9	17	1	0.584963	0.048747	4	0	9	17	1	0.584963	0.194988
9	1	9	17	1	0.584963	0.07312	2	0	9	17	1	0.584963	0.584963

11	1	9	17	1	0.584963	0.058496	1	0	9	17	1	0.584963	#DIV/0!
					0.584963	0.009154						0.584963	0.011699
Position E							Position E						
7	0	7	14	1	0.584963	0.097494	4	1	7	14	9	0.584963	-0.11699
13	0	7	14	2	0.584963	0.053178	11	1	7	14	2	0.584963	0.064996
16	1	12	24	1	0.584963	0.038998	9	1	12	24	1	0.584963	0.07312
9	1	12	24	1	0.584963	0.07312	12	1	12	24	1	0.584963	0.053178
12	1	9	17	2	0.584963	0.058496	1	1	9	17	1	0.584963	#DIV/0!
8	1	9	17	1	0.584963	0.083566	7	1	9	17	1	0.584963	0.097494
11	1	9	17	1	0.584963	0.058496	11	1	9	17	3	0.584963	0.07312
18	0	9	17	1	0.584963	0.03441	9	1	9	17	1	0.584963	0.07312
					0.584963	0.006964						0.584963	0.012999

ANNEXURE 9D: PARTICIPANT 7 AND 8

Participant 7							Participant 8						
Position A							Position A						
MT	Result	D	W	RT	ID	IP	MT	Result	D	W	RT	ID	IP
12	1	12	24	1	0.584963	0.053178	13	1	12	24	1	0.584963	0.048747
12	1	12	24	1	0.584963	0.053178	7	1	12	24	1	0.584963	0.097494
9	1	8.5	17	1	0.584963	0.07312	13	1	8.5	17	1	0.584963	0.048747
6	1	8.5	17	1	0.584963	0.116993	5	1	8.5	17	1	0.584963	0.146241
1	1	7	14	1	0.584963	#DIV/0!	13	1	7	14	3	0.584963	0.058496
8	0	7	14	2	0.584963	0.097494	11	1	7	14	1	0.584963	0.058496
15	0	7	14	1	0.584963	0.041783	11	1	7	14	2	0.584963	0.064996
11	0	7	14	1	0.584963	0.058496	19	1	7	14	1	0.584963	0.032498
					0.584963	0.008999						0.584963	0.007222
Position B							Position B						
12	1	12	24	3	0.584963	0.064996	11	0	12	24	2	0.584963	0.064996
18	1	12	24	31	0.584963	-0.045	13	0	12	24	1	0.584963	0.048747
9	1	7	14	1	0.584963	0.07312	12	0	7	14	1	0.584963	0.053178
6	1	7	14	1	0.584963	0.116993	11	0	7	14	7	0.584963	0.146241
15	1	8.5	17	1	0.584963	0.041783	12	0	8.5	17	1	0.584963	0.053178
13	1	8.5	17	1	0.584963	0.048747	6	1	8.5	17	1	0.584963	0.116993
11	1	8.5	17	1	0.584963	0.058496	12	1	8.5	17	2	0.584963	0.058496
11	0	8.5	17	1	0.584963	0.058496	12	0	8.5	17	1	0.584963	0.053178
					0.584963	0.010636						0.584963	0.008013
Position D							Position D						
8	0	12	24	2	0.584963	0.097494	2	1	12	24	1	0.584963	0.584963
11	0	12	24	1	0.584963	0.058496	11	1	12	24	1	0.584963	0.058496
11	0	7	14	1	0.584963	0.058496	11	1	7	14	2	0.584963	0.064996
10	1	7	14	1	0.584963	0.064996	14	1	7	14	1	0.584963	0.044997
13	0	8.5	17	1	0.584963	0.048747	18	1	8.5	17	1	0.584963	0.03441
10	0	8.5	17	2	0.584963	0.07312	20	1	8.5	17	1	0.584963	0.030788
7	0	8.5	17	1	0.584963	0.097494	9	1	8.5	17	1	0.584963	0.07312
8	0	8.5	17	2	0.584963	0.097494	12	1	8.5	17	2	0.584963	0.058496
					0.584963	0.008731						0.584963	0.006724
Position C							Position C						
12	0	12	24	1	0.584963	0.053178	13	1	12	24	1	0.584963	0.048747
9	1	7	14	1	0.584963	0.07312	9	1	7	14	1	0.584963	0.07312
7	1	7	14	1	0.584963	0.097494	9	1	7	14	2	0.584963	0.083566
8	1	12	24	2	0.584963	0.097494	9	1	12	24	1	0.584963	0.07312
12	1	8.5	17	1	0.584963	0.053178	1	1	8.5	17	1	0.584963	#DIV/0!
11	1	8.5	17	2	0.584963	0.064996	13	1	8.5	17	1	0.584963	0.048747
11	0	8.5	17	1	0.584963	0.058496	8	1	8.5	17	1	0.584963	0.083566
14	0	8.5	17	1	0.584963	0.044997	11	1	8.5	17	1	0.584963	0.058496

					0.584963	0.007905						0.584963	0.00914
Position E							Position E						
		7	14				12	1	7	14	1	0.584963	0.053178
		7	14				9	1	7	14	1	0.584963	0.07312
		12	24				11	0	12	24	1	0.584963	0.058496
		12	24				11	0	12	24	9	0.584963	0.292481
		8.5	17				9	1	8.5	17	13	0.584963	-0.14624
		8.5	17				12	1	8.5	17	1	0.584963	0.053178
		8.5	17				8	1	8.5	17	1	0.584963	0.083566
		8.5	17				15	1	8.5	17	2	0.584963	0.044997
												0.584963	0.010086

ANNEXURE 9E: PARTICIPANT 9

Participant 9						
Position A						
MT	Result	D	W	RT	ID	IP
12	1	12	24	1	0.584963	0.053178
10	1	12	24	1	0.584963	0.064996
11	1	9	17	1	0.584963	0.058496
9	1	9	17	1	0.584963	0.07312
8	1	7	14	1	0.584963	0.083566
13	1	7	14	1	0.584963	0.048747
12	1	7	14	2	0.584963	0.058496
9	1	7	14	2	0.584963	0.083566
					0.584963	0.007905
Position B						
8	1	12	24	1	0.584963	0.083566
6	1	12	24	1	0.584963	0.116993
8	1	7	14	1	0.584963	0.083566
9	0	7	14	1	0.584963	0.07312
11	0	9	17	1	0.584963	0.058496
10	1	9	17	2	0.584963	0.07312
8	1	9	17	7	0.584963	0.584963
9	0	9	17	1	0.584963	0.07312
Position D						
9	1	12	24	2	0.584963	0.083566
13	0	12	24	1	0.584963	0.048747
9	0	7	14	1	0.584963	0.07312
7	0	7	14	2	0.584963	0.116993
9	0	9	17	1	0.584963	0.07312
11	1	9	17	2	0.584963	0.064996
9	1	9	17	1	0.584963	0.07312
10	1	9	17	1	0.584963	0.064996
					0.584963	0.008863
Position C						
8	1	12	24	1	0.584963	0.083566
10	1	7	14	0	0.584963	0.058496
1	1	7	14	1	0.584963	#DIV/0!
7	0	12	24	1	0.584963	0.097494
12	0	9	17	1	0.584963	0.053178
11	0	9	17	1	0.584963	0.058496
14	0	9	17	1	0.584963	0.044997
9	0	9	17	0	0.584963	0.064996

					0.584963	0.008863
Position E						
10	0	7	14	1	0.584963	0.064996
9	0	7	14	1	0.584963	0.07312
10	0	12	24	13	0.584963	-0.19499
8	1	12	24	1	0.584963	0.083566
2	1	9	17	2	0.584963	#DIV/0!
10	1	9	17	1	0.584963	0.064996
13	1	9	17	1	0.584963	0.048747
7	1	9	17	2	0.584963	0.116993
					0.584963	0.012446

ANNEXURE 10A: OVERALL EFFICIENCY FOR PARTICIPANT 1, 2, AND 3

Participant 1			Participant 2			Participant 3		
Position A			Position A			Position A		
MT	Result	Speed(Cm/s)	MT	Result	Speed(Cm/s)	MT	Result	Speed(Cm/s)
40	1	0.3	25	1	0.48	40	0	0.3
45	1	0.266666667	17	0	0.705882353	33	0	0.363636364
35	1	0.242857143	31	1	0.274193548	15	0	0.566666667
28	0	0.303571429	2	0	4.25	20	1	0.425
30	0	0.233333333	22	0	0.318181818	24	1	0.291666667
21	0	0.333333333	12	1	0.583333333	14	1	0.5
20	1	0.35	17	1	0.411764706	30	1	0.233333333
36	1	0.194444444	20	1	0.35	16	0	0.4375
69.02%	62.50%		71.92%	62.50%		45.83%	50.00%	
Position B			Position B			Position B		
15	1	0.8	28	1	0.428571429	25	1	0.48
26	1	0.461538462	17	0	0.705882353	20	0	0.6
10	0	0.7	24	1	0.291666667	36	1	0.194444444
10	1	0.7	3	1	2.333333333	10	1	0.7
23	1	0.369565217	16	1	0.53125	26	1	0.326923077
3	0	2.833333333	29	1	0.293103448	10	0	0.85
11	0	0.772727273	17	1	0.5	40	0	0.2125
10	1	0.85	19	1	0.447368421	30	0	0.283333333
77.78%	62.50%		88.89%	87.50%		49.24%	50.00%	
Position D			Position D			Position D		
1152	1	0.010416667	12	1	1	21	1	0.571428571
57	0	0.210526316	23	1	0.52173913	20	0	0.6

18	0	0.388888889	23	0	0.304347826	10	0	0.7
18	0	0.388888889	14	0	0.5	21	0	0.333333333
10	0		11	1		23	0	0.369565217
25	0		13	1		30	0	0.283333333
7	0		17	1		30	1	0.283333333
22	0		7	1		29	1	0.293103448
88.01%	12.50%		69.17%	75.00%		43.48%	37.50%	
Position C			Position C			Position C		
10	1	1.2	18	0	0.666666667	22	0	0.545454545
26	1	0.269230769	15	1	0.466666667	23	0	0.304347826
37	0	0.189189189	13	1	0.538461538	23	0	0.304347826
19	0	0.631578947	20	1	0.6	30	0	0.4
4	0	2.125	10	1	0.85	10	1	0.85
28	0	0.303571429	20	1	0.425	10	0	0.85
40	0	0.2125	18	1	0.472222222	24	1	0.354166667
9	1	0.944444444	17	1	0.5	10	0	
26.01%	25.00%		86.26%	87.50%		22.37%	25.00%	
Position E			Position E			Position E		
			14	0	0.5	16	1	0.4375
			13	1	0.538461538	26	1	0.269230769
			4	1	3	21	0	0.571428571
			14	0	0.857142857	22	1	0.545454545
			16	1	0.53125	30	0	0.283333333
			15	1	0.566666667	10	1	0.85
			8	0	1.0625	4	1	2.125
			12	1	0.708333333	26	0	0.326923077
0.00%	0.00%		62.50%	62.50%		50.32%	62.50%	

Overall RE/ participant								
79.62%			76.93%			40.34%		
Effectiveness/ participant								
	35.00%			75.00%			42.50%	

ANNEXURE 10B: OVERALL EFFICIENCY FOR PARTICIPANT 4, 5, AND 6

Participant 4			Participant 5			Participant 6		
Position A			Position A			Position A		
MT	Result	Speed(Cm/s)	MT	Result	Speed(Cm/s)	MT	Result	Speed(Cm/s)
13	1	0.923076923	16	1	0.75	12	1	1
17	1	0.705882353	6	1	2	11	1	1.090909091
22	0	0.386363636	13	1	0.653846154	6	0	1.416666667
14		0.607142857	11	1	0.772727273	9		0.944444444
14	1	0.5	0.9	1	7.777777778	9	0	0.777777778
15	1	0.466666667	6	1	1.166666667	9	0	0.777777778
9	1	0.777777778	13	1	0.538461538	9	1	0.777777778
14	1	0.5	20	1	0.35	16	1	0.4375
69.49%	75.00%		100.00%	100.00%		48.15%	50.00%	
Position B			Position B			Position B		
17	1	0.705882353	7	1	1.714285714	10	1	1.2
17	0	0.705882353	8	1	1.5	11	1	1.090909091
10	1	0.7	12	1	0.583333333	16	1	0.4375
12	1	0.583333333	3	1	2.333333333	14	1	0.5
17	1	0.5	10	1	0.85	11	1	0.772727273
13	1	0.653846154	9	0	0.944444444	2	1	4.25
18	1	0.472222222	8	0	1.0625	14	1	0.607142857
15	1	0.566666667	10	0	0.85	2	1	4.25
85.71%	87.50%		59.70%	62.50%		100.00%	100.00%	
Position D			Position D			Position D		
15	1	0.8	12	0	1	13	1	0.923076923
10	0	1.2	7	0	1.714285714	11	1	1.090909091

13	0	0.538461538	9	1	0.777777778	9	0	0.777777778
10	1	0.7	7	1	1	9	0	0.777777778
14	1	0.607142857	12	1	0.708333333	9	0	0.944444444
12	1	0.708333333	8	1	1.0625	17	0	0.5
12	1	0.708333333	7	1	1.214285714	11	1	0.772727273
26	1	0.326923077	12	1	0.708333333	9	1	0.944444444
79.46%	75.00%		74.32%	75.00%		50.00%	50.00%	
Position C			Position C			Position C		
9	0	1.333333333	8	0	1.5	9	1	1.333333333
14	0	0.5	0.9	1	7.777777778	15	1	0.466666667
20	1	0.35	9	1	0.777777778	13	1	0.538461538
16	0	0.75	8	1	1.5	10	0	1.2
17	0	0.5	12	1	0.708333333	8	0	1.0625
12	1	0.708333333	13	1	0.653846154	4	0	2.125
8	0	1.0625	9	1	0.944444444	2	0	4.25
4	0	2.125	11	1	0.772727273	1	0	8.5
32.00%	25.00%		88.72%	87.50%		59.68%	37.50%	
Position E			Position E			Position E		
17	0	0.411764706	7	0	1	4	1	1.75
15	0	0.466666667	13	0	0.538461538	11	1	0.636363636
16	1	0.75	16	1	0.75	9	1	1.333333333
14	1	0.857142857	9	1	1.333333333	12	1	1
10	1	0.85	12	1	0.708333333	1	1	8.5
11	0	0.772727273	8	1	1.0625	7	1	1.214285714
23	1	0.369565217	11	1	0.772727273	11	1	0.772727273
13	1	0.653846154	18	0	0.472222222	9	1	0.944444444
63.87%	62.50%		59.57%	62.50%		100.00%	100.00%	

67.08%			72.43%			72.80%		
		Overall RE - General						
			68.99%					
	65.00%			77.50%			62.50%	

ANNEXURE 10C: OVERALL EFFICIENCY FOR PARTICIPANT 7, 8, AND 9

Participant 7			Participant 8			Participant 9			Overall RE/Task
Position A			Position A			Position A			
MT	Result	Speed(Cm/s)	MT	Result	Speed(Cm/s)	MT	Result	Speed(Cm/s)	
12	1	1	13	1	0.923076923	12	1	1	78.14%
12	1	1	7	1	1.714285714	10	1	1.2	68.35%
9	1	0.944444444	13	1	0.653846154	11	1	0.772727273	72.26%
6	1	1.416666667	5	1	1.7	9	1	0.944444444	49.04%
1	1	7	13	1	0.538461538	8	1	0.875	49.96%
8	0	0.875	11	1	0.636363636	13	1	0.538461538	65.14%
15	0	0.466666667	11	1	0.636363636	12	1	0.583333333	88.97%
11	0	0.636363636	19	1	0.368421053	9	1	0.777777778	83.23%
54.05%	62.50%		100.00%	100.00%		100.00%	100.00%		
Position B			Position B			Position B			
12	1	1	11	0	1.090909091	8	1	1.5	91.73%
18	1	0.666666667	13	0	0.923076923	6	1	2	50.74%
9	1	0.777777778	12	0	0.583333333	8	1	0.875	83.94%
6	1	1.166666667	11	0	0.636363636	9	0	0.777777778	80.56%
15	1	0.566666667	12	0	0.708333333	11	0	0.772727273	83.69%
13	1	0.653846154	6	1	1.416666667	10	1	0.85	76.84%
11	1	0.772727273	12	1	0.708333333	8	1	1.0625	57.55%
11	0	0.772727273	12	0	0.708333333	9	0	0.944444444	38.98%
88.42%	87.50%		20.22%	25.00%		57.97%	62.50%		
Position D			Position D			Position D			
8	0	1.5	2	1	6	9	1	1.333333333	98.39%

11	0	1.090909091	11	1	1.090909091	13	0	0.923076923	27.61%
11	0	0.636363636	11	1	0.636363636	9	0	0.777777778	17.70%
10	1	0.7	14	1	0.5	7	0	1	37.27%
13	0	0.653846154	18	1	0.472222222	9	0	0.944444444	46.22%
10	0	0.85	20	1	0.425	11	1	0.772727273	43.84%
7	0	1.214285714	9	1	0.944444444	9	1	0.944444444	87.16%
8	0	1.0625	12	1	0.708333333	10	1	0.85	77.78%
12.82%	12.50%		100.00%	100.00%		50.65%	50.00%		
Position C			Position C			Position C			
12	0	1	13	1	0.923076923	8	1	1.5	36.70%
9	1	0.777777778	9	1	0.777777778	10	1	0.7	69.65%
7	1	1	9	1	0.777777778	1	1	7	100.00%
8	1	1.5	9	1	1.333333333	7	0	1.714285714	35.43%
12	1	0.708333333	1	1	8.5	12	0	0.708333333	52.33%
11	1	0.772727273	13	1	0.653846154	11	0	0.772727273	56.56%
11	0	0.772727273	8	1	1.0625	14	0	0.607142857	44.03%
14	0	0.607142857	11	1	0.772727273	9	0	0.944444444	55.81%
55.95%	62.50%		100.00%	100.00%		26.39%	37.50%		
Position E			Position E			Position E			
			12	1	0.583333333	10	0	0.7	40.00%
			9	1	0.777777778	9	0	0.777777778	61.46%
			11	0	1.090909091	10	0	1.2	51.72%
			11	0	1.090909091	8	1	1.5	72.22%
			9	1	0.944444444	2	1	4.25	62.50%
			12	1	0.708333333	10	1	0.85	84.93%
			8	1	1.0625	13	1	0.653846154	89.74%
			15	1	0.566666667	7	1	1.214285714	56.00%
0.00%	0.00%		74.71%	75.00%		57.97%	62.50%		

54.68%			78.77%			59.84%			
	57.50%			80.00%			62.50%		

ANNEXURE 11: PROOFREAD LETTER

GRAMMAR GUARDIANS

22 September 2017

To whom it may concern

<u>Re: Proofreading and editing of PhD thesis</u>

I, J.L. van Aswegen of Grammar Guardians, hereby confirm proofreading and editing of “Closing the Digital Gap: Handheld Computing, Adult First-time Users, And User Experience Metric” by Mr G.R. Toko in June and September 2017.

Please contact me on 082 811 6857 or at jeanne@grammarguardians.co.za regarding any queries that may arise.

Kind regards,

J.L. van Aswegen

Grammar Guardians