Usability Attributes and Evaluation Methods for M-Commerce Websites

by

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Declaration

I hereby declare that this thesis:

Usability Attributes and Evaluation Methods for M-Commerce Websites is my own work, and that all sources used, or quoted, in the study have been indicated and acknowledged by means of complete references.

I further declare that I have not previously submitted this work, or part of it, for examination at UNISA for another qualification or at any other higher education institution.

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Abstract

The *usability* of Mobile commerce (M-commerce) websites is a key parameter in determining the success of M-commerce businesses. Literature shows that numerous M-commerce websites have failed to attract customers due to the poor usability of user interfaces. In order to offer superior quality shopping experiences to consumers, it is thus essential to determine the appropriate attributes of successful user interfaces as well as the evaluation methods which should be employed to measure them.

The available research resources consulted contained few references to usability evaluation, the identification of appropriate attributes as well as evaluation methods to be used for M-commerce applications. Consequently, the researcher proposes a new usability model for M-commerce websites to determine the suitability of attributes to be included in the proposed model for M-commerce websites. This research work aims to address the imbalance in literature by determining the appropriate attributes of the proposed usability model for usability evaluations of M-commerce applications.

In an effort to validate the proposed usability model, an appropriate method to assess usability was formulated to evaluate existing M-commerce websites. The inappropriate application of usability methods will result in major usability problems which will, in turn, negatively impact users' experiences. To facilitate improved M-commerce user experiences, this study set out to determine appropriate attributes of usability model as well as formulate a domain-specific usability evaluation method to ascertain the usability of said websites.

The research work applied a combination of a user-based evaluation method *and* the proposed domain-specific evaluation method to evaluate the usability of four selected M-commerce websites. The outcomes of the study, which aided in the development of a framework for the usability evaluation of M-commerce websites, highlighted the effectiveness of the methods. Therefore, the proposed framework will prove useful to both new, and well-established M-commerce providers, as it will help guide usability professionals as to which evaluation method to choose for a specific usability problem area when evaluating the usability of M-commerce websites.

Keywords: usability attributes; E-commerce usability attributes; mobile commerce usability attributes; usability methods; E-commerce usability; mobile E-commerce usability; mobile usability methods; E-commerce usability methods; mobile usability; usability theory.

List of Publications

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Table of Contents

List of Figures

List of Tables

Table of Acronyms

Acronym	Meaning
ACT-R	Adaptive Control of Thought-Rational
ANOVA	ANalysis Of VAriance
AR	Augmented Reality
ATM	Automated Teller Machine
CCEC	Competition Commission of the European Commission
CIF	Common Industry Format
CTA	Concurrent Think-Aloud protocol
DVD	Digital Video Disc *or* Digital Versatile Disc
EPIC	Executive-Process/Interactive Control
GOMS	Goals, Operators, Methods and Selection rules
GPS	Global Positioning System
HCI	Human-Computer Interaction
HE	Heuristic Evaluation
HND/BSc	Higher National Diploma / Bachelor of Science
HTML	HyperText Mark-up Language
ISO	International Standards Organisation
KLM	Keystroke Level Model
MBA/MSc	Master’s of Business Administration / Master’s of Science
MLUAT	Mobile Learning Usability Attribute Testing
MOSAD	MObile Shoppers Application Development
NA	Not Available
NASA-TLX	National Aeronautics and Space Administration Task Load indeX
NFC	Near Field Communication
OND/NCE	Ordinary National Diploma / National Certificate Examination
PACMAD	People At the Centre of Mobile Application Development
PC	Personal Computer
PDAs	Tablets and Personal Digital Assistants
PGD	Post-Graduate Diploma
QUIS	User Interaction Satisfaction
SEO	Search Engine Optimisation
SMS	Short Message Service
SSCE	Senior School Certificate Examination
SUMI	Software Usability Measurement Inventory
SUS	System Usability Scale
TAP	Thinking Aloud Protocol
UEMs	Usability Evaluation Methods
UI	User Interface
UNISA	UNIversity of South Africa
UPA	Usability Professional’s Association
URL	Uniform Resource Locator
USEMATE	Usability Management System
UX	User eXperience
WAP	Wireless Application Protocol
Wi-Fi	Wireless Fidelity
WML	Wireless Mark-up Language

Chapter 1: Introduction and Overview

1.1 Introduction

Mobile commerce (M-commerce) combines the characteristics of two different platforms which communicate with each other, using mobile phones and websites, to facilitate Electronic commerce (E-commerce). The adjective ‘mobile’, as used in the term “M-commerce,” includes not only Mobile Phone Devices, but also Tablets and Personal Digital Assistants (PDAs). It thus refers to an *anywhere and anytime* access to business processes. This universal access is achieved by employing computer-mediated mobile communication networks, thereby ensuring the availability of services on offer regardless of the geographic position of the users (Min, Li & Zhong, 2009: 215–217; Joubert & Belle, 2013: 27).

In this research work, the term ‘mobile’ does not include wearable technology (e.g. G-glass, Apple Watch, Android Wear Smartwatches and Samsung Gear VR). Rather, the term is used to characterise a way of doing business, other than using a Personal Computer (PC), i.e. laptop and desktop computers. It is worth noting that many businesses use cross-channel approaches. Hence, ‘mobile’ is just a component of business processes and does not refer to self-contained M-commerce. Therefore, in this thesis ‘M-commerce’ is defined as a non-PC business and economic value interaction whereby at least one end, in the form of a mobile terminal but non-wearable technology, uses a mobile telecommunication network.

In addition, the term M-commerce, as used in this thesis, does *not* include social commerce or an economic value interaction conducted on social media platforms such as Instagram, Twitter, Facebook and Pinterest. M-commerce, in this thesis, rather includes a responsive mobile website or native application version of an E-commerce website. Social commerce uses sharing of content and user-generated content as core features for Web 2.0 in online business transactions (E-commerce). Web 2.0 is a platform used to harness collective intelligence (Huang & Benyoucef, 2013: 246–250).

Most of the significant companies in the M-commerce sector, including Amazon and eBay to name but two, use social commerce as a complementary service and not as an alternative option (Hillman & Neustaedter, 2017: 11–18; Laudon & Traver, 2017: 35–88). Business providers use social commerce and/or social media to update their growing number of customers regarding the latest products on offer. This is done through ‘posts’ on, for example, a Facebook page (Curty & Zhang, 2011: 2–8). In most cases, customers who have selected the Call-To-Action (CTA) option are directed to an associated mobile website. The *Buy Now*, *Shop Now* or *Learn More* button on social media pages, e.g. Facebook, needs to be selected in order to complete the transaction (Rad & Benyoucef, 2010: 2–7)**.**

In addition, the business page on Facebook allows business owners to add *Shop* to their page, which enables the list of products on offer to appear. However, social commerce platforms have limited features when compared to a responsive M-commerce website, or native applications (Kwon, 2018: 23–44). The application of any evaluation method on social commerce will not be effective nor will it yield any significant improvement as the design of the social media platform cannot be altered by the business page owner. Even if the evaluation method is thus applied to a social commerce platform, the shop owner cannot redesign the interface as changes can only be made by the social media company. Therefore, the evaluation methods proposed in this current study are specifically for M-commerce websites and cannot be suitable to evaluate social commerce.

M-commerce is growing at a rapid rate. The introduction of E/M-commerce websites has encouraged internet users to shop online. The online shopping phenomena has allowed customers, regardless of their geographic location, to purchase preferred items via the internet (Joubert & Belle, 2013: 26–29).

Although M-commerce is attractive, customers interacting with the M-commerce platform often experience difficulty completing basic and common tasks. Typically, many users cannot effectively browse an M-commerce portal and this leads to frustration and dissatisfaction (Hult *et al.*, 2018: 10–12). Experienced users may also occasionally encounter such challenges. In terms of design, portable devices are often plagued by limited connectivity, the small size of mobile screens, limited input modalities and high power consumption rates (Rehman & Coughlan, 2011: 595). For example, new clients/users of M-commerce often experience system failures when interacting with mobile applications. Given that experienced users can also encounter problems while using this technology (Ickin *et al.*, 2012: 52), it follows that experience *alone* does not necessarily guarantee a favourable user experience.

As the number and reach of M-commerce websites increase, it is essential to evaluate how usable the mobile shoppers, who purchase products and services from different parts of the world, experience these websites. Previous studies have suggests that quality interactions between users and websites increase the profits of global electronic markets and, as such, contribute to successful internet marketing (Del Aguila-Obra & Padilla-Melendez, 2008: 60). One way to enhance the quality of user experiences is to make sure that user interfaces are simple and user friendly. The one quality factor which affects users' experiences while using the system, or user interfaces, is thus *usability*. According to the International Standards Organisation (ISO) usability is "the extent to which a product, system or service can be used by particular users to achieve specified goals, with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 9241-11, 2018).

The usability of M-commerce websites is a vital parameter in determining the success of M-commerce businesses. Studies show that numerous M-commerce websites fail to attract customers because they are not user friendly (Rehman & Coughlan, 2011: 593–595). Hence, it is essential to design user friendly interfaces which offer consumers superior quality shopping experiences. One way to achieve this is to determine which of the attributes of usability model and evaluation methods are most appropriate for M-commerce applications.

Literature records various usability models, the earliest originating between 1991 and 1999 (Alghamdi *et al.*, 2013: 63). However, among the many models noted, the ISO standards and Nielsen's models are most commonly cited in literature. These models were traditionally used to evaluate general software interfaces, however, their application in the mobile context suffered some setbacks due to the unique features associated with mobile devices (Nayebi, Desharnais & Abran, 2012: 3).

In addition, an earlier study proposed a new model for mobile applications which included cognitive load as an important characteristic of mobile applications (Harrison, Flood & Duce, 2013: 9). This model failed to address the imbalances in mobile applications and was not empirically validated within the context in which it was proposed. In light of this, this research work set out to determine which attributes of the usability model were most appropriate to the usability evaluation of M-commerce websites. In addition, it outlined the important roles played by the attributes while assessing M-commerce websites. Given that *usability* is viewed as an important quality attribute in the software and mobile websites' development (Al-Badi & Mayhew, 2010: 3; Neto & Campos, 2014: 484; Olsina, Santos & Lew, 2014: 112), it is necessary that researchers determine suitable evaluation methods to improve the user experience and usability of M-commerce applications.

Due to the ubiquitous nature of mobile applications, there are certain challenges in the usability domain that need to be addressed (Gündüz & Pathan, 2013: 116). In comparison to desktop-based applications, mobile devices have certain constraints including limited battery capability, small screen sizes, limited computing and storage capacity, slow speed and bandwidth links (Poulcheria & Costas, 2012: 87). A prior study suggests the need for precise and organised evaluation methods for mobile usability evaluation (Nayebi *et al.*, 2012: 16).

M-commerce websites possess unique features which differ to those of other mobile websites. Thus, it is important to determine the essential attributes and appropriate evaluation method/s for usability evaluation of M-commerce websites. This research work seeks to address this gap. Therefore, the outcomes of the thesis would directly contribute to ensuring the usability, and consequent future success, of M-commerce websites.

1.2 Background and Motivation

The public gained access to the internet in the 1990s, long after its inception in the military services in 1969 (Naughton, 2016: 7–15). In the last years of the 20th century, the use of the internet and mobile technology expanded exponentially (Friess, 2011: 103; Rehman & Coughlan, 2011: 596–597; Kumin *et al*., 2012: 119). The graphical interface introduced by Xerox Star in 1981 is still considered an important component of modern computing and, as such, it has enhanced the reputation of the World Wide Web (Kolhe, Khetri & Deshmukh, 2013: 90). As a result, the implementation of Wireless Application Protocol (WAP) and Web shopping, have a shared history. WAP version 1.1 was developed for those who wished to use the Wireless Mark-Up Language (WML). WML facilitated a standard for the creation of web pages which ensured the genre remained the same as the Hypertext Mark-up Language (HTML), thus enabling the browser to review consistently.

Originally, the internet was primarily used to transmit e-mails, video and audio files. Netscape initiated the first commercial transactions between 1993 and 1995 when it began selling browser software via the Web (Cohen-Almagor, 2011: 54; Campbell-Kelly & Garcia-Swartz, 2013: 30). Following this, internet sales expanded significantly. The prolific use of cellular mobile phones has also resulted in internet sales increasing dramatically in line with the ever-growing internet industry. E-commerce was introduced to the cell phone domain, and thus, in 1997 the term *M-commerce* was coined (Wiebke, 2012).

The extensive use of wireless technology featuring complex functionalities and excellent internet connection, as epitomised by mobile handheld devices, has resulted in clients addressing their needs through M-commerce. Nowadays, with the mere touch of a button on their smartphones or PDAs, businessmen and women can check their e-mails, place orders online and/or log into their company's network while on the move.

In recent years the expansion in technology and the growing number of people using said technology, has been nothing short of breath-taking. In 2014, for example, a total of £17bn was transacted via mobile payments in Kenya (Maytom, 2015). It can be argued, however, that the tempo of change in business and in marketing strategies flowing from these technological advancements, has not been as impressive when compared to the potential inherent in these advancements. For example, even though web-enabled mobile devices have been available since the late 1990s (Ozok & Wei, 2010: 112), only in recent years have the technical capabilities of the smartphone been reflecting its potential. In spite of the relatively poor attention, there has been a dramatic increase in the popularity of these devices and a booming interest in their potential commercial use, all of which strengthens the impetus for this research.

The extent of mobile device usage is highlighted by Cisco (2017) who presents several statistics in this regard. According to Cisco, in 2017 mobile data traffic in the world was 11 exabytes per month whilst, in 2019, it is projected to reach 24 exabytes. The report notes that the amount of traffic via mobile devices across the world will reach "49 exabytes per month" in 2021 and that it will surpass half a zettabyte in annual mobile traffic at the end of that same year. The outcome of the report shows a 47% increase in annual usage levels, as projected from 2016 to 2021. In addition, the speed at which connections will be made will exceed 20Mbps by 2021 (Cisco, 2017).

Further statistics state that in September 2018, mobile devices represented approximately 52% of the market share worldwide with 53% in China, 28% in Brazil, 76% in Nigeria, 67% in South Africa, 42% in the United States of America (USA) and 38% in the United Kingdom (UK) (Statcounter, 2018a). M-commerce growth in 2017 amounted to 34.5% of E-commerce total sales and is estimated to reach 54% of total global E-commerce revenue by 2021 (Mali, 2018). Other statistics show that 76% of consumers state that shopping via mobile devices saves time (Pilewski, 2018). In addition, 20% of consumers state that they desire to buy item/s *now* when shopping on mobile devices. Only 12% of consumers state that it is more convenient to shop on a mobile device than laptop or desktop computer (Pilewski, 2018).

Furthermore, research done in the USA shows that $60.2 billion was spent in online shopping in 2016. It is further estimated that the spending will increase to $93.5 billion and $175.4 billion in 2018 and 2022, respectively (Lacy, 2018). An earlier report notes that in 2017 the M-commence revenue share for the UK amounted to £36.18 billion and $23.97 billion for Germany (eMarketers, 2018). The report estimated a total revenue of £42.78 billion and £61.55 billion for the UK in 2018 and 2021, respectively. It was estimated that Germany's M-commerce sales would reach $27.55 billion in 2018 and $36.14 billion in 2021 (eMarketers, 2018). Another research study shows that in 2017, 18% of South Africans and 14% of Egyptians bought items via mobile devices (Statista, 2018).

These statistics strengthen the call for research to be conducted in this field of study. As indicated before, many countries are yet to achieve their full revenue share of M-commerce, relative to their population (Mali, 2018). This is partly due to poorly executed usability evaluations of essential attributes of the usability model as well as the use of inappropriate evaluation method/s which do not enhance users' experiences on M-commerce websites.

1.3 The Research Problem

In the early phases of M-commerce technology, only a limited number of users were satisfied with M-commerce outcomes. While it is understandable, and even expected in the early years, today many users are still being confronted with challenges when using mobile websites designed to facilitate E-commerce (Zhang & Adipat, 2005: 294; Geng *et al.*, 2012: 24).

Proir studies show that the evaluation of essential attributes and the application of appropriate evaluation methods are important factors in the adoption of M-commerce applications and also in the enhancement of user experiences of these applications (Anand *et al.*, 2010: 2; Alshehri & Freeman, 2012: 4; Alghamdi *et al.*, 2013: 58). It is, therefore, important that mobile devices and M-commerce applications will be significantly sensitive to the impact of the essential attributes of the usability model and approriate evaluation methods during evaluations. Mobile and M-comerce applications are used in different task settings and within various limitations. A proir research indicates that the components of the essential attributes, set forth by the usability model, as well as appropriate evaluation methods for M-commerce applications have not been thoroughly researched (Muslukhov *et al.*, 2013: 277).

It is important to identify appropriate attributes of the usability model as well as the most appropriate evaluation method for M-commerce applications as this, in turn, will help to enhance users' shopping experiences. The models developed by ISO and Nielsen (1994a: 26) suggest *context of use*, *user* and *task* as the three factors which greatly affect the overall success of an application's usability. However, these factors need to be discussed in the context of M-commerce websites, as they had previously been investigated in terms of ISO standards and Nielsen's model in the context of desktop-based applications.

A meta-analysis research conducted by Coursaris and Kim (2011: 129-130) on the usability of mobile applications which involved research resources between the years 2000 and 2010 asks for futher research regarding the impact of essential attributes for specific applications. Muslukhov *et al.* (2013: 277) stress the need for additional research to idenify the essential factors of mobile applications. This researcher holds forth that as they directly influence the adoption and improved user experience of M-commerce applications, there is urgent need to determine the essential attributes to be included in a usability model, as well as appropriate evaluation methods to facilitate the usability evaluation of M-commerce applications. Viewed within this context, the current research work seeks to address the imbalance in literature by coducting in-depth research to determine the attributes of a usability model and evlaution methods which are most approriate to evaluate M-commerce applications.

Therefore, to validate the proposed usability model, an appropriate usability evaluation method is required to evaluate existing M-commerce websites. The inappropriate application of usability evaluation method/s to evaluate of M-commerce applications will prevent the discovery of potential usability problems which will directly impact user experience (Fetaji & Fetaji, 2011: 184; Swierenga *et al.*, 2014: 377). Earlier studies suggest that domain-based heuristics which focus on the context of the application's use are needed as desktop-based heuristics presume the stable nature of desktop applications (Korhonen, 2011: 1; Inostroza *et al.*, 2013: 24–25; De Lima *et al.*, 2016: 6).

The desktop-based heuristics may not be suited if applied on all ranges of mobile interfaces and may, in fact, be deemed unfit in representing the characteristics of mobile-based interfaces (Inostroza *et al.*, 2013: 24). There are various heuristics used to evaluate the usability of software user interface, these heuristics might not be able to reveal some of the usability problems of mobile applications (Jerzak & Rebelo, 2014: 456–457). The researcher proposes that the development of domain-specific heuristics might serve as a solution towards improving M-commerce user experience delivery.

The main research task, which will be addressed in this research work, is to determine the essential attributes of a usability model as well as formulate a domain-based evaluation method appropriate for usability evaluation of M-commerce websites. Seeing that this problem negatively affects user experience which, in turn, limits market growth, the research will have far-reaching benefits and could be widely applied. In other words, solving these problems will allow usability experts to improve the usability of M-commerce applications and, consequently, will improve M-commerce user experience. The final goal is to improve M-commerce user experience (using usability) for this new domain. The researcher argues that there is a limited number of research resources regarding which attributes of the usability model and domain-specific evaluation method are most appropriate when evaluating M-commerce websites. As a result, there is the need for thorough review and research in order to address this identified gap in literature.

1.4 Research Questions

Based on the problem statement, five research questions have been identified. The main research question is followed by the four secondary research questions. The main research question is:

Which domain-specific evaluation method is most appropriate for the usability evaluation of M-commerce applications?

Sub-Research Questions:

1. What are the essential attributes of the usability model that are most appropriate in the context of M-commerce websites?
2. What is the landscape of usability evaluation methods in respect to when to use which evaluation method/s in the context of mobile applications?
3. How appropriate is the suggested domain-specific heuristic evaluation method for evaluating the usability of M-commerce websites?
4. What is the effectiveness of the proposed domain-specific evaluation method in the usability evaluation of M-commerce websites?

The above stated research questions focus on identifying the essential attributes of usability models and the most appropriate domain-specific evaluation method to evaluate the usability of M-commerce applications. The study focused on two fundamental variables: *the essential attributes* and *evaluation method/s* for the usability evaluation of M-commerce websites.

1.5 Study Objectives

The aim of the current study is to determine which domain-specific evaluation methods are most appropriate for evaluating the usability of M-commerce applications.

The four objectives that this research seeks to address are:

1. Determine which essential attributes of the usability model are most appropriate in the context of M-commerce websites.
2. Propose a landscape of usability evaluation methods, in respect of when to use which evaluation method/s in the context of mobile applications.
3. Develop appropriate domain-specific heuristic evaluation method for evaluating the usability of M-commerce websites.
4. Determine the effectiveness of the proposed domain-specific evaluation method in the usability evaluation of M-commerce websites.

1.6 The Research Design and Methodology

The design of a research study is the blueprint, or roadmap, which outlines the methods by which the intended research will be conducted (Baxter & Jack, 2008: 555; Creswell *et al.*, 2011: 7). A number of methods are employed to acquire data. These include: observation, questionnaires, interviews and the use of secondary data (Paltved & Musaeus, 2012: 785). However, the final decision as to the research design culminates in the choice of technique/s to acquire data and the methods used to analyse said data. This section briefly discusses the research design elements employed in this research study. It also discusses the significance of the methodological choice and strategy as well as the design timeframe. In addition, the section describes the research instrument selection process and highlights the importance of research design coherence. The following section will explain the research design elements used in this study.

1.6.1 The Research Design

The choice of design elements, which demarcate the medium and techniques used for data collection and data analysis, were afforded careful consideration. The research design elements of research philosophy, reasoning approach, research strategy, research choice and research time horizon, as suggested by Saunders, Lewis and Thornhill (2007: 102), were used. This research study adopted the metaphoric *Research Onion*, as per Chapter 5, to illustrate the elements in respect to other design elements. This research metaphor was initially formulated by Saunders *et al.* (2007: 102) and has consequently been used by many researchers and scholars to elucidate research studies (Elli, 2011: 59; Boampong, 2014: 25).

1.6.1.1 Research Philosophy

The individual opinion of the researcher regarding that which constitutes suitable knowledge and which procedures to be followed impact on the research philosophy (Al-Khouri, 2007: 1; Miles, 2015: 309–310). Researchers' strategies, as well as their choice of methodologies, can differ significantly and so too their views regarding what data are considered meaningful and applicable (Gray, 2013: 24). A researcher, who is interested in observing and forecasting possible outcomes, would be concerned with cause and effect. This approach illustrates the adoption of a positivist philosophy. In the case of a researcher who adopts a scientific approach to testing theories and which organises and measures data meticulously, his/her value system will minimally affect the research process (Taton, 2015: 32–38) which involves sizable specimens of quantitative data and statistical hypothesis examination. There are many research philosophies including: realism, interpretivism, positivism, critical research, hermeneutics, functionalism and pragmatism. Each of these research philosophy will be discussed in detail in Chapter 5.

Based on a review of the specific characteristics of each research philosophy, *pragmatic philosophy* was identified as the right fit for this study and consequently adopted as the research philosophy to guide the research. The pragmatic philosophy has certain characteristics. Firstly, empirical and subjective data are employed to gain a better insight into the problem (Hartig, 2011: 165). Secondly, the context of use of the case studies is an ontological reality (Gray, 2013: 15). This research work focuses on the natural users' environment which imbues the study with an authenticity as the investigated case study/product is problem-centred. The approach permits research execution with data, even when there is a limitation to the data collection domain process. In addition, the approach permits data collection in a concurrent way by allowing for the collection of the first and subsequent samples of data at the same time (Baxter & Jack, 2008: 554–555).

1.6.1.2 Reasoning Approach

The reasoning approach and the construct of the research argument can follow either an *inductive* or *deductive* path. The inductive approach refers to reasoning from a specific to a general view whilst the deductive approach indicates reasoning from a general to a specific or particular view (Gray, 2013: 3). This study adopted an *inductive* reasoning strategy in which research conclusions were drawn from specific observations and then applied as a general finding (Babbie, 2010: 50; Katz, 2015: 133–136).

1.6.1.3 Research Strategy

The next layer in the research onion is the research strategy, or strategies. This section in the research journey emphasises that the researcher is allowed to employ multiple strategies to address the research question/s. These available research strategies might include: grounded theory, ethnography, case study, laboratory work, surveys and action research. Each of these strategies is further discussed in Chapter 5 of this thesis. Case studies are employed to examine and/or explain observable facts by means of a thorough study of the natural surroundings (Easton, 2010: 118; Miles, 2015: 313–315). Generally, a researcher needs to perform copious amounts of research and investigative work to elucidate particular cases. This current study employed a multiple case study method and a field experimental research strategy. Multiple case studies allow for comparisons which, in turn, enhance in-depth investigations, understanding and consequent analysis of data. In addition, the current research adopted the field experimental methodology as the most suitable approach to achieving the research objectives and answering the questions, as outlined in sections 1.4 and 1.5.

1.6.1.4 Research Choice

One of the choices which a researcher must make is whether to adopt a qualitative method/s, a quantitative method/s or a combination of these two methods. The research choice of mixed methods, multiple methods or a mono-method is determined by the nature of the research questions which need to be answered. This will be discussed in more detail in Chapter 5. A *mixed methods* design includes both qualitative and quantitative data collection approaches and analysis procedures (Ellis & Levy, 2009: 332; Reimann, 2010: 14). A simple mixed method design allows the researcher to start with the collection and analysis of a qualitative data and to then augment this with quantitative data collection and analysis. Therefore, since this research work requires the collection of both qualitative and quantitative data, the *mixed method approach* was adopted as it allows the triangulation of both qualitative and quantitative data.

1.6.1.5 Research Time Horizon

The research time horizon can be described as the availability of time in which to carry out the research. When research is carried out in order to address a problem, or to answer a query by a specific time, the researcher may choose to employ strategies such as case study or survey.

This methodology is known as a *cross-sectional method* (Raoprasert & Islam, 2010: 67). Another research strategy is the longitudinal method which is discussed along with the cross-sectional method in Chapter 5. This research study adopted a cross-sectional approach because the study was time sensitive. Mobile devices and mobile websites change rapidly and new instances flood the market daily, this being the reason for adopting a cross-sectional methodology.

1.6.2 Research Methodology

The components of the research design were presented in sub-section 1.6.1. The methods used in the selection of the evaluation methods and the mobile websites used as case studies will be presented in Chapters 3, 4 and 5. The experimental procedures, materials and equipment used in the evaluation methods will be explained in more detail in Chapter 5. The following sections give a brief overview as to the stages followed in order to address the current research questions, as per sections 1.4 and 1.5.

1.6.2.1 Stage 1

The stage one of the current research involved a literature study which is discussed in detail in Chapters 2, 3 and 4. This stage sought answers to Research Questions 1, 2 and 3. Chapter 2 provides details regarding the literature review which describes the attributes of usability and frequencies of use of each attribute in the context of mobile empirical usability evaluation studies. In addition, the researcher identified attributes of a proposed usability model in the context of M-commerce applications, which helped to address Research Question 1.

Chapter 3 presents the evaluation methods and their frequencies of use in the context of mobile usability evaluations. This chapter proposes a landscape of possible evaluation methods in response to when to use which evaluation methods in the context of mobile applications. In addition, a user testing method (remote asynchronous) is identified as one of the appropriate usability evaluation methods for the evaluation of M-commerce applications. This assisted to address Research Question 2 of the current study.

Chapter 4 addresses the need for an appropriate expert-based evaluation method to execute a usability evaluation of M-commerce applications. To answer Research Question 3, this current study uses the traditional heuristics (Nielsen’s heuristics) to develop a domain-specific evaluation method for evaluating the usability of M-commerce applications.

1.6.2.2 Stage 2

Chapter 2 identifies the essential attributes of a newly developed usability model, thus providing the attributes to be considered in the usability evaluations of the four selected websites. As appropriate methods for evaluating the usability of M-commerce applications, a user-based evaluation method (remote asynchronous testing) is identified in Chapter 3 and a domain-specific evaluation method is developed in Chapter 4.

Stage 2 is addressed in Chapter 5 of the current study. Based on the findings obtained in Stage 1, the design and methodology used in the experimental studies of this research work are discussed in Chapter 5. The design and methodology for the two usability evaluations of four selected M-commerce websites are presented. The details of the experimental procedures used in both evaluation methods are presented. In addition, the test participants for both experiments, along with their demographic details, are presented. Chapter 5 also discusses research validity and reliability as well as the triangulation for both quantitative and qualitative data, as garnered from two selected evaluation methods, for usability evaluation of four M-commerce websites.

1.6.2.3 Stage 3

Chapter 5 in Stage 2 provides the details of the methodological procedures for the two experiments. Therefore, Stage 3 is addressed in Chapters 6, 7 and 8. Chapter 6 describes and analyses the qualitative and quantitative results collected by the two selected usability evaluation methods. In addition, the findings presented in Chapter 6 show the effectiveness of both evaluation methods in the evaluation of four M-commerce websites and, as such, they help to answer Research Question 4.

Chapter 7 presents a proposed framework that can be adopted for the evaluation of M-commerce applications. The chapter incorporates an updated version of a proposed model into the framework for evaluating the usability of M-commerce websites. The framework is suggested contingent on the analysis of the research findings obtained during the applications of two evaluation methods on the four selected M-commerce websites. Chapter 8 details how each of the four research objectives was accomplished. In addition, the chapter discusses the research limitations and research contributions. The researcher presents the recommendations for further studies and the formal conclusion at the Chapter 8.

1.7 Significance of the Research

The research work could benefit several sectors of society. *Firstly*, and most importantly, designers of M-commerce websites can utilise the study results to check which attribute/s and evaluation methods are most appropriate and, by including these, they could improve the end-user experience. This process could benefit both existing and newly created websites.

Secondly, the study will aid the retail sector in the following ways:

- The range of products and services offered by M-commerce websites is increasing daily. It thus follows that it is important to build a sound platform where one can access specific information regarding the end-User Experience (UX design) and User Interface (UI) available on M-commerce websites. Many experts have reported that most of the guidelines associated with E-commerce and M-commerce websites may not have been empirically validated which makes them irrelevant in certain instances (Lowry *et al*., 2006: 1; Coursaris *et al.*, 2012: 1448; Charfi, Ezzedine & Kolski, 2014: 114–115; De Lima Salgado & Freire, 2014: 178–184).
- A point worth considering is that a successful UI in M-commerce websites remains key to the success and survival of M-commerce businesses ventures. To attract users to M-commerce websites, the following pivotal points need to be considered: high quality content offered by the application, ease of use of UI, speedy response as well as periodic updates. However, various studies have highlighted that M-commerce applications suffer problems which often relate back to UI usability issues (Hillman *et al.*, 2012: 113–122; Gitau & Nzuki, 2014: 88–93).
- The role which end-UX plays in the M-commerce businesses domain has not been sufficiently researched (Rivero, Kawakami & Conte, 2014: 162; Tehrani *et al.*, 2014: 227–231) This study aims to add valuable insights to this topic.

Thirdly, this study will benefit the end users of M-commerce applications. These end users, or mobile shoppers, will be able to surf M-commerce websites which, as a result of having adopted user-friendly UIs, will be easier to navigate.

Fourthly, the study will be beneficial to the academic community. The guidelines associated with the evaluation process of M-commerce websites can be included in the scientific body of knowledge. Furthermore, the research outcomes will aid UX professionals in accessing the proposed domain-specific heuristics for evaluating the usability of M-commerce websites.

Fifthly, the approach which guided the literature review process to identify the relevant research papers (resulting in the list of attributes and evaluation methods as per Chapters 2 and 3) signifies a welcome development. This approach will go a long way in informing HCI professionals as to which database/s contain which papers in relation to mobile empirical usability studies.

This research study is particularly important as very few current resources address M-commerce usability problems. The study will thus augment this knowledge gap through its substantial contributions to this topic. Viewed against the backdrop of the pressing need to identify essential attributes of the usability model, as well as developing domain-specific evaluation method for usability evaluation of M-commerce websites, all contributions are significant. The research will thus enable future projections of M-commerce and WAP platforms as a means of generally improving UX for mobile shoppers and users of M-commerce applications.

1.8 Assumptions, Delimitations and Limitations

This research study aims to investigate concerns associated with usability attributes and evaluation methods within the context of user interaction with M-commerce websites. Therefore, the research study will examine only the areas which are affiliated with the usability context based on the M-commerce platform. Findings from current literature in this field of study will be included in this current study.

Due to the broad nature of the topic, the current study has had to impose some limitations. There are, however, similarities to the developmental processes of M-commerce and E-commerce websites. Research conducted in this study will be restricted to the usability of M-commerce platforms.

Ethical standards were maintained throughout the study. Personal or private data belonging to an individual, or a group, were only recorded once appropriate permission had been granted by the research participant/s. Statistical findings described in this research study are based on original research findings and have not been modified, unless specified otherwise. Although contributions and recommendations from the research study are aimed at enhancing mobile applications in general, specific results and/or outcomes are more suited to the improvement and enhancement of M-commerce websites.

1.9 Research Validation Methods

Many scholars have recommended various ways to address different kinds of validity. This is relevant to HCI research as well (Wetter, 2011: 68; Cooper & Schindler, 2014: 229–234). In confirming the internal validity of the research study, scholars suggest that researchers take careful note of the instrumentation and selection processes being used. Instrumentation is valid when comparing methods or groups. Therefore, the same evaluators cannot be restricted to distinct Usability Evaluation Methods (UEMs) and, at the same time, be required to determine, classify and/or evaluate usability problems. However, *selection* reflects the characteristics of the study participants.

At the beginning of the heuristic evaluation process the new draft set of heuristics, developed as per Chapter 4, was subjected to review by usability professionals in order to obtain several expert opinions regarding each heuristic. The procedure is discussed in more detail in Chapter 5, section 5.4.6.2.

To ensure validity, the recruited experts in the heuristic evaluation individually determined usability problems. However, the analysis of both heuristic evaluation and user testing data obtained from the respective test sessions was determined by the researcher. Selection problems, as and if they arrived, were carefully considered during the recruitment of participants. Participants' characteristics for each method of user testing were based on the user profiles from pre-test questionnaire. Furthermore, the experts who took part in the heuristic evaluation process all possessed comparable experience in the area of heuristic evaluation. Unanticipated features were not included in these tests.

The reliability of an evaluation technique is reflected in how well the method generates similar, or exact, findings in distinct events under comparable conditions (Leimeister, 2010: 10; Cronholm & Göbel, 2015: 471). With respect to user testing in the usability evaluation of user interface, reliability is concerned with whether or not the same results can be collected if the assessment process was to be repeated (Nielsen, 1994a: 57–71). Due to time limitations it was hard to use the same methods twice to examine whether comparable results would be achieved in the course of the research. However, certain techniques, as described in detail in Chapter 5, did test reliably in this research study.

1.10 Ethical Considerations

This research work complies with the University of South Africa's (UNISA) ethical standards.

An approval to conduct the study, along with an ethical clearance certificate, was granted shortly after a request was submitted to the UNISA's College of Science, Engineering and Technology (CSET) Research Ethics Committee as per Appendix 14.

Vulnerable participants were not allowed to take part in the research. All participants were 18 years of age, or older, and were required to complete the pre-test questionnaire, as per Appendix 5. All participants in the current research work were required to voluntary complete the informed consent form, which also contained the aims of the study, prior to soliciting information or using their data, as per Appendices 15 and 16. The methods to be used during the study were explained to the participants and they were informed that they could quit the study at any point, even after they had completed the informed consent forms.

1.11 Structure of the Thesis

This study comprises three parts: the theoretical part, the practical part and the final part which presents the research conclusions and suggestions. The three sections will now be briefly discussed:

Part 1: Theoretical Framework and Literature Review

Chapters 2 to 4 present a review of available studies. Background information is provided on the following: M-commerce websites, UX, usability of websites, various methodologies applied to evaluate usability with specific focus afforded to heuristic evaluation and user testing methods. A number of referenced literature materials form the baseline of the study. Various areas of study such as M-commerce, UX, usability attributes and evaluation methods are integrated and, as such, they give rise to the formulation of appropriate criteria for evaluating M-commerce websites.

Part 2: Empirical

The research design and methodology applied towards the usability evaluations of M-commerce applications are discussed in Chapter 5. The chapter specifies the required design, data collection methods and analysis applied as well as an explanation as to the importance of the methodological choice, road map (strategy) and time frame for design. Chapter 5 also describes the selection process of research instruments and research execution. In addition, it provides a recap of research objectives as well as the triangulation of the selected methods and concludes by highlighting the coherence of the research design.

Chapter 6 presents an extensive and in-depth analysis of the results of both testing methods. As mentioned earlier, two evaluation methods namely: *user testing* and *heuristic evaluation methods* were used to analyse the usability aspect of the selected M-commerce websites. These form the basis of the experimental research. The outcomes of the evaluation methods are documented, analysed and compared to one another. Based on this data, the main conclusions of the study are discussed.

Chapter 7 presents a proposed framework which can be used to evaluate the usability of particular problem areas on M-commerce websites. To understand and analyse the proposed framework for evaluating the usability of M-commerce websites, the research presents three phases, as described in Chapter 7. The framework includes five guidelines as pre-check guides for M-commerce usability as well as best practices to employ. The guidelines were formulated after four leading M-commerce websites had been evaluated with the aid of the two usability evaluation methods.

Part 3: Conclusions

Chapter 8 presents the summary and conclusion of the research work as well as how the research objectives were accomplished. The research guidelines are formulated in an effort to enhance UXs of mobile shoppers when interacting with M-commerce websites. In addition, the chapter defines the limitations to the study and presents recommendations to aid researchers in their future studies.

1.12 Conclusion

Chapter 1 introduces the research and details the research setting. In addition, it specifies the problem statement and explains its origins. The research questions and objectives are presented, and the aims of the research are revealed. A layout of the entire thesis is presented, and the concluding section summarises the introductory section.

This research study has both theoretical and practical applications. The research work intends to contribute significantly to the usability engineering and UX fields of study, through adding theoretical and empirical value. Similarly, the conclusions derived, and recommendations made will have practical implications in relation to the identified problems.

Chapter 2 will provide a section of the literature review on usability attributes which contextualises this research in relation to prior and related studies. In addition, Chapter 2 will outline the way in which this research will address an explicit research problem that has not been previously dealt with. The chapter will also explain certain key concepts and will present the theoretical background to this research work.

Chapter 2: Usability Attributes

2.1 Introduction

The popularity of mobile devices has promoted the widespread development of mobile applications which mobile users can access anytime and anywhere (Lin, Li & Li, 2010: 1; Poulcheria & Costas, 2012: 87; Gitau & Nzuki, 2014: 88; Kulpa & Amaral, 2014: 273). Mobile device developers, in most cases, fail to take into consideration the fact that interactions with mobile devices will sometimes occur while individuals are on the move (Asghar, Cang & Yu, 2018: 195–200; Wang, Tsai, Lu & Wang, 2019: 58–63).

Some of the problems that affect the design of small and mobile devices are: the high rate of power consumption, small size of the screen, limitations in connectivity and input modality limitation (Seix, Veloso & Soler, 2012: 2; Neto & Pimentel, 2013: 96; Raptis *et al.*, 2013: 135; Djamasbi *et al.*, 2014: 299). A major problem faced when utilising mobile technology is the context in which they are used (Quaresma & Gonçalves, 2014: 353). Mobile devices are designed to be utilised on the move, thus, the *mobility effect* is a key determinant to the successful adoption of mobile applications (Gafni, 2009: 755; Ozok & Wei, 2010: 130; Mizouni *et al.*, 2011: 184; Beul-Leusmann *et al.*, 2014: 217).

Prior studies have shown that ascertaining essential attributes in the usability evaluation is an important factor in improving the adoption and UX of M-commerce applications (Anand *et al.*, 2010: 2; Alshehri & Freeman, 2012: 4; Alghamdi *et al.*, 2013: 58). Mobile devices and M-commerce applications are significantly sensitive to the impacts of identifying essential attributes because they are utilised in different task settings. As discovered in this study, the identification of essential attributes of the usability model has not been well researched in present usability models. The developed models are often used for applications in the mobile context (Muslukhov *et al.*, 2013: 277).

The current research work proposes the MObile Shoppers Application Development (MOSAD) usability model for M-commerce applications. This model determines appropriate attributes which have a direct benefit on the adoption as well as resulting in an improved UX of M-commerce applications. The researcher presents a literature review for validating the development of the MOSAD model. This research work examined a general list of usability attributes which occurred in usability evaluations contained in various published research studies between 2005 and October 2018,[1] as well as attributes proposed in the MOSAD model.

Literature shows that few researchers have conducted usability experiments in which the essential attributes of the usability model are determined in the evaluation of a M-commerce application. In light of this, this research work seeks to address this imbalance in literature by determining which attributes of the MOSAD model are most appropriate for the evaluation of M-commerce applications.

Research conducted by Coursaris and Kim (2011: 129-130) involved a meta-analysis of research resources between the years 2000 and 2010 reagarding the usability of mobile applications. Their research seeks further investigation into the impact of essential attributes for specific applications. Muslukhov *et al.* (2013: 277) stress the need for additional research to identify essential factors that impact on overall success of the mobile applications. Thus, Chapter 2 seeks to determine the essential attributes of the usability model for evaluation of the usability of M-commerce applications. The current research will enhance the UX and directly impact adoption and result in a better UX of M-commerce applications.

In subsequent chapters the researcher will also present the findings on usability studies of M-commerce applications. Possible additional research options for researchers to consider while conducting usability evaluations on M-commerce applications will also be presented. The following section discusses the approach used for the review of the literature.

2.2 Techniques Used in the Review of Research Resources

In order to assimilate the relevant research resources in the areas of mobile and M-commerce applications to be used in the current research work, the researcher performed a review of the literature on selected resources. This study examined the general list of usability attributes and methods which formed part of usability evaluations as presented in different published research studies dated 2005 to 2018. The resources reviewed in this study were obtained from academic and non-academic sources (statistical data compilations and publications) as indicated by literature references (Howard, 2009: 5). The researcher explored different sources by using keywords (González-Pérez *et al.*, 2017: 1–5). Sources accessed included, amongst others: Google Scholar search engine, Emerald, SpringerLink, ScienceDirect, the Association for

[1] The literature search covered the period between 2005 and October 2018. Therefore, not the whole of 2018 is covered in the research resources search process.

Computing Machinery (ACM) database, the Institute of Electrical and Electronics Engineers (IEEE) database, the UNISA subject databases and other Human-Computer Interaction (HCI) database sources.

Amongst the keywords used to search for relevant articles were: usability attributes, mobile E-commerce usability, E-commerce usability attributes, mobile commerce usability attributes, usability methods, E-commerce usability, E-commerce usability methods, E-commerce usability problems, mobile usability issues, mobile usability problems, mobile usability, mobile usability methods, E-commerce usability issues, mobile E-commerce usability issues, mobile E-commerce usability problems, mobile E-commerce usability, mobile E-commerce usability methods, E-commerce usability, usability theory, usability engineering, usability studies and heuristic evaluation method.

The resources selected for this research work are based on certain selection criteria which formed the basis for the inclusion and exclusion of research resources (Álvarez *et al.*, 2017: 2). Research resources included were those published between 2005 and 2018. The selection criteria were contingent upon whether the research resource:

- Performed an evaluation of mobile applications.
- Contained software components (e.g. paper prototype) which allows users to interact with it.
- Focused on users' interactions with the applications or devices and also conducted an evaluation.

Table 2.1: Total number of research papers used in the literature review

Name of Database/Search Engine	**Step 1:** Total of publications found via Search strings	**Step 2:** Initial selection decision after reading abstracts	**Step 3:** Sub-total of papers selected after applying selection criteria	**Step 4:** Sub-total of papers selected via list of refences of papers selected in Step 3	Final total of papers selected	Search date	Year covered by search
IEEEXplore	256	188	17	15	32	2015-2018	2005-2018
ACM Portal	466	376	220	68	288		
ScienceDirect	130	111	6	3	9		
Emerald	270	189	25	12	37		
GoogleScholar	210	134	66	33	99		
SpringerLink	144	89	9	6	15		
Total	**1476**	**1087**	**343**	**137**	**480**		

The method suggested by Randolph (2009: 7) subscribes to the view that electronic searches cannot yield 100% of the total research resources required for a literature review. The residual percentage can be identified by reviewing the reference list containing the research resources which had already been retrieved. The researcher determined which among these were deemed relevant by using the inclusion selection criteria outlined above.

Table 2.1 depicts the total number of research resources identified in each database source. Initially, a total of 1476 research resources were retrieved by using the search strings and reading through the titles of the research resources. A total of 1087 research resources were chosen after their abstracts had been read. The researcher then applied the three selection criteria which reduced the total to 343 research resources. The researcher adopted the strategy proposed by Randolph (2009: 7) and revisited the reference lists of the research resources which had already been retrieved and passed the selection criteria. Using this approach, a total of 137 additional research resources were identified. The researcher repeated this process until no relevant research resources were found. Therefore, a total of 480 research resources adhered to the selection criteria and were consequently included in the literature review of the current study. The next section provides a brief background to E-commerce and M-commerce applications.

2.3 Brief Background to E-commerce and M-commerce Applications

The first M-commerce application was used in 1997 in Helsinki, Finland, in a Coca-Cola vending machine. The user could pay for the purchase via a mobile phone text message. Later that year, The Merita Bank of Finland employed the same principle (Wiebke, 2012). Subsequently, the use and application of M-commerce grew globally.

In 1999, two other platforms (i-Mode in Japan and Smart Money in the Philippines) were launched for M-commerce applications. From 2000 it became more convenient for people to buy parking tickets in Norway, train tickets in Austria and aeroplane tickets in Japan by simply using their personal mobile phones. In 2008, approximately 9 million registered users in the USA claimed to have made payments with their mobile phones to purchase goods and/or services. Although these M-commerce users only accounted for 3.6% of total mobile phone subscribers at the time, the numbers have consistently increased. By Christmas Day 2011, users of M-commerce applications had increased by 173% in the USA (Wiebke, 2012).

In April 2012, the Competition Commission of the European Commission (CCEC) conducted an in-depth investigation into the state of M-commerce. Results revealed that global mobile payment transactions in 2012 had totalled $171.5 billion (Helena, 2013). The M-commerce share of the total E-commerce sales is expected to reach in excess of $3.56 trillion by 2021 (Loesche, 2018).

In order to exploit this potential market for M-commerce, mobile phone manufacturers like Motorola, Nokia, Ericsson and Qualcomm are reaching agreements with different carriers to develop WAP-enabled smartphones with e-mail and fax capabilities. Historically, M-commerce has gradually moved away from the simple Short Message Service (SMS) systems, to actual applications, especially after the launch of iPhones. Although SMS has been used and accepted widely, it has significant drawbacks including problems with text entry and the absence of tactile feedback for key press confirmation (Page, 2013: 50).

Furthermore, the advancement in the functionalities of mobile devices has made it possible to add resources to mobile devices (Ajibola & Goosen, 2014: 954-956). Because of this improvement, mobile devices manufacturers have taken the opportunity offered by M-commerce activities to use features like location-based services, push notification and barcode scanning to enhance the shopping experience of customers in physical stores (Gündüz & Pathan, 2013: 116; Kojo, Heiskala & Virtanen, 2014: 261). Similarly, the launch of Google Wallet for mobile applications in September 2011 (Ghag & Hegde, 2012: 37–38) as well as the formation of a joint-venture for M-commerce in June 2011 further enhanced the operations of different mobile carriers. A result of M-commerce joint-ventures is that retailers can now allow their customers to: shop online, obtain product information, review products or redeem coupons while they are in the physical store (Gupta & Lakshmi, 2014: 124–125).

It is, therefore, not an overstatement to say that mobile-based M-commerce applications are being used daily. This is because the livelihood and survival of certain businesses, in the competitive sphere, depend on it. Examples of M-commerce applications available include, amongst others: mobile Automated Teller Machine (ATM), mobile advertising, mobile purchase, money transfer, content purchase and delivery of mobile vouchers, mobile auctions, location-based services, coupons and loyalty cards, mobile browsing, mobile banking, mobile transfers and information services (Golden & Regi, 2013: 11–12). These facilities have enabled people to do a lot more with their mobile phones and devices than with their wallets or purses. The next section outlines the different definitions of *usability* and identifies the particular definition which has been adopted in this thesis.

2.4 Definitions of Usability

Generally, *usability* is a term that comprises system aspects like user friendliness and ease of use of user interfaces. Over time, *usability* has been defined in different ways. These definitions are not *contradictory* but can rather be viewed as *complementary*. Usability thus involves the context of use, the users and the goal suitable to specific circumstances (Chalkia *et al.*, 2014: 359).

Usability is an important attribute in the development of products and software applications (Seffah *et al.*, 2006: 159; Bahn *et al.*, 2007: 492). In addition, usability comprises the degree to which users can achieve some design goals, while performing required tasks (Al-Badi & Mayhew, 2010: 2). Usability can be described as the level to which a software system, or product, has certain features which enable users to easily understand, operate and learn. It also refers to the degree to which they are protected from errors while interacting with user interfaces under specified conditions (Olsina *et al.*, 2014: 115).

Other researchers, such as Alghamdi *et al*. (2013: 63), consider *usability* as the quality of performing required tasks easily by any user interacting with a website. Different definitions of usability are presented in terms of different standards and in various ways.

In historical order, IEEE (1061, 1992: 33) defines usability as:

> *"…the ease with which a user can learn to operate, prepare inputs for, and interpret outputs of a system or component…"*

The ISO/International Electrotechnical Commission (IEC) (9241-11, 2000: 14) standards define usability as:

> *"…the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use…"*

In addition, ISO/IEC (9126-1, 2001: 10) standards define usability as:

> *"…the capability of the software product to be understood, learned, used and attractive to the user, when used under specified conditions…"*

The ISO/IEC (25010, 2011: 12) standards indicate that:

> *"…usability can either be specified or measured as a product quality characteristic in terms of its sub-characteristics, or specified or measured directly by measures that are a subset of quality in use…"*

Most recently, ISO (9241-11: 2018: 16) standards define usability as:

> *"…the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use…"*

Therefore, this research adopts the ISO (9241-11: 2018:16) standards' definition of usability, as presented above, which identifies satisfaction, efficiency and effectiveness as the attributes of usability. The current research argues that, for users to achieve high levels of total satisfaction with M-commerce interfaces, there is an urgent need to identify attributes and appropriate evaluation method/s to evaluate M-commerce applications. The next section outlines descriptions of *usability* for E-commerce applications.

2.5 Usability of E-commerce Applications

The characteristics of quality websites are difficult to capture and define in a general way. There are many perspectives regarding the quality obtained from using a website. The quality of websites is largely based on different task-related factors that affect end users. These include: content and function, adequacy, presentation quality, fun and pleasant presentation of the website (Kulpa & Amaral, 2014: 276). The efficiency of the end users and the service provider which manages the website are further affected by performance-related factors. These factors include: reliability of the system, system response time for ongoing tasks and transaction processes (Cáliz & Alamán, 2014: 253–255).

The most important and widely recognised requirement that websites should fulfil for user acceptance is *usability*. This requirement is essential for E-commerce websites. Therefore, if a customer is unable to perform simple tasks and becomes unsatisfied, due to poor usability, then he is likely to visit a competitor's website which is more user friendly (Al-Badi & Mayhew, 2010: 3).

Usability can be described as a characteristic that enables ease of use of E-commerce websites, not only during the development process but also during operation. Usability is one of the quality factors of E-commerce websites. According to previous research, usability is based on the reliability of the website which is linked to two aspects: *conceptual* reliability and *representative* reliability (Rababah & Masoud, 2010: 2). Conceptual reliability refers to the capacity of the E-commerce website to generate satisfaction amongst users. Representative reliability can be described as the E-commerce website's representation characteristics which affects the manipulation and understanding of the website through its lifecycle.

The researcher undertook this research study in order to provide an extensive list of attributes and quality factors. Other quality factors and attributes identified are: scalability, security and availability of E-commerce website software (Rababah & Masoud, 2010: 2–4). Scalability can be described as the capability to meet the rising demand of users and usage of the website. In the past few years, the need for scalability has been a driver for a number of technological innovations. The industry has developed new design strategies, new software languages and new communication and data transfer protocols in order to allow for the much needed growth of websites (Mizouni *et al.*, 2011: 184; Xu *et al.*, 2014: 1).

Security affects mobile communication and m-services due to the unique features associated with mobile devices. Portable computers and mobile devices are more vulnerable to loss or damage due to the physical features and contexts in which they are used (Alghamdi *et al.*, 2013: 54). The users of the mobile device are further affected by this privacy concern. It is worrisome when mobile users lose their mobile devices which contains private information including contacts, bank transaction details, photos and other personal and important information (Kakhki *et al.*, 2018: 25–32). While most interactive networked mediums are faced with privacy problems, it is more pronounced in the M-commerce application domain.

Availability can be described as the possibility that an application, or m-service, is easily accessible or the total amount of time, in percentage, that the system is in operation. The availability of a system, or m-service, can be viewed as stable when the authorised users have access to the data at all time, without any interruption. However, the system or m-service may be unavailable if there is critical network failure, physical plant disruptions or power disruptions, amongst others. Availability can be affected by the deliberate introduction of unwanted data (e.g. address spoofing) into the network (Mizouni *et al.*, 2011: 186; Yahya, Walters & Wills, 2017: 229). The next section will describe the usability of M-commerce applications.

2.6 Usability of M-commerce Applications

M-commerce has some specific features which are absent in traditional E-commerce, including: ubiquity, personalisation, flexibility and dissemination (Kurkovsky & Harihar, 2006: 227; Castro, Favela & García-Peña, 2011: 371; Chong, Chan & Ooi, 2012: 34; Oyomno *et al.*, 2013: 305). These features are explained below.

- **Ubiquity:** The mobile technology allows users to access information from any location. It assumes that the user is present within the cellular network area.

- **Personalisation:** The information is customised to address the needs of mobile shoppers/users in M-commerce because the memory capacity of the mobile hardware and software is limited.
- **Flexibility:** M-commerce offers flexibility to users. Mobile users enjoy the flexibility of using their devices to conduct transactions and to send and receive messages while they are engaged in other activities. For example, mobile devices can be used while traveling or working (Lin *et al.*, 2010: 1–2).
- **Dissemination:** Information can be delivered to cellular broadcast areas via the wireless network of M-commerce applications.

An earlier study suggests that M-commerce applications should be regarded as being complementary to E-commerce, as a shopping medium, and not as a direct alternative (Ozok & Wei, 2010: 111). Table 2.2 lists common M-commerce challenges as well their corresponding solutions.

Table 2.2: M-commerce Challenges and Potential Solutions[2]

Challenges/Problems	Solutions
Increasingly demands users' attention	Less interface attention
Real life users' environment	Provision for context-awareness
Usability and limitations of mobile devices	New and flexible I/O modalities
Security and privacy concerns	Biometrics
Safety	Strong legislation and safety-enabled design
Societal concern	Strong societal norms and law enforcement

Therefore, in order to establish a successful M-commerce environment, there are certain prerequisites that developers of M-commerce applications and usability professionals must adhere to. The simple conversion of a successful E-commerce business to an M-commerce does not guarantee success. Thus, merely translating and copying the contents of an E-commerce application onto an M-commerce application, using a step-by-step approach, would not yield good results. Kaur (2014: 21) identifies five factors fundamental to the transference of E-commerce websites to M-commerce applications.

- The first factor is the difficulty users have in using small keypads and the limited screen sizes of mobile devices which often do not display the contents properly (Seix *et al.*,

[2] The M-commerce challenges and the potential solutions in Table 2.2 are adapted from these studies (Ozok & Wei, 2010: 111–132; Tassabehji & Kamala, 2012: 489–494; Feng *et al.*, 2014: 206–215; Gitau & Nzuki, 2014: 88–93; Kaur, 2014: 20–24).

2012: 1; Xu *et al.*, 2014: 1). Therefore, when designing for mobile interfaces, developers of M-commerce applications need to provide limited and compacted web pages when compared to what is usually available on E-commerce websites.

- The second factor hinges on the fact that M-commerce has a particular goal namely its capability to present the required mobile content, in a standardised and customised way, to be considered successful (Ozok & Wei, 2010: 129; Hörold, Mayas & Krömker, 2014: 490). M-commerce customers cannot be compared to the users of E-commerce applications as M-commerce application users are usually set on attaining time sensitive goals. In most cases, M-commerce applications are designed to enable functionalities which support the time-sensitive nature of the interactions by facilitating ease of use.
- The cultural differences amongst users is the third factor that need to be addressed by developers of M-commerce applications. The users' acceptance of M-commerce applications has been, in part, attributed to developers' sensitivity to both cultural diversities as well as the unique behavioural needs of users (Coursaris *et al.*, 2012: 148). Research shows that experts hailing from different geographical locations may be influenced by their own geographic location as well as certain cross-cultural differences. The context of the expert thus affects his/her findings. This phenomenon can account for the differences experienced regarding usability problems which differ from method to method (Gündüz & Pathan, 2013: 117). However, a prior study compared the results attained by evaluators which hail from different cultural backgrounds. Said study indicates that differences in evaluators' cultural backgrounds have little, or no, impact on the identified usability problems in the thinking aloud testing during usability evaluation. Cultural differences, however, do affect severity ratings (Shi, 2010: 206-210).
- Security and privacy is the fourth essential factor to be heeded in the design of M-commerce applications. Security measures in M-commerce applications are important as mobile devices applications are particularly vulnerable. The world is a global village and security and privacy concerns substantially affect customers' perceptions of M-commerce applications. Thus, these concerns need to be addressed during the development of these applications (Sadi & Noordin, 2011: 496; Gitau & Nzuki, 2014: 92).

- Trust is the fifth important factor to be considered in the design and adoption of M-commerce applications. Users need to trust the processes implicitly as the interactions and data transmission levels inherent to the use of M-commerce applications are considerably higher than those in the E-commerce application environment (Hillman *et al.,* 2012: 113; Joubert & Belle, 2013: 36; Gitau & Nzuki, 2014: 92–93).

The above-mentioned factors indicate that M-commerce usability is still in its infancy and, consequently, only a few usability studies have been conducted. Accordingly, there is an urgent need to create a comprehensive list of attributes of usability models to help guide M-commerce system developers. M-commerce usability and user preferences thus indicate that improvement in this area is required.

Current literature suggests that M-commerce is certainly encouraging technological advances as the use of mobile devices is becoming increasingly popular and acceptable amongst users. Mobile technology is here to stay, and it promises to have a very bright future. Therefore, this chapter seeks to identify M-commerce usability attributes by reviewing a number of mobile empirical usability studies. In addition, this chapter aims to determine the essential attributes of the MOSAD model for M-commerce applications. The next section outlines the descriptions of general usability attributes in the field of HCI.

2.7 Usability Attributes

Usability attributes are defined as objective or subjective metrics, related to tasks, which are performed during the usability evaluation or testing process (Jokela *et al.*, 2006: 348). Usability attributes can be classified as either *qualitative* or *quantitative*. Examples of quantitative usability attributes are effectiveness, efficiency and learnability while the attributes of qualitative usability would be satisfaction, usefulness and adaptability (Kenteris, Gavalas & Economou, 2009: 114; Ajibola & Goosen, 2019: 41-49).

Some researchers classify usability attributes as *objective* or *subjective* (Ham, 2014: 373). Objective attributes involve the user's evaluation of task performance while a user's feelings, which relate to task attempted during evaluation, are referred to as subjective usability attributes (Ham, 2014: 373). According to the ISO definition presented in section 2.4, the *objective attributes* are effectiveness and efficiency whilst the *subjective attribute* is satisfaction (ISO 9241-11, 2018).

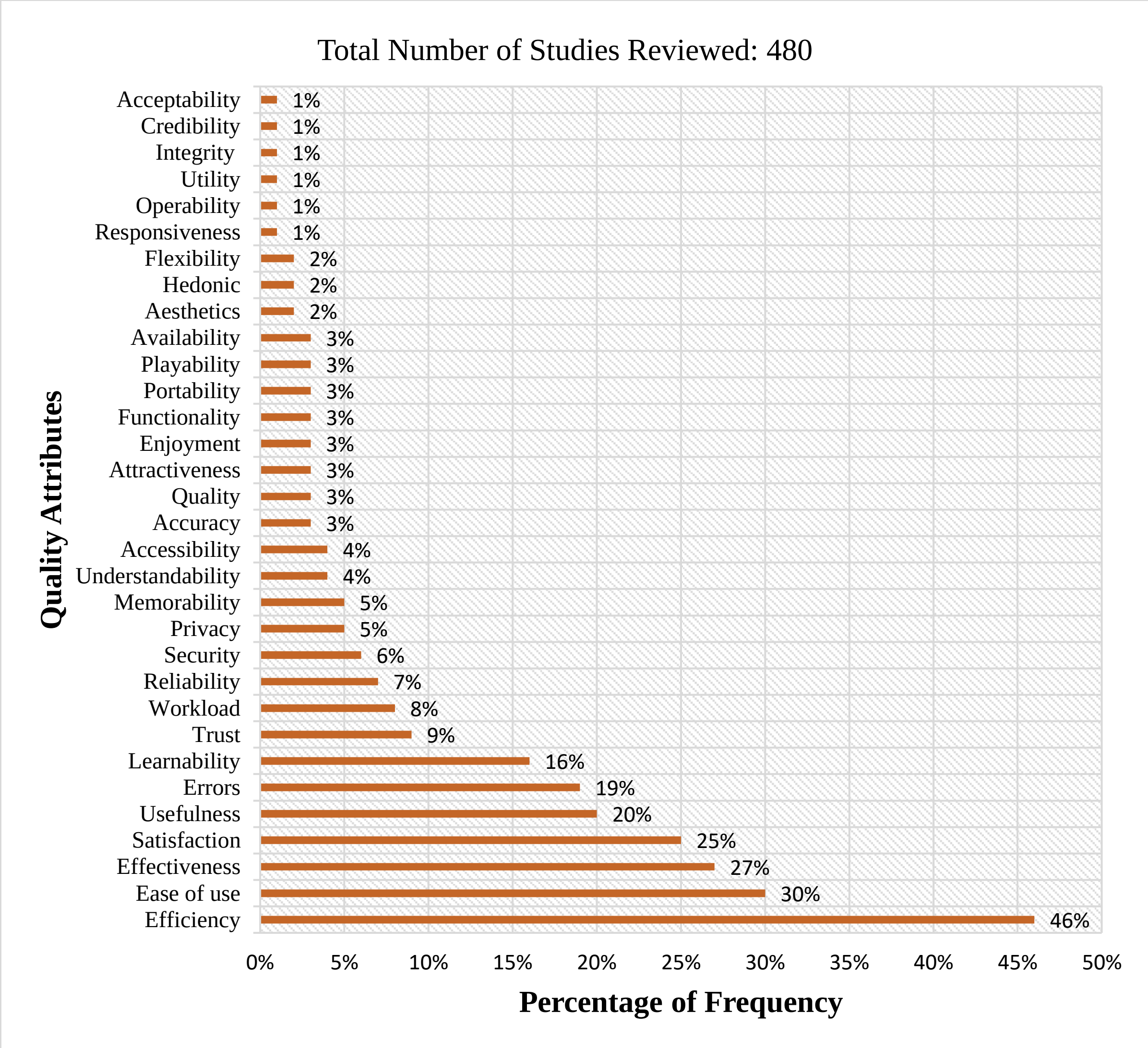


Figure 2.1: Frequency of Attributes Utilised in the Reviewed Studies

Previous research by Baharuddin, Singh and Razali (2013: 2228) identified 18 usability dimensions, while Coursaris and Kim (2011: 124–128; 2006: 4) identified 11 and 28 usability attributes, respectively, commonly evaluated in mobile applications. However, based on the literature review conducted on 480 relevant and selected studies, this research work identified 32 usability attributes in the context of mobile applications.

Figure 2.1 illustrates the frequency percentage of general attributes, as identified in the literature review of mobile empirical usability evaluation studies. The attributes of efficiency (48%), ease of use (29%), effectiveness (27%), satisfaction (25%), usefulness (22%), error rate (21%) and learnability (13%) are most frequently evaluated in the literature dated between 2005 and 2018. Table 2.3 presents a similar report regarding the percentage of most frequently evaluated attributes, as well as their similar patterns and frequencies, which support the findings of this thesis.

Table 2.3: Frequency of Attributes as Reviewed by Three Previous Studies

Attributes	Percentage	Literature Sources
Effectiveness	55%	(Baharuddin *et al.*, 2013: 2228)
Efficiency	55%	
Satisfaction	55%	
Usefulness	55%	
Aesthetics	55%	
Learnability	44%	
Efficiency	33%	(Coursaris & Kim, 2011: 24–26)
Error rate	27%	
Ease of use	10%	
Usefulness	8%	
Effectiveness	4%	
Satisfaction	4%	
Error rate	51%	(Coursaris & Kim, 2006: 4)
Efficiency	33%	
Effectiveness	11%	
Attitude	11%	
Learnability	11%	
Satisfaction	9%	

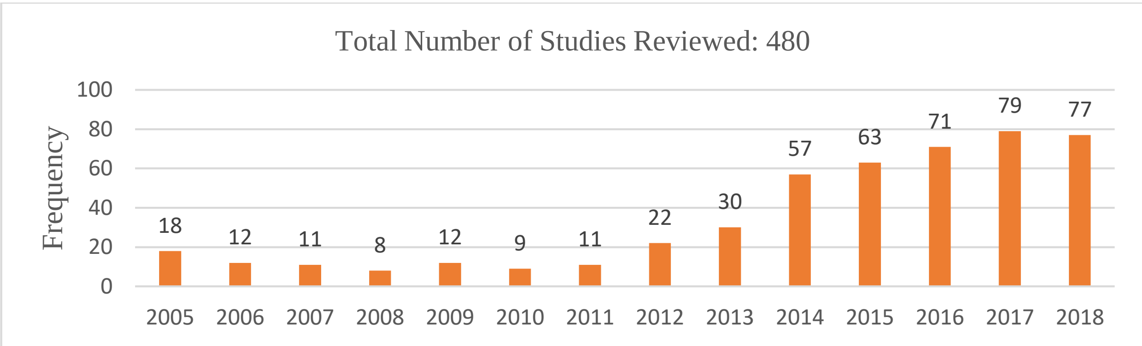


Figure 2.2: Frequency of Empirical Mobile Usability Evaluation Studies

Figure 2.2 shows the frequency of empirical mobile usability evaluation studies done between 2005 and 2018. The findings reveal that there was a significant increase in the frequency of mobile usability studies from 2010 to 2018. The increase is not accidental but can be ascribed to the fact that mobile applications (native mobile applications) became more prominent from 2012 (Budiu, 2013).

Figure 2.3 presents statistical data regarding the selected usability attributes as evaluated by usability professionals. As seen in Figure 2.3, *efficiency* is considered the most frequently evaluated usability attribute as it appears in 11 of the 14 years during which studies were reviewed. Furthermore, the domain of *usability attributes* was most frequently addressed between 2011 and 2018.

Ease of use is an attribute which indicates how easy it is for a user to learn how to operate a system. In addition to acquiring mobile applications to perform intended tasks, clarity in interaction, the ability to become more skilful in the use of the application and the ease with which the task is performed are considered important (Rivero *et al*., 2014: 167). In addition, the attribute *usefulness* is defined as a constituent of perceived ease of use (Liu & Li, 2011: 891). *Satisfaction* is described as pleasantness. A perceived degree of comfort is associated with the use of software by users (Harrison *et al.*, 2013: 4). Hence, *ease of use* and *usefulness*, as usability attributes, can be added to *satisfaction* which has a more general definition.

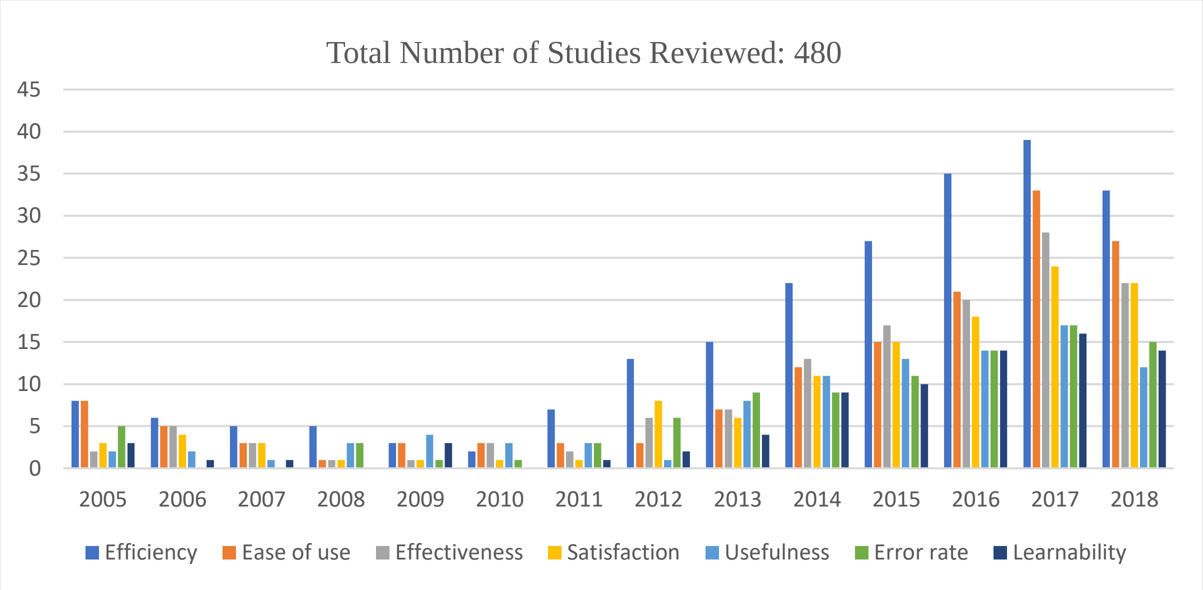


Figure 2.3: Frequency of Attributes evaluated within Mobile Usability Studies

Thus, in this research work, the main attributes to be included in the evaluation of mobile usability are identified based upon their relative appearance in the reviewed research resources. The study identified the following usability attributes in accordance with their prominence in the context of mobile applications: efficiency, ease of use, effectiveness, satisfaction, usefulness, error rate and learnability. The next section provides some background to the ISO and Nielsen’s usability attributes.

2.7.1 Brief Description of ISO and Nielsen's Usability Attributes

Various usability models are discussed in literature. The earliest usability models are those presented between 1991 and 1999 (Alghamdi *et al.*, 2013: 63). The ISO standards and Nielsen's models are, however, the most commonly and widely cited usability models found in literature (Cho, Yen, Dowding, Merrill & Schnall, 2018: 80–88; Othman, Sulaiman & Aman, 2018: 5–8). In addition, one of the earlier authoritative scholars in the field of usability engineering is Nielsen (Nielsen, 1994a: 151–169) and this justifies the inclusion of his research studies in this body of research.

Consequently, the ISO and Nielsen models serve as baselines for this research work. Nielsen identified the following five major attributes of usability:

- **Efficiency**: "Resources are expended in relation to the accuracy and completeness with which users achieve goals" (Nielsen, 1994a: 26).
- **Satisfaction:** Comfortable feeling and positive attitude of users when engaging with the product.
- **Learnability**: Users should be able to start and finish tasks easily without having to learn task processes all over again.
- **Memorability**: The system should allow users to recall their previous experiences, even if they did not utilised the system for a long period of time.
- **Errors**: The system should present minimal errors while users interact with it. If errors do occur, users should be able to address them easily. Also, the system should be free from *catastrophic* errors.

In selecting usability attributes, certain attributes are considered more important than others. Cáliz and Alamán (2014: 257) categorised usability attributes according to their importance: efficiency, effectiveness, satisfaction, learnability, accessibility, operability, memorability, acceptability and flexibility. Based on the application in use, different usability attributes play different critical roles. For example, *memorability* is a critical aspect of software which is not used frequently. *Efficiency* and *minimal errors* are more important in applications which require a short processing time (Korhonen & Koivisto, 2006: 12; Coursaris *et al.*, 2012: 1446). Determining which attributes to include in the usability evaluation of mobile and M-commerce applications is, therefore, very important. Prior studies show that the identification of essential attributes in usability evaluation plays an important role in the adoption and facilitation of an improved UXs of M-commerce applications (Anand *et al.*, 2010: 2-4; Alshehri & Freeman, 2012: 3-5; Alghamdi *et al.*, 2013: 58-60).

The ISO definition identifies three important factors when conducting usability evaluations.

- **Users**: The “person who interacts with a system, product or service” (ISO 9241-11, 2018). An earlier study indicates that users’ demographics (education, gender and/or age) as well as physical and sensory characteristics (visual and auditory, handedness and body dimensions) can also affect usability (Bevan, 2013: 283–285).
- **Goal**: An “intended outcome” (ISO 9241-11, 2018), refers to the expected outcome of user interaction with the product. In addition, it can be described as any responsibilities which are capable of affecting the usability of user interfaces (Bevan, 2013: 284–285).
- **Context of use**: The “combination of users, goals and tasks, resources, and environment” (ISO 9241-11, 2018). This factor consists of tasks or activities, users, technologies (software, hardware and materials) and psychosocial, social and physical environments in which the system or product is being used (Coursaris & Kim, 2011: 124; Ham, 2014: 373; Hörold *et al.*, 2014: 490). Prior research shows that usability depends on resource constraints, context of use and the design environment (Bevan, 2015: 2503–2504).

These factors impact on product design and development which, in turn, specifically influences user interactions with the product or system (Ponce *et al*., 2018: 111–118). The ISO standards suggest three measurable attributes which are linked to the usability of any product (ISO 9241-11, 2018):

- **Effectiveness**: The “accuracy and completeness with which users achieve specified goals”.
- **Efficiency**: The “resources used in relation to the results achieved”. The “typical resources include time, human effort, costs and materials”.
- **Satisfaction**: The “extent to which the user's physical, cognitive and emotional responses that result from the use of a system, product or service meet the user’s needs and expectations”.

Unlike the attributes of usability identified by Nielsen, the ISO standards do not include memorability, learnability and error rate as product usability attributes. It can be suggested though that they are implicitly contained in the definitions of satisfaction, effectiveness and efficiency. For example, learnability, memorability and error rates can be argued to have an overall effect on a user's effectiveness and efficiency.

2.7.2 Limitations of the Existing Models for Mobile Applications

The attributes discussed in the previous section were traditionally tailored to desktop applications and, as such, their applicability to mobile applications is limited (Costa, Silva & Aparício, 2007: 264; Coursaris *et al.*, 2012: 1446; Inostroza *et al.*, 2013: 25; Hörold *et al.*, 2014: 490; Rivero *et al.*, 2014: 161). For example, Nielsen's study focuses on the design and development of telecommunication systems which differ from computer software. The emergence of mobile devices present greater challenges for usability professionals as these devices are difficult to evaluate and align with traditional usability models (Lettner & Holzmann, 2012: 119; De Lima Salgado & Freire, 2014: 179).

Figure 2.4 presents a proposed mobile user centric model which should be considered in the design, development and usability evaluation of mobile applications in general, and M-commerce applications in particular. Figure 2.4 illustrates the main attributes which prominently feature in the review of empirical mobile usability studies: efficiency, effectiveness, satisfaction, learnability, ease of use, usefulness and error rate.

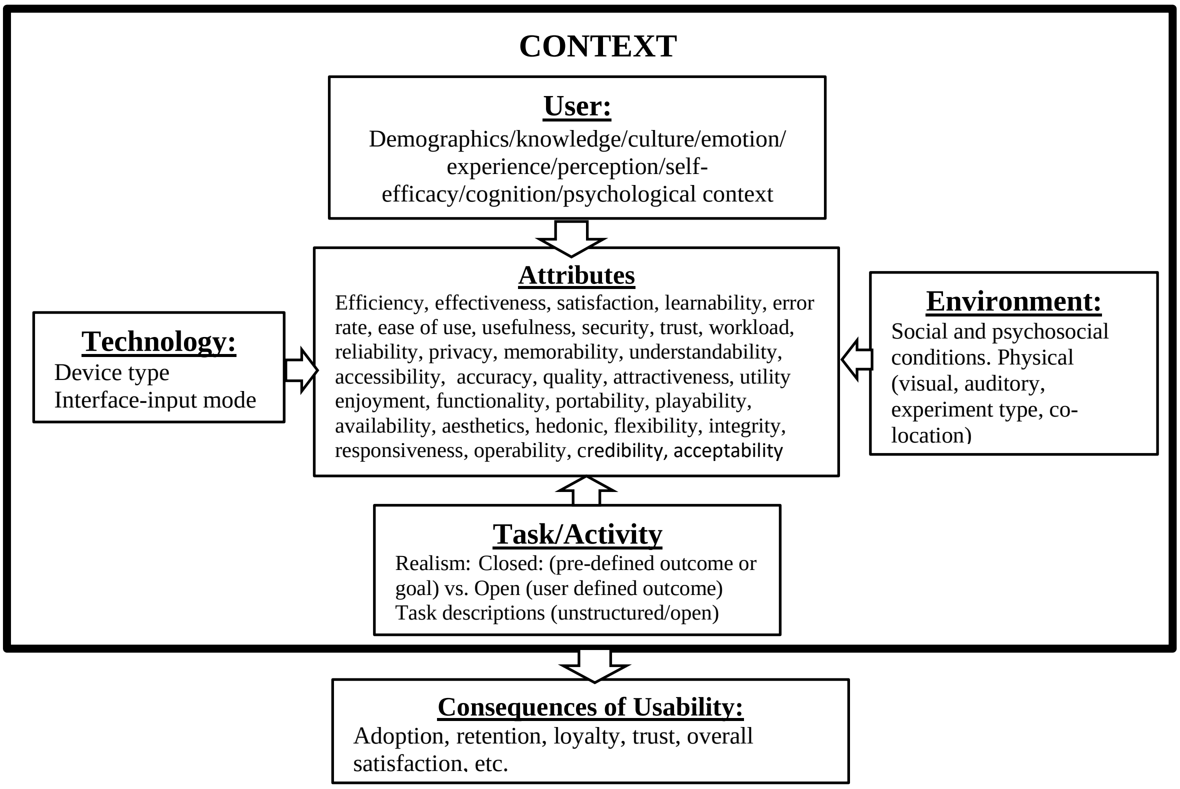


Figure 2.4: The proposed mobile User Centric model

The proposed model reveals some typical components found within the context of mobile application use namely: the user, technology, tasks and the environment. In addition, the model presents the main attributes that should be considered when conducting usability evaluations of M-commerce applications. Adoption, retention, loyalty, trust, overall satisfaction, amongst others, are considered *consequences* of usability in general and mobile usability in particular.

Furthermore, the usability of mobile applications differs from traditional software applications in terms of: screen size, limited processing capability and power, context, text and data entry methods and connectivity. These are discussed in the following section (Al-Razgan, Al-Khalifa & Al-Shahrani, 2014: 415):

- **Mobile Context:** When users interact with mobile applications, they are not restricted to a particular location. Mobile devices enable users to interact, particularly in instances where other people are near and environmental elements and objects, which may affect or restrict their mobile interactions, are present.
- **Small Screen Size:** To facilitate device portability, mobile devices usually have a limited screen size which affects the display information on the screen.
- **Data Entry Methods:** Mobile device input methods differ significantly from those of a desktop computer and, as such, they demand some level of proficiency, without which erroneous inputs would affect the rate of data entry.
- **Limited Processing Capability and Power**: Because they are very portable, mobile devices have less power and processing capability. As a result of these constraints, the type and number of applications available will be limited.
- **Connectivity:** The internet connectivity of mobile devices is often slower and not as dependable as desktop computers. This constraint affects the mobile applications' performance.

Researchers assert that the major challenge when using mobile applications is the inability, oftentimes, to predict all available environmental variables including body movement, task completion time, visibility as well as type and level of distraction (Alshehri & Freeman, 2012: 4).

The majority of literature reviewed indicated that existing models of usability fail to consider the need for mobility and other essential attributes appropriate to M-commerce applications and the consequences on UXs. This complicates the work of usability professionals who need to explicitly define task model inclusion in the context of *mobility* of mobile devices. In contrast, some usability professionals may argue that the *absence* of a specific context enhances the strength of the usability model. Thus, usability professionals should know how to initiate and modify the provided model to a specific context. The next section provides an overview of the proposed usability model for M-commerce applications. The proposed model will serve to address the previously identified gap in literature.

2.8 Proposed MOSAD Model

The MOSAD model is aimed at addressing the shortcomings evident in current usability models when attempting to evaluate M-commerce applications. Existing theories in usability studies serve as a foundation for the proposed MOSAD model for M-commerce applications. In addition, a prior study proposed a new model for mobile applications namely People At the Centre of Mobile Application Development (PACMAD) (Harrison *et al*., 2013: 9). PACMAD is applicable to mobile applications in general and does not adequately address specific mobile applications including M-commerce and Mobile health, amongst others.

The PACMAD is an extension of Nielson's model but it includes *cognitive load* as an important characteristic of mobile applications. The PACMAD fails to address imbalances in the existing mobile applications and the model has not been empirically validated in the context for which it was proposed. In addition, PACMAD does not afford guidance and metrics regarding *what?* and *how?* in measuring each of the identified attributes in the model (Saleh, Ismail & Fabil, 2017: 72).

Mobile applications differ, to some extent, in accordance with the context for which they were developed. Mobile health, mobile games and M-commerce applications, amongst others, have *uncommon* attributes unique to each of them (Liu & Li, 2011: 890; Jerzak & Rebelo, 2014: 456; Xu *et al.*, 2014: 1; Thorpe, Nesbitt & Eidels, 2019: 1). This study contends that each mobile application possesses its own, unique characteristics. Consequently, specifically tailored usability models for M-commerce applications should be designed to address these specific attribute/s as they impact significantly on overall UXs. Therefore, this section will seek to address Research Question 1: ***What are the essential attributes of the usability model that are most appropriate in the context of M-commerce websites?*** This section will determine the essential attributes of the usability model employed to evaluate the usability of M-commerce applications.

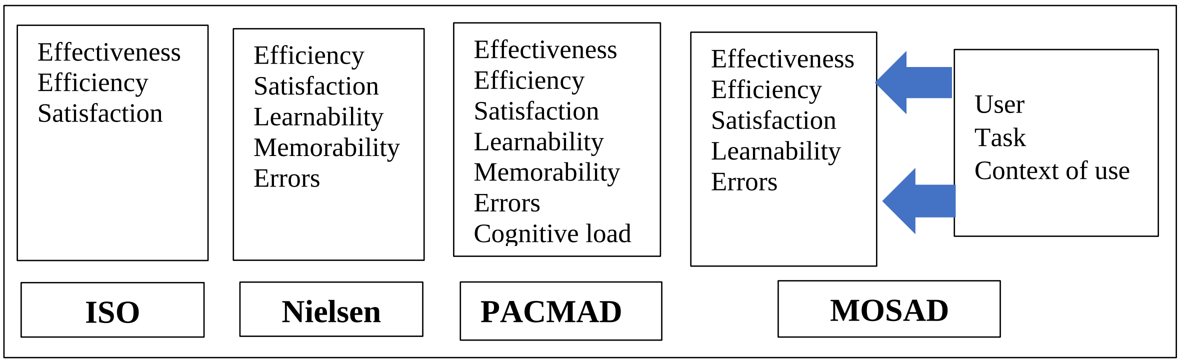


Figure 2.5: Comparing Usability Models

Figure 2.5 compares the ISO, Nielsen and MOSAD models. The MOSAD model includes some of the attributes found in the earlier and authoritative ISO standards and Nielsen usability models. After careful consideration, and at the hand of certain selection criteria, the researcher decided which attributes should be included in the MOSAD model. The attributes included in the MOSAD model had to adhere to the three selection criteria which formed the basis for including *or* excluding attributes. The three selection criteria are:

- The attributes must have been uncovered in the review of mobile empirical usability evaluation studies, as per Figure 2.1.
- The attributes must have at least a 10% frequency of use in the usability evaluation of the reviews of mobile empirical usability studies, as per Figure 2.1.
- The attributes must have been incorporated in either the ISO Standards *or* Nielsen's usability model.

The researcher applied the above selection criteria and *efficiency*, *effectiveness*, *satisfaction*, *error rate* and *learnability* were found to adhere to the conditions. Consequently, they were included as initial attributes in the MOSAD model for usability evaluation of M-commerce applications as presented in Figure 2.5.

The MOSAD model for M-commerce applications suggests certain factors (user, task and context of use) which should be considered when developing M-commerce applications. These factors are not new but need to be *re-addressed* in the context of M-commerce applications as they had previously been discussed in terms of ISO standards and the Nielsen's model in the context of desktop-based applications. Furthermore, five initial attributes of the MOSAD model are identified for the usability evaluation of M-commerce applications. The next section will present a detailed description of the proposed MOSAD model with a discussion as to each of the attributes and factors identified from the model.

2.8.1 Factors of the MOSAD Model

The MOSAD model incorporates three factors that affect the general usability of M-commerce applications namely: *task, user* and *context of use.* The models developed by ISO (9241-11, 2018) and Nielsen (1994a: 26) both suggest that these factors significantly impact on the overall success of the application's usability. However, these models fail to address the factors in the context of mobile and M-commerce applications. For mobile and M-commerce applications, the context of *use* serves as common ground because the mobile application may be used in different contexts. The factors (User, Task and Context of use) are discussed below:

- **User:** In the M-commerce application development process, it is essential to consider the end users or mobile shoppers. Due to the fact that M-commerce applications, which are a subset of mobile applications, are designed and developed to be small in size, physical desktop and laptop input methods like mouse and keyboard are not applicable (Iqbal *et al*., 2008: 528; Min *et al.*, 2009: 216; Bicakci & Oorschot, 2011: 25; Page, 2013: 40; Façanha *et al.*, 2014: 144). Therefore, designers of M-commerce applications must identify and employ alternative input methods. Many mobile shoppers may encounter difficulties using these input methods because of their physical limitations. Alternative inputs, like Swype and SwiftKey, afford mobile smartphones users certain benefits as they facilitate a similar typing speed comparable to that of a physical computer keyboard (Page, 2013: 39). However, the initial results from research carried out with sight disadvantaged individuals using virtual Braille keyboards show that the typing speed on a virtual keyboard is slower than when a physical keyboard is used (Façanha *et al.*, 2014: 134).

  The user's previous experience is another factor that should be considered. If a user is considered an expert at a particular task, a shortcut key will be used for task completion. Conversely, a novice user may need an intuitive and easy to navigate interface which facilitates an easy discovery of that which the user needs. The imbalances need to be addressed in the design phase of mobile and M-commerce applications.

- **Task:** For this study, the goal which the mobile shopper seeks to accomplish when browsing M-commerce applications is referred to as *a task*. In the development of M-commerce applications, it is expected that additional features might be added to enable mobile shoppers to accomplish more goals. The inclusion of additional features may directly affect the usability of M-commerce applications. The additional features may result in the application becoming increasingly complex, ultimately affecting the accomplishment of the user's intended goal/s (Poulcheria & Costas, 2012: 87).

For example, the development of M-commerce applications is considered more demanding and complex than the development of desktop applications. This can be ascribed to the fact that M-commerce applications are used in many different environments whilst desktop applications are generally used in inherently stable environments. In addition, the mobile nature of applications used on mobile devices has resulted in these applications being extended, both spatially and temporally. M-commerce users may thus interact with applications whilst simultaneously involved in other activities (Kurkovsky & Harihar, 2006: 227; Poulcheria & Costas, 2012: 87). The factors which characterise the dynamic context of M-commerce applications are: task difficulty, time to complete the task, complexity of the task, task completion rate and dependency between tasks (Hörold *et al.*, 2014: 490).

- **Context of use:** The context of M-commerce applications denotes the environment in which the application will be used by mobile shoppers. This study differentiates *context of use* in terms of both the *task* and the *user*. The *context of use* can be viewed in terms of the physical (auditory, co-location, visual and experiment type), psychosocial and social conditions. However, different social and cultural factors affect the context of use as well as the users' experiences while interacting with the products (Gündüz & Pathan, 2013: 117).

  Previous research shows that *context of use* is one of the challenges which impact on touchscreen-based mobile devices. In traditional applications *context of use* is defined in terms of: sound, light and input methods such as keyboard and mouse (Inostroza *et al.*, 2013: 25) . This concept is not well-defined in mobile device use as the interaction depends on the location and the way in which the task is being performed. The mobile user might be using his/her mobile device whilst standing in a queue at the bank or driving, using only one hand in both these scenarios. If the mobile user is sitting in a train, however, the device will be held with both hands in either portrait or landscape mode (Inostroza *et al.,* 2013: 25). Because of the limitations inherent to the use of mobile devices, context of use, limited user attention span, task workflow selection as well as type and number of tasks completed in a certain time, are *all* considered very important (Olsina *et al*., 2014: 119).

As mobile devices have portable characteristics which enable their use in any location, the *context of use* cannot be viewed apart from the *device*. This means that mobile application users often, via their mobile devices, perform tasks in random locations and at random times (Quaresma & Gonçalves, 2014: 353). For mobile applications thus, the *context of use* plays a pivotal role as these applications can be used in different contexts.

2.8.2 Attributes of MOSAD Model

The MOSAD model identifies five initial attributes, which cover the usability of M-commerce applications, as discussed in section 2.8. These attributes are: *efficiency, effectiveness, satisfaction, error rate* and *learnability*, and they are discussed in the following section.

- **Efficiency**: *Efficiency* is the "resources used in relation to the results achieved". The "typical resources include time, human effort, costs and materials" (ISO 9241-11, 2018). This attribute relates to the productivity of the mobile shopper while using the M-commerce application. It can be described as the ratio of problems identified and the speed, or time, required to detect them (Rivero *et al.*, 2014: 165). In contrast, the effectiveness of M-commerce applications enables users to accomplish specified task with reference to the available resources (Oyomno *et al.*, 2013: 306). Example of the metrics used to measure efficiency is task completion time to complete a specified task.

- **Effectiveness**: *Effectiveness* is the "accuracy and completeness with which users achieve specified goals" (ISO 9241-11, 2018). Or, effectiveness is the degree of accuracy and completeness with which a specified user accomplishes specified goals within the context of use (Moritz & Meinel, 2010: 367; Olsina *et al*., 2014: 119). Generally, a supervisor computes successful and unsuccessful tasks by counting the number of mistakes made by the participant whilst performing certain tests (Lettner & Holzmann, 2012: 124). Typically, *effectiveness* evaluates whether or not the test participant can accomplish the intended tasks.

- **Satisfaction**: *Satisfaction* is the "extent to which the user's physical, cognitive and emotional responses that result from the use of a system, product or service meet the user's needs and expectations" (ISO 9241-11, 2018). It is the degree of pleasantness and comfort achieved by users during the use of a particular software. This is a reflection of the user's attitudes, feelings, perceptions and opinions regarding the software (Orlandini, Castadelli & Braccialli, 2014: 195). Satisfaction is a subjective usability attribute and, therefore, its perception differs for each individual user. Typically, qualitative tools, like questionnaires, are used to measure the user's attitude when engaging with software applications. The System Usability Scale (SUS), a questionnaire tool, is a 10-item data collection method which provides usability overviews in terms of effectiveness, efficiency and satisfaction. The SUS is a versatile, robust tool used to evaluate both the *subjective* and *objective* usability attributes of software applications (Ravendran, MacColl & Docherty, 2012: 81). SUS provides an overview of subjective usability measurement in terms of a non-complex ten-item scale. The user satisfaction index (ranging from 0 to 100) helps to highlights usability problems in websites. The scoring on SUS provides the generation of a single number which, in turn, represents an overall measurement of the general usability of the system.

- **Learnability:** *Learnability* is the ease with which users, during their first use, achieve intended tasks on the software application (Ivanov, 2014: 348). However, Kenteris *et al.* (2009: 113) define *learnability* as a situation where the user of the application improves his/her task performance at the second attempt. In this research work, *learnability* is defined as the ease with which users of M-commerce applications gain some level of proficiency. There are many available mobile applications and if users find any one difficult to use, then they may switch to another. Ease of learning is considered a usability attribute which allows users to accept applications (Nyumbeka & Wesson, 2014: 355). For this reason, the MOSAD M-commerce model includes *learnability* as proposed in the Nielsen usability model.

  Users are more *easily distracted* when using mobile devices than when using desktop computers. When attempting to simultaneously conduct different cognitive tasks on a mobile device, users tend to become impatient and less focused. This response could be further distorted by demanding and/or stressful environmental factors (Haapalainen *et al.*, 2010: 301; Olsina *et al.*, 2014: 119).

  Furthermore, the *mental bandwidth* capability of mobile device users for retaining and understanding mobile content is more limited than that of individuals using desktops and/or laptops (Lei *et al.*, 2014: 589). Mobile users prefer to interact with mobile interfaces which respond to quick manipulation and which have fewer steps in processing information. Mobile users appreciate factors such as convenience as well as time and communication flexibility. The latter entails receiving only the necessary information in a friendly, personalised manner as final objective. Hence, the information architecture should ideally *reduce* the amount of options available to only those options necessary to complete the task (Page, 2013: 54). Conversely, the *quality* of information is more important than the *quantity*. To measure *learnability*, usability professionals observe participants performing a set of tasks and measure how long it takes them to achieve a pre-determined level of proficiency (Xu *et al.*, 2014: 1).

- **Error:** *Errors* can be described as *preventive errors* based on the ability of users to recover from said errors (Von Zezschwitz, Dunphy & De Luca, 2013: 261; Nyumbeka & Wesson, 2014: 355). *Errors avoidance* are those which need to be avoided while *error recovery* is the ability of the application's user to easily overcome the error when encountered. An earlier study concluded that the inclusion of *error recovery* in mobile software applications is more important than *error avoidance* (Von Zezschwitz *et al.*, 2013: 269). If a design error is detected in an application, the designer would need to re-design or correct the interface (Charfi *et al.*, 2014: 116).

  The MOSAD M-commerce model broadens the error description initially suggested by Nielsen to include errors made by mobile application users when using their mobile devices. Thus, mobile application developers are able to uncover problematic areas of an application and necessary improvements can then be made during successive iterations of the development process. For mobile users with a limited attention span, a reduced error rate is critical to the acceptance of the M-commerce application. It is impractical for mobile users to continually encounter errors when executing their intended tasks (Olsina *et al.*, 2014: 119).

  The MOSAD M-commerce model considers the characteristics of errors and the number of times they occur. Through a proper understanding of the characteristics of the errors committed, it is possible for M-commerce application developers to prevent the occurrence of these errors in subsequent versions of the application.

2.9 Conclusion

The empirical usability evaluation of M-commerce applications, though still in its infancy, is expanding rapidly. The processing power of mobile phones and devices (tablets, smartphones and iPhones) is rapidly increasing along with the services available on them. Furthermore, the usability of mobile applications differs from traditional software applications. Mobile applications present some problems including: screen size and resolution, limited processing capability and power, context, text and data entry methods and connectivity (Al-Razgan *et al.*, 2014: 415). These problems result in limitations to user interactions with mobile and M-commerce applications. The widely cited ISO and Nielsen usability models fail to capture the unique nature and interaction complexities associated with M-commerce applications. Therefore, this research study presents the proposed MOSAD model in the context of M-commerce applications which incorporates existing usability models.

In an effort to justify the conceptual model, a thorough literature review was conducted. The review shows the extent and frequency at which attributes included in the MOSAD model are evaluated within the context of mobile and M-commerce applications.

Therefore, the identification of the essential attributes of the MOSAD model for M-commerce applications addresses the first research objective as stated in Chapter 1, section 1.5.

Chapter 3 will consider the pattern and frequencies of UEMs in the context of mobile and M-commerce applications. In addition, Chapter 3 will present the background to mobile UEMs as identified in the review of empirical mobile usability evaluation studies.

Chapter 3: Usability Evaluation Methods

3.1 Introduction

It is a widely accepted tenet that the usability of a website is one of the most important requirements in website design and development (Sá, Shamma & Churchill, 2014: 695–701; Troyer & Janssens, 2014: 19–23). Usability is a vital characteristic for specific websites, including E-commerce and M-commerce websites. Customer dissatisfaction arises when websites perform poorly. This often results in customers searching for and utilising other websites (Lettner & Holzmann, 2012: 118). Given that website end users vary in terms of their age, knowledge level, intended goal/s and skills in using the website, amongst others, the task of developing a successful and usable website is daunting.

An earlier study states that: 1) usability is a prerequisite to a well-designed website as no one buys via a website if they cannot easily access the product information they are searching for, and 2) a website has the potential to attract business as many customers make impromptu decisions to buy, or not to buy, by simply browsing. If they are not satisfied with the website, they simply try another (Nielsen, 1999: 9).

Therefore, the fundamentals of website, or application usability, can be described as follows:

- It should provide necessary information, clearly and quickly, when required. A poorly designed website, with reduced usability attributes, will exact considerable operating and maintenance costs (Al-Badi & Mayhew, 2010: 3). In this highly competitive information age commercial websites, or mobile applications, with poor usability attributes will only yield negative consequences and little, or no, benefits (Bruun *et al.*, 2009: 1619).

Thus, to improve the usability of website, or mobile applications, usability evaluation is crucial (Beul-Leusmann *et al.*, 2014: 217).

In the last few decades, different UEMs have been created to assess the usability levels of software systems or mobile applications (Ham, 2014: 373). In addition, UEMs for testing the usability standard of software applications is on the increase and slowly becoming a standard approach in the software development process (Sabariah, Santosa & Ferdiana, 2019: 129–130). Incorporating usability evaluation in website development has thus become a necessity when aiming to facilitate improved website, or mobile application use, and consequently enhance UX (Joyce & Lilley, 2014: 465).

The previous chapter provides background information regarding M-commerce applications and the attributes to be incorporated into the proposed MOSAD model for M-commerce applications. This chapter discusses UEMs, in general, and mobile applications, in particular, and presents some context for UEMs. In addition, based on the literature review discussed in Chapter 2, this research work presents the pattern, trend and frequencies of UEMs. This can be viewed as the *context* of mobile and M-commerce applications. Therefore, this chapter seeks to determine which evaluation methods are appropriate for the evaluation of M-commerce applications. The next section discusses UEMs in general.

3.2 Usability Evaluation

Usability studies cut across many fields and disciplines including Human-Interface Design, Engineering, Information Architecture and Technical Communication, to name but a few (Johnson, Salvo & Zoetewey, 2007: 325). It is thus clear that *usability* is rooted in diverse fields of study. Generally, usability evaluation can be divided into two parts: *formative* evaluation and *summative* evaluation (Ham, 2014: 374). Formative evaluation occurs at all stages of the system design process - from development to advanced stages. Summative evaluation, on the other hand, judges and assesses the system design results when completed.

Usability evaluation provides organised methods to attain enhanced usability attributes during the design of user interfaces in product development. The evaluation is considered to have *failed* if proper usability engineering practice has not been adequately considered. Usability engineering consists of three stages: analysis of requirements, development/design/testing and installation. Usability can also be addressed during the requirement stage. During the development/design/testing stage, iterative testing is done. Users provide feedback to aid developers in checking the functionality and usability of the product at the installation stage.

Becoming familiar with the concept of *usability evaluation* is essential to understanding the UEMs. Usability evaluation can be defined as the assessment of a specific software's user interface, or interaction method, or a device's functionality and usability (Koutsabasis, Spyrou & Darzentas, 2007: 569).

In addition, UEMs are well-composed guidelines incapsulating activities and procedures, used in an effort to gather data which reflects the degree of usability of the software system (Rivero *et al.*, 2014: 162). UEMs also include other methods in so far as they are used to evaluate system usability in specific applications. The outputs of UEMs are varied in relation to the different methods used. Some of them provide problem reports, or a list of usability problems, as causative features and/or alternative solutions to current problems (Beul-Leusmann *et al.*, 2014: 217; Rivero *et al.*, 2014: 161).

Over the past four decades different UEMs have been developed in an effort to overcome usability problems in software systems (Berkman & Karahoca, 2016: 90–92). Table 3.1 highlights the development stages of UEMs. From Table 3.1 it is interesting to note that UEMs originated in the 1970s, with most methods being developed between 1980 and 1989. This fact may be connected to Xerox Star introducing the most important component of the Internet, the graphical interface, in 1981, thus greatly improving the reputation of the World Wide Web (Kolhe *et al.*, 2013: 90).

Table 3.1: Highlights and developmental stages of UEMs
(adapted from Scholtz & Consolvo, 2008: 4)

Year	UEMs
1970-1979	User problem documented, Platform Style Guide, Usability Labs (Scholtz, 2004: 1)
1980-1989	Metrics for user performance, Rapid prototyping, UI Standard, GOMS model, Comprehensive Guidelines, Wizard of Oz, Iterative Design, Software Usability Measurement Inventory (SUMI), Questionnaire for User Interaction Satisfaction (QUIS) (Scholtz & Consolvo, 2008: 4)
1990-1999	Heuristic Evaluation, Cognitive Walkthrough, Remote usability testing, Think-aloud evaluation (Costa *et al*., 2007: 264; Ham, 2014: 374; Rivero *et al.*, 2014: 162).
2000+	Common Industry Format (CIF) Report Format – American National Standards Institute (ANSI) Standard (Carta, Paternò & Santana, 2011: 129; Jadhav, Bhutkar & Mehta, 2013: 10; Ham, 2014: 374).

For the purpose of this study, only the UEMs identified in the review of 480 mobile empirical usability studies, as per Chapter 2, will be discussed. In the following sub-sections, the researcher presents a brief introduction to the broad classifications of UEMs: user-based usability testing methods, model-based methods and expert-based usability methods.

3.2.1 Classifications of Usability Evaluation Methods

UEMs can be classified based on the source which is used for the evaluation. These sources are: users, models or usability experts (Zapata *et al.*, 2014: 3). Table 3.1 presents the dates to which each of the UEMs can be ascribed. *Users* were the first source enlisted for usability evaluation as they provided valuable usability feedback. However, models have attracted usability professionals for over 20 years. Since the early 90s, *expert-based sources*, like heuristics and cognitive walkthroughs, have gained popularity for gathering information regarding the usability of software user interfaces. However, usability professionals or usability engineers use all three sources when designing, conducting and analysing usability evaluations of software systems (Deegan, 2013: 147; Xu *et al.*, 2014: 1).

3.2.1.1 User-Based Usability Evaluation Methods

In the 1980s, user-based evaluation method was the major testing method used and is currently still regarded as a popular choice, especially in the later software design and development stages (Ahmad, Sulaiman & Johari, 2010: 110). Usability testing methods can be considered as usability appraisal tactics that implement experiential testing of the interface design by typical users of such interfaces (Otaiza, Rusu & Roncagliolo, 2010: 33, Reeves, 2019: 3).

The testing process encompasses similar stages for all methods or usability assessment methodologies. The testing process implements a *test design* (comprising objectives, explanations, required resources and planning), *users' choices* (referring to profiles distinct from the preceding phase), *test case formulation*, *test case execution* and, finally, the *analysis* of results/outcomes (Otaiza *et al.*, 2010: 33). In addition, earlier studies show that the most extensively recognised usability evaluation approaches are user-based and expert-based testing methods (Sivaji, Abdullah & Downe, 2011: 68–70; Mazlan *et al*., 2012: 473).

In-lab testing, an example of a user-based method, is considered a usability testing method. This means that it is conducted in a laboratory environment and is primarily suited for the usability evaluation of desktop-based systems. This testing method would be problematic when applied to mobile applications (Seix *et al.*, 2012: 1). Certain methods, therefore, have limitations when used in a real mobile environment as they do not represent the mobile context of use and do not exercise sufficient procedural control (Porat, Schclar & Shapira, 2013: 266).

Remote usability testing, however, can be defined as a method for evaluating the usability of websites or applications, where the test participants and usability evaluators are *detached* from each other by means of geographical location and/or time. In this case the term *remote* refers to the distance in location and/or time separating the test participant/s from the evaluator/s (Carta *et al.*, 2011: 129). Remote usability testing can thus be used to conduct usability testing of user behaviour remotely and, in this way, evaluate interactions in real and natural user environments.

Nowadays, many UEMs include usability testing methods, such as: questionnaire surveys, in-lab tests, interviews, observations, log files/device data, think aloud, focus groups, video/sound/screen recording and prototyping. Other methods include: eye tracking, device sensor, Wizard of Oz, diary/camera studies, remote asynchronous testing, Web Analytics, remote synchronous testing and card sorting.

3.2.1.2 Expert-Based Usability Evaluation Methods

Usability inspection methods, also known as expert-based evaluations, refer to an individual expert, or a group of usability experts, monitoring and investigating the usability aspect of a user interface. These experts or evaluators test the user interface, locate the usability problems and consequently provide suggestions for improving them (Fortes, Antonelli & De Lima Salgado, 2016: 7; Herr, Baumgartner & Gross, 2016: 3069).

However, one of the major weaknesses in expert-based usability evaluations is that users are not involved and that the experts try to predict how the users would use the system being investigated. The experts performing heuristic evaluations can be wrong. It is thus possible that they register false usability problems, *unverified* by users in user testing (Mendoza, 2009: 13–17). *False problems* thus refer to usability problems discovered by evaluators using the *expert evaluation* method, rather than by users in the *user testing* method.

Among the usability inspection methods are: formal usability inspection, cognitive walkthrough, heuristic evaluation, feature inspection, standard inspection, consistency inspection as well as pluralistic walkthrough (Costa *et al.*, 2007: 264; Ham, 2014: 374; Nielsen, 1994: 413; Rivero *et al.*, 2014: 162). Other examples of expert-based methods are action analysis and guideline reviews (Al-Sharafat & Qadoumi, 2016: 2–3).

3.2.1.3 Model-Based Evaluation Methods

Compared to the two methods discussed in the previous sections, model-based methods are not commonly used in usability evaluations. The model-based method relies on a psychological prediction of a specific user’s performance whilst using a certain software interface. The main objective of the model-based method is to evaluate system usability by assessing the total task time and/or difficulty level posed in learning the task sequence of a system. An example of this model-based approach is the Goals, Operators, Methods and Selection rules (GOMS) model which investigates system usability by forecasting the interface functionality and time duration of specific tasks (Carta, Paternò & Santana, 2011: 129; Jadhav, Bhutkar & Mehta, 2013: 10; Ham, 2014: 374). The Keystroke Level Model (KLM), aided by detailed empirical studies, predicts a user's performance in a numerical format (Jokela *et al.*, 2006: 348). Other examples include the Executive-Process/Interactive Control (EPIC) and Adaptive Control of Thought-Rational (ACT-R) models.

The next section will discuss the 19 UEMs as identified in the review of the mobile empirical studies.

3.3 The 19 Mobile Usability Evaluation Methods

Based on the data yielded by the selected 480 relevant mobile empirical usability studies, this research work identified 19 UEMs to be used within the context of mobile applications. This section will present these 19 mobile UEMs as identified from the literature review.

1. ***Questionnaire Survey:*** This is one of the most commonly used methods. It is usually administered to test participants at the end of the test to gain insight into their interactions with the product. The SUS, a specific type of questionnaire, is administered to discover users' feelings regarding the use of a particular product, it thus gauges the degree of user satisfaction (Chaparro *et al*., 2014: 72). Another example of a questionnaire survey is the National Aeronautics and Space Administration Task Load Index (NASA-TLX) which measures the cognitive load of test participants (Lim & Feria, 2012: 300; Tchankue, Wesson & Vogts, 2012: 267; Lawson *et al*., 2013: 2502). The intercept survey is triggered while the user interacts with a live application or website. Test participants are often recruited to complete e-mail surveys through e-mail messages.

   One advantage of using a questionnaire is the ease with which it measures the satisfaction level of the user, as well as the user's attitude towards the target interface (Nyumbeka & Wesson, 2014: 357). A questionnaire survey was conducted to obtain socio-demographic factors of 174 mobile users from semi-urban areas in India. The findings of the pilot study show that mobile users were satisfied with the mobile advertising campaign by marketers. In addition, the results indicate that there is no statistical difference in satisfaction among marital status, age, occupation and gender of mobile users (Balakrishnan & Balu, 2018: 16–20).

2. ***In-lab testing***: In-lab testing is an example of a user-based method. It is conducted in a laboratory environment and is primarily suited for the usability evaluation of desktop-based systems. Laboratory testing is the customary method which is extensively used in assessing software programmes prior to their release (Liang *et al.*, 2011: 312). Laboratory tests on informational websites can sometimes, mistakenly, ignore some elusive properties such as style of writing, navigation and the application's graphical impact on users' insights and presentation (Cuddihy & Spyridakis, 2012: 4). In addition, this method only *simulates* the day to day scenarios of users in the evaluation of mobile devices. In-lab testing does not adequate describe *uncontrollable factors* which often impact on real-life situations in which mobile phones are used. This testing method would be problematic when applied to mobile applications (Seix et al., 2012: 1). In addition, this method is thus *limiting* as it does not represent the real-life mobile context of use and it also does not have sufficient procedural controls (Porat *et al.*, 2013: 266).

3. ***Interview:*** The interview method is frequently used to obtain qualitative data about the product being evaluated. This method provides insight into the reasoning which motivates users' actions while they interact with the product or application (Asghar, Cang & Yu, 2018: 193–199). Interviews enable the researcher to recognise and observe the reactions of users in their natural context of use and can thus assist the researcher in extracting problem areas during the investigation (Gündüz & Pathan, 2013: 122; Djamasbi *et al*., 2014: 303; Stopka, 2014: 513). For example, this method is useful when conducting usability evaluations of mobile device product prototypes as it aids in the elimination of problems found in the existing mobile applications (Gündüz & Pathan, 2013: 120). In most cases, this method is used in combination with other methods, like the field and laboratory testing methods, to gain a deeper understanding of users' reactions and behaviour towards the product.

4. ***Observation method****:* This method requires that users interact with the developed system or application (Wyche & Murphy, 2013: 1961). The user could, for instance, be casually observed whilst interacting with the mobile application affording the researcher the opportunity to complete his/her investigations, with suitable principles and control variables, to thus identify problematic areas (Ahmad *et al.*, 2010: 112; Orlandini *et al*., 2014: 196; Silva, Holden & Nii, 2014: 347). In this method, data is thus obtained from a direct observation of the user's behaviour when using the

application via mobile testing tool. All objective and subjective information, such as the time it took to finish the task, user frustration as well as the level of anxiety experienced are to be taken into account (Lesemann, Woletz & Koerber, 2007: 444; Deegan, 2013: 147; Wyche & Murphy, 2013: 1961). Observation methods involve various analysis including: recording of observations in observation notes, computation of the task completion time, recording the success and problematic factors encountered during task completion and data interpretation, to name but a few (Swierenga *et al.*, 2014: 375).

5. ***Log file/Device data:*** This is an electronic recording system which records a user's activities and/or interactions with a particular mobile application. The system automatically updates itself when any request (hit) is made using the electronic mobile device (Miesler *et al.*, 2014: 416). The qualitative analysis of the log file, in most cases, results in the identification of usage problems in the mobile application (Miesler *et al.*, 2014: 421). The auto logging nature of this method allows for the collection of Uniform Resource Locator (URL) history, input speed, error rate and task completion time of the mobile application which can be quantitatively analysed (Maramba, Chatterjee & Newman, 2019: 102). It can also reveal whether the task completion paths are in the correct order and whether they have been designed correctly (Lokoč *et al.*, 2019: 21–23). Log file/device data is mostly used in combination with questionnaires and/or the interview method as the log file method does not excel at collecting the qualitative data necessary to address the identified usability problem (Bruun *et al.*, 2009: 1620; Von Zezschwitz *et al.*, 2013: 263).

6. ***Heuristic Evaluation:*** This method, developed and modified by Jakob Nielsen in 1994, is one of the most widely used UEMs (Neto & Pimentel, 2013: 484; Orlandini *et al.*, 2014: 195; Lyzara *et al.*, 2019: 249–250). It comprises set guidelines, or heuristics, used by usability experts to evaluate the user interface of the desktop and mobile applications. It is customarily conducted by 3 to 5 experts and is considered a cost effective and successful method when compared to other UEMs, especially the laboratory method. In general, evaluation approaches should consider the mobile interface design with the comprehensive assistance of heuristic techniques which are based on analysis, rather than on experience. These inspections are often conducted by industry professionals in the area of usability, whose focus is on the identification of

prevalent design problems in the context of user interaction (Otaiza *et al.*, 2010: 33-35). However, it is rarely used in a summative manner for a *score-based comparison* between competitive systems (Tyllinen, Kaipio, Lääveri & Nieminen, 2016: 4130–4139).

7. ***Think Aloud:*** This is one of the most widely used methods applied in the laboratory during usability testing. The test participant is requested to articulate his/her feelings and thoughts as they come to mind *or* the test participant is required to speak aloud and verbalise his/her thoughts while interacting with the mobile application (Moritz & Meinel, 2010: 368; Kumin *et al.*, 2012: 121). Think Aloud can be considered as a special instance of the direct observation method in which users verbalise feelings and thoughts as they relate to the mobile application being utilised (Kumin *et al.*, 2012: 121). The purpose of this method is to elucidate evaluators' observation of the user's thought processes and understanding of the mobile application interface which, in turn, informs the usability evaluation of the interface (Moritz & Meinel, 2010: 368; Brunet, Serey & Figueiredo, 2011: 148). However, thinking and speaking out loud while performing tasks results in longer task execution times and it also limits the user's ability to complete the task because of the added cognitive load of verbal effort (Mayas *et al*., 2014: 548; Naiakshina *et al.*, 2017: 312).

8. ***Focus group:*** This is a qualitative research method where groups of preselected people gather to discuss their beliefs, opinions, attitudes and perceptions regarding a mobile application. The participants are free to express themselves along with their group members (Heuwing, Mandl & Womser-Hacker, 2016: 5–8). This approach is suited to an interactive environment. In the field of usability engineering, this method is regarded as a survey method and is often employed to record users' views regarding the mobile application, software or website (Carmien & Manzanares, 2014: 28; Façanha *et al*., 2014: 139; Kulpa & Amaral, 2014: 273). This method differs from other ergonomic methods as it involves the inclusion of several users, or future users, of a software or mobile application as participants in the discussion. This EUM involves facilitator/s, which forms a very important part of a focus group discussion. In addition, a number of participants are involved from whom subjective data regarding the mobile application can be collected (Iqbal *et al.*, 2008: 530; Sieger & Möller, 2012: 108).

9. ***Video/Sound/Screen Recording:*** These methods enable evaluators to gather qualitative data which yields an in-depth understanding as to the characteristics of user interaction and the context of use with mobile application. This context improves the evaluator's assessments regarding the type, number and nature of the identified problematic area/s in the mobile application (Gabrielli *et al*., 2005: 77; Yan, Zhang & Deng, 2012: 1299). In most cases, these methods are combined with others, such as cognitive walkthrough, during the usability evaluation to support and exploit data richness in relation to user contextual details and characteristics. However, a company which has offices spread across geographical areas might consider using remote interviews conducted via video conferencing facilities (Gatsou, Politis & Zevgolis, 2014: 10–15). In addition, the excessive time involved to analyse the video and time footage is a major drawback.

10. ***Prototyping*[3]*:*** In this method participants are presented with design elements, or developed materials, in order to garner their actual experiences when using the mobile application. This process includes recording what is most important to them and why (Cho *et al*., 2018: 79–80). In order to facilitate this process, blueprints of the mobile applications are produced for the validation of developed functionalities (Klasnja *et al.*, 2017: 3075).

    There are different modes according to which the prototype can be perceived including: haptic, visual, tactile and computer-based prototyping (Miao *et al.*, 2014: 2). However, the most widely used method for design and concept evaluation, in early stage mobile product design, is visual paper prototyping (Miao *et al.*, 2014: 2). Paper prototyping is applied in usability evaluations to identify usability problems in mobile user interfaces at the early stage of application development. In addition, prior research shows that it can be used during the early stages of mobile application product development. The early stages of testing focus on checking layout and navigational features ahead of actual product implementation (Losada *et al*., 2012: 7). For example, research carried out in Negara (Indonesia) shows that expert comments had helped in mobile product prototyping, leading to an increase in tourist visits (Tehrani *et al.*, 2014: 227). However, paper prototyping is not the best suitable for *usability evaluations* of mobile applications because it is difficult to emulate mobile applications which are used in the context of a rich real world. This method also yields an unrealistic testing experience

[3] In most cases, prototyping refers to a means of evaluating something, not an evaluation method in itself.

as participants during mobile usability evaluation experience the sketched screen as misleading and confusing (Holzmann & Vogler, 2012: 159).

11. ***Eye Tracking:*** In the course of performing a task, or naturally interacting with the mobile application/s or website/s, this electronic device precisely measures the test participant's eye movements. This method provides additional information regarding which areas the user focuses on during the usability test (Ritthiron & Jiamsanguanwong, 2017: 184–187). Data quality is based on the mobile device's adjustment to external influence and users (Mayas *et al.*, 2014: 548). This method is gaining popularity in the field of usability engineering and UX as it is viewed as a useful method. Among eye-tracking tools that can be used by usability professionals to conduct usability tests on mobile applications are Tobii Technology, TrackEye and OpenEyes, Pupil, Chronos Vision, amongst others (Yousefi, Karan & Mohammadpour, 2015: 2–7).

12. ***Device Sensor:*** This method aids in limiting user involvement when attempting to gather useful information regarding users' activities or interactions with mobile applications. It helps the evaluator to gather mobile sensor data which, in turn, significantly limits the involvement of users (Micallef *et al*., 2013: 588). In some cases, multiple data can be collected from different mobile sensors which would enable a comparison of their capabilities during cognitive load assessment (Haapalainen *et al*., 2010: 301). Smartphones, like modulo iPhones, are rapidly becoming more popular and affordable than hardware devices. For example, an average smartphone includes an array of technologies such as: Wireless Fidelity (Wi-Fi), Near Field Communication (NFC), Global Positioning System (GPS), a compass, cameras (video and still), 3-D accelerometers, Bluetooth, a gyroscope and proximity sensors (Carmien & Manzanares, 2014: 27). Diverse types of information are thus made available through mobile sensor fusion.

13. ***Wizard of Oz:*** The Wizard of Oz (WOz) is used to simulate the omitted "parts" in the early stage of mobile product development and to gather important feedback from users. This type of testing is another common method of usability testing which was developed to assist in assessing the impact of low-fidelity prototypes on intended users (Alce, Hermodsson & Wallergård, 2013: 603). This method allows users to interact with sample mobile prototypes in a similar manner as they would interact with the

actual mobile interface (Chalkia *et al.*, 2014: 364). This type of usability testing has gained recognition with agile test teams due to its increased benefits which include: short time-frames between releases, less stress, lower costs involved in gathering participants and lower costs of execution (Hosseini-Khayat, Hellmann & Maurer, 2010: 59).

14. ***Diary/Camera Studies:*** This method enables test participants to record and illustrate, using a camera or diary, certain areas in their daily mobile activities which are relevant to the mobile application or software (Hillman *et al.*, 2012: 115). This data collection method, especially suited to longitudinal studies, makes it easy for test participants to record usability problems which they experience during their interaction with mobile application interfaces (Bruun *et al.*, 2009: 1621; Yan *et al.*, 2012: 1299; Spillers & Asimakopoulos, 2014: 358).

15. ***Cognitive Walkthrough:*** This expert-based usability evaluation method (Ham, 2014: 374) was developed to provide teams of designers with the opportunity to do a quick mock-up design evaluation on mobile or desktop-based applications (Min *et al.*, 2009: 219; Jadhav *et al.*, 2013: 9). This method is considered a task-oriented walkthrough based on the recognised cognitive model of *novice user behaviour* rather than an *ease of learning analysis*. In essence, the technique identifies specific types of *impasses* regarding the user of the mobile application. These impasses, for example, could be that the user becomes confused and fails to complete a task or that the user provides the wrong response at specific stages of each micro-interaction (Jadhav *et al.*, 2013: 12; Sim, Cassidy & Read, 2013: 196).

16. ***Remote Asynchronous Testing:*** Remote asynchronous or unmoderated testing (Ahmad *et al.*, 2010: 110; Liang *et al.*, 2011: 312) occurs when the moderator and the test participant/s are located in different remote locations and thus separated by time and/or place. In remote testing, usability testing can be executed by enabling users to remotely log onto the mobile application in order to carry out tasks on a mobile application under development. This approach allows tests to be conducted remotely with the assistance of prevailing communication technologies (Miao *et al.*, 2014: 3). A widely used technology is Loop11 which enables the mobile tester to conduct test cases via the internet from a remote environment. One advantage of this method is that it allows the

mobile test participant to perform the usability test in his/her natural environment, without any interference by a moderator.

17. ***Web Analytics:*** Web analytics are methods used to measure user behaviour while utilising a mobile application. Data are collected automatically through large samples, or complete visitor populations (Djamasbi *et al.*, 2014: 299–301). The following instances of data, to name a few, can be reported and analysed: the total number of visitors utilizing the mobile website or its *traffic*, visitor demography, the number and types of links clicked and the page views. Web analytics are important tools which aid usability and UX professionals as they yield large-scale behavioural data regarding the perceptions of mobile website users. This information can be used to optimise the mobile website (Cáliz & Alamán, 2014: 254).

    However, this method cannot be used to understand a user's motivations or his/her primary goals and needs. This method can only show that users are, in actual fact, using the mobile websites but the reason/s for their actions remain unknown (Lettner & Holzmann, 2012: 119). Usability issues, discovered through web analytics, provide an in-depth understanding to the identified usability problems. This is necessary when solutions are being sought. Examples include: Google Analytics, CrazyEgg, Clicktale, Webtrends, Mint and tealeaf, amongst others (Porat *et al.*, 2013: 266; Cáliz & Alamán, 2014: 254).

18. ***Remote Synchronous Testing:*** Remote synchronous testing allows evaluators to observe mobile test participants in real time, even though they are separated geographically (Andreasen *et al.*, 2007: 1406; Miao *et al*., 2014: 2). The term *remote evaluation* cuts across a number of other usability methods used to collect series of data. Depending on the context, slight differences may exist between *remote evaluation* and *task-based testing*. The major difference though is that with remote evaluation the test participant and evaluator, or moderator, are in different locations (Shanab *et al.*, 2012: 21).

    This method is qualitative and involves the use of screen-sharing and audio devices. The mobile test participant and moderator, or evaluator, perform the usability testing together, in real time. One advantage of the remote synchronous testing method is that it allows tests to be done in the mobile test participant's natural environment making it easy to recruit subjects for the test (Miao *et al.*, 2014: 11). Amongst the tools that can be used are GoTomeeting, LiveLook, WebEx, Adobe Connect, NetMeeting, UserVue, Skype, Youguu and Glance (Andreasen *et al.*, 2007: 1408; Miao *et al.*, 2014: 8).

19. ***Card Sorting:*** This method is beneficial for information generation as it relates to the groupings and associations of particular data items. During a card sorting mobile test participants are requested to structure individual, unordered or unsorted items into different groups and to label the groups based on the method used (Keates, 2015: 100).

    Card sorting is typically conducted at the early design stage of products as a specific activity for defining an architecture, but they are also useful during the usability evaluation process of the product. This approach will reveal whether the identified usability problems are as a result of the grouping or labelling of the groups (Dahl & Svanæs, 2008: 469). This sorting method can be done with post-it notes or index cards, or may be done automatically with other software packages (Böhm & Wolff, 2014: 23). For example, this method is used in user-centred design computing during the mobile website architecture development process. It is, however, most useful for workflow development, toolbars, menus and various system design elements.

The next section discusses the frequency of UEMs, which are specific to mobile applications, as identified in the review of selected empirical mobile usability studies.

3.4 Usability Evaluation Methods for Mobile Applications

The traditional UEMs are mostly lab-based. They are used in the simulation of scenarios of user activities during the evaluation of mobile devices (Lallemand & Koenig, 2017: 136–148). This traditional method cannot adequately represent unforeseen factors which impact upon mobile device usage in natural environments. Due to the highly dynamic nature of mobile devices, a few of the earlier UEMs had various usability problems. To reveal the most commonly employed UEMs, in the context of mobile applications, the results of the review of the relevant and selected mobile empirical usability studies are presented.

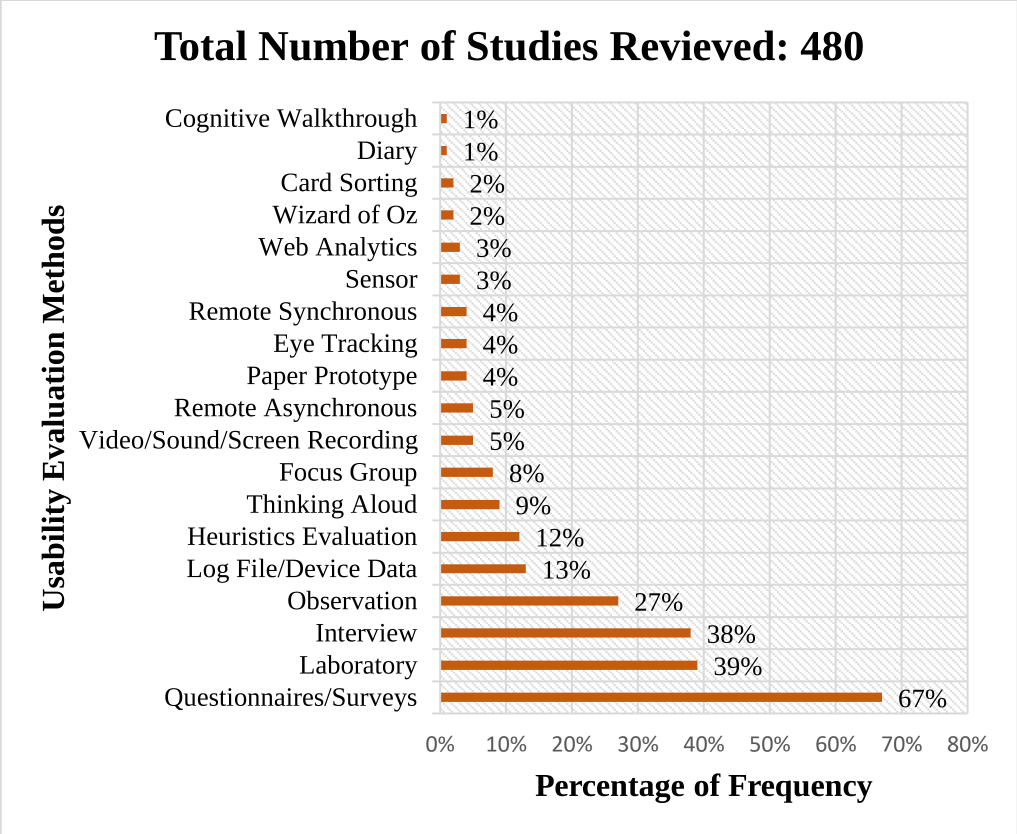


Figure 3.1: Frequency of UEMs Used in the Reviewed Studies

Figure 3.1 illustrates the frequency of the general UEMs, as presented in the reviewed empirical mobile usability studies. The findings show that *Questionnaires/Surveys* (67%), *In-lab studies* (39%), *Interview* (38%), *Observation* (27%) *and Log file* (13%) are the most commonly used methods. Each of them account for more than 13% of the 480 reviewed mobile usability studies. In addition, *Heuristic evaluation* has 12% frequency, while *Think aloud* has 9% and *Focus group* has 8% frequency.

Furthermore, the results of the review of the mobile empirical usability evaluation studies show that remote asynchronous, web analytics, remote synchronous and card sorting are rarely used as UEMs. The reason for this can be attributed to the general view that remote testing on mobile devices is difficult (Andreasen *et al.*, 2007: 1406; Miao *et al.*, 2014: 11).

The next section details the landscape of the identified UEMs in the context of mobile applications.

3.5 The Landscape of Mobile Usability Evaluation Methods

The fields of *UX* and *usability engineering* comprise several UEMs, ranging from in-lab usability evaluations to the more recent online remote asynchronous testing methods (Ham, 2014: 373; Miesler *et al*., 2014: 412).

When dealing with a specific project it is often beneficial to combine a set of usability methods to facilitate a better insight (Cáliz & Alamán, 2014: 257; Ham, 2014: 373; Lamche, 2014: 490; Miesler *et al.*, 2014: 412). Usability professionals are often familiar with a number of these methods, they tend to use either one or two usability methods. Therefore, this section will seek to answer the Research Question 2: ***What is the landscape of usability evaluation methods in respect to when to use which evaluation method/s in the context of mobile applications?*** This section will determine the landscape of UEMs in the context of mobile applications. To attain a proper understanding of *which* methods to use and *when* to use them for evaluations, it is important to categorise the methods using a three-dimensional approach with the axes being:

- Qualitative versus Quantitative (Cheng, 2011: 21; Porat *et al.*, 2013: 266).
- Attitudinal versus Behavioural (Spiekermann, 2009: 427; Liu & Li, 2011: 890; Gündüz & Pathan, 2013: 119; Gitau & Nzuki, 2014: 88).
- Product context of use (Olsina *et al*., 2014: 119; Yao *et al.*, 2014: 301).

The three categories are discussed in the following sub-sections.

3.5.1 The Qualitative and Quantitative Dimensions

There is a clear difference between these two dimensions.[4] This goes beyond a mere understanding of the qualitative method as open-ended questions in a research study (Joyce & Lilley, 2014: 467). Qualitative studies provide useful data on user attitude, or behaviour, based on direct observations (Gündüz & Pathan, 2013: 122; Von Zezschwitz *et al*., 2013: 261). Quantitative research studies gather attitude or behavioural data indirectly using surveys and/or analytical tools (Cáliz & Alamán, 2014: 255).

Usability researchers have direct contact with people and observe them while they use the intended technology, or product, in a field or in a laboratory. This allows the researcher to pose

[4] There can certainly be direct quantitative research (e.g. asking someone to complete a Likert scale, timing their completion or counting the number of errors they make) and indirect qualitative research (e.g. field notes from a video of a person using a mobile app).

questions to participants, probe their behaviour and, in most cases, readjust the design or study protocol to meet its intended goals. Data analysis, in most cases, is not mathematical or statistical. However, user perceptions in quantitative research studies are generally obtained through mathematical analysis. The data collection instrument, like log file or survey, gathers large quantities of data that can be numerically coded (Bailey, 2014: 3; Jing *et al.*, 2014: 107).

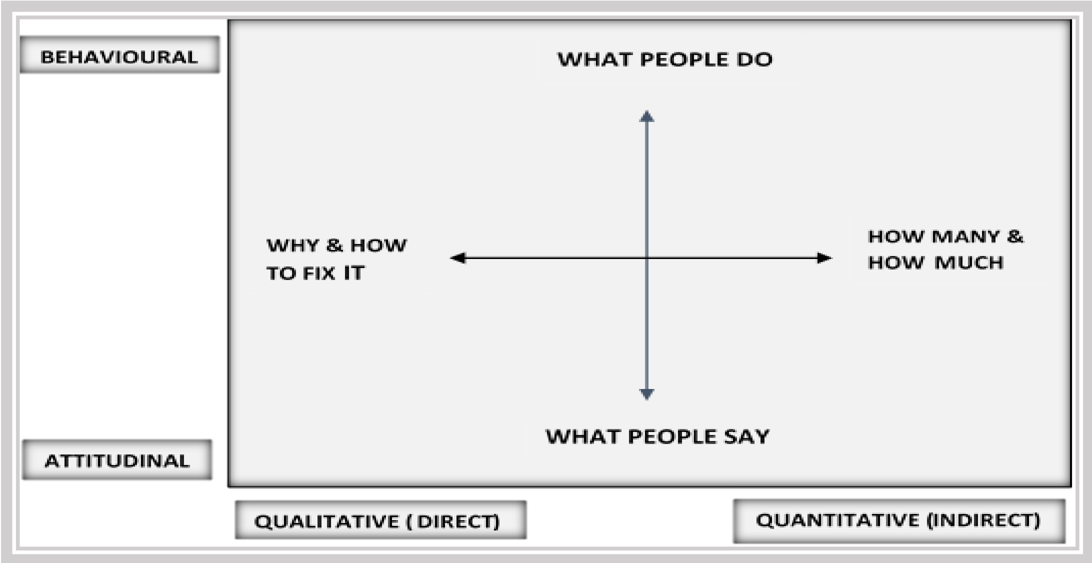


Figure 3.2: The landscape showing research questions answered by UEMs

Qualitative research methods are more suitable to answering questions like *why*? or *how to fix?* usability problems, while quantitative research methods deal with questions like *how many*? and *how much*? in a usability evaluation (Cheng, 2011: 21; Porat *et al.*, 2013: 266). The large amount of data gathered, assists in resource prioritisation as it allows researchers to focus on problems that yield the biggest impact. Figure 3.2 illustrates how the two dimensions (behavioural and attitudinal; qualitative and quantitative) affect the particular type of question being answered.

3.5.2 The Behavioural and Attitudinal Dimensions

Figure 3.3 illustrates where the 19 identified UEMs appear in accordance with the dimensions presented before. The dimensions inform the approach that allows one to differentiate between studies, in relation to the type of questions they answer and the reasons for their suitability. The difference can be expressed by contrasting *what users do* and *what users say* as they differ in most cases. The goal of attitudinal research work is often to ascertain, or measure, the belief of the users, hence its use in marketing departments (Liu & Li, 2011: 890).

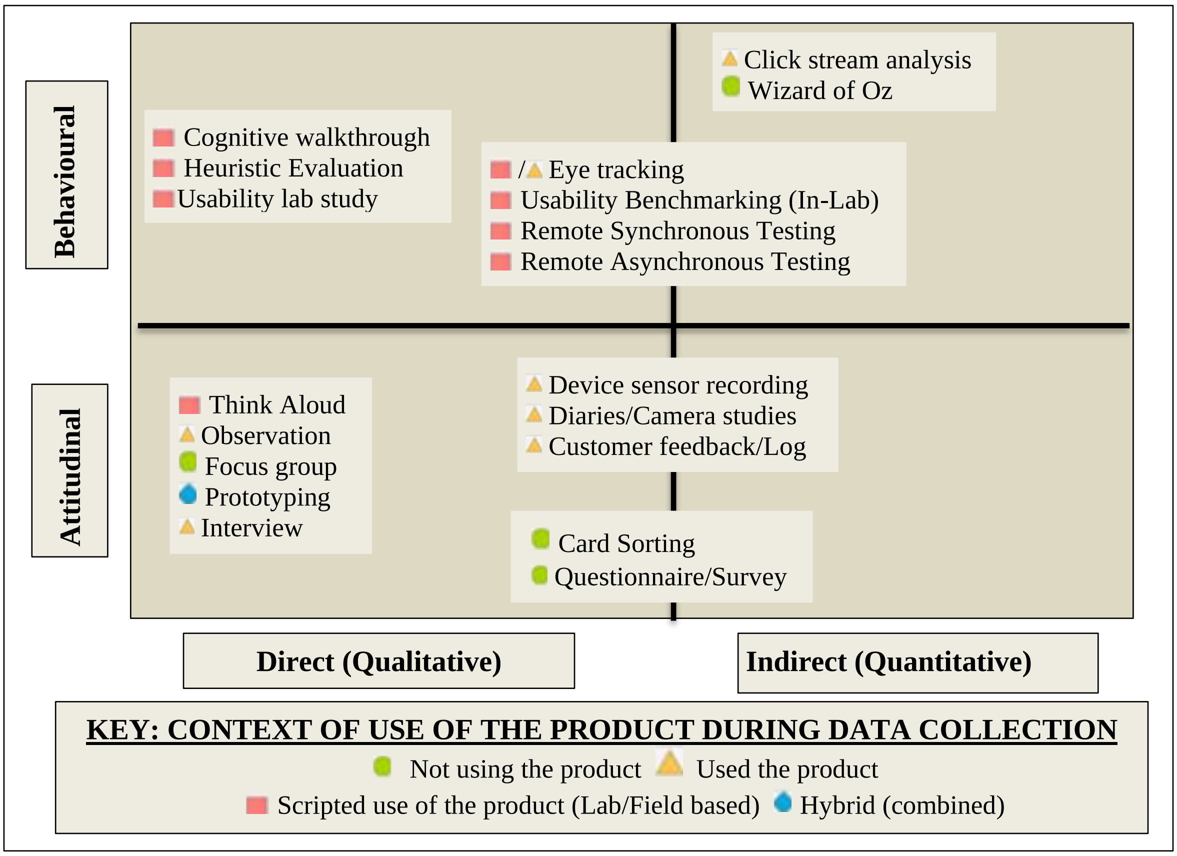


Figure 3.3: The Landscape of Mobile UEMs

It is, however, vital that usability professionals focus on behavioural methods which use self-reported data information sheets. These sheets have proven to be useful tools for designers or usability professionals (Micallef *et al.*, 2013: 588). For example, *card sorting* is rarely used in the context of mobile applications, even though it provides the mental model of users' perceptions and assists in obtaining the best and most reliable information architecture for applications or websites (Otaiza *et al.*, 2010: 33). *Questionnaire/Survey* as a tool helps to measure and classify attitudes and aids in the collection of self-reported data that tracks major problems which require attention (Moritz & Meinel, 2010: 121; Kjeldskov & Skov, 2014: 43; Kojo *et al.*, 2014: 264).

Focus group is not used as much in usability evaluations, however, in mobile usability evaluations it has attracted the attention of usability professionals because it expresses the views and general perceptions of people, regarding the product concept, in a group setting (Sieger & Möller, 2012: 108; Carmien & Manzanares, 2014: 28). For *what users do* with the brand or product, *eye tracking* can be applied as a tool as it reveals the way in which users interact with the product interface.

However, one of the most popular methods used is *in-lab study* (Castro *et al.*, 2011: 371) which employs a combination of behavioural and self-reported data and tends to move to either of the dimensions. It is recommended, however, that in-lab studies should lean more towards the behavioural dimension.

3.5.3 Context of Use of the Product

The third dimension deals with *how* and *if* the subjects in the usability study are actually using the product, or the software application. The descriptions are as follows:

- *Natural* or close to natural usage of the product.
- Usage of the product in a *scripted* form.
- The study does *not use* the product.
- A *hybridization* of the above.

When the study focuses on the *natural use* of the product, the purpose is to ascertain the user's behaviour and attitude, hence interference with the study needs to be limited (Alshehri & Freeman, 2012: 5). This approach leads to less control over the subject matter and some observational biases, but it does imbue the findings with greater validity. Examples of such methods are: intercept, analytic methods (e.g. Google Analytics and remote evaluation, amongst others) and data mining (Charfi *et al.,* 2014: 116).

Using a *scripted* product in a study allows the researcher to concentrate on particular product usage areas such as a new or redesigned product. The purpose for which the study was originally embarked upon will determine the level, or degree, of scripting. To obtain reliable usability metrics, benchmarking usability studies in nature is a quantitative process that needs to be highly scripted (Nuovo *et al.,* 2014: 2190). However, there are cases in which the *product is not used*[5] – usually to observe problems that are wider than usability and usage of user interface. An example is when a researcher intends to observe the wider cultural behaviours amongst participants (Coursaris *et al.,* 2012: 1446).

The *hybrid* methods employ a creative form of product usage to satisfy the goals of the product. For example, prototyping methods permit user interaction as well as the rearrangement of the design elements that serve as a user's product experience. This suggests solutions that satisfy

[5] Sometimes, users in the WoZ study might be using a real interface but some of the more complex interactions, like speech recognition, might not be real behind the scenes – but they are still using a version of the product.

the users' expectations and provide reasons for making particular selections (Holzmann &Vogler, 2012: 159; Tehrani *et al*., 2014: 227).

Most of the identified UEMs, as illustrated in Figures 3.2 and 3.3, can move toward one or more dimensions. Some move during the study period in order to meet different goals. For example, field studies can deal with what people do (extensive observation) or what people say about a product (ethnographic interview). In addition, card sorting and desirability studies, in most cases, can have quantitative and qualitative versions while eye tracking methods may be scripted and at the same time unscripted.

The next section presents general concerns regarding UEMs.

3.6 The Major Challenges Associated with UEMs

Although HCI experts conduct usability evaluations to assess the usability of products, or software, the main concern in usability evaluations is to find an optimum evaluation method. The available usability methods can provide a wide range of system usability evaluations and procedures, however, each method has its own limitations and comparisons between these methods are complex and yield non-conclusive results (Ham, 2014: 373).

Firstly, what measurement (Jadhav *et al*., 2013: 12) should be used for the comparison of UEMs? Secondly, how does one judge the results of evaluation methods in terms of their reliability? Each evaluation method is designed and used differently and there are many shortcomings associated with the conclusions derived. However, there is no doubt that implementing some form of usability evaluation for a system, *before* utilising the system, is more beneficial than not testing the system at all. Some form of usability evaluation does, in fact, reduce and manage the risk of potential usability problems arising.

A commonly used method for implementing usability evaluations is to apply several evaluation methods in order to obtain reliable and useful data regarding the product's usability problem/s (Moritz & Meinel, 2010: 368). Advances in mobile and global computing technology have brought about new opportunities for making improvements to existing usability evaluation techniques. Therefore, the evaluation methods, which are created to evaluate the usability levels of desktop systems, such as traditional in-lab assessments, will encounter difficulties when attempting to evaluate mobile applications (Seix *et al*., 2012: 1). Mobile and multi-user systems should be assessed for confidentiality and any other usability matters which pertain to their set up, development and the use of such policies.

Website and mobile application creation processes occur and are completed at a very rapid pace. Consequently, in an effort to shorten the product development time, the usability evaluation is generally omitted in most cases (Alshehri & Freeman, 2012: 5). However, UEMs provide the developer with the opportunity to simulate the context wherein the website or application will be used by employing remote testing and heuristic evaluation methods. Innovative evaluation methods for system usability are expected to be introduced to enable the accomplishment of all technology-oriented tasks and mimic the context of use of mobile applications. Future usability challenges include the need to develop suitable usability methods which address the application's context of use (Parsazadeh *et al.*, 2018: 97–99).

Because of the unique nature of mobile applications, the conventional UEMs suitable for a laboratory environment may not be an optimal method to be applied to the complex and rich nature of the natural environment in which mobile applications are used (López-Gil *et al*., 2014: 1). For example, field studies and laboratory experiments have different and unique limitations such as a lack of procedural control and failure to represent mobile context of use. Hence, prior studies called for the development of new UEMs (Porat *et al*., 2013: 266; Manakhov & Ivanov, 2016: 3149).

An earlier study suggests that the challenges associated with laboratory testing can be overcome by employing remote usability testing methods (Liang et al., 2011: 312-313). Prior studies show that remote asynchronous testing is considered as a comparable or better quality than the traditional laboratory testing method when analyzing their similarities and differences. The research works indicate that remote asynchronous testing is time and cost-effective when compared to the laboratory testing method (Martin, Al Shamari, Seliaman and Mayhew, 2014: 99–103, Mockler, 2014: 632–635). Therefore, Section 3.7 of this research work provides a discourse on remote usability testing methods for mobile applications.

3.7 Remote Usability Testing

As mentioned before in Section 3.2.1.1, remote usability testing methods can be defined as a form of usability evaluation of websites or applications in which test participants and usability evaluators are detached in terms of geographical location and/or time. The term *remote* here means the distance in location or the separation in time between the test participant/s and evaluator/s (Carta *et al.*, 2011: 129).

Remote usability testing is usually conducted using software that has been released to the users (Liang *et al.*, 2011: 312-313). Prevailing usability problems are not always easily detected when testing the mobile applications in traditional laboratory environments. Yet, this option needs to be explored and utilised in order to identify possible pitfalls and/or limited functionalities of the applications. Usability testing conducted for mobile applications provides increased opportunities for remote usability testing, as it aligns with identification and evaluation of mobile applications in a given user's natural environment (Charfi *et al*., 2014: 116).

A laboratory environment compels the user to work in a specific and less dynamic way. The outdoor setting could result in users feeling even more uncomfortable as they are obliged to, in some cases, carry a camera along with them or be videotaped by another person (Lim *et al.*, 2012: 342).

Rush *et al.* (2009: 2) also noted that laboratory testing is expensive for it requires costly equipment and expertise to conduct tests in controlled environments. It is thus necessary to focus on method/s which produce greater benefits but at a reduced cost (Barišić, 2017: 16–17). In addressing this notion, different researchers have suggested Augmented Reality (AR) remote laboratories or virtual laboratories as a way of addressing the prevailing issues (Alarcón *et al.*, 2006: 470; Ridene & Barbier, 2011: 1–2; Shanab *et al.*, 2012: 17). The reason for this is because AR remote laboratories and virtual laboratories can supplement the interaction with virtual objects in a real-time environment (Wang *et al*., 2019: 58–66). Accordingly, a virtual laboratory can be considered for software simulation as it is a manufactured version of an actual experimentation signified by a mathematical imitation. This approach may not be as effective when compared to testing with real software applications used by participants in their natural environment/s (Chalil Madathil & Greenstein, 2017: 502–511; McGowan, 2019: 2–22).

Ahmad *et al*. (2010: 110) suggested that a Usability Management System (USEMATE) would be a precise method of resolving the dominant issues associated with laboratory environments being used for data collection and analysis. A USEMATE is an automated system, i.e. an alternative solution, which supports a usability tester, or expert, to perform usability testing more proficiently and efficaciously.

However, Cooke (2010: 202) suggests that the Concurrent Think-Aloud protocol (CTA) can be considered as a usability assessment tool which allows users to articulate their opinions while performing intended tasks. In addition, the main goal of CTA is to derive some insight into user behaviour which is difficult to acquire from mere observation alone.

Figure 3.4: Remote Usability Testing Environment (adapted from Liang *et al*., 2011:313)

However, as already stated, usability problems are not easily detected when testing applications in a traditional laboratory environment. An earlier study shows that remote usability testing methods can be used to overcome the prevailing problem associated with laboratory testing (Liang *et al.*, 2011: 312-313). Remote usability testing emerged about 20 years ago in response to an increased need for tools to facilitate cooperative working and the sharing of information (Andreasen *et al*., 2007: 1405; Ahmad *et al.*, 2010: 111). Remote methods assist the assessor in different location or/and time to reach the intending users. Figures 3.4 and 3.5 provide pictorial views of remote usability settings.

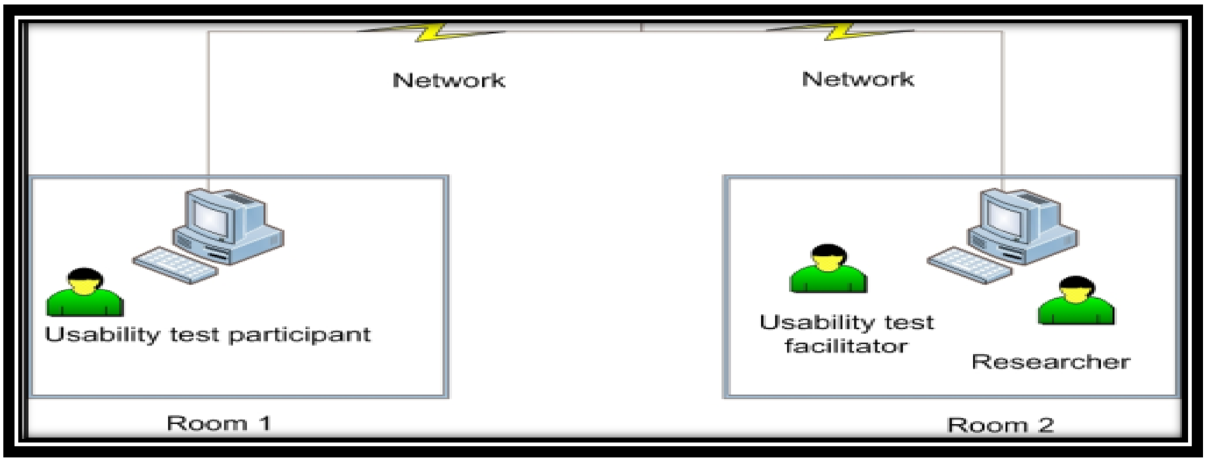


Figure 3.5: Model of Remote Usability Testing (adapted from Alghamdi *et al*., 2013: 65)

Therefore, usability problems can be overcome by remote usability testing methods in which the testing can be conducted remotely, in moderated and unmoderated environments (Liang *et al.*, 2011: 312). As discussed in section 3.3, remote usability testing can be categorised as either synchronous or asynchronous testing (Miao *et al.*, 2014: 2–3). In synchronous testing, the test case is performed in a real-time environment and evaluated by the moderator, whereas in asynchronous testing, the moderator and the client are placed in remote locations. In addition, many researchers note that remote testing has gained recognition due to its increased benefits in the context of usability practices, as outlined below (Andreasen *et al.*, 2007: 1406; Gardner, 2007: 64–65; Miao *et al*., 2014: 11):

- *Increased flexibility for both users and moderators:* This is the ability to perform tests with participants located in different geographical locations.
- *Freedom of location:* Ability of observers to evaluate and observe participants in a location convenient to them.
- *Convenient environment:* The users are more likely to perform in familiar environments when using the hardware/software setup they use daily.
- *Accessibility:* This method paves the way to evaluate the behaviour of people with disabilities and to adapt applications to encourage access.

Although the method has certain benefits, it also displays some shortcomings namely (Kjeldskov & Skov, 2014: 44):

- In a remote environment, the moderator cannot perceive the participant's behaviour in terms of body language and/or other indirect modes of communication.
- Technical breakdowns, inconsistencies or difficulties may interfere with the test session.
- The testing is done entirely on-screen which does not present a representative environment.

This research work is conducted in South Africa and the websites that serve as case studies for this research work are hosted in Nigeria, therefore, it is practical to use remote asynchronous usability testing. The next section discusses the selected usability method – remote asynchronous usability testing – which will be used to validate the MOSAD mobile model proposed in section 2.8, Chapter 2. In addition, the section will compare laboratory testing, remote synchronous and asynchronous usability testing methods.

3.7.1 Remote Asynchronous Testing

In the asynchronous testing method users are separated from the system evaluator by time and space (Ahmad *et al.*, 2010: 110; Liang *et al.*, 2011: 312). The remote usability evaluation offers a cost efficient and quick analysis of data. Instead of using an evaluator, questionnaires are applied to guide the user. This will reduce financial costs and limit the time spent on the evaluation process (Andreasen *et al.*, 2007: 1408).

However, a limitation of this method is that the asynchronous approach only works within a narrow scope and does not conduct evaluations of or observational recordings of sudden verbal data (Kumin *et al*., 2012: 121–22). This feature of the asynchronous testing method introduces limitations on the validation and accuracy of results. This will inhibit the chances of exploring and solving usability problems.

This method, however, is widely used in analysing large user samples because it is cost effective, easily accessible, and it produces fairly realistic results. A larger sample size would yield results that are accurate. In contrast, lab-based testing methods could contain testing bias as a result of participants having to perform under pressure (Kjeldskov & Skov, 2014: 44–49).

Therefore, after considering the facts presented in Table 3.2, it is more practical to utilise the remote asynchronous usability testing method when conducting usability testing of user behaviour remotely and to evaluate interactions in real and natural user environments. This enhances the researcher’s ability to make better decisions regarding users’ experiences. This method will be suitable for the evaluation of mobile and M-commerce applications.

There are various methods used in remote asynchronous testing namely: auto logging, forum, unstructured problem reporting, diary and the user-reported critical incident methods (Bruun *et al.*, 2009: 1620–1621). One of the more recent types of remote asynchronous usability testing is online remote asynchronous testing which allows the automatic collection of data during the usability testing of mobile applications (Verkijika & De Wet, 2018: 22). Examples of testing tools for remote testing can be found at Loop11, UserZoom and UserTesting, amongst others.

Table 3.2: Comparison of Some Usability Evaluation Methods

Attribute	Laboratory Based	Remote Synchronous	Remote Asynchronous
Geographic Diversity	Very limited, usually 1 to 2 locations.	Can be established with participants in various geographic locations, yet time zone differences pose a major challenge or limitation.	Participants can enrol in testing exercises at their convenience.
Recruiting	Difficulties are faced since geographic pool is limited to the testing location.	Geographic limitation but sessions are still longer.	No geographic limitation, but sessions are shorter than in the case of remote synchronous testing.
Sample Quality	Limited participants are willing to allocate time for laboratory testing and this method has a tight control over user activity.	Able to recruit specialised users at minor inconvenience and can view most interactions.	Can attract users with similar interests relating to the website.
Qualitative Insights	Can easily probe usability problems as the facilitator observes the interaction of the user with the interface.	Direct observation of the interface and limited user reactions. However, the facilitator has the opportunity to start a dialogue and to uncover issues i.e. gaps and opportunities.	This method is effective if the session is recorded and then observed to note the user's behaviour. However, the facilitator does not have the privilege of asking questions relating to issues uncovered during the testing period.
Sample Size	Restricted due to geographical location.	Somewhat restricted due to time zones in different geographical locations.	Easy to run large sample sizes.
Cost	Usually, in this method, companies pay a higher recompense cost for users' and facilitator's time.	User recompense is considered comparatively low and this necessitates less facilitation time. Is costly when compared to asynchronous method.	This method is considered the least expensive as it does not necessitate facilitation or facility costs. This is the right fit for researchers with limited resources (personnel, time and money).

Table 3.3 presents the results of the survey conducted by the Usability Professional's Association (UPA). It indicates that remote asynchronous usability testing is the only usability evaluation method of which the use by usability professionals increased by 18% between 2007 and 2009 (UPA, 2009: 16). The survey is based on the responses of 1318 respondents from 34

countries across the world. In addition, a recent study shows that in the last 12 months remote asynchronous testing was conducted by 45% of the 750 usability professionals from 52 countries (Loop11, 2018: 12). This statistic highlights the importance and popularity of this method employed by usability professionals to evaluate the usability of software products in order to deliver the required UX. Therefore, there is a need to explore this method in the current study.

Table 3.3: Percentage Change in Methods Used in 2007 and 2009

Method	Year 2007	Year 2009	% Change between 2007 and 2009
Remote Asynchronous	0%	18%	18
Remote Synchronous	42%	42%	0
In-Lab Testing	54%	54%	0

Other factors which influence the method selection for evaluations are: time and cost effectiveness, geographic diversity, recruiting method, sample quality, sample size and usability standard approaches, as indicated in Table 3.2 (Andreasen *et al*., 2007: 1406–1408; Baharuddin *et al.*, 2013: 2228–9; Miao *et al.*, 2014: 11). The following section provides the conclusion to the Chapter 3 of this study.

3.8 Conclusion

The fundamental purpose of website usability is to provide all the necessary information and functions that users need, clearly and quickly and at a particular time. A poorly designed website, with poor usability, exacts considerable operating time and maintenance costs from the company responsible for it (Al-Badi & Mayhew, 2010: 3). In this highly competitive information age the inadequate usability of commercial websites, or mobile applications, will quickly result in serious consequences and afford little, or no, benefits for online business owners.

Different UEMs have been developed in the past four decades in an effort to overcome the usability problems of software systems. This study highlights the general problems common to the development stages of UEMs. It should be noted that UEMs date as far back as the1970s whilst the majority of methods were developed between 1980 and 1989.

Research has shown that it is good practice and beneficial to combine usability methods in order to gain more insight during evaluation processes (Cáliz & Alamán, 2014: 257; Ham, 2014: 373; Lamche, 2014: 490; Miesler *et al.*, 2014: 412). Although usability professionals are familiar with most methods, they use either one or two usability methods during usage evaluation. In order to facilitate a proper understanding of *when* and *how* to use the UEMs, this chapter presented 19 identified UEMs. The presented landscape is a goldmine for any usability professional, especially new researchers, as it can guide them in their selection and use of mobile usability methods.

Therefore, in Chapter 4 of this study a new set of Mobile COMmerce (MCOM) heuristics for M-commerce applications is proposed and developed which will, in turn, be used for empirical usability evaluations. Chapter 4 will present the MCOM heuristic evaluation method for M-commerce applications.

Chapter 4: Heuristics for M-commerce Applications

4.1 Introduction

Heuristic evaluation, developed by Nielsen and Molich (Nielsen & Molich, 1990: 225), is characterised as a valuable and inexpensive expert-based method used professionally for the evaluation of software usability. Heuristic evaluation was traditionally developed and used for desktop software (Neto & Pimentel, 2013: 93). An earlier survey, conducted by the UPA, revealed that heuristic evaluation is the second most employed usability evaluation method by usability professionals. The survey was based on responses from 1318 respondents, from 34 countries, worldwide (UPA, 2009: 16). This shows that the method is regarded as important and is widely accepted by usability professionals for the evaluation of software products' usability in order to deliver the required UX. However, as a result of the unique characteristics of mobile devices, the application of usability methods and skills developed specifically for the usability evaluation of desktop applications may *not* yield the required results when applied to mobile devices (Fetaji & Fetaji, 2011: 178).

Thus, the application of desktop-based heuristics may not be the right fit for different ranges of mobile user interfaces and may not properly describe the characteristics of mobile-based interfaces (Inostroza *et al.*, 2013: 24). The numerous heuristics employed for the usability evaluation of the software user's interface are not necessarily suited to identifying the usability problems of mobile applications (Jerzak & Rebelo, 2014: 456–457). Prior studies confirm the need for specific heuristics within the context of *use* as traditional heuristics assume the static nature of desktop applications (Korhonen, 2011: 1; Inostroza *et al*., 2013: 24–25).

Numerous domain-specific heuristics have been developed recently. Due to their unique characteristics, these heuristics are distinct from general mobile applications. Amongst these heuristics are a set of playability heuristics developed especially for the evaluation of mobile games and educational computer games. Results indicate that they are useful in identifying playability problems (Korhonen & Koivisto, 2006: 16; Omar & Jaafar, 2010: 192).

M-commerce applications have unique characteristics which differ from the characteristics of other mobile applications. It is important to address the literature gap by identifying a set of heuristics to be used for the evaluation of M-commerce applications. Therefore, Chapter 4 will seek to answer Research Question 3: ***How appropriate is the suggested domain-specific***

heuristic evaluation method for evaluating the usability of M-commerce websites? This chapter seeks to address this literature gap by developing a domain-specific usability evaluation method (heuristics), for the assessment of M-commerce applications' usability. The next section provides a theoretical background to this genre of study based on the reviews of 480 mobile empirical usability studies, as discussed in Chapter 2.

4.2 Heuristic Evaluation Method for M-commerce Applications

M-commerce applications have unique characteristics which set them apart from other mobile applications. In M-commerce the goal is to acquire information about the product enabling users to enjoy better shopping experiences (Chong et al., 2012: 35; Jing et al., 2014: 99). When using M-commerce applications, mobile shoppers expect similar experiences to those on offer in a conventional shopping mall. Therefore, an appropriate heuristic evaluation method needs to be considered when developing M-commerce applications. The following sub-sections discuss Nielsen's heuristics and Shneiderman's eight golden rules.

4.2.1 Nielsen's Heuristics

Heuristic evaluation, which contains a set of usability principles or guidelines, was introduced by Nielsen and Molich (1990). It is regarded as a usability engineering method which is used by a small number of evaluators to ascertain usability problems in user interface designs. The method thus examines and judges interfaces according to recognised usability principles, or heuristics (Nielsen & Molich, 1990: 254). The nine usability heuristics, as proposed by Nielsen and Molich (1990), are presented in Table 4.1.

Table 4.1: Nine Nielsen and Molich Heuristics in (1990)

Heuristic Name
Simple and natural dialogue
Prevent errors
Minimise the user memory load
Provide shortcuts
Provide feedback
Speak the user's language
Be consistent
Good error message
Provide clearly marked exits

Table 4.1 presents the original set of heuristics developed in 1990 by Nielsen in partnership with Rolf Molich for usability evaluations (Nielsen & Molich, 1990: 254). However, in 1994 Nielsen did a factor analysis of 249 usability problems and consequently improved the original

heuristics to a new set which was more explanatory (Nielsen, 1994b: 153). For the purpose of comparison, the revised heuristics in Table 4.2 are called *traditional heuristics*.

The heuristics presented in Table 4.2 are guidelines to be used when designing a user interface with the purpose of discovering problematic areas in order to improve the design (Savoy *et al*., 2018: 22–28). The method involves the use of usability experts as evaluators to identify usability problems, or design violations, associated with user interaction with designed interfaces (Jerzak & Rebelo, 2014: 456; Xu *et al.*, 2014: 1; Zapata *et al*., 2014: 3). Generally, evaluators are viewed as *double* experts because of their expertise in design principles and their domain interest (Orlandini *et al.*, 2014: 195; Tehrani *et al.,* 2014: 227).

Heuristic evaluation is characterised as *intuitive* and is used in the design process. It is less expensive and involves no extensive planning process compared to other usability methods, such as lab studies (Fetaji & Fetaji, 2011: 179; Joyce & Lilley, 2014: 473; Neto & Campos, 2014: 484). Research has shown that heuristic evaluation can be applied to all stages of product development (Neto & Campos, 2014: 486; Zapata *et al.*, 2014: 3). In most cases, it is used in combination with other usability methods for the usability evaluation of user interfaces in order to uncover other usability problems (Fetaji & Fetaji, 2011: 184; Swierenga *et al*., 2014: 377; Watbled *et al.*, 2018: 12–13).

Table 4.2: The Ten Revised Nielsen's Usability Heuristics (1994)

Heuristic Name
Visibility of system status
Error prevention
User control and freedom
Recognition rather than recall
Aesthetic and minimalist design
Help and documentation
Match between system and the real world
Consistency and standards
Flexibility and efficiency of use
Help users recognise, diagnose and recover from errors

Generally, usability heuristics are developed for the evaluation of software user interfaces (Min *et al.*, 2009: 216). The intended primary goal during usability evaluation is to ascertain how easily and efficiently users interact with the software (Carmien & Manzanares, 2014: 36). Research has shown that Nielsen's heuristics are well-established and applied usability heuristics employed by usability professionals (Cho *et al*., 2018: 80–88; Othman *et al*., 2018:

5–8). Nielsen redefined the original heuristics which resulted in the existing 10 sets of usability heuristics (Joyce & Lilley, 2014: 466). Other researchers have made some effort to add to Nielsen's heuristics while conducting the evaluation of utility software. For example, Neto and Campos (2014: 494), developed a new set of heuristics for a new interaction paradigm which is considered appropriate and useful.

4.2.2 Shneiderman's Eight Golden Rules

Shneiderman *et al.* (2017: 23–37) suggested "the eight golden rules for interface design" which are considered important underlying principles associated with the design of interactive systems. The suggested principles need to be understood and adapted for each environment. The golden rules are listed in Table 4.3.

Table 4.3: Shneiderman's Eight Golden Rules (Shneiderman, 1986: 172)

Usability Principles
Strive for consistency
Enable frequent users to use shortcuts
Reduce short-term memory load
Offer informative feedback
Design dialogues to yield closure
Permit easy reversal of actions
Enable frequent users to use shortcuts
Support internal locus of control
Offer error prevention and simple error handling

Good user interfaces are essential and, therefore, their design is very important as well, not only to the specific application, but also to the development of M-commerce applications and mobile applications in general. The research conducted by Shneiderman *et al*. (2017: 43–54) shows that "there are also lifeboat websites offering design principles, but often the style parallels the early user interface writings of the 1970s" within the World Wide Web of information. The problem of avoiding users' abilities and/or skills and preferences, associated with the development of early user interfaces, is still common today (Cayola & Macías, 2018: 163–164). Previous studies show that Shneiderman's golden rules, as well as other non-domain specific heuristics, or guidelines, are not necessarily appropriate to domain-specific mobile applications (Greifeneder, 2012: 1; Swierenga *et al.*, 2014: 373). There is no single magic formula which can be applied to *all* systems or *all* applications.

The application of Shneiderman's eight golden rules to the user interface helps to increase users' productivity through facilitating: an easy to use data entry approach, quick informative feedback, easy to use of displays and system control (Shneiderman *et al.*, 2017: 66–77). However, according to Shneiderman, the eight golden rules have limitations and, as such, they need to be refined and interpreted before being applied to different environments (Shneiderman *et al.*, 2017: 25–69).

Prior research shows that Shneiderman's golden rules and other traditional heuristics are not appropriate for evaluating mobile interfaces. Additionally, the need exists to bridge the gap between web and mobile standards by developing new mobile domain standards for the evaluation of mobile interfaces (Swierenga *et al.*, 2014: 373). However, the developed mobile standards have not been empirically validated in the context in which they were developed.

In addition, prior research shows that, even with the availability of Shneiderman's eight golden rules for interface design, experts prefer to use Nielsen heuristics for evaluation of users' interfaces (Silva *et al.*, 2014: 327). The reason may be connected to the interpretation and suitability problems associated with the golden rules. Prior research also shows that half of Shneiderman's eight golden rules for interface design (Reduce short-term memory load, Error prevention and simple error handling, Reversal of actions as well as Consistency) are not appropriate for mobile applications (Gong & Tarasewich, 2014: 3751–3756). The golden rules: require additional descriptions, lead to backtracking, require training, are difficult to understand by novice users and do not easily accommodate changes, amongst other limitations.

In addition, research shows that Shneiderman´s eight golden rules are not suitable for the evaluation of video or mobile games. The research shows that mobile games, with their playability feature, have a multifaceted structure which comprises both the user interface and game content. As such, mobile games need a domain specific evaluation method to assess the usability of their interface. The game environment contains many players which act and interact. Shneiderman´s eight golden rules and traditional heuristics are not suitable for evaluating the usability of players' social interactions because they focus mainly on users' interfaces (Korhonen, 2016: 140–143).

Other research shows that Shneiderman´s eight golden rules and Nielsen's heuristics are not domain specific but target *broader applications*. As such they are not suitable for evaluating the usability of a mobile applications instance, e.g. M-commerce (Novak, 2014: 13). The proposed heuristics have not been empirically validated in the context of M-commerce or mobile applications.

Because of the limitations inherent to the traditional heuristics and rules, an earlier study employed *both* Shneiderman´s eight golden rules and Nielsen's heuristics to develop new heuristics for the usability evaluation of mobile information appliances. The result of the experiment was that the new set of heuristics, which is domain specific, *outperformed* the traditional heuristics and rules in the usability evaluation of the Apple iPod Nano and Kobo Glo information appliance applications (Meier *et al.*, 2017: 148–155).

A prior study argues that Nielsen's heuristics were developed without consideration for mobile computing and other heuristics were developed based on the concept of the traditional heuristics (Neto & Pimentel, 2013: 93–96). Research shows that a domain specific heuristic, compiled to evaluate the usability of mobile devices, discovered many cosmetic usability problems which Shneiderman´s eight golden rules and Nielsen's heuristics had not (Neto & Pimentel, 2013: 95–96). The result implies that the developed domain-specific heuristics are more appropriate in the usability evaluation of mobile devices. However, the developed heuristics were only used to evaluate a mobile news application (UOL Notıcias) and, as such, lack comprehensive empirical validation for use with other mobile applications. Therefore, in the current study, the researcher argues that with the use of suitable technology, as well as a domain-specific heuristic evaluation method, M-commerce applications will be properly designed and, as such, deliver a better UX.

M-commerce application developers create M-commerce content with the defined purpose of enabling mobile shoppers to buy any goods they desire (Kurkovsky & Harihar, 2006: 229; Gündüz & Pathan, 2013: 116; Inostroza *et al.*, 2013: 24). Shopping on mobile devices, or smartphones, has certain challenges such as: lack of trust, fear of possible security lapses, limited screen sizes, difficulty of input mode and poor screen resolution, amongst others (Hillman *et al.*, 2012: 115). Therefore, the application of traditional usability heuristics in M-commerce applications is not appropriate. The use of said heuristics might even result in significant parts of the M-commerce applications not being investigated.

4.2.3 Other Domain-Specific Heuristics

Various domain-specific heuristics have been developed in the past and amongst these are playability heuristics for the evaluation of mobile games. These heuristics have proven to be much more effective than the traditional or Nielsen desktop-based heuristics (Korhonen & Koivisto, 2006: 15–16). Omar and Jaafar (2010: 192) developed a modified version of playability heuristics for the evaluation of educational computer games which have yielded some promising results. A playability heuristic, which is player-centred, was also recently developed for the online reviews of computer games. The heuristics, however, were not empirically validated (Zhu & Fang, 2014: 502-03).

Another example is the domain-specific heuristic developed for the evaluation of mobile health applications (Nike+ and RunKeeper applications). Results show that the two applications fail to comply with the required standards for ease of use applicable to the older adult population (Silva *et al.*, 2014: 355–356). However, because of the frequent release of mobile health applications, Xu *et al*. (2014: 6–7) developed automated mobile health heuristics to reduce the workload of usability experts in the evaluation of user interfaces. The proposed framework is believed to have reduced both cost and time required for evaluating mobile health applications. Fetaji and Fetaji (2011: 179) proposed a Mobile Learning Usability Attribute Testing (MLUAT) usability methodology for the usability evaluation of m-learning applications. This method provides better results and performs better in terms of cost effectiveness, when compared to traditional heuristics, in the evaluation of m-learning applications.

To have a successful business-oriented M-commerce application it is necessary to develop and implement suitable UEMs for the evaluation of user interfaces (Iqbal *et al*., 2008: 528; Al-Razgan *et al.*, 2014: 416; Xu *et al*., 2014: 7). This research work seeks to develop and validate the MCOM heuristics for the usability evaluation of M-commerce applications. To understand the applicability of heuristic evaluations to M-commerce applications, the researcher performed an analysis of 480 peer-reviewed resources in the field of mobile usability studies. The review indicated that there is huge literature gap in the availability of heuristics designed especially for M-commerce applications. Most studies failed to target M-commerce applications as one of the recently emerging applications.

In 2002, a set of ten guidelines were developed for the development of WAP enabled M-commerce websites (Condos *et al*., 2002: 347–350). However, the set of guidelines were based on a single experiment and had not been subjected to expert reviews, something other researchers did while developing principles and guidelines for mobile specific applications. In addition, the *feature phones* (Trium Mars) used in the study had limited features and these were not applicable to the present technology age. Recently, studies have proposed suggestions for the usability of M-commerce websites to reduce potential usability problems (Ou *et al*., 2015: 154–160). However, these suggestions were not validated or subjected to usability professionals' reviews. It is thus necessary for usability professionals to have access to a new set of domain-specific heuristics, something which this study seeks to provide.

Therefore, this research work seeks to develop specific heuristics for the usability evaluation of M-commerce applications, which can be used to test the efficiency, effectiveness and user satisfaction associated with M-commerce interfaces. The researcher seeks to address the gap in this study. The next section discusses the frequency of the evaluation of M-commerce applications and the set of usability heuristics, as revealed in this study.

4.3 M-commerce and Heuristics Used in Reviewed Studies

As reported in Chapters 2 and 3, research studies, which span a period of 14 years, from 2005 to 2018, were systematically mapped. Table 4.4 provides a breakdown as to the types of usability testing methods employed in the context of M-commerce applications. Only 23 of the 480 studies reviewed focus on M-commerce applications, however, some researchers use heuristic evaluation, or field methods, including remote synchronous or asynchronous testing, in their empirical usability evaluations.

This scarcity in studies may be connected to the unavailability of appropriate heuristics for the evaluation of M-commerce applications to address challenges in their development (Cheng, 2011: 21; Alshehri & Freeman, 2012: 5; Seix *et al.*, 2012: 1; Porat *et al.*, 2013: 266). In addition, Table 4.4 shows that 65% of the reviewed studies made use of the questionnaire survey as a quantitative research method for the collection of qualitative data. About 27% of these studies combined the questionnaire survey with the interview method. This is done because questionnaires are easy to administer and less expensive to execute when compared to other qualitative methods like the think-aloud method (Jokela *et al.*, 2006: 348; Jeong & Yoon, 2013: 31). From Table 4.4, the usage of Nielsen's heuristics in only two studies may be connected to the fact that there are little, or no, domain-specific heuristics for the context of M-commerce applications.

In recent years, diverse heuristics have been developed and used in the context of mobile applications. Identifying *which* usability heuristics should be applied in mobile empirical usability studies is important for this research study. The researcher, therefore, presents the collection and mapping of the heuristics according to different sets of usability heuristics.

Table 4.4: Usability evaluation methods used in M-commerce applications

Usability Evaluation Methods	**Research Sources**
Cognitive Walkthrough and Nielsen's Heuristics	(Yohandy & Setyohadi, 2018: 2–3)
Device sensor	(Poulcheria & Costas, 2012: 16–22)
Diaries and Interview	(Hillman *et al*., 2012: 120)
Diary and Interview	(Hillman & Neustaedter, 2017: 13)
Interview	(Lund & Sieverthson, 2017: 13–15)
Interview and Observation	(Octavianus, Wijaya & Andry, 2017: 82–84)
Observation	(Hussain, Mkpojiogu & Suleiman, 2018: 1363)
Survey	(Kurkovsky & Harihar, 2006: 237–239)
Survey	(Min *et al*., 2009: 217)
Survey	(Ou *et al*., 2015: 154–160)
Survey	(Hussain & Mkpojiogu, 2016: 3–5)
Survey	(Ozok & Wei, 2010: 120–122)
Survey	(Sadi & Noordin, 2011: 495)
Survey	(Hassan, Manna & El-Ebiary, 2017: 3–4)
Survey	(Olaleye, Sanusi & Oyelere, 2017: 933)
Survey	(Mkpojiogu, Hashim & Adamu, 2016: 366–368)
Survey (SUS)	(Hsu *et al*., 2014: 320–322)
Survey and Focus group	(Sieger & Möller, 2012: 2–4)
Survey and Interview	(Wu & Wang, 2005: 722–724)
Survey, Interview and Focus group	(Iqbal *et al*., 2008: 530)
Survey, Interview, Observation and Google Analytics	(Djamasbi *et al.*, 2014: 304)
Survey, Think Aloud and Interview	(Novak, 2014: 26–35)
Nielsen's Heuristics	(Yen *et al*., 2018: 10–17)

In the analysis of the reviewed studies, the researcher identified 15 research studies in which distinct sets of heuristics were developed for the evaluation of different domain-specific mobile applications.

Table 4.5 presents twelve sets of usability heuristics, as identified by different researchers and research sources, for each of these heuristics. It should be noted that heuristics for elderly people using smartphones and heuristics for touch screen-based applications are the most widely researched and developed sets of heuristics, accounting for 4 and 7 studies respectively. Mobile health, mobile learning, mobile virtual museum and multimodal sets of heuristics are the least commonly researched usability heuristics in the context of mobile applications. Heuristics which have not been researched frequently, in the context of mobile applications, are mobile games and haptic and audio interface heuristics (Darin *et al.*, 2017: 2488–2492).

Table 4.5: Domain-specific Heuristics

Domain-Based Heuristics Sets	Research Sources
Heuristics for elderly people using smartphones	(Al-Razgan *et al.*, 2014), (Carmien & Manzanares, 2014), (Silva *et al.*, 2014: 349–350), (Silva, Holden & Jordan, 2015: 3237–3235).
M-learning Heuristics-MLUAT	(Fetaji & Fetaji, 2011)
Touch Screen/Smartphone Based Heuristics	(Inostroza *et al.*, 2013), (Mi *et al.*, 2014), (Neto & Pimentel, 2013) (Joyce *et al.*, 2014: 1–2), (Joyce & Lilley, 2014: 471–473) (Ahmad, Rextin & Kulsoom, 2018: 130–145), (Inostroza, Rusu, Roncagliolo, Rusu & Collazos, 2016: 42–50)
Playability Heuristics (M-Game)	(Korhonen & Koivisto, 2006), (Korhonen, 2011)
Multimodal Heuristics	(Neto & Campos, 2014) (De Lima Salgado, Rodrigues & Fortes, 2016: 2–8)
Heuristics for Haptics and Audio Interface	(Orlandini *et al*., 2014), (Humayoun, Chotala, Bashir & Ebert, 2017: 1–6)
Anglo-Mobile Learning	(Rufi'i, 2015: 937–941)
Heuristics for Mobile Virtual Museum	(Tehrani *et al*., 2014) (Othman *et al.*, 2018: 2–12)
M-Health Heuristics	(Xu *et al.*, 2014) (Khajouei, Gohari & Mirzaee, 2018: 37–42)
Mobile Procurement Heuristics	(Tyllinen *et al.*, 2016: 4130-4139).
M-Spending Heuristics	(Swaid & Suid, 2019: 80–87)
M-Decision Heuristics	(Artinger, Petersen, Gigerenzer and Weibler, 2015: 34–51)

In spite of the above-mentioned domain-specific heuristics, developed for different mobile applications, the need exists for a set of heuristics for the evaluation of M-commerce applications. The next section will discuss the approach employed for the development of the MCOM heuristics for M-commerce applications.

4.4 Development of Heuristics for M-commerce Applications

There are several approaches to the development of heuristics for software interfaces. However, based on the analysis of the previous studies, there is no fixed or standard approach employed by usability professionals during the development of various domain-specific heuristics (Quiñones, Rusu & Rusu, 2018: 109–113). Nielsen's set of heuristics were the first set developed in 1990 and revised in 1994 (Nielsen, 1994b: 152–153). He applied factor analysis of the variance to usability problems and developed the most popular and widely cited heuristics (Cho *et al*., 2018: 80–88; Othman *et al*., 2018: 5–8). These are known as traditional heuristics (Joyce & Lilley, 2014: 473).

Flexibility in the characteristics of heuristics allows usability professionals to define different heuristics, associated to the particular type of user interface, during usability evaluation (Silva *et al*., 2014: 349–350). According to Al-Razgan *et al*. (2014: 416), the development of usability heuristics for older people on touch screen-based smartphones involves two major steps. The first step is the conversion of *usability guidelines* to *usability problems* and categorisation of the related usability problems into groups. The second step is the translation of the categorised *usability problems* into *heuristics* which then presents proper guidelines to elucidate possible courses of action. Other domain-specific heuristics are developed as a result of critical analysis of research literature, systematic guidance and ideas gained from Nielsen's heuristics. These then serve as the baseline for generating new sets of heuristics for elderly people using mobile applications (Carmien & Manzanares, 2014: 28; Joyce *et al.*, 2014: 1).

Usability experts have employed different design guidelines in the evaluation of hardware portions for the purpose of user feedback. As a result, the most rated guidelines by participants in the evaluation of prototypes have resulted in the development of smartphone based heuristics (Mi *et al.,* 2014: 357). In order to develop heuristics for multimodal interactions, Neto and Campos (2014: 489) executed a mapping of developers' guidelines. They combined the guidelines based on the accumulated characteristics from surveys and Nielsen's heuristics, to generate new domain-specific heuristics. In addition, Xu *et al*. (2014: 3) developed helpful sets of mobile health heuristics at the hand of specific guidelines associated with mobile health applications. In addition, the researchers made use of six user interface properties (text contrast ratio, button distance, text word count, user actions per task, button size, animation and scrolling) in developing the set of mobile health heuristics with promising results. In some cases, usability experts are involved in direct observations by critically analysing the identified guidelines associated with system interactions and assigning values to each of them. The guidelines are then used to generate heuristics for haptic and audio interfaces (Orlandini *et al*., 2014: 196).

Furthermore, the inspection of four mobile applications (Facebook, Gmail, Foursquare and Twitter) yielded 53 usability problems. The identified usability problems were analysed and categorised, according to Nielsen's heuristics, with appropriate instructions. This process resulted in the compilation of new sets of heuristics for touch screen-based heuristics (Neto & Pimentel, 2013: 94). Other approaches include: the use of feedback from questionnaire surveys and structured interviews to identify usability problems that will, in turn, be used to generate usability heuristics. In order to generate heuristics for mobile learning applications, Fetaji and Fetaji (2011: 179) utilised feedback from a questionnaire survey and proposed specific design guidelines which resulted in new sets of heuristics. In a similar way, structured interviews are employed to obtain tourist feedback which is then analysed and used to identify usability problems. The analysis of literature assisted usability experts in the development of new sets of heuristics for a mobile virtual museum (Tehrani *et al.*, 2014: 228).

It can thus be seen that mobile applications (such as entertainment, health and fitness, utility, games, social networking, learning, location-based, news and magazines, tours and travel, lifestyle, music and audio and M-commerce applications) have *different* attributes and requirements unique to each of them (Liu & Li, 2011: 890; Jerzak & Rebelo, 2014: 456; Xu *et al.*, 2014: 1). This research posits that different mobile applications are individually unique. It reveals the need for specific usability heuristics, in the development of M-commerce applications, which will include the specific attribute/s which impact on overall UX.

The next section examines design considerations for M-commerce applications.

4.5 M-commerce Design Considerations

This section presents considerations that developers of M-commerce applications should incorporate into their design processes. These factors can enhance mobile usability and improve the UX of M-commerce applications. The design considerations are as follows:

1. **Touch Interfaces**

   Touch screen devices are very popular and are regarded as being more intuitive than laptop track pads or a desktop mouse. This is because users interact with the interface by *tapping* and *pushing* the content sheets with their fingers (Lin *et al*., 2010: 10-12). However, this method of interacting with a software interface has certain limitations when compared to the modes of interaction with a PC's mouse and keyboard, the traditional input methods for navigating a website and operating systems since their inception almost 20 years ago (Kjeldskov & Skov, 2014: 44).

   No provision exists for a hovering state nor is there any provision for a right/left click because these devices use a variety of *hidden gestures* (Zhou *et al.*, 2014: 194). *Touch* is less accurate because its precision depends on the fingertip-size of the user. The mouse, on the other hand, can be used with pixel-precision (Carmien & Manzanares, 2014: 27-36). In most cases touch keyboards are made from optical coating materials (Raptis *et al.*, 2013: 135)**,** as presented in Figure 4.1, which covers half of the mobile screen (it does, in fact, take up 82% of screen space in landscape mode).

Figure 4.1: Description of the Touch Screen on a Mobile Device

Usability evaluation studies of 18 M-commerce applications revealed that 50% of test participants find touch screens problematic to use and frequently *tap* the wrong elements on the user interface (Appleseed & Holst, 2013: 65–70). Thus, the general reference to a *fat-finger-problem* is, in fact a very real problem. One can conclude that mobile websites are poorly designed if 50% of test participants experience the same problem while trying to click, or tap, on their desired links (Lim & Feria, 2012: 295).

Limitations inherent to the touch screen interface have paved the way for mobile design considerations. Due to disparities in the screen sizes of mobile devices, and the structure of the human finger, the hit size areas and the space between clickable items need to be increased when compared to full desktop websites. Because the hover state is absent in touch screen devices, and users get to know the interface through trial and error, it is essential that mobile interface are easy to read, clickable and designed as clickable icons.

2. **Mobile Screen Size**

The screen size (Seix *et al.*, 2012: 2) of mobile phones can be compared to a business card as a means of measurement. The size of the business card is about a 75% rough estimate size of what mobile users will be able to view of the whole M-commerce store, as illustrated in Figure 4.2

Figure 4.2: Touch Screen (5.0” Screen size) and Business Card Comparison

Online assistance, like form field descriptions and tooltips, are useful in helping users to interact properly with a mobile interface during the shopping and checkout processes (Brajnik & Giachin, 2014: 552). In addition, other design considerations include the use of good micro-copy and progressive disclosure which can be used to address the absence of a hover state on the touch screen device.

3. Mobile versus Desktop Contents

Scholars have argued as to whether the same content available on desktop/laptop applications needs to be available on mobile applications *or* whether separate curated versions need to be created for mobile visitors (Lin *et al.*, 2010: 12).

Figure 4.3: Sample of Mobile Content (adapted from Djamasbi *et al.*, 2014: 300)

In light of this, research conducted by Appleseed and Holst (2013: 65–70) shows that the limited content on mobile application versions confuses users and leads to poor shopping experiences and purchase abandonment. Figure 4.3 presents a description of M-commerce content. It can be observed that the limited content is specifically problematic, especially with product cataloguing. The features and layout of mobile websites should be adjusted to make them more mobile-oriented. This can be done by optimising the limited mobile screen size, including touch screen interactions and heightening the features' adaptability (Mercurio, Torre & Torsani, 2014: 452).

4. **Recoverability from Errors**

The ability to recover from errors on a mobile interface is very important (Ivanov, 2014: 348; Nyumbeka & Wesson, 2014: 355). In mobile shopping, for instance, the ability of mobile shoppers to recover from unintended errors is crucial. Among the questions which need to be answered when developing M-commerce applications are: Do the applications permit mobile shoppers to edit before making selections?

For example, if the user makes a mistake (Oyomno *et al.*, 2013: 318) and wishes to edit the order *before* checkout, how easy is it for him/her to edit the information? Do the applications allow users to *undo* certain actions while shopping? How suitable is the back button in supporting native browsers? How often do errors occur and how often is there support for error validations?

Figure 4.4: A Faded Mobile Error Recovery Button (adapted from Olsina *et al.*, 2014: 124).

The inclusion of error recoverability involves some level of expertise in the deployment and user testing of the application to uncover problematic areas. Nevertheless, it is essential to invest considerably in improving the recoverability of M-commerce applications to avoid high levels of mobile abandonment and to enhance mobile user shopping experiences. Figure 4.4 illustrates a faded mobile error recovery button.

5. **Content and Loading Performance**

   The slow loading time of mobile applications significantly affects UX and the desire to explore every aspect of a mobile website. Therefore, it is important to consider certain factors while developing mobile applications, especially M-commerce applications. These factors include: the avoidance of unnecessary ornamentation, simplifying the layout and making use of native technologies. If possible, JavaScript should be loaded using a non-blocking approach to ensure that proper asset caching is done (Kane *et al.*, 2009: 729; Li & Yeh, 2010: 677). The performance of M-commerce applications is crucial as it directly affects mobile users' shopping experience.

Figure 4.5: Description of Mobile Content Loading (adapted from Hinckley *et al*., 2016: 5)

Users' first experience of a mobile applications is how it performs on the interaction and loading page. If the website is slow (Hillman *et al.*, 2012: 122), pages will be sluggish and frail causing the user to abandon such websites and rather subscribe to fast and lightweight websites (Anokwa *et al*., 2012: 22; Mercurio *et al*., 2014: 452). Figure 4.5 illustrates a mobile content loading process. The next section discusses 11 usability heuristics proposed for the evaluation of M-commerce applications.

4.6 The Proposed Usability Heuristics for M-commerce Applications

The proposed draft set of heuristics for M-commerce applications is presented in the following sub-section.

4.6.1 Draft Set of MCOM Heuristics

Before the conduct of the heuristic evaluation, the below draft set of heuristics were subjected to review by usability professionals to obtain expert opinions regarding each of the heuristics. This approach is in accordance with prior studies on the validation of newly developed sets of heuristics for usability evaluation of user interfaces (Bertini *et al*., 2009: 26–29; Artinger *et al*., 2015: 38–44; Rufi'i, 2015: 939–940; Korhonen, 2016: 123–127). The usability professionals performed the review of the proposed draft heuristics via a customised online survey. Prior to taking part in the survey, the selected professionals were informed about the literature gap which the development of the new set of heuristics for M-commerce applications was aiming to address. The draft set of the MCOM heuristics, obtained from the reviewed literature and examined by usability professionals, is presented in this sub-section.

1. **Ensure that the home page is easy to view at a glance**

   The home page needs to be easy to scan in order to obtain an overview of the whole website. If not, mobile shoppers will become frustrated and may choose incorrect paths while interacting with the application.

2. **Be sensitive to users' fear of losing data**

   Users of mobile applications fear the loss of inputted data as typing on mobile devices is cumbersome. An example is the way in which users prefer to open links in a different window during checkout. They do so as they fear that data will be lost if the links are opened in the current window. Some users perceive that if they leave the checkout process their data would be lost. Consequently, they choose not to revisit the website to search for other products.

3. **Include a primary button at the end of each product page**

   The *Add to Cart* button needs to be available below every product page to avoid misinterpretation of cart buttons. Some websites have two similar *Add to Cart* buttons, one at the top or middle and a second at the bottom of the product page. This may, in many cases, confuse users.

4. **Be careful of including animated carousels**

   Users often experience difficulty in identifying and interacting with carousels. Some carousels change too quickly without affording users enough time to read and select an appropriate option.

5. **Be careful of adding images or product information on different subpages**

   Users may experience difficulty understanding the scope of the product subpage/s. To gain a full understanding of the current page's scope is problematic due to the limited screen size of mobile devices. Page-scope clues (including a current page overview, breadcrumbs and full URL paths) are available on full size pages but are lacking in mobile pages.

6. **Take care with the arrangement and design of account selection options**

   Ensure that users know how to use the *Guest Checkout* feature as well as the field relationships, options selection and account-selection steps of the buttons.

7. **Ensure that the auto-correction of the dictionary is disabled when needed**

   The auto-correction should be activated otherwise users may become frustrated. In most cases, auto-correction does not work well for acronyms, e-mail addresses, street names and words that are not included in the dictionary.

8. **Ensure that fields are long enough to display common data in full (Add label at the top of the field)**

   The interface should make it easy for users to notice errors and correct them (error prevention and recovery).

9. **Allow for the verification of inputted day and date**

   Avoid the use of text fields for date as this causes users needless mental processing and can lead to vital selection errors. In most cases, users encounter problems with drop-down menus or simple text field dialog in the selection of the date.

10. **Clearly distinguish each hit area and list item**

    Ensure that users are not confused about where to tap while selecting product items because of the existence of different lists.

11. Ensure that users' privacy and security concerns are addressed

The mobile application must be able to protect users' private information and enhance mobile shoppers' trust while they use the M-commerce application.

The detailed procedure for the validation and review of the draft heuristics is presented in Chapter 5, sub-section 5.4.6.2. The next section presents the conclusion to this chapter.

4.7 Conclusion

Heuristic evaluation, developed by Nielsen and Molich (1990: 225), is characterised as a valuable and less expensive expert-based method used professionally for the evaluation of software usability. Heuristic evaluation was traditionally developed and used for desktop software (Neto & Pimentel, 2013: 93). As mentioned in section 4.1, the outcome of the UPA survey highlights the importance and the popularity of this method amongst usability professionals to evaluate the usability of software products and thus enable the delivery of the required UX. However, as a result of the unique characteristics of mobile devices, the application of usability methods and skills developed specifically for the usability evaluation of desktop applications, may not yield the required results (Fetaji & Fetaji, 2011: 178).

M-commerce application developers have created M-commerce content with the defined purpose of enabling the purchase of any goods or product desired by mobile shoppers (Kurkovsky & Harihar, 2006: 229; Gündüz & Pathan, 2013: 116; Inostroza *et al.*, 2013: 24). Shopping on mobile devices, or smartphones, is challenging. Issues like trust, fear of security lapses, limited screen sizes, difficulty in input mode and poor screen resolution, amongst others, often arise (Hillman *et al.*, 2012: 115). Therefore, the application of traditional usability heuristics in M-commerce applications is not appropriate and their use would result in omitting many significant parts of the M-commerce application during the usability evaluation.

Following from the review of mobile empirical studies, it became evident that the most common usability testing methods in the context of M-commerce applications are: questionnaire survey (Sadi & Noordin, 2011: 495), focus group (Sieger & Möller, 2012: 2–4), observation and interview methods (Djamasbi *et al.*, 2014: 304). The M-commerce researcher and developer are faced with some difficulty in this genre of study. Some heuristics do exist for general mobile applications (Inostroza *et al*., 2013: 26–27; Neto & Pimentel, 2013: 95; Mi *et al.*, 2014: 357–361) and for E-commerce applications (Rababah & Masoud, 2010: 3–4). However, these heuristics are not suitable for the evaluation of M-commerce applications.

Following the analysis of relevant literature, this thesis decided to use Nielsen's heuristics (Nielsen, 1994b: 153) as a baseline for the development of the MCOM heuristics for M-commerce applications. In addition, the research applied the guidelines approach adopted by different scholars (Mi *et al.*, 2014: 357; Neto & Campos, 2014: 489; Orlandini *et al*., 2014: 196; Xu *et al*., 2014: 3) in their development of domain-specific heuristics for different mobile applications. Thus, this thesis was able to address the gap in literature by developing domain-specific UEMs (heuristics) for the assessment of the usability of M-commerce applications. The proposed MCOM heuristics will be validated in this study by conducting mobile empirical usability evaluations on the selected M-commerce applications. Chapter 5 will present the research design and methodology employed in this research.

Chapter 5: Research Design and Methodology

5.1 Introduction

The task of designing a research project is a systematic process which involves a connection between questions to be answered and the execution of the research study (Rajasekar, Philominathan & Chinnathambi, 2006: 22; Stuthridge, 2012: 31). A research design can be described as a logical sequence which links the empirical data collection process to the associated research questions and, finally, to the concluding part of the research study (Yin, 2009: 21–22; Evans, 2011: 3–4; Kothari, 2011: 31).

The research design is a blueprint, or plan, of methods according to which the intended research will be conducted (Baxter & Jack, 2008: 555; Creswell *et al*., 2011: 7). To acquire data, a number of techniques are involved such as: interviews, observation, questionnaires and employing secondary data (Paltved & Musaeus, 2012: 785). However, the final decision for the research design is represented by the choice of technique/s applied for data acquisition and the methods employed to analyse the data.

Chapter 5 presents the research design and methodology used during the experimental phases of this research work. The chapter also explains the design elements employed for the research and discusses the significance of methodological choice, a road map (strategy) and the time frame for design. The research instrument selection process, research execution and a recap on research objectives are also include in Chapter 5 along with the research methodology for the two usability evaluations of four selected M-commerce websites. The detailed experimental procedures of both evaluation methods, as well as the test participants, with their demographic details for both experiments, are also included.

In addition, Chapter 5 presents the research validity and reliability as well as the data triangulation for both the qualitative and quantitative data from the two selected evaluation methods in the usability evaluations of four M-commerce websites. The chapter concludes by highlighting the importance of research design coherence. The following section describes the mapping of the research objectives and the methods used.

5.2 Mapping of Research Objectives

This section plots the research objectives to the research design, as illustrated in Table 5.1.

Table 5.1: Description of Research Objectives and Research Design

Objectives	Methods
To determine which essential attributes of the usability model are most appropriate in the context of M-commerce websites.	The fusing of information regarding domain-specific attributes of mobile websites and a review of the relevant literature.
To propose a landscape of UEMs in respect of when to use which evaluation method/s in the context of mobile applications.	A critical synthesis of relevant empirical studies with respect to the formation of usability evaluations (e.g. regarding the users' tasks/activities, technology/system/ product and environment).
To develop appropriate domain-specific heuristic evaluation method for evaluating the usability of M-commerce websites.	MCOM heuristics is developed by studying relevant literature. Based on the existing domain-specific heuristics, modifications are made for M-commerce websites in accordance with mobile usability guidelines for mobile websites and M-commerce websites.
To determine the effectiveness of the proposed domain-specific evaluation method in the usability evaluation of M-commerce websites.	***Study A:*** Employing remote asynchronous testing as identified in Chapter 3 and using SUS as post-test questionnaires. ***Study B:*** Employing the MCOM heuristics to conduct expert usability inspections on the selected M-commerce websites. For the selected M-commerce websites; the results of the heuristic evaluation methods are triangulated with the findings of remote asynchronous testing. A comparison of the usability problems identified by the MCOM heuristic evaluation method were compared to a combined list of the problems identified by conducting asynchronous user testing. The comparison resulted in a standardised identification list of problematic areas and sub-areas associated with the website's usability. This comparison pinpointed the most suitable method/s for identifying the minor and major usability problem areas, relevant to the10 major usability problem areas and 44 sub-areas. The research also described the severity levels of each identified usability problem separately in respect to the 44 sub-areas, as identified through the two evaluation methods.

5.3 Elements of the Research Design

The researcher used the metaphoric *Research Onion* to indicate the way in which the concluding elements are to be studied in respect to other design elements. This metaphor was initially formulated by Saunders *et al*. (2007: 102) and has consequently been adopted by many researchers to elucidate the design of their research studies (Knox, 2004: 123; Kulatunga, Amaratunga & Haigh, 2007: 480; Elli, 2011: 59; Boampong, 2014: 25). In this study, careful consideration was afforded to the *design elements* which provide both the medium *and* limitations according to which the techniques of data collection and the process of data analysis were implemented. The research design elements are presented in Figure 5.1 and are discussed in the following sub-sections.

5.3.1 Research Philosophy

The approach implemented by a researcher when viewing the world and encapsulating his/her perspectives regarding human knowledge and the nature of actualities, shows how well the research question and research design have been understood. The researcher's opinion as to what constitutes *suitable knowledge* and the procedures involved also significantly impact on the research philosophy (Al-Khouri, 2007: 1; Miles, 2015: 309–310). Researchers' strategies, as well as their methodological choices, differ significantly and, consequently, so do their views regarding what data are deemed meaningful and applicable (Gray, 2013: 24).

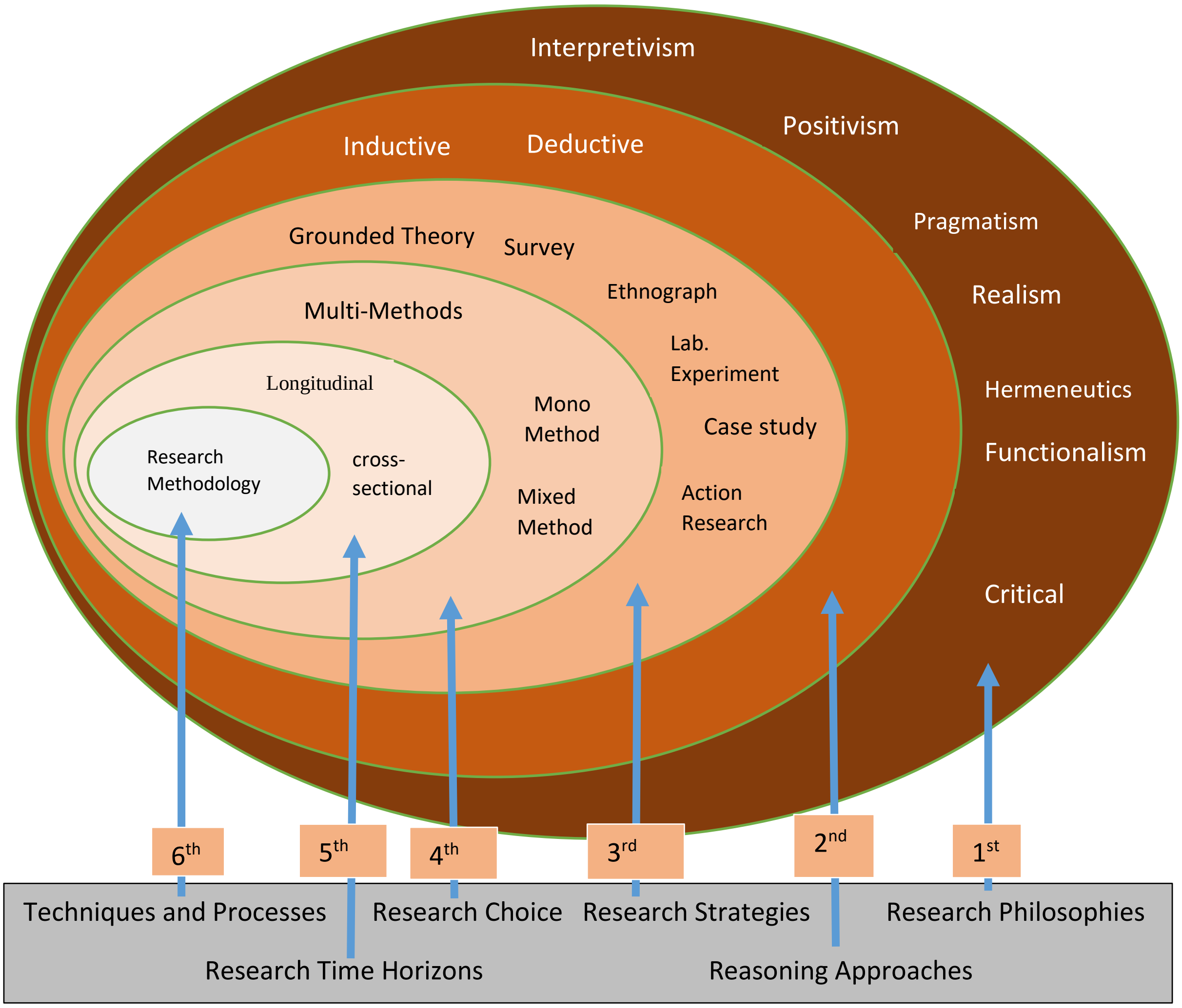


Figure 5.1: The Research Onion (adapted from Saunders *et al*., 2007: 102)

A researcher who is interested in observing and forecasting possible outcomes is concerned with concepts like cause and effect. This illustrates the choice of positivism as a philosophy. If a scientific approach for testing theories is adopted and this is accompanied by a choice of data that are well organised and commonly measured, the researcher's personal values will not affect the research much (Taton, 2015: 32–38). The research process involves sizable specimens of quantitative data and statistical hypothesis examination. Often the theory will need to be revised if it does not verify the findings based on the data analysis (Knight & Cross, 2012: 7).

A philosophical position associated with scientific inquiry is called *realism* (Gray, 2013: 13; Rudnick, 2014: 248). Realism refers to the existence of reality and it is *independent* of the researcher's senses and mind. However, the researcher may often also be inspired by his/her own world view and individual experiences. Realism can be divided in two approaches: direct and critical realism (Al-Khouri, 2007: 5). If a researcher views him/herself as a *direct realist*, he/she claims that an accurate representation is offered by whatever is experienced by the senses. A researcher who is a *critical realist* believes that whatever is first experienced through the senses, is then individually processed in the mind. The challenge with the critical realist position is ascertaining what is instantly experienced and which relationships and structures should be associated with it (Knight & Cross, 2012: 8–9).

The philosophy of *interpretivism* is adopted where a researcher is mostly interested in collecting general perspectives and transforming them into subjective meanings, instead of delivering law-like generalisations (Knight & Cross, 2012: 8–9; Starman, 2013: 30). Interpretivism is the study of social occurrences in relation to the individual natural environment. In addition, interpretivism is generally focused on researching people rather than objects. It embraces a compassionate attitude in trying to comprehend the social world and the way people perceive it. In interpretivism, the researcher believes that research is value bound, unlike the positivist view (Gray, 2013: 10–24; Ponelis, 2015: 537–539). The purpose of the research is thus a function of different sets of conditions and individuals in a particular period. Hence, a collection of data and analysis usually consists of qualitative data from detailed examinations of small samples (Al-Khouri, 2007: 2–3).

The word *positivism* refers to a research philosophy that is rooted in the natural sciences and is commonly referred to as an objective research strategy (Leimeister, 2010: 9; Aliyu *et al.*, 2014: 81–82; Jabbar, 2014: 98). In other words, only a single objective is real and obtainable via experimentation (Saunders *et al.*, 2007: 129–134). The epistemological perspective of positivism reveals that it is a conceptual way of hypothesising, scrutinising and reporting genuine research, initially in the natural sciences and later in the social sciences (Kura &

Sulaiman, 2012: 4–11). Hence, positivism deduces that the object being inspected and the explanation attributed to it have a clear and separate existence from the researcher's outlook (Mack, 2010: 6). This perspective also holds in ontological research philosophy that a researcher is free from the influence of any other individual and the survival of the researcher and social individuals chiefly depends on collective behaviours and practices (McGregor & Murnane, 2010: 420–422).

Critical researchers believe in the historical nature of social reality and that it is *created* and *recreated* by people (Knight & Cross, 2012: 8). Critical research emphasises the criticisms, contradictions and disputes in modern society and attempts to be emancipatory, eradicating the causes of domination and alienation (Stahl, 2008: 2–8; Rubin & Rubin, 2011: 21–22). Offering social critique is viewed as the main task of critical research because the alienating and restrictive situations of the status quo are unveiled (Goldkuhl, 2012: 137). Critical theory is only acceptable when it meets the following criteria: it should simultaneously be normative, explanatory and logical. That is to say, it should discuss what is erroneous in the contemporary social reality and then offer both simple norms for the opposition and attainable practical targets for social transformation (Leimeister, 2010: 11).

However, *hermeneutics* focus on the concept of understanding and on the study of the methods involved in the philosophy of understanding the meaning of concepts (Tien, 2009: 248). The hermeneutic approach emphasises that the story has some intrinsic meaning from the perspective of the people telling it and the research must be able to decipher the meaning (Moules *et al*., 2014: 1–10; Oppong, 2014: 245–251). The researcher should be aware of the fact that meanings can change over a period of time. In today's world, hermeneutics, as a research procedure, is being applied in the social sciences and all forms of text, including songs or jokes, are related to it (Kandababu & Indukuri, 2011: 8–14).

Functionalism is rooted in sociology and requires the study of societal structures with correspondence on how those structures satisfy the needs of society (Bechtel, 2010: 360). It is also perceived as an interpretive philosophical framework that comes with control and management of all organisational matters, which is placed in the structural constitution of the organisation as a miniature society (Sprevak, 2009: 510). In addition, a researcher describes a society in terms of social order, consensus, cohesion, integration, status quo, system or individual needs of fulfillment. Research in the social sciences employs the functional philosophical framework in the sociological field of research (Uddin & Hamiduzzaman, 2009:

656–658).

Pragmatism entails that the researcher believes that the weight of study undertaken depends on the results in terms of practical consequences. The entire phenomena cannot be explained by a single viewpoint because there may be diverse realities (Creswell *et al.*, 2011: 6). It is unlikely that a pragmatist researcher would make use of a variety of data collection methods, instead, the research design used must be relevant and consistent with the data to be collected. This aids successive action (Gray, 2013: 15–16).

Based on the findings of the specific characteristics of each research philosophy, the *pragmatic philosophy* is the right fit for this study and, as such, it is adopted as the research philosophy to guide the study (Gray, 2013: 15). The pragmatic philosophy has the following characteristics: firstly, empirical and subjective data are employed in an effort to gain better insight into a problem (Hartig, 2011: 165); secondly, pragmatic philosophy can identify the conceptual, implementation, philosophical, and evaluation tasks and phases, in relation to the complexity of the research project (Knight & Cross, 2012: 18).

The research procedure allows for the exploration of both the *qualitative* and *quantitative* uses of participant experiences and expert views regarding the usability of selected M-commerce websites (Lu & Gatua, 2014: 2). The approach permits research execution with data, even when there is a limitation in the data collection domain process. This approach permits data collection in a concurrent mode, thus it allows for the collection of the first and subsequent samples of data simultaneously (Baxter & Jack, 2008: 554–555). The outer layer (philosophical views) of the research onion has been discussed in this section. The next section will address the reasoning approach layer in accordance with its application to the research.

5.3.2 Reasoning Approach

The construct of the research argument can follow either an *inductive* or *deductive* path. Reasoning from a general to a specific or particular view is called deduction while reasoning from a specific view to a general view is called induction (Gray, 2013: 3). In addition, quantitative research applies dialectic or deductive reasoning, while inductive and exploratory methods are employed in qualitative research (Creswell *et al.*, 2011: 6; Given, Winkler & Willson, 2014: 4–5).

As discussed in Chapter 4, this study adopted an inductive reasoning strategy, which involves drawing research conclusions from specific observations and applying them as a general finding. For example, inductive reasoning moves from observations to the expected logical or theoretical pattern, which confirms whether specific observations actually occurred (Babbie, 2010: 50; Katz, 2015: 133–136).

5.3.3 Research Strategy/ies

The next layer of the research onion refers to the research strategy/ies. Researchers have the option of using multiple strategies in their research design when addressing their research questions. A researcher and/or practitioners may be guided by an *action research* strategy to bring about organisational change but within this context they may also apply a *survey strategy* to gather data from a large number of workers in an organised way (Rubin & Rubin, 2011: 20–21). Because it is not feasible to discuss all the types of strategies in this study, it is vital to note that the demarcations between research strategies and research philosophies are often permeable. *Ethnography,* as an example, is related to both interpretivism and realism. Survey research and experiments are, on the other hand, commonly related to positivism and are applied by pragmatist and realist researchers (Paltved & Musaeus, 2012: 781).

Furthermore, ethnography is directed at a specified person, programme or event. An ethnographic researcher studies a complete group belonging to the same culture (Reeves, Kuper & Hodges, 2008: 512). In addition, ethnographic research focuses on the qualitative examination of a particular group who share the same background or traditions (Jonker & Pennink, 2010: 170; Cooper & Schindler, 2014: 158; Moses & MacCarty, 2019: 222–230). Ethnography can best be used to elucidate different subjects within a group of people who have been living together for a long time and who have become a part of the same culture (Ellis & Levy, 2009: 329). Ethnographic research can assist information system researchers in the collection of useful facts during a system's development cycle (Creswell, 2013: 11–16).

Grounded Theory is a systematic inquiry of theory, interaction and action at a general conceptual level to substantiate the view of participants. The procedure comprises multiple stages of data collection and modification and takes into consideration the hierarchical relationship amongst groups of information (Pathirage, Amaratunga & Haigh, 2008: 5; Petty, Thomson & Stew, 2012: 378–379; Creswell, 2013: 11). In addition, it is noted that when the current theories available in literature fail to sufficiently describe a particular situation, then the grounded theory can be applied to develop a new theory (Jonker & Pennink, 2010: 98; Chapman, Hadfield & Chapman, 2015: 202–204). In most cases though there is a need to revise existing theories in such circumstances as these theories might not be applicable.

Action research is a method of practical research in which a researcher reaches conclusions which are important to the people to whom the research is being addressed and, simultaneously, it enhances theoretical knowledge (Al-Khouri, 2007: 6). The researcher, through practical interference and involvement in the problem, produces a practical outcome (Paltved & Musaeus, 2012: 780). The personal principles of the researchers are significant since the opportunity for direct researcher intervention is always present (Ellis & Levy, 2009: 329; Gray, 2013: 18).

Laboratory experiments allow researchers to find the accurate relation between a small number of variables which are then studied in a designed laboratory condition using quantitative and investigative methods. This process allows researchers to make generalised statements applicable to real life situations (Schaufeli, Leiter & Maslach, 2009: 209–211; Leimeister, 2010: 12; Singh & Yadav, 2013: 10). The weakness of a laboratory is that it is limited in its representation of true user environments and thus restricted to the situation being examined. It also isolates some variables present in the natural environment (Castro *et al*., 2011: 372). Therefore, field experiment, an extension of the laboratory experiment, achieves more practical results and abates the scope of criticisms or artificial conditions when performed in a real life environment (Al-Khouri, 2007: 5; Mukherji & Albon, 2010: 17).

Surveys uncover and collect information regarding the views of people during one process at a specific time such as opinion polls and interviews (Balka, 2011: 42; Bakogiannis *et al.*, 2014: 42–46). Quantitative observational techniques are generally used to arrive at conclusions derived from given facts and information (Creswell *et al*., 2011: 7–9). Surveys permit data triangulation and help the researcher to perform studies on multiple variables at a time. It also enables the researcher to perform experiments where all the information can be collected from the natural surroundings (Heath, 2015: 639). However, the outcome of the quantitative data method makes it difficult to understand the insights related to the issue, or processes involved in data interpretation and analysis (Cooper & Schindler, 2014: 174). Additionally, there is bias present in the survey process when respondents reveal a self-selecting attitude. The time duration of the survey and the questionnaire design are both important (Al-Khouri, 2007: 5; Heinecke, 2011: 138).

Generally, in *a case study*, the evidence used is qualitative and deals with in-depth, broad and comprehensive facts (Jabbar, 2014: 103–105). Case studies are used to investigate, or explain, observable facts by a thorough study of natural surroundings (Easton, 2010: 118; Miles, 2015:

313–315). In some instances, a researcher needs to perform a lot of research and investigative groundwork. In a case study, a phenomenon is examined in its natural surroundings using various methods to collect data and information from a group of people, or organisations (Jonker & Pennink, 2010: 151). However, there are numerous points that should be considered when applying the case study approach.

A case study is advantageous if a particular phenomenon, or event, occurs in natural surroundings (Widdowson, 2011: 26; Hyett, Kenny & Dickson-Swift, 2014: 1–3). A case study is not suitable if the researcher intends to control or manipulate the variables. It is vital that the research should be related to the problem and not reflect the researcher's failure to carry out the research with a particular methodology (Wahyuni, 2012: 73–77). A common criticism of case study methodology is that meaning cannot be generalised from case study results and various methods to suit the particular hypothesis testing. Theory building is also considered difficult (Vissak, 2010: 374–375; Balka, 2011: 43).

This research adopts a multiple case study approach and the field experimental research strategy. The multiple case studies will allow comparisons which will enhance in-depth investigations, understanding and analysis of the data. In addition, the field experimental methodology was selected as the most effective method of answering the research questions and achieving the research aims and objectives, as outlined in the previous chapters. Additionally, quantitative measurements and qualitative assessments in the data collection and analysis processes are applied in this study. Details of the selected case studies are presented in section 5.4.2. The next section explains the research choice adopted in this study.

5.3.4 Research Choice

A very basic, but fundamentally important choice faced by a researcher when designing his/her research, is the choice between using qualitative or quantitative method/s or a combination of both. The researcher can employ one data collection method and an associated single analysis procedure (e.g. *mono-method* quantitative design, based on the use of a questionnaire data collection method which is analysed statistically, or an in-depth interview data collection method as a *mono-method* qualitative design which is analysed as a narrative) (Taton, 2015: 32–37). Otherwise, *multiple methods* can be used. The researcher can use multiple quantitative data collection techniques as multi-method quantitative designs, while multiple qualitative data collection methods can be used in the case of multi-method qualitative designs, like diary accounts or in-depth interviews. These are generally used with associated analysis procedures (Macdonald & Headlam, 2008: 36; Hyett *et al*., 2014: 2; Heath, 2015: 639).

A *mixed methods* design includes qualitative as well as quantitative data collection techniques and analysis procedures (Ellis & Levy, 2009: 332; Reimann, 2010: 14; Russ *et al*., 2018: 179–183). A simple mixed method design allows the researcher to start with a qualitative data collection method and analysis and then accompany this with a quantitative data collection method and analysis. For a complex mixed method design, the researcher could select a quantitative analysis technique to analyse qualitative data quantitatively, or the other way round (Saunders *et al.*, 2007: 128–134). Therefore, since this research work involves the collection of both quantitative *and* qualitative data (heuristic evaluation and remote asynchronous usability testing) the mixed method approach was adopted. The mixed method approach also allows for the triangulation of both qualitative and quantitative data.

5.3.5 Research Time Horizon

The layer of the research onion which surrounds the core addresses the amount of time needed to execute the research. When research is carried out to address a problem, or to answer a query at a specific time, the researcher may employ strategies such as case study or survey. This methodology is known as a *cross-sectional method* (Raoprasert & Islam, 2010: 67). Otherwise, the research is *longitudinal* where data has to be collected over an extended period of time (Macdonald & Headlam, 2008: 8; Cheung & Hew, 2009: 169; Heinecke, 2011: 133). This process requires strategies like action research, experimenting and grounded theory (Wetter, 2011: 69). The timeframe for a research study usually reflects the researcher’s available time and resources. If the required time is limited, then a *snapshot* approach may be adopted. This is also referred to as a cross-sectional study (McLeod & Elliott, 2011: 3). Research studies are generally time sensitive and resource constrained. This results in the use of cross-sectional methodologies by most researchers (Gray, 2013: 22).

As discussed before, the developed MOSAD model for an M-commerce application identifies five initial attributes for usability evaluation of M-commerce applications. The attributes are *efficiency*, *effectiveness*, *satisfaction*, *error rate* and *learnability*. Unlike the attributes of usability identified by Nielsen, the ISO standards do not include learnability and error rate as product usability attributes, as discussed in Chapter 2. An earlier study shows that *error rate* and *learnability* are implicitly included in the broader definitions of efficiency, user satisfaction and effectiveness as attributes of usability (Harrison *et al.*, 2013: 2–3). Therefore, only the attributes of *efficiency, effectiveness* and *satisfaction* among the five attributes of MOSAD model are evaluated in this research work. In addition, a cross-sectional approach is adopted because of the time sensitivity of the study (Cooper & Schindler, 2014: 126–145; Taton, 2015: 1). Mobile devices and mobile websites are changing every day and new devices are forever flooding the market, hence, the reason for the adoption of a cross-sectional methodology.

5.4 Research Methodology

The main components of the research design were presented in the previous section. The selected websites for studying and describing the test tasks and participants are detailed in this section along with: the pilot study, steps of conducting usability test, selection of the targeted websites, design of the test tasks, selection of test participants, outline of effectiveness criteria, materials and equipment and experimental procedures used in both evaluation methods.

5.4.1 The Pilot Test

To ensure that all procedures ran smoothly during the real test, the researcher of the current study conducted a pilot test *prior* to the actual test (Jeong & Yoon, 2013: 35; Lu & Gatua, 2014: 6; Perry *et al.*, 2018: 223). Five participants were selected for the pilot test of the asynchronous remote testing process. They were invited via phone calls and Facebook while two evaluators for the heuristic evaluation process were invited via LinkedIn. These individuals had no further involvement with the study. The number of participants recruited for the pilot study and the approach to their selection, by convenience sampling, were in line with Nielsen's recommendations (Nielsen, 1994a: 57–71).

The researcher obtained satisfactory results from the pilot test. This is an indication that all the procedures were correctly undertaken. Literature suggests that the level of difficulty of test tasks should be in an ascending order, thus enabling users to gain confidence in performing the tasks as they work through the questions (Al-Razgan *et al.*, 2014: 420). However, based on the pilot test results, it was observed that the second task was more difficult than the other tasks and it was, therefore, moved to the end of the test.

5.4.2 Steps to Conduct Usability Test

In order to conduct an actual usability test and minimise inaccurate results, six important steps should be considered (Jokela *et al.*, 2006: 345–348; Kenteris *et al.*, 2009: 113). The six steps are described in the next sub-sections.

5.4.2.1 Defining the Goals of the Test

A clear and concise goal will enable the evaluator to form clear ideas about what the expected results of the test are and what factors will affect the results. The goals of usability tests can be very simple, such as measuring the user acceptance level of an interface, or they can be very particular, such as assessing the readability of specific contents of the website (Oyomno *et al.*, 2013: 306; Olsina *et al*., 2014: 118). The final goal of the current research is to improve M-commerce UX, using *usability*, for this new domain.

5.4.2.2 Selecting Appropriate Data Collection Techniques

There are currently several data collection techniques available for usability testing (Micallef *et al.*, 2013: 588–589). The most commonly used methods are discussed in Chapters 3 and 4 of this study. For the past 30 years, to determine the functional level of a defined software system, various UEMs have been employed. The trend in the past two decades has been that less expensive UEMs have been employed, including the remote asynchronous usability testing method and the heuristic evaluation method, as discussed in Chapters 3 and 4 of this study. For this research, the MCOM heuristic evaluation and remote asynchronous methods were utilised.

5.4.2.3 Selecting the Sample of Test Users

There are three major factors that must be considered when selecting participants for testing usability namely: the number of participants, the relevance of participants and experience of the participants. There is no specified number of test participants for exploring possible usability problems (Gündüz & Pathan, 2013: 120). However, it was suggested that at least five participants are sufficient to ascertain 85% of the usability problems, as shown in Figure 5.2 (Nielsen, 2000). Other researchers reported that most of the usability problems are identified by the first three or four participants and additional participants rarely reveal fresh usability problems (Oppong, 2014: 247).

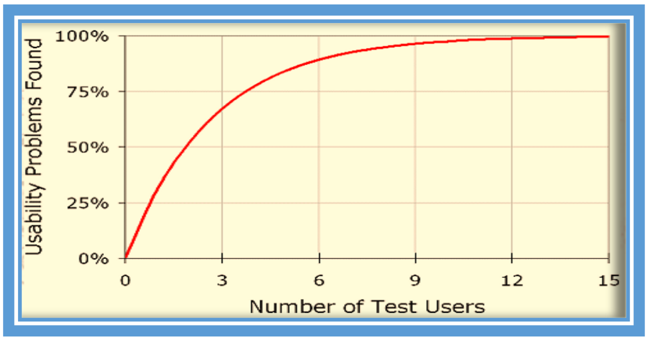


Figure 5.2: The mapping of test participants against the usability problem (adapted from Nielsen, 1994c: 33)

Some researchers suggest that the number of participants needed to test a system or website with above average usability should not exceed 10 (Fetaji & Fetaji, 2011: 179). Application users will likely encounter problems which, in turn, will produce relevant results. The experience of users is also important in a usability test. Experienced users are more likely to easily spot problems compared to non-experienced users (Kulpa & Amaral, 2014: 276). Another criterion that may be useful for testing is the experience of past users who have encountered the interface. Evaluation by different age groups is also required in the usability testing process (Sim *et al.*, 2013: 194).

5.4.2.4 Designing Tasks

Usability test tasks must relate to the actual activities which a user undertakes on mobile websites to achieve certain purposes. Also, the tasks should represent major problems which significantly impact usability testing (Alshehri & Freeman, 2012: 4; Deegan, 2013: 147). New features of the task can improve the user's interaction during the first trial. Tasks with new features can highlight usability problems with big databases and other system usability problems. While completing the tasks, users act *normally* i.e. as they would do in their daily environment while using the application interface (Duh, Tan and Chen, 2006: 183).

5.4.2.5 Establishing Usability Metrics

In most cases, usability test tasks involve the metrics employed to measure a system's usability level. The commonly employed usability metrics are (Cheng, 2011: 25; Lettner & Holzmann, 2012: 119; Raptis *et al.*, 2013: 135; Malandrino *et al.*, 2014: 26):

- *Task completion rate*: the correctly completed percentage of tasks during the test.
- *Time consumption*: total time for task completion.
- *Satisfaction score*: user's level of satisfaction with an interface during the test. Other usability attributes can be incorporated such as understandability and memorability, amongst others.

5.4.2.6 Preparing Test Material and Equipment

The researcher must ensure that all test materials and equipment are available before undertaking the experiment. Prior to the test execution, it is important to conduct a pilot test to ensure that the testing procedures are clearly understood and that modifications can be done, if needed, *before* the real test (Hörold *et al.*, 2014: 493).

5.4.3 Selection of the Targeted Websites

The Loop11 testing tool is used for asynchronous testing and requires the start and end URLs of each task to be added in the design phase (Greifeneder, 2012: 106–107). This study, therefore, made use of the mobile version of the selected websites instead of their mobile applications.[6] Several efforts were made to secure permission to use websites hosted in South Africa because the researcher is studying at the University of South Africa. Request letters were sent to 25 E-commerce companies to obtain permission to include their websites as case studies for this research.

The recruitment of South African E-commerce providers did not yield any results. The recruitment was not specifically targeted at retailers offering specific merchandise, but rather, open to all providers, as long as the providers sell physical products on their websites. However, most of these companies failed to respond after repeated reminders. The few which responded, however, indicated that they did not want to be included in the case studies. The following extracts are from two e-mail responses received from two E-commerce providers in South Africa:

1. *"I'm sorry Sunday, but we can't give you permission to conduct research on the site. This is against company policy. Good luck with the studies."*.

2. *"Our apologies for the delay in our response. After having read your letter we have decided that, unfortunately, we will not be able to allow you to run your usability test on our website and therefore we are not granting you permission. Wishing you all the best with your research."*

The e-mail extracts above illustrate the samples of many rejections which the researcher received from E-commerce providers in South Africa. The researcher failed to obtain permission, even after several efforts were made to explain the benefits of using the websites as case studies.

The reason for rejections may be connected to the existing law in South Africa as well as the privacy policy of each of the E-commerce providers. In South Africa, there is legislative and

[6] Mobile Apps are actual applications which need to be downloaded and installed on a mobile device instead of being accessed via website. A mobile website comprises of browser-based HTML which is designed to be accessed through the internet (majorly via 3G or, 4G or WIFI networks). They are typically designed for touch-screen interfaces and mobile devices.

regulatory frameworks and policies, consumer protection concerns, customer traffic log data, privacy and confidentiality, non-disclosure agreements, proprietary information and designs, amongst others (Joubert & Belle, 2013: 26–29; Ajibola & Goosen, 2013: 1-3).

The researcher consequently sent similar request letters to 25 E-commerce administrators in Nigeria. Four companies agreed to take part in the research study. It is interesting to note that South Africa and Nigeria have the biggest economies in Africa and their E-commerce sectors are relatively similar (Tétényi, 2014: 2–6; Amao & Okeke-Uzodike, 2015: 2–4; Ogunnubi & Isike, 2015: 2–8; Sekoai & Yoro, 2016: 3–6).

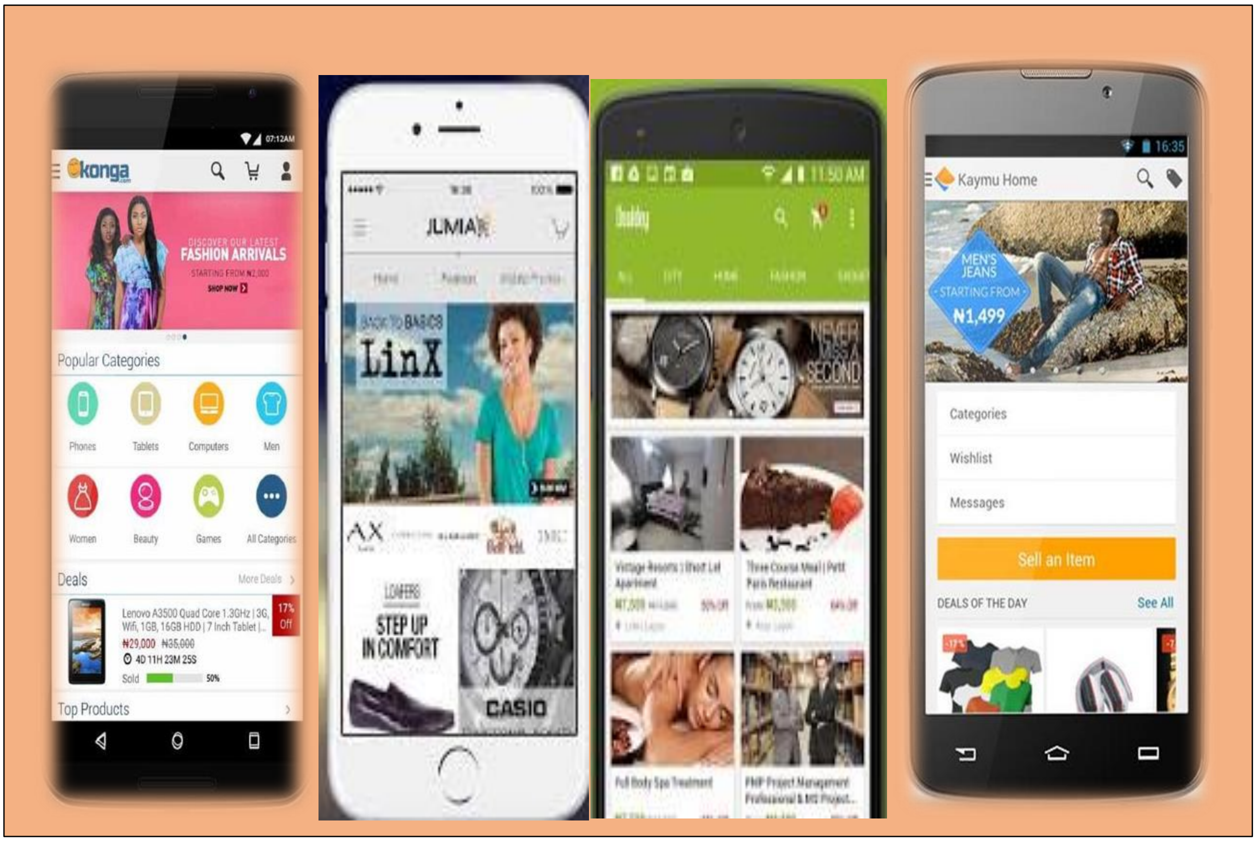


Figure 5.4: Samples of mobile views of the four case studies

Figure 5.4 presents screenshots of the M-commerce websites of: Konga (Website 1), Jumia (Website 2), Dealdey (Website 3) and Kaymu (Website 4). These are the mobile websites which were targeted for this research study.

The main reasons for selecting these websites are: firstly, the websites have interactive interfaces with multiple functions, processes and features. Secondly, representative users of these websites are easily accessible because they are the major E-commerce and M-commerce websites that are popular amongst online shoppers in Nigeria. This makes the sample selection process simpler, as representative participants can be easily found. For this research, no modification or alteration to the interfaces were made during the testing to gain preliminary information regarding the selected websites.

Covering letters (See Appendix 1) were sent to the website administrators to: assure them in advance that there was no intention to modify or alter the interface during testing and to gain preliminary information regarding the websites. In accordance with the University's ethics standard, the covering letters are a prerequisite to the issuing of an ethical clearance certificate by UNISA's ethics committee.

5.4.4 Designing Test Tasks

In testing tasks for usability studies, the emphasis should be on the actual activities of end users while using the website. The researcher utilised information obtained from users' reviews, which are available on the Google Play Store. These available information illustrate user activities and patterns and help guide the design of various test tasks. Four tasks were designed in the usability evaluation process. This is an adequate number to ensure that task completion time is sufficient and not excessive (Duh *et al.*, 2006: 183). Tasks gradually change from easy to complex, as information processing and associated cognitive demands become greater. All tasks require that participants extract a certain amount of information from the websites, but at different levels, in different stages. All tasks were self-contained and designed to be undertaken in isolation so that participants were able to start with new tasks, even when they were unable to finish a task within the specified time frame. This study employed problem-solving tasks and participants were not offered guidance while undertaking the tasks on the websites (Bao *et al*., 2011: 447). Problems encountered while navigating the mobile website were dealt with independently.

Based on an extensive review of relevant literature and users' reviews on Google Play Store (Duh *et al*., 2006: 183; Cooke, 2010: 204), four tasks were given to participants as original questions which pertained to the selected websites. These were undertaken using the asynchronous remote usability testing method. Since the products available on the four selected websites were not the same, four sets of task scenarios representing the usual websites real-life situations were created. These scenarios were similar for all four selected mobile websites. Appendix 2 contains details as to the four task scenarios designed for the selected websites.

The four-task scenario detailed which tasks users were expected to perform while interacting with the website interfaces. The four sets of task scenarios were similar to thus enhance comparisons across the selected websites (Tan, Liu & Bishu, 2009: 622–624). However, the tasks for evaluators in the heuristic evaluation were open-ended tasks, which highlighted and identified problem areas during the evaluation with the aid of heuristic guidelines.

5.4.5 Selection of Test Participants

The study used *snowball sampling* to identify suitable participants through referral networks. In an effort to select the test participants, advertisements were placed on Facebook and LinkedIn (see Appendix 3). The Facebook advertisement was designed to target a Nigerian audience aged 18 to 65 years. None of the selected participants were personally known to the researcher. According to StatCounter (2018b), 82.26% of Nigeria's population of 198 million are Facebook subscribers. This statistic is also a realistic reflection of the number of Nigerians who use social media.

The Facebook advertisement for asynchronous testing yielded 60 subjects of which only 35 individuals were finally selected to participate in the usability testing based on the information they supplied in the pre-test questionnaire, as per Appendix 5 (Brown *et al.*, 2018: 66). Through snowball sampling, the selected participants recommended other participants to the researcher who were also required to complete the pre-test questionnaire. This resulted in 45 participants being identified. A total of 80 test participants were thus selected to participate in the asynchronous testing. Furthermore, three experts were selected through the LinkedIn advertisement for heuristic evaluation. The other two experts were recommended by the previously selected experts which totalled 5 experts for heuristic evaluation. The researcher is a member of a few UX LinkedIn groups which also aided him in the recruiting process. Snowball sampling has been used by different scholars, with good effect, as a method for garnering quality data (Cooper & Schindler, 2014: 360–361; Lu & Gatua, 2014: 6–9; Taton, 2015: 1). However, the sampling method may not be appropriate for use in a heterogeneous population and may, consequently, result in poor quality data (Lu & Gatua, 2014: 13).

As discussed previously, in the third step of Section 5.4, the number, relevance, and experience of potential participants are crucial aspects which have bearing on the sample selection process (Chaparro *et al.*, 2014: 71). Participants were included on "has prior experience" if they had previously attended a 'HCI' course and if they had completed a practical project in 'Usability Testing'. The following sub-sections describe the procedure employed for selecting the two groups of participants who took part in the remote asynchronous testing and the MCOM heuristic evaluation processes.

5.4.5.1 Remote Asynchronous Testing Participants

Much contention surrounds the question as to how many participants are required for usability testing in order to provide accurate results. Researchers suggest various numbers, ranging from five to twenty, to obtain contrasted test results in a sole usability test (Andreasen *et al.*, 2007: 1413; Gündüz & Pathan, 2013: 120).

After considering these factors, a total of 80 participants were selected for this study. A total of 20 participants were assigned to each of the four M-commerce websites in the asynchronous usability testing process.

Table 5.2: Demographic Details of the Participants

Participants' Data	**Remote Asynchronous Testing**								**Heuristic Evaluation for the 4 websites**
	Website 1		**Website 2**		**Website 3**		**Website 4**		
	Novice	**Experts**	**Novice**	**Expert**	**Novice**	**Expert**	**Novice**	**Expert**	
Total of Test Participants	**20**		**20**		**20**		**20**		**5**
Age	18-50	18-50	18-50	18-50	18-50	18-50	18-50	18-50	30-70
Gender	Male: 6 Female:4	Male:6 Female:4	Male: 6 Female:4	Male:6 Female:4	Male:6 Female:4	Male:6 Female:4	Male: 6 Female:4	Male:6 Female:4	Male: 3 Female: 2
Country of Origin	Nigeria	Nigeria	Nigeria	Nigeria	Nigeria	Nigeria	Nigeria	Nigeria	UK: 2 USA: 1 Germany:1 Canada: 1
Internet Experience	Below 3 years (5 Testing Users)	Above 3 years (15 Testing Users)	Below 3 years (5 Testing Users)	Above 3 years (15 Testing Users)	Below 3 years (5 Testing Users)	Above 3 years (15 Testing Users)	Below 3 years (5 Testing Users)	Above 3 years (15 Testing Users)	All used internet daily
Targeted Website Experience	No	No	No	No	No	No	No	No	No
Usability Experience	No	No	No	No	No	No	No	No	Average of 10 years' experience

Table 5.2 presents an overview of participants' demographic profiles for the asynchronous remote testing and heuristic evaluation methods. In order to obtain representative samples, the criterion for the sample selection was that all test participants must be *Nigerian mobile shoppers*, as they are the target users of the selected websites (Ozok & Wei, 2010: 129; Chin *et al.*, 2012: 5–6). Appendix 4 presents the detailed profiles of the test participants in the remote asynchronous testing.

After having been selected, each participant was asked to complete an online background pre-test questionnaire, as per Appendix 5. This pre-test questionnaire was developed using the online survey tool SurveyMonkey (Luojus *et al.,* 2013: 110). This questionnaire essentially collected basic background information of the participants including: gender, country of origin, internet experience, prior use of the target website and previous experience/s with usability problems (Zapata *et al.*, 2014: 5; Engelbrecht, Lukosch & Datcu, 2019: 10). The pre-test questionnaire aided in the final selection of the 80 participants who took part in the study.

5.4.5.2 Heuristic Evaluation Participants

The same recruiting procedure, discussed in sub-section 5.4.3.1, was applied to recruit experts for the heuristic evaluation process. An earlier study suggests that three to five experts are sufficient for the heuristic evaluation process (Nielsen, 2000). Hence, five experts were recruited for the heuristic evaluation process. Table 5.2 provides an overview of the experts' demographic profiles for the heuristic evaluation. The evaluators were considered *experts* if they had passed coursework or completed a module in HCI and/or human factor web design and development (Beauchemin *et al*., 2019: 38). In addition, the expert had to hold a graduate degree and have, at least, one practical experience in the heuristic evaluation of website interfaces. These criteria are in line with the belief that expert evaluators yield better results in the heuristic analysis of website interfaces (Akers, 2010: 47–48; Martínez, 2012: 245–299; Davids, 2015: 74–76).

5.4.6 Outlining the Effectiveness Criteria

Comparing the effectiveness of usability testing methods is very important in appraising the value of a usability testing method. The comparative criteria must be defined before the test. The criteria are stated in terms of one, or more, performance related indicators which are computed from raw empirical usability data, such as a usability problem lists produced by usability testing methods (Olsina *et al*., 2014: 112). Determining the correct criteria and performance indicators is dependent upon a proper understanding of the alternatives available and the shortcomings of each of these alternatives (Sánchez Riera, Redondo & Fonseca, 2015: 372). Therefore, the main focus at this stage of the study was to refine the criteria employed to evaluate and compare the effectiveness of the MCOM heuristic evaluation and remote synchronous testing methods being examined.

In view of this, an extensive literature review on studies dealing with comparative usability testing methods was undertaken. The conclusions drawn from this review suggest that there is no singular standardised criterion for assessing and comparing the effectiveness of the usability testing methods. Instead, researchers focused on different aspects when comparing usability testing methods. The most popular criteria addressed were: the number of usability problems, types of usability problems, task performance level and satisfaction of the participants (Bruun *et al.*, 2009: 1625; Neto & Pimentel, 2013: 96). As noted, these specific criteria were used and referred to in usability research studies and, as such, they were selected as criteria to be applied in the heuristic evaluation and asynchronous remote testing methods. It is important to note that since heuristic evaluation is not a user-based testing method, only a few of the problems discovered are reported in this study. The results are compared to those from the remote asynchronous testing method.

1. Number and Types of Problems Discovered

As a result of literature surveys, four different indicators were applied to specify the number and nature of problems which arose from the heuristic evaluation and remote asynchronous testing methods.

- **The total number of usability problems discovered**: This is a measuring parameter in a usability test which indicates the total number of usability problems discovered by the remote testing and heuristic evaluation methods. It is considered a very effective measure for usability testing techniques in different comparative studies (Holzmann & Vogler, 2012: 159; Neto & Pimentel, 2013: 96).

Table 5.3: Scoring Systems for Usability Problems (Nielsen, 1994a: 115–171)

Rating	Description
1	Cosmetic problems: These problems are noticed when test participants faced certain difficulties, or when abnormal behaviour was discovered, or when users make certain comments when completing the task. Addressing these types of problems should be afforded low priority.
2	Minor problems: Users commit errors in the process of performing certain test tasks but are able to overcome and finish the required test tasks within a specified time frame. Fixing this type of problem should be afforded medium priority.
3	Major problems: These are classified as major errors or mistakes from which users fail to recover and which result in them not being able to perform tasks on time, as required. Users might know what the errors are, but they are unable to overcome them. Fixing this type of problem should be afforded high priority.
False Problems	These are problems discovered by the evaluators using the expert evaluation method, but not discovered by the users in the user testing (asynchronous testing).

- **Types of usability problems discovered**: This indicator evaluates usability problems as belonging to several classes namely: major, minor, cosmetic and false problems. Evaluating the extent of usability problems uncovered by a specific usability testing method will highlight the extent of problems which the method can, or cannot, detect. This procedure has been applied in several comparative studies for performance measurement (Duh *et al.*, 2006: 185; Bruun *et al.*, 2009: 1627).

  Nielsen's scoring system, as presented in Table 5.3, is widely used by different scholars (Chalil Madathil & Greenstein, 2011: 2229; Neto & Pimentel, 2013: 93; Al-Razgan *et al*., 2014: 420) as an objective assessment of the problems discovered during the testing process. Table 5.3 incorporates *false problems* in the scoring system for usability problems. This is one of the major weaknesses of heuristic evaluation method, as indicated in Table 5.3. However, a prior study shows that it is difficult to assign appropriate rating scores to usability problems. This can be ascribed to the inadequacy of rating scale label descriptions as well as the fact that these descriptions are often misinterpreted (Molich, McGinn & Bevan, 2013: 304–306).

- **The number of unique usability problems uncovered**: Unique problems are defined as those identified by only one test method. Unique problems are important indicators, which have been used in many comparative studies of other methods, with the in-lab and synchronous remote testing methods (Bruun *et al.*, 2009: 1625; Jonker & Pennink, 2010: 47).

- In the test session, the **number of usability problems** discovered is the total number of problems found by the testing users while interacting with the software interface during a particular test session. This indicator has been used in many comparative studies (Fetaji & Fetaji, 2011: 183; Holzmann & Vogler, 2012: 159; Neto & Pimentel, 2013: 96).

2. Task Performance

Research studies have shown that there are two main aspects to task performance testing methods namely: task completion rate and time spent on tasks (Wentz & Lazar, 2011: 95; Sim *et al*., 2013: 194).

- **Task completion rate**: Task completion rate relates to the percentage of tasks which are correctly completed during usability testing. The completion rate of tasks can be divided into two categories: successful (completed) or unsuccessful (uncompleted).

- **Time spent on tasks:** This refers to the total time expended on each task, regardless of whether the task was successfully completed or not. The different times can then be added together to calculate and identify the total time expended on all tasks.

3. Participant Satisfaction in Remote Asynchronous Testing

Participant satisfaction is another important indicator which is applied in different comparative studies (Nyumbeka & Wesson, 2014: 357; Sánchez Riera *et al*., 2015: 372). For example, the emphasis in this study was on obtaining subjective data from participants reflecting their degree of satisfaction as regards the usability of a targeted website. Other studies have focused on gaining insight into the degree of participants' satisfaction with the remote testing method used (Brush *et al*., 2004: 1182). For this research, an online post-test questionnaire survey, using the SurveyMonkey tool, for remote asynchronous testing users was used (Luojus *et al.*, 2013: 110; Zapata *et al*., 2014: 5). This tool contained two parts. The first part sought to gather subjective data relating to the degree of a participant's satisfaction with the targeted websites. The second part sought to gain information which would elucidate their feelings regarding the actual testing method (Sánchez Riera *et al*., 2015: 372).

The first part of the survey included both a rating scale format and open-ended questions, to collect data relating to participants' satisfaction with the chosen websites. The SUS was utilised to rate the scale questions. SUS provides an overview of subjective measurements of usability with a non-complex ten-item scale (Ravendran *et al*., 2012: 81). It can lead to an inclusive usability and user satisfaction index (ranging from 0 to 100) regarding the websites' usability problems.

Therefore, after completion of the test tasks, SUS was completed by all participants taking part in the remote asynchronous tests. One of the important features of SUS is that it allows for the evaluation of the product as a whole rather than evaluating only particular aspects (Tassabehji & Kamala, 2012: 490–491). The researcher processed all ten SUS statements and respective SUS scores, for each of the selected websites. In order to obtain the SUS score, the researcher added all the odd items' contribution scores. The contribution scores of these items are their respective item scale positions subtracted by one. The contribution scores of the other items are added together: five subtracted from their position's scale. Lastly, the addition of all the scores was multiplied by 2.5 to arrive at the general score of each of the selected websites. These ranged from 0 to 100 (Ng, Lo & Chan, 2011: 1299–1300; Tiefenbacher, Bumberger & Rigoll, 2014: 598).

SUS is typically used after a user has interacted with the system being assessed (Tchankue *et al.*, 2012: 266; Reyes *et al.*, 2014: 139). The researcher records the user's feedback regarding every problem. Scoring SUS provides the generation of a single number, which represents an overall measurement of the general usability of the system. Appendix 6 presents a copy of SUS, as used in this research.

Furthermore, participants answered open-ended questions on whether they liked or disliked the target websites. The reason for including this question is to obtain qualitative feedback from participants regarding their satisfaction with the chosen websites. Subsequently, participants' satisfaction level regarding the testing method they had interacted with was collected. Research shows that this is a beneficial method and tool for evaluating usability testing (López-Gil *et al.*, 2014: 1; Mercurio *et al.*, 2014: 456).

Additionally, participants were asked to answer open-ended questions regarding what they liked and disliked about the remote testing method. This was done in an effort to obtain qualitative feedback regarding their participation in the test session and to understand their reasons for the rating scales provided.

5.4.7 Preparing Test Material and Equipment

The following sub-sections discuss the necessary test materials and equipment for conducting the asynchronous testing and heuristic evaluation methods. The discussion on asynchronous testing includes the descriptions of Loop11 as a remote asynchronous testing tool (Sauro, 2011; Varga, 2011: 69; Cuddihy & Spyridakis, 2012: 1).

5.4.7.1 Asynchronous Remote Testing and Loop11 Testing Tool

For the testing section, participants were not provided with any equipment when they performed the test in their own environment. However, participants were required to have either a smartphone or tablet devices with internet access. They carried out the tests without using additional equipment in their own natural environment.

The current study used Loop11 because it is an inexpensive tool for collecting data without exacting the physical presence of a researcher in a laboratory. This method is gaining popularity amongst researchers (Arrue, Valencia, Pérez, Moreno & Abascal, 2019: 569–583; Yu *et al*., 2019: 10–33). Other key players in the industry include: *Usertesting, Userzoom, EasyUsability, Usabilla* and *Mikogo*. Loop11 is a web-based remote usability testing tool which was used to remotely ascertain the usability of selected websites and to generate appropriate results regarding usability performance.

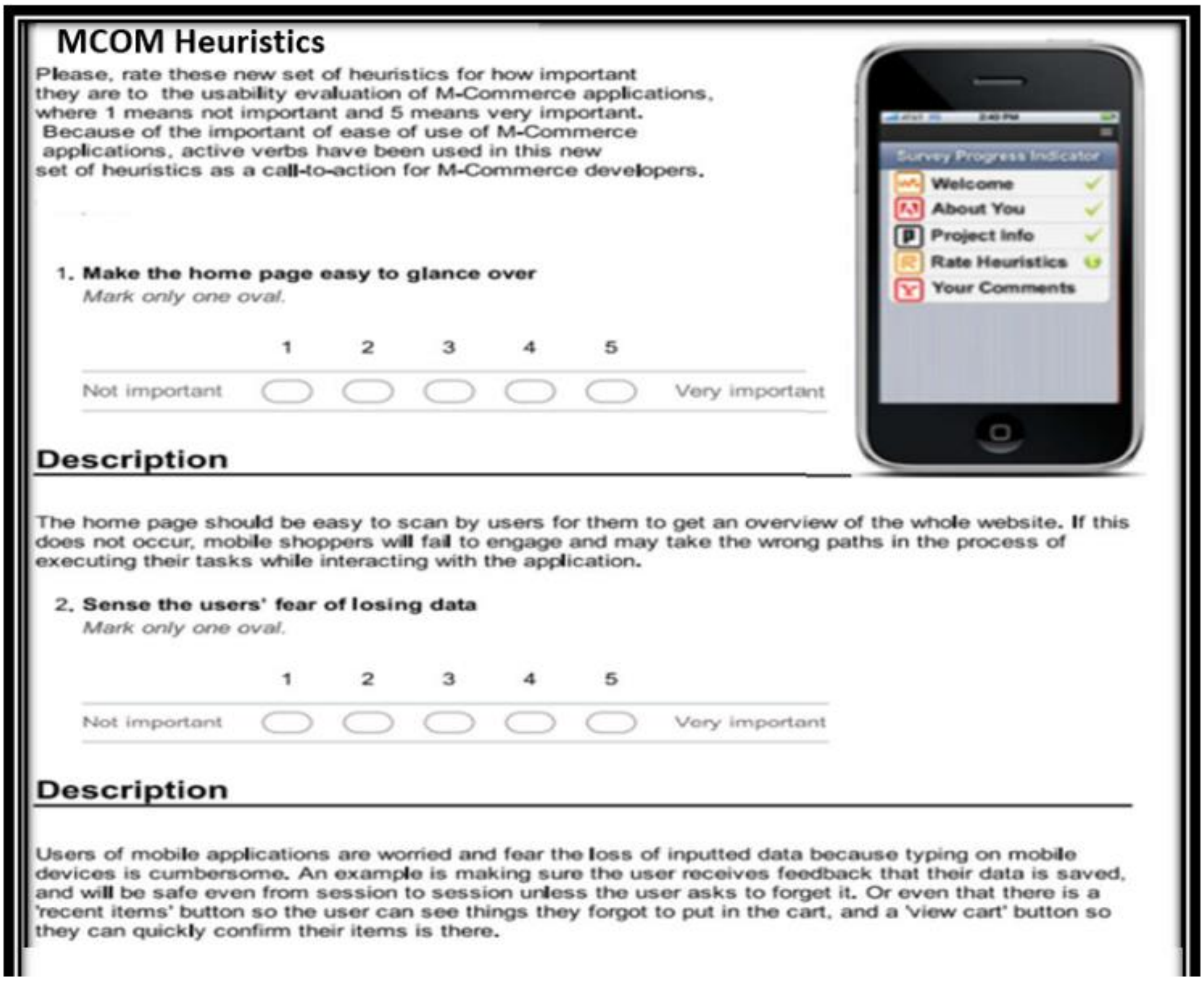
By asking participants to complete a set of questions and tasks focused on the target M-commerce websites, the researcher obtained a detailed understanding of users' interactive behaviour with the help of Loop11, via an online interactive environment. All data were collected during real time interactions using both qualitative and quantitative procedures. Data collected included: task completion time, task accomplishment status, number of tasks completed and satisfaction levels. Figure 5.5 presents the screenshots of the first screen when participants started the evaluation of the mobile website with the Loop11 testing tool during the remote asynchronous method tests.

Figure 5.5: Loop11 Screenshots on Different Devices

5.4.7.2 Heuristic Evaluation and Validation of MCOM Heuristics

Based on the critical analysis of relevant literature, the researcher employed Nielsen's heuristics (Nielsen, 1994b: 153) as a baseline in the development of the MCOM heuristics for M-commerce applications. In addition, this research work adopted the popular set of guidelines, as used by different scholars (Mi *et al.*, 2014: 357; Neto & Campos, 2014: 489;

Orlandini *et al.*, 2014: 196; Xu *et al.*, 2014: 3) to develop domain-specific heuristics for different mobile applications. The research work developed 11 draft sets of heuristics applicable to the usability evaluation of M-commerce interfaces. The MCOM heuristics were subjected to reviews by UX and HCI professionals in order to garner expert opinions regarding each heuristic.



MCOM Heuristics

Please, rate these new set of heuristics for how important they are to the usability evaluation of M-Commerce applications, where 1 means not important and 5 means very important. Because of the important of ease of use of M-Commerce applications, active verbs have been used in this new set of heuristics as a call-to-action for M-Commerce developers.

1. **Make the home page easy to glance over**
   Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

Description

The home page should be easy to scan by users for them to get an overview of the whole website. If this does not occur, mobile shoppers will fail to engage and may take the wrong paths in the process of executing their tasks while interacting with the application.

2. **Sense the users' fear of losing data**
   Mark only one oval.

	1	2	3	4	5	
Not important	◯	◯	◯	◯	◯	Very important

Description

Users of mobile applications are worried and fear the loss of inputted data because typing on mobile devices is cumbersome. An example is making sure the user receives feedback that their data is saved, and will be safe even from session to session unless the user asks to forget it. Or even that there is a 'recent items' button so the user can see things they forgot to put in the cart, and a 'view cart' button so they can quickly confirm their items is there.

Figure 5.6: Usability Professionals' Survey

A total of 142 usability professionals were invited to participate in the review process. These professionals were invited via individual e-mails as obtained from the reviewed papers and LinkedIn social platform. The experts were required to review the MCOM heuristics using the five-point Likert scale which was placed below each of the heuristics on a customised online survey. Additional areas for expert comments were provided in order to obtain qualitative data. The researcher performed the analysis and refined both the qualitative and quantitative data obtained from the selected usability professionals who participated in the review process. The proposed MCOM heuristics for M-commerce applications are presented in Chapter 4, sub-section 4.6.1.

As mentioned in section 4.6.1 of Chapter 4, the initial set of MCOM heuristics were subjected to review by usability professionals. The selected usability professionals were required to rate each of the 11 developed set of MCOM heuristics using a five-point Likert Scale (1: Not important to 5: Very important) as presented in Figure 5.6. Additional areas were provided to obtain experts' comments for the qualitative data collection process. One hundred and twenty of a total of 142 usability experts from 26 countries were invited to participate in the review process. Eighty-seven of the reviewers are UX professionals while the rest are HCI researchers from different universities.

Selected usability professionals were able to provide detailed reviews of the proposed MCOM heuristics. The text comment options, provided in the customized online survey, were adequately utilized and beneficial to the review process. The findings provide rating scores for each of the developed heuristics as obtained from the usability professionals. Heuristics 2, 4, 5, 6, 9 and 10 each obtained a rating score of 5, while the remaining heuristics obtained rating scores of 4 (modal score 1: not important to 5: very important). The results of the Likert scale are used to judge the relevance of each heuristic in the usability evaluation of M-commerce applications. Thus, heuristics with modal scores of either 4 or 5 are considered *relevant*.

In addition, since the standard stacked bar chart has no provision for a common baseline, the researcher used the centred stacked bar chart to illustrate the findings obtained from the review (Robbins, 2012: 73–74). The Likert scale of 3 (Neutral) was removed. This process helped to create a middle line from the provided quantitative data. The analysis of the remaining negative and positive feedbacks enabled the visualisation of all feedback, as presented in Appendix 7 (Petrillo *et al*., 2011: 60–63). The majority of usability professionals rated the developed heuristics as either "Very Important" or "Important" as per Appendix 7. However, heuristics 1, 3 and 7 were rated as being less useful with little or no modifications.

Based on the feedback from the usability professionals, and their ratings, the researcher made the required modifications to the affected heuristics as presented in Appendix 8. Heuristics 1, 4, 7, 8 and 10 required no modification and, thus, they were not altered. The researcher performed the analysis, aggregation and implementation of qualitative and quantitative data, as obtained from the review process by usability professionals. Appendix 9 presents the final set of the MCOM heuristics and their descriptions for the usability evaluation of M-commerce applications.

The current study presents the mapping between Nielsen's traditional heuristics and the MCOM heuristics for M-commerce applications, as presented in Table 5.4. The comparison is based on the *concept* rather than the *context* of use of the traditional heuristics. M-commerce applications differ and the primary goal of the developer is not to facilitate a *fun* or *playability* experience, as in the case of mobile game applications, but to facilitate recurrent sales through the optimisation of the website (Poulcheria & Costas, 2012: 88; Djamasbi *et al*., 2014: 305; Quaresma & Gonçalves, 2014: 352; Barnett, Harvey & Gatzidis, 2018: 82). Therefore, the MCOM heuristics are tailored primarily to achieve this purpose and to improve UX of M-commerce applications. The initial set of the proposed MCOM heuristics have been published in the ACM digital library (Ajibola & Goosen, 2017: 3–8).

Table 5.4: Mapping of MCOM Heuristics in relation to Nielsen's Heuristics

Heuristic Number	**MCOM Heuristics**	**Nielsen's Heuristics** (Nielsen, 1994b: 153)	**Comparison**
1	Make the home page easy to view at a glance	Visibility of system status	Similar
2	Be sensitive to users' fear of losing data	Error prevention	Similar
3	Make primary button ('Add to Cart') visible on each product page		New
4	Be careful of including animated carousels	Aesthetic and minimalist design	Same
5	Be careful of adding images or product information on different subpages		New
6	Take care when arranging and designing account-selection options	Consistency and standards	Similar
7	Ensure that the auto-correction of the dictionary is disabled when needed	Error prevention	Similar
8	Ensure that fields are long enough to display common data fully (add label at the top of field)	Recognition rather than recall	Similar
9	Allow for the verification of inputted day, date and shopping details	Help users recognize, diagnose and recover from errors	Similar
10	Ensure that each hit area and list item is distinct	Flexibility and efficiency of use	Similar
11	Ensure that users' privacy and security concerns are addressed		New

As listed in Table 5.4, one of the traditional heuristics is the same as the MCOM heuristics, while seven other heuristics are similar in content, or definition, but not in the context of use.

The new added heuristics are: 1.) ensure that user privacy and security concerns are addressed, 2.) be careful of adding images or product information on different subpages and 3.) make primary button ('Add to Cart') visible on each product page.

In the heuristic evaluation process, no special equipment is required except that evaluators are provided with the website links to the four selected M-commerce interfaces. The expert evaluators are also provided with the proposed MCOM heuristics as well as the score rating scale.

5.4.7.3 Other Supporting Materials

For the remote asynchronous testing methods, supporting materials such as an online background questionnaire, informed consent form, welcome page and online post-test questionnaire were prepared.

- Online background questionnaire: This questionnaire was used to collect participants' background information.
- Informed consent form: Prior to the real test, users needed to confirm their agreement by completing this form.
- Welcome page: This provided a brief overview of the research and welcomes participants to the test task.
- Online post-test questionnaire: Participants' opinions regarding the test session and the target website were collected using this questionnaire.

5.4.8 Experimental Procedure

This section details the experimental procedures undergone in this study. Detailed testing scripts were prepared, as per Appendix 10, and sent to participants in the asynchronous testing session and heuristic evaluators in the heuristic evaluation sessions. This section describes how the UEMs were carried out.

5.4.8.1 Remote Asynchronous Usability Testing

In this study experimental procedures, as presented in Figure 5.7, were utilised for the asynchronous testing process. During the test each participant was given an identification number with which he/she could gain access to the testing platform. This identification number thus enabled the identification of participants during the online test in which each participant used his/her own mobile device (e.g. smartphone or tablet).

There were no restrictions as to the location within Nigeria where participants could take the test. Participants, however, had to be Nigerian as the selected websites or M-commerce websites are targeted to Nigerian online shoppers. The welcome page, which included test regulations as well as rules and procedures, was sent to each participant via e-mail. Before starting the test, each participant had to confirm that he/she had read the rules and instructions. Following this, the online background questionnaire had to be completed. Participants were instructed to familiarise themselves with the website interface. At the beginning of the test, test contents were sent to the participants via a website link. Participants were then directed to the test and to Loop11, which both opened in *independent* frames, after the website link had been clicked. Participants were expected to answer four different questions by browsing the websites.

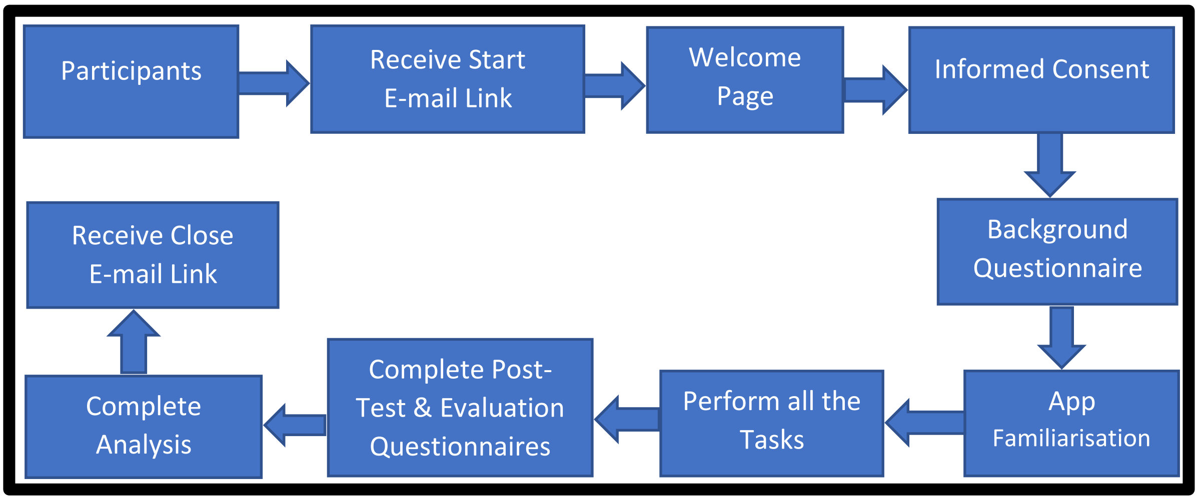


Figure 5.7: Experimental procedures in this study

When participants completed the task, they were required to submit the answers by tapping the "Answer Field" button in the "Analysis Window" after which they had to tap the "Task Complete" button to end the task. An "Abandon Task" button was available for instances when participants were unable to answer a particular question. In asynchronous testing, participants can record the usability problems they encounter by typing them in the analysis window. After each task, the participants had to tap the "Next" button to proceed to the next question. The time utilised for the completion of the previous task was automatically recorded. Loop11 software facilitates the recording of usability problems encountered by participants and the results from tasks completed, or not completed, for each participant. When all the tasks were completed, an evaluation was done by the participants to indicate that they understood the results obtained.

All the test participants were expected to note their respective satisfaction levels by completing the post-test questionnaire, as per Appendix 11, as part of the remote asynchronous testing process. Quantitative and qualitative data were thus collected from the test participants via the completion of their post-test questionnaire. The Likert scale was used to collect *quantitative* data whilst open-ended questions were used to collect *qualitative* data. Likert scores were computed for all statements, within the questionnaires administered during the post-test, for the selected websites.

Furthermore, the post-evaluation questionnaire, as per Appendix 17, was completed by all test participants. These results helped to ascertain which of the four selected websites had the best features as per test participants' interactions. The post-evaluation questionnaire contained seven open-ended questions. The post-evaluation questionnaire was used to obtain general usability details regarding the four selected websites based on test participants' ratings of six characteristics: design, navigation, security and privacy, internal search, purchasing process and architecture, of the websites, as per Appendix 13. The results were used to categorise the identified usability problems into separate usability problem areas.

5.4.8.2 Heuristic Analysis Procedure

This section describes the procedures undergone for the heuristic evaluation of the proposed MCOM heuristics developed in this study. The heuristic evaluators examined the selected mobile website interfaces independently to judge whether they comply with the standard set of heuristic guidelines. It should be noted that all the evaluators were familiar with traditional heuristics and the newly developed heuristic, which follows the same pattern as the traditional heuristic.

Evaluators were then required to interact with the selected websites twice, as a minimum. This enabled a flow of interaction, concentrating on specific interface elements of the selected websites (Tan *et al*., 2009: 622–624). The evaluators were expected to be as precise as possible, listing all the identified usability problems individually. In addition, evaluators were provided with a heuristics checklist to enable them to gather quantitative data on the selected websites (Khajouei *et al.,* 2018: 37–40). After having completed the heuristic evaluation, the researcher interacted with the evaluators individually to coordinate the collection of all the results and analysed the findings from the evaluations via e-mail.

5.5 Data Triangulation

Data triangulation can be described as a strategy which enables more than one data collection, or data analysis, procedure to be applied to the same set of data to achieve a certain goal (Creswell *et al.*, 2011: 18; Wahyuni, 2012: 73; Cooper & Schindler, 2014: 194; Jabbar, 2014: 105). Various views and corroborations regarding discoveries made across procedures eventually lead to more accurate and justifiable findings (Osei, 2012: 53).

This study employed the MCOM heuristic evaluation and the remote asynchronous usability testing process, comprising of a standardised usability questionnaire called SUS, to achieve triangulation of the results. To achieve the desired results, it is suggested that researchers compare the user testing method with the heuristic evaluation during usability assessment (Fetaji & Fetaji, 2011: 178; Porat *et al*., 2013: 266; Cáliz & Alamán, 2014: 254). In this study, data triangulation is guaranteed by merging data collected from the Loop11 tool test with data garnered from the standardised SUS questionnaire and expert inspection of the MCOM heuristic evaluation.

5.6 Data Analysis

Data collected were analysed and the results obtained helped with the identification of various methods and the deliniaton of usability problems. The analysis procedure involved three stages. The analysis method adopted is the multiple case studies approach, as suggested in other research studies (Yin, 2009: 45–57). The first stage of the analysis entails an investigation into individual case specific methods before the results are individually interpreted.

The second stage comprises a comparison across all cases which leads to the formulation of a conclusion for the entire study. Each usability method is thus separately analysed for each individual case and the usability problems, as extracted from each of the methods, were also identified separately. The aim of the second stage of the procedure was to create an inventory of common usability problems determined by employing each of the evaluation methods. The analysis was done by comparing each method’s usability evaluation for each of the four selected M-commerce websites.

In addition, based on the MCOM heuristics guidelines, the identified usability problems for the four selected M-commerce websites were categorised into 10 usability problem areas. Earlier studies classify the usability evaluation of commercial websites into seven problem areas namely: navigation, information content, security and privacy, common look and feel, availability of tool, content and compatibility (Tan *et al*., 2009: 624). This study extended the number of identified problem areas from seven to ten. This is due to the unique features of M-commerce websites which were uncovered in the course of the research. Therefore, the ten usability problem areas associated with M-commerce websites are: ***navigation, purchasing process, accessibility and customer service, architecture, internal search, design, content, inconsistency, security and privacy, and missing capability.***

In addition, the analysis process was taken a step further with the goal of producing an inventory of standardised usability problem areas and their equivalent sub-areas. This list was used to facilitate comparisons between the variety of evaluation methods used. As a result, problem areas and sub-areas were identifed within these standardised usability problem areas, as generated from each evaluation method. Thereafter the identified problems were classified.

The list was progressively generated through an analysis of the first method. This was followed by an analysis of additional methods which identified new problem categories and sub-categories. These were identified in problem areas which were not considered part of the standardised categories and were thus added to the list. Each method's analysis further described the general usability of each of the websites. The identified usability problems discovered by users and experts, in both asynchronous testing and MCOM heuristic evaluation methods, were categorised as minor, major and false problems, as listed in Table 5.3. In order to identify *false problems*, the researcher made a list of the problems found as a result of evaluating with the asynchronous testing and a separate list which indicates the problems identified by the MCOM heuristic evaluation. These two lists were then compared and if a problem was found to be included on *both* the MCOM heuristic evaluation *and* asynchronous testing list, it was *not* considered a false problem. If it was present on only MCOM heuristics, it was considered a false problem. The process was carried out accros all ten usability problem areas, as indenfied in this research work. The next section will explain how qualitative and quantitative data, which had been identified from the various usability testing methods, were analysed at each stage, as described above.

5.6.1 Asynchronous Testing Analysis

During the remote asynchronous user testing process, the identified data were analysed in various ways. The participants who took part in usability testing were divided into *expert* and *novice* user groups, as recommended in previous research (Shluzas *et al*., 2013: 8–10). In addition, this separation of users is one of the main features, within the categories of test users, in usability testing experiments (Nielsen, 1994a: 115–171).

A criterion used to separate users into groups is their experience in using the internet. *Novice participants* are individuals who used the internet intermittently for a period of three years, or less. Experts had used internet for more than three years. The group users belonged to was determined during the analysis of the pre-test questionnaires in user testing method. The next section presents an analysis of each of the five methods.

5.6.1.1 Pre-Test Questionnaires

Various methods were applied in analysing the data obtained from pre-test questionnaires. Descriptive analysis was employed with the aim of obtaining a description of participant features in the *novice* and the *expert* categories as well as their mobile online shopping experience. The Likert scores for each statement were computed to describe participants' overall perception of the online shopping process as well as their experience/s.

Likert score ratings were used to analyse the collected data. The values of users' testing responses, which were negative, had been inverted before Likert scores were calculated. This approach was also adopted when analysing the pre- and post-test questionnaires and the heuristics checklist statements.

The Mann-Whitney test was used to investigate whether or not a statistically substantial variation could be detected between novice participants' and expert participants' ratings regarding their perceptions of online shopping statements (Cooper & Schindler, 2014: 443–444). The Mann-Whitney test is non-parametric and, therefore, the most suitable statistical method to employ as statements were measured using an ordinal scale (Boone & Boone, 2012: 2–4). As it cannot stipulate whether or not variations between scores would be identical, the Likert score, which was at seven points, was determined to be an ordinal scale. Literature shows that the variation between "strongly agree" and "agree" is not similar to the variation between the statements "strongly disagree" and "disagree" (Gadermann, Guhn & Zumbo, 2012: 4–8).

5.6.1.2 Performance Data of Asynchronous Users Testing

Performance data can be summarised using various methods. Task timing was calculated using descriptive statistics such as the number of seconds, the meantime, as well as standard deviation. Furthermore, the accuracy of completed tasks was determined showing the percentage of participants who had successfully completed each task within a certain time.

The average of the performance data contains values from participants who had completed their tasks within a certain time. One method of detecting usability problems and performance data from the tasks is by including the start and end URLs of each task on the Loop11 platform. This method allows for the calculation of performance data to be automatically generated from the Loop11 testing tool.

Inferential statistics, which uncovered various usability problems and provided a summary of the total amount of tasks which participants successfully completed, explained the websites' overall usability. In order to collect statistically significant results, the Analysis of Variance (ANOVA) test was done. The ANOVA test for one-way within-subjects was used (Bornoe, Bruun & Stage, 2016: 455–459). The websites were the within-subject factor and they displayed the following four levels: 1, 2, 3, and 4. The total amount of time used by participants to complete each task was measured in seconds and viewed as the dependent variable.

In addition, this research study used Pearson's correlation coefficient to show the relationships between: the problem discovered and time spent, problem discovered and users' satisfaction, time spent and users' satisfaction. Pearson suggests that: if the $\boldsymbol{p}$ value is $\leq \pm 0.09$ then there is no relationship; if $\pm 0.1 \leq \boldsymbol{p} \leq \pm 0.3$ then it is a weak relationship; if $\pm 0.3 \leq \boldsymbol{p} \leq \pm 0.5$ then it is a middle relationship; if $\pm 0.5 \leq \boldsymbol{p} \leq \pm 1.0$ then there is a strong relationship between the two variables (Kothari, 2011: 131–381; Alghamdi *et al*., 2013: 88–92; Cooper & Schindler, 2014: 469–500).

5.6.1.3 The Post-Test Questionnaire and Qualitative Data

Evidence of usability problems in the websites were acquired using data collected from post-test questionnaires (see Appendix 11). To collect the overall results regarding participants' satisfaction with each of the websites, Likert scores were computed for all statements contained within the questionnaires, during the post-test.

In accordance with the established heuristic guidelines, the categories of: architecture, navigation, content, design and buying process statements, from the post-test questionnaires, were grouped into four different categories. Statements 17, 26 and 28 were excluded from the post-test questionnaires. Statements 17, 26 and 28 were assembled into a new sub-category to denote the general usability evaluation of the websites' interfaces. In addition, these statements were categorised to enable the discovery of other problems from the selected websites' interfaces.

Statements associated with the category and sub-categories of *accessibility and customer service*, were not included in the post-test questionnaire. This means that the category was not considered in the grouping of post-test questionnaire statements.

If the questionnaire administered in a post-test contained a statement with a Likert score rating which is considered negative (1 to 3), it was interpreted as an indication of a usability problem from the user's perspective. These negative statements served to identify several usability problems within the websites and they were plotted to those usability problem areas and sub-areas which the previous method had uncovered. In addition, there were three additional usability problem areas which were identified in the four statements.

The current study performed two inferential statistical tests, in respect of individual questionnaire statements, that were provided in the post-test to explain the websites' overall usability:

- In order to ascertain whether or not a statistically substantial deviation existed amongst the ratings provided by novice and expert users. Here, the Mann-Whitney test was employed.
- In order to ascertain whether or not a statistically substantial deviation between participants' ratings of the four M-commerce websites existed. For this, the Friedman test was employed.

These tests are nonparametric tests which are the most appropriate statistical methods for this process because they are measured using an ordinal scale on data collected.

5.6.1.4 Qualitative Data as Gathered from the Post-Test Questionnaires

Users' qualitative data and responses, as garnered by the post-test questionnaire's open-ended questions, were employed to identify usability problems as per Appendix 11. Reported answers were combined for each of the websites and grouped under previously generated categories and sub-categories which were developed using the heuristic guidelines.

Users' responses helped to identify several usability problems and these were then plotted to the main and sub-problem areas, as determined by the earlier methods. Nine new sub-areas were created. Seven of these were plotted to the correct problem areas, whereas the other two sub-areas were added to problem main areas.

5.6.1.5 Post-Evaluation Questionnaires and Qualitative Data

The qualitative data reflected testing participants' responses to open questions to determine which website had the best six features. The data were then assembled under the six websites aspects mentioned within the heuristic guidelines.

5.6.2 Heuristic Evaluation Analysis

The evaluation of the selected websites by heuristic evaluators generated both quantitative and qualitative data which were collected and investigated through various methods. In this sub-section, the results concerning the identified heuristic evaluation method (the MCOM heuristics) are analysed.

5.6.2.1 Analysis of the Qualitative Data from Heuristic Evaluation

The heuristic evaluators' comments, in line with each of the heuristic principles, were collected during the evaluation sessions for each website and analysed. They were also grouped into various categories and sub-categories using the designed heuristic guidelines as per Appendix 12. The heuristic evaluators identified a number of common usability problem areas, through the examination of heuristic sub-categories. The compliance level of each websites was also ascertained in accordance with heuristics guidelines.

5.6.2.2 Heuristic Evaluation Checklist

Likert scores were computed for every one of the statements found in the heuristic checklist in order to calculate the overall ratings of the five heuristic evaluators, as per Appendix 13. Statements from this checklist were plotted to the five areas, as well as their equivalent sub-areas, through the use of heuristics. However, statements 87, 88, and 89 were excluded as they required purchasing from the websites.

Heuristic checklist statements which gained a negative Likert score rating (1 to 3) were interpreted as significant or serious usability problems and, as such, they were added to the usability problem list. These negative statements were plotted according to the identified usability problem areas and sub-areas.

The current study applied the Friedman test for the collection of additional information related to the overall usability of the four websites. The goal of this approach is to determine whether a statistically significant difference could be found, amongst the ratings provided by heuristic evaluators on the websites, in relation to each heuristic checklist statement.

5.7 The Research Design Reliability and Validity

The evaluation method and its associated validity relates to whether or not a technique measures what it should measure. Understanding the technique itself and how it performs are necessary to validate the research (Ellis & Levy, 2009: 332–333; Zucker, 2009: 10–12). For instance, the validity of the user testing method is related to whether or not findings accurately imitate usability problems which an investigator intends to test (Nielsen, 1994a: 150–171). In addition, typical problems associated with validity include: incorrect users, creating incorrect tasks or an absence of time frames and social influences (Nielsen, 1994a: 130–145).

In the field of HCI, validity threats associated with tentative studies are identified through examining experiments which, in turn, are used to design various UEMs. Furthermore, different scholars have also provided recommendations to address various kinds of validity as most relevant to HCI research (Wetter, 2011: 68; Cooper & Schindler, 2014: 229–234). For instance:

1. To ensure internal validity scholars recommend that the following be taken into account:
    a) ***Instrumentation***: This has to do with the way human observers determine or evaluate the seriousness of usability problems. Instrumentation is valid when comparing methods or groups. Therefore, the same evaluators cannot be restricted to distinct UEMs and at the same time be required to determine, classify, and/or evaluate usability problems. Categories of usability problems, identified by a specific UEM, cannot be employed by the evaluator to categorise issues that were determined through a different UEM.

    b) ***Selection:*** This relates to the characteristics of those who participate in the study. For instance, whether or not their connections and interests will lead to results manipulation, and whether certain participants in a particular group share similar experiences are related to the test circumstances.

2. The researcher who conducts the research must deliver unambiguous feedback regarding the precise operations and methods employed to ensure causal construct validity. UEMs must be used in a way which can be understood by the reader. For instance, the person doing the heuristic evaluations must utilise guidelines and clarify whether or not evaluators will work alongside one another, or independently, when

identifying usability problems. It is strongly suggested that researchers do not use the same set of test users when doing multiple UEMs, to avoid interactions between different assessments.

To ensure internal validity in this research, *selection* and *instrumentation* were considered. The recruited expert evaluators for the heuristic evaluation individually determined certain usability problems. However, the analysis of both user testing data and the heuristic evaluation data gained from the respective test sessions were organised by the researcher. The researcher noted the findings obtained from the heuristic evaluation experts. Classification of usability problems was determined by all methods. Each of these methods was individually subjected to analysis processes. The subsequent identified problems for each individual method were consequently compared to those which had been identified in the other methods to thus present the overall problem areas and sub-areas.

Selection problems were considered during the recruitment of participants. Participants' characteristics for each method of user testing were based on the user profiles gained from the pre-test questionnaire. Furthermore, the experts who took part in heuristic evaluation all possessed comparable amounts of heuristic evaluation experience. Unanticipated features were not included in these tests.

Furthermore, the fundamental paradigm of *validity*, was considered. The way each method was applied is explicitly described within the data collection section and discussed in line with current theoretical literature. *Interaction* as a theme was circumvented as those individuals who took part in the user testing were not involved in the heuristic evaluation as well.

The multiple-case study design employed in the current research would improve the generalisation and exterior legitimacy of the results (Ellis & Levy, 2009: 332–334; Knight & Cross, 2012: 10). The reliability of an evaluation method is linked to how well that method generates similar, or exact findings, in distinct events, under comparable conditions (Leimeister, 2010: 10; Cronholm & Göbel, 2015: 471). For instance, with regard to user testing, reliability is concerned with whether or not the same results can be collected if the assessment was to be repeated (Nielsen, 1994a: 57–71). Furthermore, if an investigation is carefully organised, it will ensure a high level of reliability. This means that if another person followed the same procedures, they would obtain similar results.

Due to time limitations it was difficult to use the same methods twice in order to ascertain whether similar research results would be obtained. However, in this research certain techniques do test reliability. For instance, reliability is ensured when the measure consistently mirrors the concept being measured, as is the case with questionnaires (Wahyuni, 2012: 77).

The measure of reliability which is most commonly used is Cronbach's Alpha (Khajouei, Ameri & Jahani, 2018: 14). With this measure, a value of 0.7 – 0.8 is considered satisfactory and thus reflects a consistent measure. Substantially lower values would reflect an unreliable measure (Ellis & Levy, 2009: 332–334). The questionnaire, which was administered as a post-test, was found to be a reliable measure with a Cronbach Alpha of more than 0.89. The questionnaire is thus an appropriate method for the evaluation of M-commerce websites in Nigeria. The overall Cronbach's Alpha for each website was calculated to ascertain the reliability of the questionnaire administered for the post-test. The Cronbach Alpha values were: 0.935 for website 1; 0.937 for website 2; 0.931 for website 3 and a value of 0.933 for website 4. All Cronbach's Alpha values were above 0.8 for each website, thus signifying high levels of reliability.

5.8 Ethical Considerations

The epistemic imperative of science is supported by this study. In simple terms, the epistemic imperative refers to the ethical commitment which researchers make to search for knowledge and truthfulness (Bricki & Green, 2007: 7; Widdowson, 2011: 32; Cooper & Schindler, 2014: 62). An approval to conduct the study along with an ethical clearance certificate was granted shortly after a request was submitted to the UNISA Ethics Committee. Appendix 14 presents the ethics' certificate to conduct the research.

For the quantitative section of the study, validity and dependability were guaranteed in the following ways:

1. Before participants took part in the study, informed consent forms containing the aims of the study, along with other information, were prepared and sent to all participants. The methods to be used during the study were explained in addition to the form of participation required while responding to the SUS questionnaires.
2. The researcher ensured that the research was planned and executed in a manner that did not pose any harm to participants. Participants were informed that they could leave the research study at their own accord, at any time they chose. They were also informed that the information provided would be terminated in due course after having been used for the intended research purpose.

Participants acknowledged that they would not answer any question/s they did not feel comfortable with or respond to questions which they felt violated their right to privacy. To ensure that privacy and anonymity were observed, participants were informed and assured that their names would not be used in the study. Appendices 15 and 16 contain examples of the consent form used for the participants.

5.9 Conclusion

When designing research to solve a query, or address a problem, one is always restricted to what is *practicable* and *ethical*. In this research work, the researcher draws special attention to the following crucial elements and their inter-relationships which influence the design process: research philosophy, possible methodological alternatives, research plan or strategies, time frame and inter-relationships. A thorough comprehension of these elements assisted the researcher in guaranteeing that the data collection techniques and analysis procedures employed in the study were, in fact, relevant and logical.

To empirically verify the usability of the four selected M-commerce websites, a free SUS standardised survey was employed. This survey was conducted simultaneously with the heuristic evaluation thus resulting in a concurrent mixed method strategy being employed for the study. The selected research philosophy and design, as well as the techniques which served to accomplish the objectives and aims of this study, were presented and justified in this chapter. In addition, various techniques employed in collecting and analysing data, connected to the methodologies employed in the study, were also explained. Chapter 6 will present the obtained experimental results.

Chapter 6: Results and Discussion

6.1 Introduction

This chapter presents the qualitative and quantitative results obtained from the selected UEMs. These evaluation methods are: remote asynchronous testing (as identified in Section 3.7) and the newly developed MCOM heuristic method (as developed in Section 4.6). Therefore, Chapter 6 will answer Research Question 4: ***What is the effectiveness of a domain-specific evaluation method in the usability evaluation of M-commerce websites?*** This chapter will seek to validate the effectiveness of MCOM heuristics through comparing the results obtained with remote asynchronous testing in the usability evaluation of four selected M-commerce websites. The chapter will also discuss the identified usability problems in respect to the UEMs employed during the evaluation of the four selected websites. A set of usability problem areas and sub-areas were employed to assist in comparing the effectiveness and efficiency of the evaluation methods and to pinpoint other possible usability problem areas. In addition, an overview of the *usability* of these four websites, as evaluated by the two evaluation methods, is presented.

6.2 Remote Asynchronous Testing Results

The study evaluated only three of the attributes of the MOSAD model (satisfaction, effectiveness and efficiency), as discussed in section 5.3.5, Chapter 5. The characteristics, feelings and the mobile shopping experiences of users are also presented. In addition, the performance data, qualitative and quantitative results obtained with the aid of post-test open-ended questionnaires and post-evaluation questionnaires are discussed.

6.2.1 Pre-Test Questionnaires

During the usability test, all participants completed pre-test questionnaires as contained in sections 1 and 3 (see Appendix 5). Only experienced mobile online shopping users answered the questions in section 2.

6.2.1.1 Characteristics of the Test Users

A total of 80 test participants were recruited for the research, 20 participants for each of the four selected websites. The number of *novices* and *expert* participants were the same for each of the websites. There were 24 males and 16 females which were regarded as novices. Forty of the total number of participants indicated that they had more than three years' experience in the use of mobile phones while the other 40 participants indicated that they possessed less experience. Forty of the participants, comprising 16 females and 24 males, were classified as *experts* in line with their responses recorded in the pre-test questionnaire. This group of individuals indicated that their experience of using mobile phones and the internet exceeded three years. These participants also indicated that they used their mobile phones to make online purchases.

Table 6.1: Frequency distribution of the testing users' characteristics

No	Participants' Characteristics	Range		Frequency Distribution	
				Expert Users	Novice Users
Personal Information					
1	Gender	Female		16	16
		Male		24	24
2	Age	18-25		3	2
		26-30		7	5
		31-35		6	9
		36-40		9	8
		41-45		8	8
		46-50		5	6
		Above 50		2	2
3	Academic Qualification	SSCE		0	8
		OND/NCE		4	12
		HND/BSc		12	8
		PGD		8	8
		MBA/MSc		12	4
		PhD		4	0
Computer Experience					
4	Years of Computer Experience	More than 3 years		40	4
		Between 1-3 years		0	28
		Less than 1 year		0	4
5	Daily Use of Computer	Under 2 hours		0	0
		Between 2-4 hours		0	8
		Above 4 hours		40	32
Internet Experience					
6	Internet Browser Name	Opera Mini		20	24
		UC Browser		16	16
		Google Chrome		4	0
7	Internet Experience	More than 3 years		40	0
		Between 1-3 years		0	36
		Under 1 year		0	4
8	Internet Usage Per Week	Under 2 hours		0	0
		Between 2-4 hours		0	8
		Above 4 hours		40	32
9	Have you ever interacted with any of the following websites?	Konga.com	No	10	10
			Yes	0	0
		Jumia.com	No	10	10
			Yes	0	0
		DealDey.com	No	10	10
			Yes	0	0
		Kaymu.com	No	10	10
			Yes	0	0
10	Have you ever used the internet to buy any product?	No		0	40
		Yes		40	0

(HND: Higher National Diploma; PGD: Post-Graduate Diploma; NCE: National Certificate Examination; OND: Ordinary National Diploma; SSCE: Senior School Certificate Examination)

The selected M-commerce websites were new to the novice and expert participants. Table 6.1 provides the characteristics and the frequency distributions of the test participants.

6.2.1.2 M-commerce Shopping Experience of the Participants

Table 6.2 below details the mobile shopping experience of the expert participants.

Table 6.2: Expert users' experiences of online shopping

No.	**Extracts from Pre-Test Questionnaire**	**Range**	**Percentage Distribution**
11	How often do you buy products with your smartphone?	Once a week	0
		Once a month	20
		Once a year	80
12	The first time you used your smartphone to purchase a product was?	About a year ago	40
		About 2 or 3 years ago	40
		More than 3 years ago	20
No.	**Extracts from Pre-Test Questionnaire**	**Answer**	
13	What was the last product you bought online using your smartphone?	• Laptop • Cell Phone • Antivirus Software • Digital Versatile Disc (DVD)	
14	Name the website that you used to buy the product?	• femtechit.com • aliexpress.com • amazon.com • yudala.com	
No	**Extracts from Pre-Test Questionnaire**	**Payment method**	**Percentage Distribution**
15	Indicate the payment method you used to buy the product.	Debit Card	60
		Cash on Delivery	20
		Bank Transfer	20

- Eight participants indicated that they bought products with their smartphones monthly, while 32 participants indicated that they made online purchases annually.
- Thirty-two participants stated that they had made their first online purchase 1 to 3 years ago while 8 participants had made their first online purchase a lot earlier (more than 3 years ago).
- Items bought via the internet included: Laptops, Cell Phones, Antivirus Software and DVDs.
- Thirty-two participants bought items via a Nigerian website (www.femtechit.com) while 8 participants bought items via international websites.
- As stated in Appendix 5, the pre-test questionnaire participants were required to indicate which payment method/s (debit card, credit card, bank transfer, cash on delivery,

PayPal and others) they had used to buy items in their previous online transactions. Sixty percent of the participants indicated that they had used debit cards[7] as their preferred method of online payment. Twenty-four participants made use of debit cards while 16 participants affected their transactions through bank transfers and paying cash on delivery.

Table 6.3 lists the average Likert score of users in relation to their online shopping experience.

Table 6.3: Likert scores for expert users on their online shopping experiences

No.	Extracts from Pre-Test Questionnaire	Likert Scores for Expert Users
16	It saves time to buy items online.	6.7
17	I prefer to buy online from a well-recognised website.	7.0
18	The website search feature is helpful while buying online.	6.8
19	Personally, I find buying online is cheaper when compared to going to the store.	5.6
20	Personally, I find the full descriptions of the product unimportant when online.	5.4
21	I used to buy online because the products are cheaper.	4.6
22	Before I purchase anything, I would rather do detailed research on products.	7.0
23	Due to the fact that I am able to purchase items whenever I want, I prefer to shop online.	6.8
24	Because I can buy products worldwide, I like to shop online.	7.0
25	When I shop online, I find it hard to recall passwords.	4.1
26	Usually, the company delivers products within the time frame they promised.	6.6
27	Websites accurately represent their products and I am usually happy with what I get using internet shopping.	7.0
28	I believe that delivery costs are irrational.	6.2
29	Online companies usually provide adequate customer service.	5.7
30	Usually, online prices are lower than they would be in other places.	5.2
31	If sites have a clear return and refund policy, I feel more encouraged to shop online.	5.1
32	A shopping site needs to be able to deliver items to a different address other than shopper's address.	3.7
33	If a website keeps me informed of the status of my order, it makes me feel like it is more reliable.	7.0
34	If a site provides alternative types of ordering/delivery/payment, I prefer to shop on that website.	6.8
35	The fact that some websites contain very specific or restricted areas for product delivery frustrates me.	6.2

NOTE: The maximum and minimum possible values of the Likert scale are 7 and 3.5 respectively on a scale of 1 to 7.

[7] Debit cards are the most widely used means of online payment in Nigeria. Credit cards (not even known to many customers) are not commonly available to customers and many financial institutions are reluctant to issue them (Abioye, 2016).

- Shopping via the internet is easy, it saves time and it enables users to buy products from any geographical location without restrictions and at any time.
- It is convenient to buy via the internet, using popular websites that have long-standing reputations, as they offer a variety of payment options, easy ordering and delivery methods as well as the fact that purchases can be delivered to any location.
- The search functions on websites facilitate shopping via the internet. Full details regarding each product are provided. Participants appreciate this information as it affords them the opportunity to explore the product/s they wish to buy. Participants are comfortable buying via online platforms from companies that provide adequate information regarding their refund and return policy.
- The items bought were delivered within the time frame stated on the websites and participants were happy with the products delivered. The presentation of the product/s on the websites were accurate.
- The companies' online customer service was good. Participants were happy with the updates which communicated the status of their order.
- The cost of delivery is unreasonable. The shopping websites should be capable of delivering items bought from their websites to different addresses, apart from the shoppers' registered address on the websites.

6.2.1.3 Perceptions of Participants on M-commerce Shopping

The research employed the Mann-Whitney Test to obtain results that reveal the statistical differences between the two groups of participants in the usability test.

The Mann-Whitney Test shows that a significant statistical difference exists between the *novice* and *expert* participant, as to statement number 37, as illustrated in Table 6.4. It further shows that there are no significant statistical differences in the other statements, in terms of mobile online shopping experience/s. In addition, Table 6.4 displays the Likert scores for mobile online statements for both novice and expert participants.

Table 6.4: The Mann-Whitney test results for novice and expert users from pre-test questionnaire

Pre-test Questionnaire Statement Number	Extracts from Pre-Test Questionnaire	Average Likert Score		Mann-Whitney Test (Two-tailed at the 0.05 significance level)
		Expert Group	**Novice Group**	**Are expert and novice groups significantly different? (N1=10, N2=10)**
36	Using the internet is usually not too expensive.	3.80	3.40	U=33.500, p = 0.218 **No**
37	If a company presents its information on their websites, I am not interested in it.	5.80	3.60	U = 17.000, p = .011 **Yes**
38	If a site has user-friendly navigation, I prefer to use that site.	7.00	6.10	U = 25.000, p = .063 **No**
39	If a website is well-organised, I would enjoy using it.	7.00	7.00	U = 50.000, p = 1.000 **No**
40	I get frustrated when asked to complete compulsory registration when I shop online.	5.40	5.60	U = 28.000, p = .105 **No**
41	Whenever I want to purchase items from the internet, I am concerned about the safety of my financial details.	7.00	7.00	U = 50.000, p = 1.000 **No**
42	Whenever I want to purchase items from the internet, I am concerned about the privacy of my personal information.	7.00	7.00	U = 50.000, p = 1.000 **No**
43	Lack of legal regulations which manage online transactions worries me.	6.56	7.00	U = 25.000, p = .063 **No**

6.2.2 Performance Data

Tables 6.5 and 6.6 present a summary of the performance data obtained from the remote asynchronous testing process. Table 6.5 presents mean time data calculated in seconds with their associated standard deviations, in respect of expert and novice participants.

Table 6.6 presents the statistical analysis which shows that expert participants consistently performed quicker than novice participants for the four selected websites, except in task 1 for website 3. Here, novice users were faster than expert users and the percentage is highlighted in the table. This exception may be because website 3 was regarded as the most problematic, thus showing that expert users may not always be quicker than novice users in all case. The speed of a particular user in completing a task may depend on the website's degree of usability. Findings show that the inability to complete even basic and common tasks is not simply a matter of *inexperience* as experienced users also experienced problems when using mobile applications (Ickin *et al*., 2012: 52).

Table 6.5: Average time (in seconds) spent by expert and novice groups per test task per website

Test Tasks	Novice & Expert Users	Website 1		Website 2		Website 3		Website 4	
		Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
Task 1	Expert Users	73.5	32.1	33.2	21.9	82.1	36.3	80.7	29.7
	Novice Users	105.7	14.6	63.8	40.3	76.5	35.3	86.5	39.4
	Total	**89.6**	29.3	**48.5**	35.2	**79.3**	35.0	**83.6**	34.1
Task 2	Expert Users	80.5	31.9	74.6	57.6	159.4	27.7	112.8	49.7
	Novice Users	109.8	54.1	111.7	70.2	164.4	21.6	155.6	43.1
	Total	**95.2**	45.7	**93.2**	65.3	**161.9**	24.3	**134.2**	50.3
Task 3	Expert Users	17.6	11.1	35.9	18.5	17.2	12.1	31.2	20.8
	Novice Users	27.9	29.1	57.4	23.3	20.0	11.8	33.2	21.8
	Total	**22.8**	22.1	**46.7**	23.3	**18.6**	11.7	**32.2**	20.8
Task 4	Expert Users	68.8	41.7	34.1	42.5	50.2	40.1	62.2	38.5
	Novice Users	97.7	33.3	50.0	62.9	67.0	45.7	72.1	45.0
	Total	**83.3**	39.6	**42.1**	52.8	**58.6**	42.7	**67.2**	41.1

Table 6.6: Analysis showing the percentage of expert participants who consistently performed quicker than novice participants

Test Tasks	Website 1	Website 2	Website 3	Website 4
	% indicating how much quicker experts are than novice users	% indicating how much quicker experts are than novice users	% indicating how much quicker experts are than novice users	% indicating how much quicker experts are than novice users
Task 1	17.9%	31.55%	**3.53%**	3.47%
Task 2	15.40%	19.91%	1.54%	15.95%
Task 3	22.64%	23.04%	7.53%	3.11%
Task 4	17.36%	18.91%	14.34%	7.37%

The highlighted cell shows the task where novices finished ahead of expert users

Table 6.7 indicates the accuracy of the test tasks for individuals as for the four websites. The problematic tasks, highlighted in the task accuracy table, are:

- Test tasks 1 and 2 performed satisfactorily in the four selected websites. These tasks involved amending the shopping cart content, using the websites' internal search, amending the item's shipping address and looking for shipping information.
- Test task 4 was problematic because it required the participants to make use of the advanced, or enhanced features of internal search on website 1.

Table 6.7: Accuracy Scores of Users' Tasks (%) with problematic tasks highlighted

Test Tasks	Users' Category	Accuracy Scores obtained by Users (%)			
		Website 1	Website 2	Website 3	Website 4
Task 1	Expert Users	100	100	**90**	100
	Novice Users	100	100	**50**	100
Task 2	Expert Users	100	100	**90**	100
	Novice Users	**90**	**70**	**50**	**80**
Task 3	Expert Users	100	100	**85**	**95**
	Novice Users	**90**	**85**	**60**	**75**
Task 4	Expert Users	100	100	100	100
	Novice Users	**95**	**80**	**50**	**85**

- Purchasing products via websites 2 and 3: users experienced task 2 on website 2 as problematic whilst tasks 3 and 4 were problematic when using website 3.
- Tasks 1 and 2 on website 3, which entailed searching for the desired item/s to buy as well as related descriptions, were also experienced as difficult.

Participant comments, as generated from the Loop11 platform during the remote asynchronous usability testing process, were collated and summarised. As illustrated in Table 6.8, the conclusions drawn from the comments provide a snapshot as to individual test tasks and, in so doing, they pinpoint usability problems which were identified in the course of performing individual tasks on the four websites. As suggested in earlier studies, the reported usability problems were grouped into three areas (Madathil & Greenstein, 2011: 2229, Neto & Pimentel, 2013: 93, Al-Razgan *et al.*, 2014: 420).

- **Major problems**: These are major errors, or mistakes, which users do not recover from and which prevent them from completing tasks on time, as required. Fixing this type of problem should be afforded high priority.
- **Minor problems**: These are errors which test users can overcome while performing the test task. They would still be able to complete the required test task within the specified time frame. The process of fixing this problem should be afforded medium priority.
- **Cosmetic problems**: These errors arise when test participants face certain difficulties, when abnormal behaviour is discovered or when users make comments while completing the task. These errors can be addressed, time and resources permitting.

Table 6.8: A snapshot of test users' comments extracted from the Loop11 platform

Test Tasks	Major Problems[8]	Minor Problems[9]	Major Problems	Minor Problems
	Novices		Experts	
Task 2 (Website 1)		-**Product page**: On this page, three users made errors. Instead of the 'add to cart' link, they tapped 'checkout' so they could add products to carts. They corrected these errors once they had read the message. -**Registration page**: 1- On this page, four users made errors, they did not enter the state/province information required for registration. This was corrected after the error message had been read. 2- On this page, there was an error from one user who printed the e-mail address information. This was fixed after the error message had been read. **- Free Shipping Coupon page:** Several errors were committed by four users on this page, they used incorrect coupons. They used the correct coupons after they had read the error message.	-**Product page**: On this page, two users tapped the 'checkout' button instead of the 'add to cart' button. They did this to add products to the carts. They corrected the mistake once they had read the error messages. Suggestion and recommendations for areas of improvement: If there is nothing in the cart when the checkout is requested, the user could be asked whether they wanted to add the current item to the cart before checking out.	-**Registration page**: 1- On this page, there were four users who made errors because they did not enter their state/province information, as required for registration, but they corrected this after having read the error message. 2- On this page, there was one user who made an error by printing the e-mail address. This was rectified after the error message had been read.
Task 2 (Website 2)	There were six users who could not find information on shipping. They continued to navigate various pages until the end of the testing process.	Two users tried various search terms on the site's internal search but navigated the website when the search had yielded no results.	1- There were two users who could not find information on shipping. They continued to navigate various pages until the allotted time had passed. 2- Two users only visited the company's page with its contact details and believed that they had completed the task successfully – one did not navigate the site beforehand, the other did.	

Each of the problematic pages were noted and the page headings were recorded for the individual website, as illustrated in Table 6.8. From the users' summary report, numerous usability problems were reported for individual tasks on each website; some of which occurred as a result of problematic test tasks and others were as a result of non-problematic test tasks. For instance, expert and novice users encountered difficulties while trying to tap the checkout

[8] They might not have realised their mistake, but the user could not finish the task on time after making a mistake.

[9] They could not recover or finish the task on time and made a mistake.

icon on a particular item from website 1. However, Table 6.7 shows that the majority of test users were able to successfully complete all the required tasks.

Table 6.9: Usability problem areas and sub-areas extracted from users' performance data

Usability Problems Areas		Descriptions
Main Areas	**Sub-areas**	
Content	Unsuitable content.	Some of the contents were unclear to the test users in that some webpages displayed repetitive or unclear information while some showed that they were undergoing construction. Unsuitable auto-rotating carousels content was present.
Accessibility and customer service	Difficult to locate helpful information in customer support/help section.	Hard to locate support, or help information, for customers. Incorrect support or help information was displayed in the customer section.
	Information provided via the customer service/help section is inappropriate.	Some webpages displayed inaccurate content about help/customer information which did not meet test users' expectations.
Architecture	Structural problems or inadequate structure.	Locating required information, or products, on the website is difficult due to the poor architecture, or structure of the website.
Internal search	Wrong results.	The internal search results were inappropriate and contained limited options.
Design	Confusing images.	The links associated with some images were not functioning when testing users tapped on them.
	Unsuitable webpage design.	One webpage failed to display its expected content correctly. Users had to scroll through the pages for a long period of time and the pages had large clustered images with inaccurate headings and titles.
Purchasing process	Problem in completing some required fields.	The process of completing the required fields was unclear to test users while trying to order products on the web page.
	Problem in differentiating between fields (required and non-required).	There were no clear differences between non-required and required fields when users were required to enter information to some entry fields.
	Problem encountered in recognising the required web links to tap.	Certain information on the website needs to be updated. Some webpages required for updates were missing and users did not know what action to take next.
	Session problem.	The website faced sessional problems such as the testing users' information did not save. This forced users to re-enter the same information for an individual order in the same session.
	Illogicality of the required fields.	Certain entry fields on the webpage contained some illogical fields.
	Lack of required information when products are added to the shopping cart.	Certain information was missing when products were added to the shopping cart, i.e. confirmation.
Navigation	Confusing webpage links.	The link name and the corresponding destination page differed. This confused users as to the next action to take.
	Unclear webpage links.	The location of each link is hidden, making it difficult for users to identify them.
	Poor navigational support.	The navigation menu was absent on one of the webpages. There were missing links to other web-pages on the website.

Commonly reported usability problems of the individual websites were compiled into a problem list. This list was later analysed to identify specific problems related to the four websites. Hence, a total of sixteen similar usability problem sub-areas were uncovered, generating seven problem areas as per different types of problems reported. The seven usability problem areas are: ***design, purchasing process, navigation, accessibility and customer service, architecture, internal search*** *and* ***content.*** An overview of the seven problem areas, sixteen problem sub-areas, as well as their associated descriptions are presented in Table 6.9. Appendix 19 provides additional details which include corresponding tasks for the individual problems, as well as their respective locations on each website. The problem location is tagged as either an entire website or by page title. The *entire website* indicates that the problem encountered by test participants relates to the entire website. Some tasks resulted in more than a single problem, as reported in Appendix 19.

Table 6.10: Asynchronous testing data with identified problem areas and sub-areas and websites' location for corresponding test tasks

Usability Problem Areas	Distribution of Usability Problems				Total
	Website 1	Website 2	Website 3	Website 4	
Content	1	0	2	0	3
Accessibility and customer service	1	1	2	1	5
Architecture	0	0	1	1	2
Internal search	1	1	0	1	3
Design	0	1	2	1	4
Purchasing process	4	4	4	4	16
Navigation	6	4	7	3	20
Total	**13**	**11**	**18**	**11**	**53**

The application of remote asynchronous testing on the four M-commerce websites provided positive results. The distribution of all the identified usability problems across the seven usability problem areas for the four selected websites are presented in Table 6.10. Website 3 has the most usability problems and websites 2 and 4 the least. A total of 20 navigation problems were recorded. These represent the highest number of usability problems identified from amongst the six other usability problem areas.

6.2.2.1 General Usability Study of the Selected Websites

The overall analysis of the user performance data and the reported comments generated the following findings regarding the general usability of the selected websites:

- The comments suggest that novice and expert participants, respectively, encountered a few common usability problems, or difficulties, while they attempted to complete the tasks on the four websites, as shown in Table 6.7. Expert users were able to overcome difficulties quicker than the novice users.

- As presented in Table 6.7, the total number of tasks successfully completed by the test participants, novices as well as experts, was low for website 3. The report, therefore, suggests that websites 1, 2 and 4 yielded better performance data than website 3.
- The percentage performance of novices who adequately completed the test tasks was lower than the percentage of experts who completed their test tasks. This can be attributed to their limited experience.
- The ANOVA test indicates that the performance test-time users spent in asynchronous testing on three of the four test tasks showed statistical substantial variation across all four websites. Detailed findings of the ANOVA (one-way within-subjects) test for the individual test tasks are presented in Table 6.11.

Table 6.11: ANOVA Test results of one-way within-subjects across the four selected websites

Testing Task Number	**ANOVA Test** **Was the time spent on the four selected websites statistically different?**
Task 1	F(3,57) = 6.020, *p* =.005 **Yes**
Task 2	F(3,57) = .501, *p* =.609 **No**
Task 3	F(3,57) = 4.470, *p* =.019 **Yes**
Task 4	F(3,57) = 2.363, *p* =.108 **Yes**

6.2.3 Quantitative Data of the Post-Test Questionnaires

The researcher recorded negative statements as reflected in the ratings (1 to 3 on the Likert questionnaire). These statements were used to generate the usability problems list. The individual identified problems on the list were compared to the problem sub-areas, as reported in the performance data. Consequently, the statements, the reported problem areas as well as their corresponding sub-areas were mapped together. The analysis identified three usability problems which were assigned to the design, purchasing process and navigation problem sub-areas. Table 6.12 illustrates the identified usability problems and their descriptions. In addition, Table 6.13 presents a detailed overview of Likert scores, negative statements and usability problem areas and sub-areas.

Table 6.12: Description of newly identified usability problems from the post-test questionnaires - quantitative data

Usability Problem Area		Descriptions
Main Areas	**Sub-areas**	
Purchasing process	Mandatory registration	The website required the test users to register on the webpage before they could proceed to the checkout.
Navigation	Orphan webpage links	There were a few broken links on the web page.
Design	Poor aesthetic design	The webpage interface was lacking in attractive and aesthetic features.

The statements below summarise findings as garnered from the general usability evaluation of the four selected M-commerce websites:

- As presented in Table 6.14 and Appendix 20, the conducted Mann-Whitney test showed no significant difference/s between several of the post-test statements completed by the novice and expert users. As a result the rating, or grading process, of expert and novice users was grouped together in terms of each post-questionnaire statement. The distribution test yielded positive results. Table 6.14 presents the distribution of all agreements (*yes*) and disagreements (*no*) by novice and expert groups for each website. The highest number (25) of disagreements are recorded for websites 3 and 4 whilst website 2 recorded the highest number (8) of agreements for novice and expert groups.

Table 6.13: Post-test questionnaires' statements and the identified problems

Usability Problem Areas		Post-Test Questionnaire's Statement Number	Likert Score			
Main Areas	**Sub-Area**		**Website 1**	**Website 2**	**Website 3**	**Website 4**
Architecture	Structural problems	1	N. A.	N. A.	2.95	N. A.
		2	N. A.	N. A.	2.60	N. A.
		8	N. A.	N. A.	2.70	2.75
Navigation	Poor navigational support	9	N. A.	N. A.	2.55	N. A.
		10	N. A.	N. A.	3.70	N. A.
	Orphan webpage links	14	N. A.	N. A.	3.85	N. A.
Purchasing process	Mandatory registration	15	3.25	2.75	N. A.	3.00
		16	N. A.	N. A.	2.25	N. A.
Content	Unsuitable content	20	N. A.	N. A.	3.50	N. A.
	Presence of unsuitable auto-rotating carousel content	24	N. A.	N. A.	3.25	N. A.
Design	Poor aesthetic design	25	N. A.	N. A.	3.80	N. A.
	Unsuitable webpage design	27	N. A.	N. A.	2.95	N. A.

- Surprisingly, expert and novice groups fail to agree on any of the statements with respect to website 3. The Mann-Whitney test was not applied to some statements as no ratings had been reported for at least one of the websites. Hence, the equivalent frequency number is recorded under the Not Available (N.A.) heading in the table.

- Consequent to the ratings, expert and novice users' results were combined using the Friedman test. The test shows, as reported in Table 6.15, that a significant difference exists between expert and novice users' ratings of the four selected websites. Table 6.15 and Appendix 21 also show that website 3 scored the lowest rating of the four selected websites in the usability problem areas of: architecture and navigation, purchasing process, design and content. The general usability evaluation statements, as reflected by the Likert scores, showed that website 3 scored the lowest rating of the selected websites. Websites 4 and 2 had the second and third best ratings while website 1 scored the highest positive rating.

Table 6.14: Distribution of the results of the Mann-Whitney test from post-test questionnaire[10] statements as regards the four websites

Post-test questionnaire (Statement Number)	Mann-Whitney (Two Tailed) Test Results											
	Website 1			Website 2			Website 3			Website 4		
	Are expert and novice groups significantly different?			Are expert and novice groups significantly different?			Are expert and novice groups significantly different?			Are expert and novice groups significantly different?		
	Yes	**No**	**N.A.**	**Yes**	**No**	**N.A.**	**Yes**	**No**	**N.A.**	**Yes**	**No**	**N.A.**
1 to 7	2	5	0	1	6	0	0	6	1	1	5	1
8 to 14	3	4	0	7	0	0	0	4	3	0	4	3
15 to 17	0	2	1	0	2	1	0	2	1	0	3	0
19 to 28	1	9	0	0	10	0	0	10	0	0	10	0
29 to 31	0	3	0	0	3	0	0	3	0	0	3	0
Total	**6**	**23**	**1**	**8**	**21**	**1**	**0**	**25**	**5**	**1**	**25**	**4**

However, Table 6.15 shows that the Friedman test was not applied to seven statements as websites 1, 2 and 4 did not record a rating for one statement and website 3 did not record a rating for six statements (see Appendix 21 for additional detail). Particularly, the table indicates the absence of Friedman results for: four statements relating to architecture and navigation as well as three statements relating to purchasing process problem areas as no rating had been recorded for at least one statement in these usability problem areas.

[10] The post-test questionnaire (Appendix 11) is categorised into different parts in order to capture different components of the four selected M-commerce websites. Therefore, Table 6.14 shows the results as captured from test participants in respect of each statement category.

Table 6.15: Distribution of the Friedman Test results from the post-test questionnaire in respect to usability problem areas

Usability Problem Areas	**Average Likert Score**				**Friedman Test: Are the four selected websites statistically different? (N=20)**		
	Website 1	**Website 2**	**Website 3**	**Website 4**	**Yes**	**No**	**Not Available**
Architecture and Navigation	5.7	5.2	3.2	5.4	7	0	4
Content	5.2	4.6	3.4	5.1	2	0	0
Design	5.7	4.9	4.0	5.3	5	0	0
Purchasing process	5.1	4.6	3.4	4.8	6	0	3
Overall Evaluation of the Websites	5.3	4.5	2.5	4.7	3	0	0
Total					**23**	**0**	**7**

These results further confirm that the four websites are statistically significantly different for the seven statements on architecture and navigation problem areas. Also, the results show that website 3 did not receive ratings for four statements (3, 11, 12 and 13) due to the feature not being present on the website. As regards statements 4 and 15, the website had disabled registration. In addition, no rating was recorded for websites 1, 2 and 4 for one statement (16) because optional registration was lacking.

6.2.4 Qualitative Data from Post-Test Questionnaires

The qualitative data, as reflected by the post-test questionnaire analysis, indicated that expert and novice users encountered common usability problems when completing tasks on the four selected websites.

Findings from the Manny-Whitney test show that expert and novice users' responses did not differ significantly, as reported in the post-test statements, as per Table 6.14. The reported answers from the post-test questionnaire for both user categories were thus merged. The usability problems identified were linked or assigned to their corresponding problem areas, and sub-areas, as reported in the extracted performance data.

Two new usability problem areas with respect to ***missing capabilities*** and ***inconsistency*** problems were identified with their corresponding two sub-areas, as per Table 6.16. Seven new additional sub-areas were discovered. The new sub-areas were assigned, or linked to, six suitable usability problem areas namely: ***purchasing process, internal search, content,***

customer service and accessibility, design and ***navigation.*** Table 6.16 lists the newly identified usability areas, and sub-areas. Additional detail per location is presented in Appendix 22.

Table 6.16: Description of the newly identified usability problems from the post-test questionnaires - qualitative data

Usability Problems		**Descriptions**
Main Areas	**Sub-Area**	
Purchasing Process	Lengthy ordering process	The processes for ordering products from the website is lengthy. Many steps need to be addressed before a product can be bought. This could be a possible source of frustration to potential customers.
Internal Search	Restricted options	The displayed results from the internal search facility contained few options.
Navigation	Dead-end webpages	There was a broken webpage which contained no associated link.
Inconsistency	Inaccurate layout/design/content	There were inconsistencies in the website's layout and design so much so that the mobile version differed when used on different operating systems. The webpage was not considered responsive enough.
Design	Choice of colours and fonts deemed unsuitable	The formatting of the content of the website was inappropriate as the font size, font styles, font colour, background and link colour were not consistent.
Missing Capabilities	Incomplete website capabilities/ functionalities	The website lacked some basic functionality such as an internal search function and the absence of adequate information from the search results.
Accessibility and Customer Service	Supported only one language	The content of the website was presented in English only.
Content	Incomplete information	Inaccurate information was displayed on the website such as the product being incorrectly indicated as being out of stock or the inclusion of an incorrect product description.
	Lack of product information	The website displayed inadequate information regarding the product including: fabric, size guide, in stock, out of stock.

Table 6.17: Distribution of the identified usability problems from the post-test questionnaire (the qualitative data) in respect to the usability problem areas

Usability Problem Areas	**Distribution**				**Total**
	Website 1	**Website 2**	**Website 3**	**Website 4**	
Navigation	2	2	2	1	7
Content	2	2	2	2	8
Design	1	1	1	0	3
Architecture	0	0	1	1	2
Internal Search	1	1	2	2	6
Purchasing process	1	1	2	0	4
Customer service and Accessibility	0	1	1	1	3
Inconsistency	0	0	2	0	2
Missing Capability	0	0	1	0	1
Total	**7**	**8**	**14**	**7**	**36**

The application of the post-test questionnaire in order to get qualitative data about the M-commerce websites yielded promising results. The distribution of the identified usability problems, across nine usability problem areas, for the four selected websites, are presented in Table 6.17.

Website 3 presented the highest number (14) of usability problems whilst websites 1 and 4 had the least. A total of eight problems in the content problem area was recorded. This represents the highest number of problems from the nine problem areas.

6.2.4.1 General Usability Study of the Selected M-commerce Websites

Regarding question 35 of the post-test questionnaire (refer to Appendix 11), the researcher collected individual users' opinions regarding the usability of the four selected websites. Sixteen of the twenty users expressed their dissatisfaction with website 3. This was based on their interactions with, and the performance of website 3. They stated that they would not be willing to use it for any future purchase/s. In contrast, twenty users reported that they would not patronise all four websites because of personal problems outside the websites' usability. One of the problems raised had to do with the feeling, or perception, that their financial information is not securely protected.

6.2.5 Qualitative Data of Post-Evaluation Questionnaires

The researcher combined the qualitative data reported by novice and expert users, as previously discussed in section 6.2.4, of this research. Appendix 17 presents the post-evaluation questionnaire (indicating which website has the best feature, according to user ratings) which contained seven open-ended questions which uncovered no specific usability problems. The information provided details as to general usability of the selected websites in relation to the six characteristics of the websites, as per users' perceptions:

- ***Navigation***: All user responses to questions 2 and 6 show that the navigation feature, as implemented on websites 1, 2 and 4, assisted novice and expert users to easily locate specified products and information. The rating and recommendations for website 1 were better than those afforded websites 2 and 4. Website 1 exhibited suitable features which facilitated the easier locating of product information when compared to the other websites.

- ***Internal Search***: Participants' responses to questions 2 and 6 show that the internal search processes for websites 1, 2 and 4 assisted test participants to easily locate required product information.
- ***Architecture***: Participants' responses to questions 2 and 6 show that websites 1, 2 and 4 have simple and straightforward architectures which makes it easier for test participants to locate product information. The total number of test participants which endorsed websites 2 and 4 were less than those who had endorsed website 1.
- ***Design***: Participants' responses to question 1 show that website 1 was most frequently recommended for its professional appearance. No participants recommended website 3 while only a few recommended websites 2 and 4.
- ***Purchasing Process***: The responses of the test users to questions 3, 4 and 7 indicated that the product ordering method on website 1 was highly recommended. In addition, the recommendations for website 1 included better customer service support and additional features which would enable users to easily change their shopping cart contents. Website 2 was recommended as the easiest website for changing customer information while websites 3 and 4 received no recommendation.
- ***Security and privacy***: Participants' responses to question 5 in the post-evaluation questionnaire reveal that most users recommended website 1. Websites 2 and 4 gained a few recommendations whilst website 3 was not recommended at all. Two test users stated that the inclusion of a secure socket layer on websites 1, 2 and 4 was the reason for their recommendation. Test users recommended website 1 partly because the organisation is a key player in the M-commerce industry.

6.2.5.1 Results of the Post-Questionnaire from the SUS

Though it is important to report different usability problem areas and sub-areas associated with each of the selected websites, this type of data fails to provide additional useful information regarding the general satisfaction level of the test participants. It is important to note that user satisfaction levels are a major motivating factor and, as such, they facilitate user performance of a particular product (Jokela *et al.,* 2006: 345; Poulcheria & Costas, 2012: 88; Ravendran *et al*., 2012: 80; Orlandini *et al*., 2014: 195).

Table 6.18: Overall Satisfaction Level (SUS scores) of the selected websites

Test Users	Website 1	Website 2	Website 3	Website 4
P1	82	71	46	67
P2	88	77	55	77
P3	78	80	51	64
P4	85	69	57	57
P5	76	67	48	55
P6	80	72	50	66
P7	75	78	50	58
P8	72	82	49	61
P9	79	73	60	70
P10	81	75	54	55
P11	87	70	45	56
P12	72	66	55	71
P13	74	62	52	58
P14	80	68	56	69
P15	73	60	51	57
P16	77	65	44	52
P17	89	70	50	55
P18	90	57	46	65
P19	84	58	50	66
P20	86	76	40	73
Average	**80.40**	**69.80**	**50.45**	**62.60**

The analysis of SUS provides data regarding the general satisfaction level/s of users of the selected websites as presented in Table 6.18. Previous studies show that: an average value over 90 is regarded as level A, a value between 80 and 90 is regarded as level B, a value between 70 and 80 is regarded as level C, a value between 60 and 70 is regarded as level D and a value below 60 is regarded as level F (fail) (Bangor, Kortum & Miller, 2009: 121). Website 1 has a mean value of 80.4, which is above the threshold of 80 and thus considered a level B. Websites 2 and 4 with mean values of 69.8 and 62.6, respectively, are considered a level D and website 3, with a value of 50.45, is considered a level F, which signifies failure.

In general, website 1 was rated as the best website by nearly all the test participants because of its interface. The reported errors on website 1 were, firstly, ‘out of stock’ was displayed for products on the product page and, secondly, the large number of product images resulted in the webpage being unreasonably long. Generally, test participants expressed their satisfaction with website 1’s interface in terms of its simplicity and intuitiveness.

The usability evaluation of the selected websites indicated that many test participants regarded them as ‘intuitive’ and ‘easy to use’. After the analysis of the SUS data, website 1 emerged as the best overall website with a level B rating. The usage of SUS in the evaluation of the selected websites helped to uncover other potential usability concerns with respect to websites 2, 3 and 4. It also revealed which areas should be addressed to enhance the websites' usability (Lewis & Sauro, 2009: 98–102; McLellan, Muddimer & Peres, 2012: 61–64; Orfanou, Tselios & Katsanos, 2015: 235–241).

6.3 Results of the Proposed MCOM Heuristics

This segment describes the analysis of quantitative and qualitative results garnered during the application of the proposed MCOM heuristics in the usability evaluation of the four selected M-commerce websites.

6.3.1 Analysis of Qualitative Data of the MCOM Heuristics

A detailed account of each website's adherence to the heuristic guidelines has been provided through the qualitative data generated by MCOM heuristic evaluators during their investigations.

This research analysed all individual heuristic principles for every sub-category in relation to every website with the aim of pinpointing usability problems for each of the studied websites. Problems identified were catalogued and usability problems, which were commonly encountered, were collated to determine similar usability problems across all the websites.

Table 6.19: Distribution of the usability problems identifed from the heuristic evaluation report for the four selected websites

Usability Problem Areas	**Distribution**				**Total**
	Website 1	**Website 2**	**Website 3**	**Website 4**	
Navigation	6	7	15	6	34
Content	4	5	7	4	20
Design	8	8	12	11	39
Architecture	0	1	3	1	5
Internal Search	3	2	1	2	8
Purchasing process	5	3	3	2	13
Customer service and accessibility	3	5	4	6	18
Inconsistency	1	3	2	1	7
Security and Privacy	0	1	2	1	4
Missing capability	3	3	6	3	15
Total	**33**	**38**	**55**	**37**	**163**

Table 6.20: Distribution of usability problems across the proposed MCOM heuristics identified from the heuristic evaluation report

MCOM Heuristics Name	Number of Problem Found				Total
	Website 1	Website 2	Website 3	Website 4	
Make the home page easy to view at a glance	3	4	8	5	20
Sense users' fear of losing data	1	3	7	4	15
Make "Add to Cart" button visible on each product page	2	3	9	5	19
Be careful of including animated carousels	2	3	7	5	17
Be careful of adding images or product information on different sub-pages	2	4	7	3	16
Be careful in the arrangement and design of account-selection options	3	3	6	4	16
Ensure that the auto-correction of the dictionary is disabled when needed	1	2	5	4	12
Ensure that fields are long enough to display common data in full (Add label at the top of the field)	2	5	4	2	13
Allow verification of inputted day, date and shopping details	2	3	7	3	15
Ensure that each hit area and list item is clearly distinguished	2	3	5	4	14
Ensure that users' privacy and security concerns are addressed	1	1	2	2	6

The application of the MCOM heuristic evaluation method for the four M-commerce websites provided promising results. Table 6.19 presents an overview of the distribution of all the identified usability problems, across ten usability problem areas, for the four selected websites. Website 3 had 55 usability problems (the highest score) whilst website 1 had 33 (the lowest of the four websites). A total of 39 problems were recorded in the *design area*. This represents the highest number of identified problems across the ten problem areas while the problem area *security and privacy* recorded four usability problems.

Furthermore, in order to pinpoint common problem areas regarding usability, the analysis was conducted across all four selected M-commerce websites. As stated in the earlier sections, Tables 6.8, 6.11 and 6.15 present problem areas related to usability as identified by test participants during the remote asynchronous testing process. These problem areas were categorised according to their various main and sub-areas, within the guidelines.

A new problem area, *privacy and security*, was uncovered during the application of the MCOM heuristic evaluation method. This was in addition to sixteen new problem sub-areas, each of which was assigned to its corresponding problem areas. Appendix 23 describes the identified problems, and their associated usability problem area/s and sub-area/s, and the location of each problem as per website. In addition, Table 6.20 presents the distribution of identified usability problems across the proposed MCOM heuristics from the heuristic evaluation report. These are further explained in Appendix 18.

6.3.1.1 Analysis of General Usability of the M-commerce Websites

Website 1 comparatively recorded the best usability as reported by the evaluators. However, heuristic evaluators uncovered a few numbers of usability problems. Website 3 performed the worst in terms of usability when compared to the other websites. Additional details of each identified usability problem, as well as their location on each of the four websites, is presented in Table 6.19.

6.3.2 Results from the Heuristic Checklist

To uncover different usability problems, the study analysed qualitative and quantitative data identified from the heuristic evaluation reports. Furthermore, the analysis assisted in determining other usability problems which heuristic evaluators might not have identified while reporting the qualitative data. Negative statements, extracted from the heuristic checklist, were tested to evaluate their usefulness in the identification of various usability problems. These statements were also categorised in accordance with appropriate problem areas and sub-areas. A detailed list of usability problems, as well as corresponding problem areas and sub-areas, were matched to those identified in the remote asynchronous user testing method.

Table 6.21: Heuristic checklist statements and identified problem areas

Usability Problems Areas	Heuristic Checklist's Statements Number	Average Likert Score			
		Website 1	Website 2	Website 3	Website 4
Navigation	8, 10	N. A.	3.3	2.9	3.0
Internal Search	12	3.00	3.80	N. A.	3.60
Content	25, 27, 29, 31, 33, 35, 36	2.8	3.1	2.4	3.0
Design	18, 59, 67, 68, 54, 55, 58	3.3	3.2	2.8	3.4
Architecture	9, 19, 20, 21, 22, 23, 24	N. A.	N. A.	2.7	N. A.
Security and Privacy	95, 96	N. A.	N. A.	3.3	N. A.
Accessibility and Customer Service	38, 42, 44, 45, 46, 47, 48, 52, 53	2.0	2.6	2.5	2.8
Inconsistency	1, 2, 3, 4, 6, 7	N. A.	2.8	3	3.6
Missing Capabilities	16, 76, 78, 85, 86, 90, 92	2.7	2.5	3.5	2.5

Note: No negative statement was recorded for the purchasing process usability problem area, therefore, only nine out of the ten identified usability problem areas with one, or more, negative statement/s are recorded in Table 6.21

However, the identified negative statements did *not* provide new problem areas and sub-areas. This revealed that the heuristic evaluators' investigations were successful in determining whether the websites complied with the MCOM heuristics guidelines for all sub-categories.

All the negative statements, their corresponding Likert scores, as well as their areas and sub-areas are presented in Table 6.21 and Appendix 24.

6.3.2.1 Analysis of the General Usability of the Websites

A general analysis of the websites shows that the four selected M-commerce websites differ significantly with regard to heuristic evaluator ratings, as shown by the Friedman test presented in Table 6.22.

Table 6.22: Distribution of Friedman Test results from the heuristic checklist for usability problem areas

Usability Problem Areas	**Average Likert Score**				**Results of Friedman Test Are the four selected websites statistically different? (N=5)**		
	Website 1	**Website 2**	**Website 3**	**Website 4**	**Yes**	**No**	**Not Available**
Architecture	5.2	5.1	3.2	5.3	10	1	2
Content	5.2	4.6	3.4	4.7	7	6	0
Accessibility and customer service	5.5	3.9	4.5	4.0	7	4	5
Design	5.3	5.5	4.5	5.6	10	5	0
Navigation	5.2	5.1	3.2	5.3	9	1	1
Purchasing process	3.6	3.8	2.7	3.8	10	12	6
Total					**53**	**29**	**14**

Note: No rating was recorded for at least one statement of missing capability, navigation, security and privacy, inconsistency and internal search usability problem areas. Therefore, these five usability problems areas are not included in the table and hence, only five out of ten identified usability problem areas are presented in Table 6.22.

The Friedman test, presented in Table 6.22, was not applied to fourteen statements as websites 1, 2 and 4 recorded no rating for four statements, while no ratings were recorded for ten unique statements for website 3, as per Appendix 25. The table also indicates that there were no Friedman test results for three statements in *architecture and navigation*, five statements for *accessibility and customer service* and six statements for *purchasing process* problem areas. This is because no rating had been recorded for at least one statement in these usability problem areas. Table 6.22 also reveals that the four websites differ significantly statistically for ten statements each in architecture, design and purchasing process, and nine statements concerning navigation usability problem areas. It is interesting to note that website 4 had the highest rating score of 5.6 in the design problem area compared to other websites. However, website 1 recorded the best overall rating score of 5.0 whilst website 3 recorded the lowest average rating across the six usability problem areas.

Appendix 25 provides additional detail on the heuristic checklist statements where the Friedman test was not employed for certain statements. This is because no ratings were reported for at least one of the four selected websites.

6.4 Discussion

This section discusses the study findings which are organised in eight categories as follows: (i.) usefulness of heuristic evaluations and remote asynchronous testing, (ii.) number of usability problems, (iii.) number of identified minor and major usability problems, (iv.) total time required in the use of UEMs, (v.) the identified false, common and unique problems, (vi.) the relationship among the variables (vii.) the comparison of usability problems by evaluation methods and (viii.) the significance of security attributes as related to the evaluation of the selected M-commerce websites. These eight sub-sections contain a literature review linked to each category and a discussion of the findings.

6.4.1 Usefulness of Heuristic Evaluations and Remote Asynchronous Testing

Both the heuristic evaluation and user testing methods have often been applied to previous studies to evaluate how *usable* website or software applications are (Hvannberg, Law & Lárusdóttir, 2007: 235; Fetaji, Fetaji & Kaneko, 2011: 271; Petrie & Power, 2012: 2113; Paz *et al.*, 2015: 550; Singun, 2016: 5).

Previous research investigated the effectiveness of these two UEMs when applied to different interfaces. This provided valuable results as to which method is more effective in the identification of the highest number of major and minor usability problems (Tan *et al.*, 2009: 623–626; Paz *et al.*, 2015: 549–552; Singun, 2016: 4–6). Previous studies also provided certain instances where usability problems were identified through the use of these usability methods.

Previous studies, however, did not provide specific details in terms of particular usability problems which these usability methods could discover. The current study's results emphasise the total number of usability problems that these two methods identified. In the sections which follow, the results collected from earlier studies are compared with the findings of the current study. This comparison will be divided into four parts: the number of identified problems, the number of minor and major usability problems, the total time for conducting the evaluation methods and a comparison of the identified usability problems.

6.4.2 Number of Usability Problems

The findings of the current research are in line with several previous studies which compared user testing and heuristic methods, as previously discussed. When compared to the user evaluation method, the heuristic evaluation method, in a similar fashion to previous studies, determined the highest number of usability problems (Nielsen, 1994c: 41; Hub & Čapková, 2009: 65; Fetaji *et al*., 2011: 270–271; Alrobai *et al*., 2013: 26). The results of the current study thus reflect those obtained in previous studies. This is to be expected as similar procedures were employed (Tan *et al.*, 2009: 627).

For instance, *user testing* is aimed at determining the usability problems encountered by users while performing certain tasks during their interaction with the interfaces. However, heuristic evaluators were not subjected to any task, they only investigated the websites based on the proposed MCOM heuristic evaluation method. The MCOM heuristic evaluation method was found to yield consistent results with earlier research, suggesting their usefulness as a research usability evaluation method.

6.4.3 Number of Identified Minor and Major Usability Problems

With respect to the current study, the findings show that *user testing* is the less effective of the two evaluation methods. The *heuristic evaluation method* (MCOM heuristics) is most effective in the identification of unique minor usability problems, while *user testing* is found to be more effective in identifying major usability problems. This result is in line with findings garnered from previous studies (Law & Hvannberg, 2012: 77; Allen *et al*., 2007: 4–6). The results reveal that the two evaluation methods are complementary as they jointly determine usability problems in a way which neither method can achieve independently. It was thus valuable to use both UEMs in this research (Law & Hvannberg, 2012: 79; Granic & Cukusic, 2011: 121; Paz *et al*., 2015: 551; Singun, 2016: 6).

The percentage of usability problems regularly determined by using both evaluation methods was reported in earlier research (Thompson & Kemp, 2009: 31–33; Fetaji *et al.*, 2011: 270–271; Granic & Cukusic, 2011: 119; Petrie & Power, 2012: 2113; Alrobai *et al*., 2013: 14; Tognolli *et al*., 2014: 151–152; Paz *et al*., 2015: 551). However, whether or not both methods are considered equal in determining the severity of usability problems was not addressed in earlier studies.

This research study categorises the discovered usability problems, as identified by the two different evaluation methods, into *minor* or *major* problems. Furthermore, results show that these two evaluation methods agree in 20% of the 208 identified problems. This is in line with literature which states that heuristic evaluators are unable to fulfil the function of real users as the evaluators find it difficult to pass judgment regarding the severity of usability problems on website interfaces (Fetaji *et al.*, 2011: 184; Davids, 2015: 76–77).

6.4.4 Total Time Required for Usability Evaluation Methods

Previous studies agree on how much time the two evaluation methods take noting that the heuristic evaluation method is more cost effective than the user testing method (Nielsen, 1994c: 36; Law & Hvannberg, 2012: 77; Somervell & McCrickard, 2004: 2483; Allen *et al.*, 2007: 3; Alrobai *et al.*, 2013: 26). The current study, as per Table 6.23, presents similar results in term of time spent for the evaluation methods.

Table 6.23: Overview of time spent for usability evaluation methods

User Testing Evaluation Method (Time Spent)	MCOM Heuristic Evaluation Method (Time Spent)	Research Sources
239 hours The total time spent was: 5 hours for design and setup, 20 hours for data collection from 20 test participants for each of the four selected websites and 154 hours for data analysis.	**63 hours** The total time spent was: 6 hours for research design and setup, 10 hours for data collection and reporting from the selected 5 usability experts, and 47 hours for data analysis.	Current Research
296 hours The reported time was 112, 88 and 96 hours in performing the tasks by 20 test participants in the test sessions for websites 1, 2 and 3 respectively. The reported time excludes the setup time and time used for data analysis.	**122 hours** The reported time was 42, 30 and 50 hours spent by one evaluator on each of the three websites. Four evaluators were involved in the experiment. The reported time excludes the set-up and data analysis.	(AlRoobaea, Al-Badi & Mayhew, 2013: 97–101)
200 hours The reported time was used for method design and application. A total of 10 test participants took part in the study.	**9 hours** The two selected evaluators used the time for method design and implementation, which excluded the time for data analysis.	(Law & Hvannberg, 2012: 4–9)
220 hours The reported time involved: 75 hours to perform the tasks by 20 test participants in the test sessions, 145 hours was used for reporting and for completing observation notes.	**57.5 hours** The reported time was used for: method learning and familiarisation with the website interface (7.5 hours), interface evaluation (20 hours) and problem reporting and debriefing (30 hours). A total of 5 expert evaluators performed the experiment	(Lauesen & Musgrove, 2007: 452–453)

It is important to note that a wide margin of variation exists in this study, as well as in earlier studies, regarding the amount of time required when performing tasks related to usability testing techniques. This is due to the fact that, firstly, previous studies involved usability experts in their geographical locations which influenced their interaction with the website interfaces. This research work involved usability experts from outside the geographical area of the study. Secondly, previous studies reported that culture greatly influences the assessment of website interface usability (Kim & Lee, 2005: 307; Shi, 2010: 18; Coursaris *et al.*, 2012: 1439).

It can thus be deduced that the experience of usability specialists can reduce the time they need to conduct the usability evaluation. This is specifically true in terms of time required to set up and design tests as well as time required for data collection and analysis.

Another factor which contributes to the variation in times recorded for these two evaluation methods is that previous studies did not adopt standardised categorisations to reflect how much time had been spent in using the two methods. For instance, previous research, as per Table 6.23, did not specifically indicate the time spent on setup or design, nor did it indicate the time spent on data collection and analysis. This means that *unreported* time reduces the total reported time.

From Table 6.23, the time reported in previous studies was dependent on the number of heuristic evaluators and users who took part in the evaluation process. These studies did not overtly report costs in terms of that which was *fixed* or *variable*. Fixed costs refer to the time used for design and set up, regardless of the number of participants involved. In contrast, the variable cost is the cost of actually performing the usability evaluations and gathering data. This is dependent on the number of users and evaluators involved.

6.4.5 Number of the Identified False, Common and Unique Usability Problems

The success of a UEM depends, in part, on whether it allows the evaluators to identify the most critical problems and whether it allows system developer to rectify false problems (i.e. those problems discovered by evaluators using the expert evaluation method, but not by the users in the user testing e.g. asynchronous testing) (Hvannberg, Law & Lárusdóttir, 2007: 234–235). A major problem when conducting expert-based usability evaluations is that the users are not involved, and the experts try to predict how the users would use the system and what their experiences in doing so would be. The experts can be wrong, so the tendency exists to register false problems, or false alarms (Mendoza, 2009: 13–17). Table 6.24 shows the number of false problems with respect to each of the ten usability problem areas recorded by the MCOM heuristic evaluators. It can be observed that a total of 77 false problems were recorded. The majority of these were reported in the following usability problem areas: design (28), missing capability (14) and accessibility and customer service (10). These three usability problem areas (design, missing capability, and accessibility and customer service) are less important to users in asynchronous testing. It indicates that evaluators are good at discovering problems which impact on the negative website areas, not on the positive (Law & Hvannberg, 2012: 77–79). However, users in user testing are expected to comment on both the negative and positive areas of the system as investigated via satisfaction questionnaires.

Table 6.24: The number of the identified false problems across the usability problem areas

Usability Problem Areas	Usability Problems			Total
	Asynchronous Testing	MCOM Heuristics	False Problems	
Navigation	27	32	5	64
Content	11	20	9	40
Design	9	37	28	74
Architecture	4	5	1	10
Internal Search	9	10	1	20
Purchasing Process	20	12	-	32
Accessibility and Customer Services	8	18	10	36
Inconsistency	1	6	5	12
Security and Privacy	0	4	4	8
Missing Capability	1	15	14	30
Total	**90**	**159**	**77**	**326**

Prior studies used the metric of 'false problems' to measure effectiveness and compare the usability problems discovered in heuristic evaluation and user testing methods (Mendoza, 2009: 13–17; Jaferian *et al.*, 2011: 8–9). There are instances where novice users identified more problems than expert evaluators. This may be because novice users tend to explore *other* areas of the user interfaces. If more samples had been included in the expert-based evaluation, it may also have resulted in increased instances of identification (De Lima Salgado, 2017: 71). As expected, users discovered the most usability problems (such as difficulty in differentiating between lengthy ordering processes and sessional problems as well as essential and non-essential fields) in the *purchasing process usability problem area*. Therefore, no false problems were recorded in this section of problem areas, as highlighted in Table 6.24. The reason may be that users are more concerned and careful when supplying their personal details and thus easily spot errors associated with different fields (Maass *et al.*, 2010: 427–431; Sieger & Möller, 2012: 107–110; Djamasbi *et al.*, 2014: 299–301).

However, the 77 false problems recorded by MCOM heuristic evaluators should not be considered as *dubious* even if they were not verified or recorded by users in asynchronous testing. Prior studies suggest that *unverified* problems should not be considered *false* problems.

Users taking part in the user testing may not always be able to locate the unverified problems discovered by heuristic evaluators (Law & Hvannberg, 2012: 75–78). In addition, the large number of reported false problems may be ascribed to the newly developed domain specific evaluation method (MCOM heuristics) specifically tailored to M-commerce applications.

Table 6.25: Common and Unique Problems Identified in Asynchronous Testing and MCOM Heuristic Evaluation with Percentages

Problem Type	Asynchronous Testing		MCOM Heuristics		Total	Percentage
Major	Common	15	Common	15	**82**	32.9%
	Unique	40	Unique	12		
	Sub-total	**55**	**Sub-total**	**27**		
Minor	Common	27	Common	27	**167**	67.1%
	Unique	8	Unique	105		
	Sub-total	**35**	**Sub-total**	**132**		
	Total	**90**	**Total**	**159**	**249**	
	Percentage	36.1%	Percentage	63.9%		

Table 6.25 present statistics of the identified problems by MCOM heuristics and asynchronous testing methods. It can be observed that the number of unique minor and unique major problems discovered by MCOM heuristics are 12 and 105, respectively. While the number of unique minor and unique major problems identified by asynchronous testing are 8 and 40, respectively. The number of common problems in both evaluation methods are 27 and 15 for minor and major problem types, respectively. The percentages of problems discovered by MCOM heuristics and asynchronous testing are 63.9% and 36.1% respectively. It is important to note that the exact and total number of usability problems identified in a particular system will be difficult to calculate. Hence, the researcher only used a rough estimate as to the total number of usability problems for the sum of the unique usability problems identified by each testing method and its common usability problems. From the stated results, it can be deduced that MCOM heuristics outperformed asynchronous testing. However, this result is to be expected since the heuristic evaluators used a new set of domain-specific heuristics (MCOM heuristics). The results are in accordance with a prior study in which heuristic evaluation discovered more usability problems than user testing (Tan *et al*., 2009: 622–626).

6.4.6 Relationship of Usability Attributes Across the Four Websites

The current study used Pearson's correlation coefficient to indicate the relationship/s governing: the problem discovered, time spent and users' satisfaction as discussed in section 5.6.1.2, Chapter 5. Table 6.26 presents the correlation coefficient scores of problems discovered, time spent and users' satisfaction across all four of the selected M-commerce websites. The statistical ***p*** values between *time spent* and *users' satisfaction* for websites 1, 2, 3 and 4 are 0.19, 0.25, 0.29 and 0.27, respectively. These values indicate that there is no strong statistical relationship between time spent and users' satisfaction scores while interacting with all four the selected M-commerce websites. This finding agrees with a prior study which argued that the amount of time spent by users in completing tasks does not affect their satisfaction rating scores of the system being investigated (Alghamdi *et al.*, 2013: 88–94).

Table 6.26: Relationship Amongst the Attributes Across the Selected Websites

(a)

Variable	**Website 1**			**Website 2**		
	Problem/s Discovered	**Time**	**Satisfaction**	**Problem/s Discovered**	**Time**	**Satisfaction**
Problems Discovered	1	0.63	0.51	1	0.53	0.57
Time	0.59	1	0.19	0.62	1	0.25
Satisfaction	0.23	0.17	1	0.15	0.09	1

(b)

Variable	**Website 3**			**Website 4**		
	Problem/s Discovered	**Time**	**Satisfaction**	**Problem/s Discovered**	**Time**	**Satisfaction**
Problems Discovered	1	0.63	0.73	1	0.53	0.60
Time	0.77	1	0.29	0.66	1	0.27
Satisfaction	0.23	0.17	1	0.15	0.09	1

In addition, the statistical ***p*** values between *problems discovered* and *users' satisfaction* for websites 1, 2, 3 and 4 are 0.51, 0.57, 0.73 and 0.60, respectively. These values indicate that there is a strong statistical relationship between the problems discovered and users' satisfaction scores. The findings show that the higher the number of usability problems, the lower the users' satisfaction rating scores. This result did not agree with a prior study which states that the number of usability problems discovered in a system does not affect users' satisfaction (Alghamdi *et al*., 2013: 90–91). The reason for this disparity may be linked to the fact that the prior study evaluated a student union website (www.ueastudent.com), not a mobile website (e.g. M-commerce website), as is the case in this study. The users of mobile application are more concerned about the number of errors discovered in a system which, in turn, will determine their satisfaction rating scores (Nyumbeka & Wesson, 2014: 352-358). It can be deduced that the *lower* the number of usability problems discovered in a system, the *higher* the users' satisfaction rating score.

Furthermore, the statistical ***p*** values between *time spent* by users and *problems discovered* for websites 1, 2, 3 and 4 are 0.59, 0.62, 0.77 and 0.66, respectively. These values show that there is a strong statistical relationship between the time spent by the users and problems discovered. The findings show that the longer the time spent on tasks, the higher the number of usability problems discovered. This finding is in accordance with the prior study, which notes that the more time users spend on tasks, the more usability problems will be discovered (Alghamdi *et al.*, 2013: 88–94).

6.4.7 Comparisons of the Results of Asynchronous User Testing and MCOM Heuristic Evaluation Methods

Four sub-sections are addressed in this section. The first sub-section summarises the comparison of the results of both evaluation methods on the specific samples of problems identified (e.g. features of usability problems discovered by the remote asynchronous testing and the MCOM heuristic evaluation methods) of the four selected websites. The second sub-section illustrates the effectiveness of the evaluation methods in identifying usability problems, while the third sub-section explains the types of usability problems identified by the two evaluations of the four selected M-commerce websites. The fourth sub-section illustrates the distribution of the identified usability problems identified through asynchronous testing and MCOM heuristic evaluation methods across the usability problem areas. In addition, the sub-section illustrates the effectiveness of the methods in uncovering the exact type of usability problem, in relation to how many problems were identified.

6.4.7.1 Comparison of the Research Results In Relation to Specific Features

This study illustrates the efficiency of the MCOM heuristic evaluation method and user testing (remote asynchronous) in the identification of 44 usability problems, which were uncovered in M-commerce websites. The current research identified usability problems align to ten different usability problem areas.

The findings provide an in-depth explanation into usability problems, as determined through the use of the MCOM heuristic evaluation and user testing methods. The results obtained are in line with the findings of earlier studies as per Table 6.27.

The results show that the identified usability problems impact the way in which users conduct certain purchasing tasks on the websites. Furthermore, the heuristic evaluators found that this specific technique determines usability problems in terms of the interface features and its quality, which is in line with previous research.

Table 6.27: Usability evaluation methods and their respective problems

Usability Testing Method	Usability Problems (Samples)	Sources
Features of usability problems discovered by the remote asynchronous testing method	Associated with testing user performance Connected to insufficient help facilities and the absence of precise feedback Associated with website learnability and functionality problem/s Connected to frequent use of complicated technical terms and jargon Connected to unsuitable selection of content font size Associated with bad formatting of links Presence of few inconsistencies	(Jensen, 2007: 170) (Tognolli *et al.*, 2014: 151) (Singun, 2016: 6) (De Kock *et al.*, 2009: 127–128) (Petrie & Power, 2012: 2113–2115) (Nielsen, 1994c: 27–41) (Law & Hvannberg, 2012: 76–79) (Fetaji *et al.*, 2011: 270–271) (Allen *et al.*, 2007: 3–4) (Chattratichart & Brodie, 2004: 1121) (Granic & Cukusic, 2011: 120–121) (Hub & Čapková, 2009: 64) (Lei *et al.*, 2014: 589) (Chen & Macredie, 2005: 527)
Features of usability problems discovered by the MCOM heuristic evaluation method	Connected to website interface quality and features Connected to website interface layout or appearance Inconsistency in webpage interface Problems with delay in response time when displaying results Compatibility related problem Privacy/security related problem	(Akers, 2010: 128–136) (Davids, 2015: 76) (Silva *et al.*, 2014: 354–356) (Allen *et al.*, 2007: 3–6) (Alrobai *et al.*, 2013: 14–26) (Granic & Cukusic, 2011: 120–121) (Thyvalikakath *et al.*, 2009: 2–3) (Chen & Macredie, 2005: 526–528) (Hvannberg *et al.*, 2007: 237) (Law & Hvannberg, 2012: 76–79) (Nielsen, 1994c: 27–41) (Paz *et al.*, 2015: 550–551) (Tan *et al.*, 2009: 624) (Maass *et al.*, 2010: 431) (Singun, 2016: 6) (De Kock *et al.*, 2009: 127–128) (Fetaji *et al.*, 2011: 270–271)

In addition, the user testing technique, like in other earlier studies, revealed additional usability problems which were linked to the absence of help and feedback facilities, navigation problems, use of complicated terms, unsuitable choice of font size and consistency problems. The findings also confirmed usability problems including aesthetics, inconsistency and design problems as well as security and privacy concerns.

However, some results of earlier studies have not been reiterated in this research, as shown in Table 6.27. For instance, previous studies noted that heuristic evaluation experts identified a problem regarding the interface's slow response time (Singun, 2016: 5–6). In this study, similar problems were uncovered by both evaluators from the user testing and heuristic groups. This was linked to the inappropriate way in which some pages of some websites were designed. These pages contained a substantial amount of visuals which, in turn, adversely affected the pages' download speed (Thompson & Kemp, 2009: 32–34).

The seemingly distinct nature of previous studies' results could be related to the way in which the identified usability problems were discovered through quantitative data, including performance data, as well as observational data (Singun, 2016: 2–6). However, this study identified the problem of unsuitably designed pages through user testing. This observation was made based on quantitative data collected from the satisfaction questionnaire and not from performance data. This points to the importance of employing different techniques to determine various problem types.

There were other instances in which prior results did not align with the findings of this research. For example, three problems were identified by the user testing method which had *not* been identified by the heuristic evaluation method, as presented in previous studies (Chen & Macredie, 2005: 527–530; Petrie & Power, 2012: 2113; Tognolli *et al.*, 2014: 151–152). These three usability problems are: incorrect font sizes, unsuitable formats and consistency problems. In this study, however, it was ascertained that these problems were identified using both heuristic evaluation and user testing methods. The problems were identified because they had been included in the MCOM heuristics guideline employed by the heuristic evaluators.

In contrast, in previous studies, these features were not included in the heuristic guidelines employed by evaluators (Tognolli *et al*., 2014: 150–152; Singun, 2016: 2–6). Previous research adds that differences result from the application of the heuristic evaluation method as the method is dependent on heuristic guidelines and the type of evaluator/s doing the heuristic evaluations (Tan *et al*., 2009: 626).

6.4.7.2 Effectiveness of Usability Evaluation Methods in Identification of Problems

This study compared two UEMs to determine usability problems in terms of ten major problem areas and equivalent sub-areas. Three different user testing methods were employed: qualitative and quantitative data garnered from questionnaires, observational reports and performance data garnered from Loop11. Furthermore, the current study used qualitative data collected from the MCOM heuristic evaluation method and quantitative data from the heuristic checklist. The goal was to determine how effective these UEMs were in the overall identification of particular usability problems, as well as in revealing the contribution of each of these methods to uncover usability problems.

Two main problems emerged from this comparison. The first emphasises the usefulness of each of the methods in identifying M-commerce websites' usability problems. The second problem has to do with which type of usability problems each technique could, or could not, identify. The two approaches are valuable for future studies which may strive to determine particular usability problems. For instance, this study posits that the user testing method was efficient in identifying problems related to ambiguous links. In order to gather similar findings, it is necessary to explain which particular usability method assisted in the identification of these usability problems. This process is done based upon data obtained during users' performances as well as Loop 11 observation reports.

It should be noted that the evaluation methods employed in this study are advantageous as they distinctively identify a variety of usability problems. In addition, the evaluation methods yielded consistent results in their description of the usability of the websites and in demonstrating which website had the highest level of usability.

The following section summarises the contribution of the selected UEMs which were employed in this study. In addition, the respective roles played by these methods in the identification of specific usability problem types are also addressed.

1. **Performance and Observation Report Data**

   The results of the current study emphasise the usefulness of performance data and data obtained from observational reports to identify particular usability problems found on M-commerce websites. To this end, the results of the current study align with the results from earlier research studies (Chattratichart & Brodie, 2004: 1121; De Kock *et al.*, 2009: 126–128; Alrobai *et al*., 2013: 26; Tognolli *et al*., 2014: 151).

   Table 6.28 presents the particular kinds of usability problems identified by the evaluation methods. The current study also highlights those areas for which the employed methods could not identify any usability problems. There were three specific areas wherein the methods did not identify usability problems: privacy and security, missing capabilities as well as inconsistency.

2. **Satisfaction Questionnaire: Quantitative Data**

   With regards to the satisfaction questionnaires which yielded quantitative data, this study uncovered two different usability problems. The first usability problem is linked to an ostensible variation identified amongst data collected through the use of satisfaction questionnaire, while the other is linked to the satisfaction questionnaire (qualitative data), performance data and observation report garnered from Loop11. For instance, website 2 contained usability problems which participants explicitly reported when answering open-ended questions on satisfaction. During the identification of usability problems on the website, users did not afford negative ratings to equivalent statements.

Table 6.28: Identified usability problems from users' performance data

Usability Problem Areas	Corresponding Specific Usability Problems
Accessibility and Customer Service	Hard to locate support or help information; wrong support or help information was displayed in the customer section
Architecture	Poor architectural webpage structure
Content	Most of the content are not appropriate
Design	Ambiguous images; webpage design not suitable
Internal Search	Wrong website search results
Navigation	Links are ambiguous; unclear links; navigation support is weak
Purchasing Process	Difficult to denote the meaning of some fields; hard to differentiate between expected and unexpected fields; difficult to know which particular link to tap; presence of illogical fields; the required information was absent when products are added to cart; sessional problem

Note: No usability problem was discovered in privacy and security, missing capabilities and inconsistency usability problem areas from users' performance data. Therefore, only seven out of the ten identified usability problem areas are presented in Table 6.28.

Furthermore, the observation report and performance data revealed that many users successfully performed task 3 on website 3 compared to task 3 on websites 1, 2 and 4. In addition, a similar number of users successfully completed the fourth task on all the websites. However, the third website is the only website that recorded negative ratings, for associated statements, linked to tasks 1 and 2. The quantitative data reported in this study reflect users' general satisfaction levels regarding the usability of a website, without considering how the particular usability problems were determined. This means that the evaluation method was not efficient in determining particular kinds of usability problems associated with M-commerce websites. These results are in line with available results reported in literature.

Previous studies show that the satisfaction of users with a particular website cannot be used to judge the usability of that website (Chen & Macredie, 2005: 531; De Kock *et al*., 2009: 128; Tognolli *et al.*, 2014: 152). In addition, studies have shown that participants tend to be polite in their evaluations and consequently afford a website a higher rating, even if it is not easy to use said website due to its numerous usability problems (Jensen, 2009: 31; Riihiaho, 2015: 71–124). For example, a prior usability study shows that the results of users' evaluation ratings were positive in spite of the website's glaringly poor user performance. These users are termed "Appeasers". The study suggests that the reported irregularity may be associated with different users' cultural background. This may be the reason why several research participants acted extremely polite and refused to award negative ratings (Krishna *et al*. 2005: 7). Another problem uncovered from data obtained from the satisfaction questionnaire is the failure of the method to determine particular usability problems. This was true in terms of the problems which dealt with the accuracy of a website's internal search facility as well as privacy and security concerns.

3. **Satisfaction Questionnaire: Qualitative Data**

This study has shown that open-ended questions, which focus on satisfaction, are useful in identifying usability problems in M-commerce websites. These usability problems were not identified from the observation report or performance data obtained through the remote asynchronous testing method.

Therefore, the current study supports results obtained by previous research studies which included open-ended questions in their satisfaction questionnaires. Prior studies ascertained that the use of open-ended questions elicit more detail regarding usability problems for the selected websites (Kandababu & Indukuri, 2011: 43–45; Chin *et al*., 2012: 5–7; Khan, Tahir & Raza, 2013: 108; Díaz-Bossini, Moreno & Martínez, 2014: 66; López-Gil *et al*., 2014: 1; Mercurio *et al*., 2014: 456).

Table 6.29: Identified usability problems from post-test questionnaire (qualitative data)

Usability Problem Areas	Associated Usability Problems
Accessibility and Customer Service	Only one language option is provided
Content	Wrong and inconsistent information resulting in product information missing or
Design	Colours and font sizes of the content are not appealing
Inconsistency	Content/layout and design are inconsistent
Internal Search	Provided options are inadequate
Missing Capabilities	The functions or information are missing
Navigation	Several website links are broken, resulting in orphaned webpages
Purchasing Process	Ordering process too extensive

Note: Users' responses to open-ended questionnaires revealed no usability problems for *architecture* or *privacy and security*. Therefore, only eight of the ten identified usability problem areas are presented in Table 6.29.

In addition, the results obtained by this research study highlighted particular usability problems, as identified by users employing various techniques, after they had interacted with M-commerce websites. Table 6.29 presents some particular usability problems and the corresponding eight usability problem areas.

4. **The MCOM Heuristic Evaluation: Qualitative Data**

The results of the current study support earlier studies investigating the usefulness of users' comments in generating qualitative data. Results were also collected from heuristic evaluators during the analysis and inspection of the selected M-commerce websites. This research also showed that the heuristic evaluation method is effective in the identification of particular kinds of usability problems found in M-commerce websites. The evaluators applied the MCOM heuristic evaluation method and, in so doing, identified eighteen additional usability problems which had not been discovered by the remote asynchronous testing method. As presented in Table 6.30, the remote asynchronous method thus failed to determine the following usability problems: the purchasing process, navigation, security and privacy, design as well as accessibility and customer support.

Furthermore, the findings prove that the usability problems, as determined by heuristic evaluators, were in-depth and comprehensive. Unlike remote asynchronous testing, they provided proposals on how certain problems could be solved. This study also discussed three possible explanations extrapolated from the findings of the heuristic evaluators.

Table 6.30: Usability problems identified from the MCOM heuristic evaluation method (qualitative data)

Usability Problem Areas	Associated Usability Problems
Accessibility and Customer Service	The website is difficult to locate via popular search engines; only one currency is supported; does not allow customers to send comments.
Architecture	Menu arrangement is not logical; menu items are not grouped and categorised in a logical manner.
Content	Company information is missing, grammatical styles are inaccurate.
Design	Poor image quality; webpage title is not suitable; poor aesthetic design; distorted images and lack of optional text.
Internal Search	The search location and position are not easily visible.
Purchasing Process	It is very difficult to log into the website; absence of confirmation when users face difficulty in signing into the website; missing information when customers mistakenly delete a product in the shopping cart; steps to follow on the registration page are too long; mandatory registration before the product can be bought may not be necessary.
Security and Privacy	Users have no confidence in the privacy and security policy of the company**.**

Note: No usability problem was discovered in *navigation, missing capabilities* and *inconsistency* usability problem areas from evaluators' comment reports. Therefore, only seven of the ten identified usability problem areas are presented in Table 6.30.

Firstly, evaluators used detailed MCOM heuristics guidelines, which were specifically created for the usability evaluation of M-commerce websites. Secondly, evaluators taking part in the heuristic evaluation process for the selected websites are more experienced than the test users participating in the remote asynchronous test process. In addition, most test users had never tried to buy items from the selected websites. Lastly, heuristic evaluators extensively investigated the websites and consequently scrutinised more pages than the users. Furthermore, heuristic evaluators were not restricted to performing particular tasks on the websites, as was the case with the users. A prior study supports the current research findings, as well as the logical justifications provided for the reported results (Tan *et al.*, 2009: 623–626).

5. MCOM Heuristic Evaluation: Quantitative Data

In this study, heuristic evaluators identified uniformity as a usability problem in accordance with a heuristic checklist. The results obtained in this study thus indicate the existence, or not, of certain usability problems.

The MCOM heuristic evaluation method incorporated a checklist which contained reports that had been extracted from its sub-categories. These reports were employed to identify further usability problems which could have been missed during the examination of the selected M-commerce websites.

The findings show that no sub-categories of the heuristic guidelines were overlooked by MCOM heuristic evaluators. This implies that the method is not effective to discover new or additional specific usability problems.

6.4.7.3 Types of Usability Problems and their Severity Levels

Previous studies showed that only a limited number of research projects investigated *usability problems* in terms of heuristic evaluations and user testing methods. These methods took into account the number of usability problems and their level of severity (Tan *et al.*, 2009: 624–627). This study established seven categories of usability problems. However, the study failed to take note of particular instances of usability problems which could be connected to these categories. The study only showed how effective the two methods were to identify the particular usability problems and their respective severities.

This research work indicated how effective each of the methods were in the identification of forty-four particular usability sub-problem areas and ten identified usability problem areas. This process helped to reveal the number of usability problems, as well as their level of severity, as distinctively determined by one of the evaluation methods. In addition, the study revealed *usability problems* frequently uncovered by both, or one, of the methods. The findings illustrated that most usability problems, distinctively determined through remote asynchronous user testing, are considered *major usability problems* which prevent users from effectively using M-commerce websites. The technique ascertained *minor* problems, connected to one problem area, and major usability problems linked to four sub-problem areas. In contrast, most usability problems identified by MCOM evaluators, were not considered *major* and could be used to improve various features of the selected M-commerce websites. The method thus determined most of the *minor* usability problems within eight of the areas, as well as *major* usability problems within four.

6.4.7.4 Distribution of the Usability Problems Across Usability Problem Areas

The study of the identified usability problems is based on the distribution of these problems across ten usability problem areas. The problems identified were classified according to the ten usability problem areas, as presented in Table 6.31.

The analysis of results of the remote asynchronous testing and proposed domain-specific heuristic methods show that both methods were proficient in detecting usability problems relating to the nine problem areas, except *security and privacy*. The remote asynchronous testing method (user testing) completely failed to detect problems associated with the security and privacy problem areas. These results support previous research work where user testing failed to detect any problem in the *compatibility* as well as *security and privacy* attributes, during the usability evaluation of the four tested websites (Tan *et al.*, 2009: 626).

Table 6.31: Distribution of the identified usability problems in terms of usability problem areas, evaluation types and severity level

Usability Problem Areas	Major Problem			Minor Problem			Total (Excluding common problems)
	MCOM Heuristics	Remote Asynchronous	Common	MCOM Heuristics	Remote Asynchronous	Common	
Navigation	5	17	3	27	10	8	**59**
Content	4	7	3	16	4	3	**31**
Design	3	5	2	34	4	3	**46**
Architecture	2	2	2	3	2	1	**9**
Internal Search	3	5	1	7	4	3	**19**
Purchasing Process	4	13	3	8	7	5	**32**
Accessibility & Customer Services	2	6	1	16	2	2	**26**
Inconsistency	1	0	0	5	1	1	**7**
Security & Privacy	3	0	0	1	0	0	**4**
Missing Capability	0	0	0	15	1	1	**16**
Total	**27**	**55**	**15**	**132**	**35**	**27**	**249**

The distribution of the minor and major usability problems, and their corresponding ten usability problem areas, is presented in Table 6.31. As per the table, major problems were discovered in the *navigation* and *purchasing process* problem areas with a total of 22 and 17 usability problems identified, respectively. However, minor problems were mostly identified in the *design* and *navigation* usability problem areas with a total of 38 and 37 usability problems, respectively. The lowest number of usability problems was discovered in *architecture*, *inconsistency* and *security and privacy*, with a total of 9, 7 and 4 usability problems, respectively.

Notably, three of the four identified usability problems with respect to the *security and privacy* usability problem area were identified as *major* problems. This finding shows that *security and privacy* are critical factors which need to be seriously considered during the development and evaluation of the user interface for M-commerce websites (Aziz & Hashmi, 2009: 7–10; Rehman & Coughlan, 2011: 593–596). The general understanding is that mobile devices and M-commerce applications will be significantly sensitive to the impact of security because these applications are used in different task settings and operate within various size limitations (Billard, 2019: 1–10). Hence, it is important to discuss the significance of security as identified during the evaluation of the four selected M-commerce websites.

6.4.8 Significance of the Security Attribute in the Evaluation of M-commerce Websites

The MCOM heuristic evaluation method presented results highlighting the significance of the security component in the evaluation of M-commerce websites. Most user interfaces have individual usability-related problems. However, the type and number of usability problems may not be readily available. Heuristic and user testing evaluations are frequently used to address this by detecting and predicting potential usability problems on user interfaces. As a website undergoes multiple evaluations, certain undiscovered problems become apparent. This affords usability professionals access to additional information regarding the website. Some usability problems are easy to detect while others are hidden. From Table 6.31, the percentage of problems associated with *security* was the lowest of the usability problem areas, contributing only 5% to the overall major usability problems. However, it is an important attribute of M-commerce websites because it prevents unauthorised access to the personal data of users and minimises risks associated with online payment transactions.

The importance of the *security attribute*, as presented in the current study, supports findings from earlier studies which indicate that security plays an important role in the adoption of M-commerce applications and that it enhances the UX of these applications (Anand *et al*., 2010: 2; Alshehri & Freeman, 2012: 4; Alghamdi *et al*., 2013: 58). Mobile devices and M-commerce applications are very sensitive to the impact of security as these applications are used in different task settings and operate within various size limitations (Realpe-Muñoz *et al.*, 2017: 1–8).

The M-commerce business domain is expanding in the face of tough competition. In an effort to absorb this competitive pressure, this study proposed a new MOSAD model, as discussed in Chapter 2. This model will be updated in Chapter 7 where the *security* attribute will be incorporated as one of the quality attributes. Findings garnered from this research indicate the importance of the security attribute and its effect on the adoption of M-commerce websites.

6.5 Conclusion

This chapter described and analysed qualitative and quantitative results collected using the selected UEMs. The study identified similar usability problem areas for individual usability methods in respect of the selected websites and usability areas and sub-areas, as well as their corresponding descriptions. In addition, the findings presented in the chapter show that the research achieved its aims and objectives. This chapter also presented the effectiveness of the MCOM heuristic evaluation and remote asynchronous testing methods, as per the usability evaluation of the four selected M-commerce websites which helped to address Research Question 4 of the current study. Chapter 7 will present the updated MOSAD model and propose a framework for usability evaluation of M-commerce websites.

Chapter 7: Framework for Usability Evaluation of M-commerce Websites

7.1 Introduction

This chapter presents a framework that can be used for the usability evaluation of M-commerce websites. The updated MOSAD model, which is incorporated in the proposed framework for usability evaluation of M-commerce applications, is discussed. This framework is suggested based on the analysis of the research results during the applications of MCOM heuristics and remote asynchronous testing methods on the four selected M-commerce websites. The chapter presents an overview of the average time involved in the applications of each of the two methods before the presentation of the proposed framework. In addition, the framework illustrates which evaluation method should be used to ascertain a specific usability problem area in the usability evaluation of M-commerce websites.

7.2 The Updated MOSAD Model

Figure 7.1 presents the quality attributes to be considered in the evaluation of M-commerce applications. The initial MOSAD model consisted of five attributes identified during the literature review and discussed in Chapter 2 of this study. These attributes are: efficiency, effectiveness, satisfaction, learnability and error rate and are discussed along with three factors (user, task and context of use) in Chapter 2 as essential attributes and factors in the evaluation of M-commerce websites.

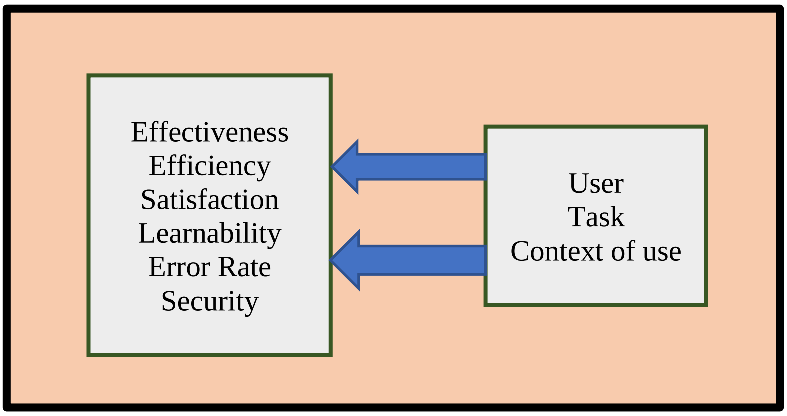


Figure 7.1: The Updated MOSAD Model

However, *security*, a new quality attribute, was discovered during the application of MCOM heuristics in the evaluation of four selected M-commerce websites as presented in Chapter 6.

The significance of security as quality factor in the evaluation of M-commerce websites is described in section 6.4.8, Chapter 6. Therefore, the next sub-section will discuss the *security attribute* of the MOSAD model.

7.2.1 Description of the Security Attribute of MOSAD Model

Security affects mobile communication, particularly if one considers the physical dimension of mobile devices. Thus, the physical features of mobile devices and contexts in which they are used result in these devices being more vulnerable to loss and/or damage (Alghamdi *et al*., 2013: 54). This aspect further impacts upon the privacy concerns of users. For example, what happens when a user loses his/her mobile device which contains private information, including messages, pictures, contacts, and other personal information? Although privacy issues are common to most interactive network media, it is acutely important in the domain of M-commerce applications.

Furthermore, the capability of context-aware systems to reveal detailed personal information has great implications on users' privacy (El Aassal & Verma, 2019: 15–22). Any indication of privacy violations, however slight, could result in mobile users losing confidence in the application and even exiting. To this end, transparency and controllability of mobile applications are fundamental. Research reveals that, in order to make the security mechanism of mobile applications acceptable to both users and corporations, certain steps need to actioned (Bao *et al.*, 2011: 453). These are:

- Mobile password applications need to be simple. Users should not be required to enter difficult or complex corporate passwords.
- Password structures need to be changed to avoid users having to switch between keyboard modes (number and letters and/or lower and upper case).
- In order to improve password interfaces, mobile application developers should allow the last few characters of the password to be visible, not only one.

The SMS system of payment, though widely accessible and available, is vulnerable to security and congestion problems (Oreku, 2013: 87). In the event of sensitive and private data leaking due to a security breach, the owner of the mobile application may be penalised by law. Incidences like these may severely affect the organisation's reputation (Benou, Vassilakis & Vrechopoulos, 2012: 101).

While the mobile shopper interacts with the M-commerce application, the mobile context of use will significantly impact on the security consciousness of the application (Kiljan, Vranken & Van Eekelen, 2018: 435–444). Therefore, it is imperative that usability professionals consider *security* as a priority when developing and evaluating M-commerce applications. One approach to measure the security aspect of mobile and M-commerce applications is through the use of questionnaires and its inclusion in heuristics (e.g. MCOM heuristics) (Kainda, Flechais & Roscoe, 2010: 278–281; Novak, 2014: 26–27; Vatankhah, Wei & Letchmunan, 2014: 6–8; Woo *et al.*, 2019: 2–20). Another approach is the use of the simple Goal-Question-Metric (GQM) technique (Islam & Falcarin, 2011: 72–75; Ahmad, Sahib & Nor'Azuwa, 2014: 3–7; Mohammadi *et al*., 2014: 31–32; Yahya *et al.*, 2017: 233–237). GQM can be used as a subjective assessment tool to measure the security concerns of users while interacting with the system. In some cases, mathematical formulae (usually 3D, where x, y and z represent the security factor, HCI and E/M-commerce requirements, respectively) can be combined with GQM to obtain accurate evaluations (Gonzalez *et al.*, 2009: 79–80).

Prior research reveals that 22% of mobile shoppers do not wish to execute payments via their mobile phones for fear of it being stolen or misplaced. However, 44% of participants prefer to make payments using a Personal Identification Number (PIN) via their mobile phone or using their credit cards or cash (Oyomno *et al.*, 2013: 314). However, studies show that in Nigeria and Bangladesh, users' experiences are improving and mobile shoppers who use M-commerce applications are confident enough to make payments via mobile phones. In addition, they believe that monetary transactions, via M-commerce applications, are secure enough and would not be subjected to theft and/or fraud (Rahman, 2013: 84; Okolo, Ani & Ofoegbu, 2014: 32).

Therefore, the inclusion of *security* in the proposed MOSAD model clearly shows that the security attribute is one of the major determinants of success for M-commerce businesses, as per Figure 7.1. The conclusions obtained from this research provide guidelines for website designers and developers to construct M-commerce websites with good functionalities which are easy to use, thus enhancing users' experiences of M-commerce websites. A better user interface and enhanced security capability will motivate customers to shop online, thus, boosting M-commerce business.

7.3 The Comparison of the Average Time of the Evaluation Methods

Two evaluation methods, MCOM heuristics and remote asynchronous user testing, were compared in terms of their design and analyses times. Time spent by the researcher to collect and analyse data, as well as design and set up tools used for the research, was recorded. Table 7.1 presents the average time spent on the four selected M-commerce websites.

Table 7.1: The Comparison of Average Time for Evaluation Methods

Phases	**Asynchronous Testing**	**MCOM Heuristics**
Setup and Design Tools	5 Hours	6 Hours
Data Collection	80 Hours[11]	10 Hours
Data Analysis	154 Hours	47 Hours
Total Time	**239 Hours**	**63 Hours**

7.3.1 MCOM Heuristic Evaluation Method

It took approximately 63 hours to design and analyse the application of the MCOM heuristic evaluation method, as presented in Table 6.23, Chapter 6. The total time spent was: 6 hours for research design and setup, 10 hours for data collection and reporting by five usability experts, 47 hours for data analysis.

7.3.2 Remote Asynchronous Testing Method

It took 239 hours to design and analyse the remote asynchronous user testing method, as discussed in section 6.4.4, Chapter 6. The total time spent was: 5 hours for design and setup, 20 hours for data collection from 20 test participants for each of the four selected M-commerce websites, 154 hours for data analysis.

The study results indicate the usability problem areas and the type of problems identified by the evaluation methods. Therefore, an urgent need exists to develop a framework which can be employed to evaluate the usability of M-commerce websites in relation to specific usability problem areas, as uncovered in the study. The use of the framework will reduce the time needed and simplify the choice as to which evaluation method should be used when assessing the usability of M-commerce websites.

7.4 Framework for Usability Evaluation of M-commerce Websites

The current research work proposed a framework in three phases for the usability evaluation of M-commerce websites. The proposed framework will help usability professionals (Poltronieri *et al.*, 2018: 6–12) and M-commerce managers who want to identify their

[11] The data collection took 20 hours for 20 test participants for each of the four selected M-commerce websites, which totals 80 hours, as indicated in Table 7.1

company's website usability problem/s and who might want to improve the website's design in order to enhance the mobile UXs.

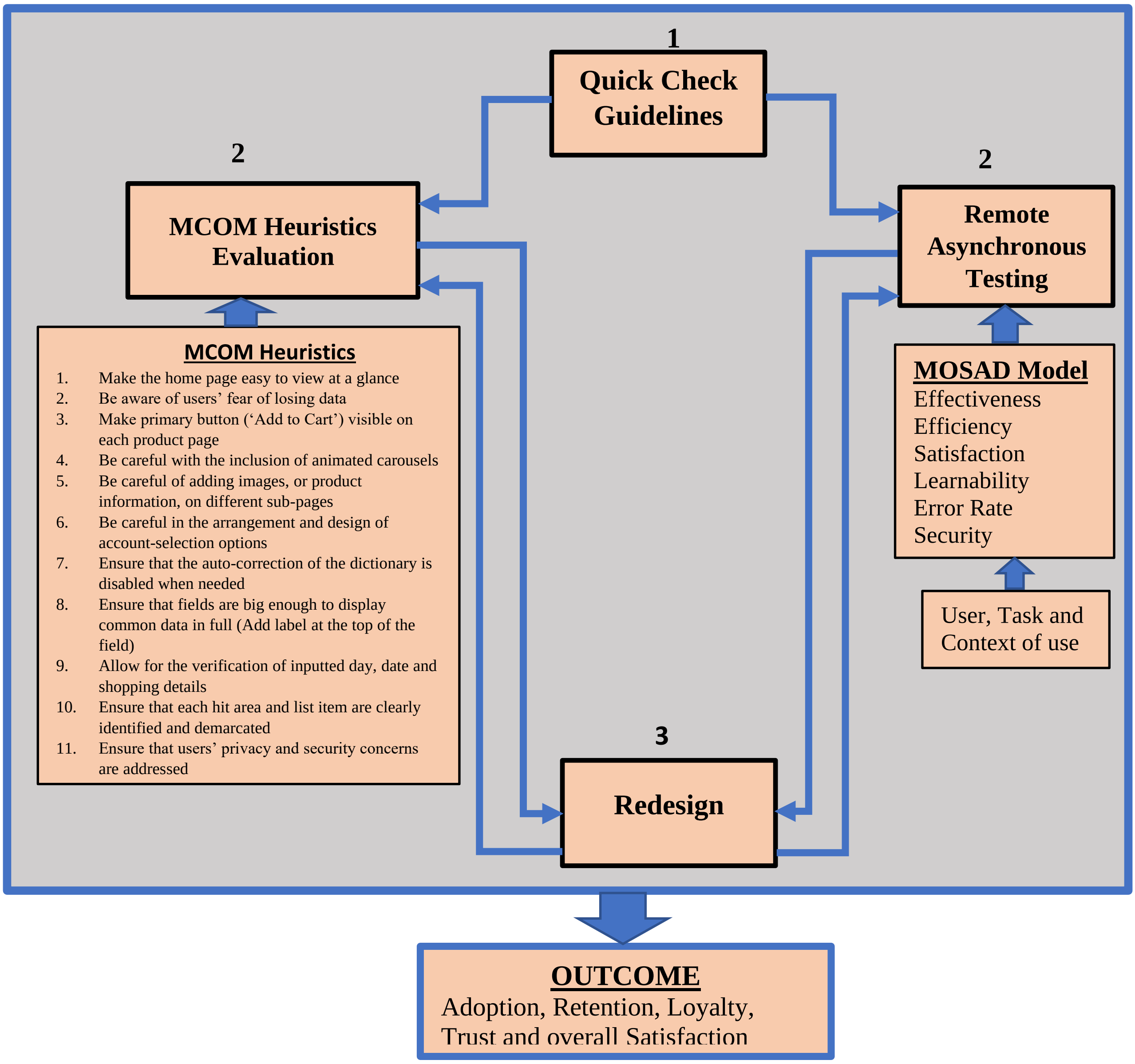


Figure 7.2: Three-Phases Framework for the Evaluation of M-commerce Websites

It is crucial to discuss the importance of the proposed framework before reviewing its steps. There are two main reasons for this: firstly, the framework can reduce the cost of using two evaluation methods (remote asynchronous testing *and* MCOM heuristic evaluation) and secondly, the framework can illustrate specific usability problem areas as identified by the UEMs.

7.4.1 Cost-Effectiveness of Using the Evaluation Methods

The proposed framework can yield suitable results in identifying a broad spectrum of M-commerce website usability problem areas when viewed in relation to time spent and cost incurred by the two evaluation methods. Specifically, the proposed framework involves *quick check guidelines* as pre-evaluation guides which assesses the M-commerce website's conformity before either MCOM heuristics or remote asynchronous testing methods are applied.

The *quick check guidelines* present a way in which companies can identify potentially problematic usability areas in their M-commerce websites. The framework will also *decrease* the time spent to identify specific usability problem areas through either asynchronous user testing, or MCOM heuristic evaluation, or both. For instance, fewer participants could be included in the asynchronous testing method, or a limit could be placed on the time afforded to apply the MCOM heuristic evaluation method. As a result, more time could be spent on the website's particular problem area/s.

7.4.2 Identification of Particular Problem Areas through Evaluation Methods

The proposed framework can describe particular problems within usability as identified by remote asynchronous testing and MCOM heuristic evaluation methods. Consequently, the facilitation of decisions regarding the choice of methods, or combination of methods, becomes easier. This choice is based upon which areas are significantly problematic, as identified by the framework presented in Figure 7.2. This framework comprises three phases.

7.4.2.1 Phase 1: Quick Check Guidelines

Table 7.2 is extracted from Table 6.9 and Appendices 19, 20 and 23, as discussed in Chapter 6. The table presents a total of 44 usability problem sub-areas across the ten identified usability problem areas.

Table 7.2 shows that ***navigation*** (5), ***content*** (5), ***design*** (8), ***purchasing process*** (11) and ***accessibility*** (6) accounted for 35 of the usability problem sub-areas which represent almost 80% of all the identified problem sub-areas. Therefore, the five stated problem areas are used as guides in the development of the quick check guidelines. These need to be considered *before* applying any evaluation methods.

Table 7.2: The 44 Usability Problem Sub-Areas Identified by the Two Evaluation Methods

Usability Problem Areas	Problem Sub-Areas	MCOM Heuristics	Asynchronous Testing	Total
Navigation	Confusing webpage links	Y	YY	5
	Dead-end webpage	YY	Y	
	Poor navigational support	YY	Y	
	Orphan webpage links	YY	Y	
	Unclear webpage links	Y	YY	
Content	Unsuitable auto-rotating carousels content	YY	Y	5
	Incomplete information	YY	YY	
	Presence of grammatical errors	YY	-	
	Lack of company's information	YY	-	
	Lack of product information	YY	Y	
Design	Confusing images	YY	YY	8
	Unsuitable webpage design	Y	YY	
	Poor aesthetic design	YY	Y	
	Unsuitable image quality	YY	-	
	Lack of alternative text	YY	-	
	Fragmented images	YY	-	
	Unsuitable colours and fonts choice	YY	Y	
	Unsuitable webpage titles	YY	-	
Purchasing Process	Problem in completing some required fields	Y	YY	11
	Problem in differentiating between fields (required and non-required)	-	YY	
	Problem in knowing which web links are to be tapped	-	YY	
	Lengthy ordering process	YY	YY	
	Sessional Problems	YY	YY	
	Difficulty to login into customer's account	YY	-	
	No confirmation is displayed when users delete shopping cart item	YY	-	
	Lengthy webpage registration	YY	-	
	Mandatory registration	YY	YY	
	Illogicality of the required fields	YY	YY	
	Lack of required information when products are added to the cart	-	YY	
Accessibility and Customer Service	Absence of product image zooming gestures	YY	Y	6
	Supported by only one language	YY	YY	
	Supported by only one currency	YY	-	
	The provided information via the customer service/help section is inappropriate	YY	Y	
	Customers' comments are not supported	YY	-	
	Locating helpful information in customer support/ help section is difficult	Y	YY	

Usability Problem Areas	Problem Sub-Areas	MCOM Heuristics	Asynchronous Testing	Total
Architecture	Structural problem	YY	YY	3
	Menu items not ordered logically	YY	-	
	Menu items not grouped logically	YY	-	
Internal Search	Inaccurate Results	YY	YY	3
	Restricted options	YY	YY	
	Search position not clearly visible	YY	-	
Security/Privacy	Customer fears regarding privacy and security	YY	-	1
Inconsistency	Inaccurate layout/design/content	YY	Y	1
Missing Functions	Incomplete website capabilities/functionalities	YY	Y	1
Total				**44**

Note: "YY" Effective to discover the exact usability problem area
"Y" Was not able to discover a few specific usability problem areas
"-" Failed to discover the exact usability problem area

In addition, a prior study suggests that ***navigation***, ***content*** and ***accessibility*** are the most important usability problem areas which need to be considered in the usability evaluation of M-commerce applications (Lund & Sieverthson, 2017: 5–40). The current research identified five guidelines based upon five stated problem areas for M-commerce usability as well as best practices to employ. These guidelines were identified after four leading M-commerce websites were evaluated in terms of the usability of their interfaces. However, during the evaluation process, a severe lack of core mobile UX components were noted amongst the selected M-commerce websites. This could result in some of them having about half of the desktop website's conversion rates[12]. The following guidelines apply:

1. ***Navigation (The website should allow users to search within the currently navigated category):*** The application of the Loop11 usability testing tool revealed that many test participants attempt to search within the navigated category path to filter a list of products. However, this is not supported by 75% of M-commerce websites as a site-wide search query would rather be performed. The left image (Konga - one of the research case studies) in Figure 7.3 did not support a category search of the product. Users were trying to search for Ideapad Lenovo Laptop ("ideap") as indicated.

[12] Conversion is the action/s taken by the website's visitors. It can either be a combination of: e-mail signup, the download button's click, live chat initiation or the purchase of products. While the *conversion rate* is the frequency at which the M-commerce providers obtain conversions from the advert's clicks.

However, the right image (Jumia - one of the research case studies) allowed test participants to search within the category path.

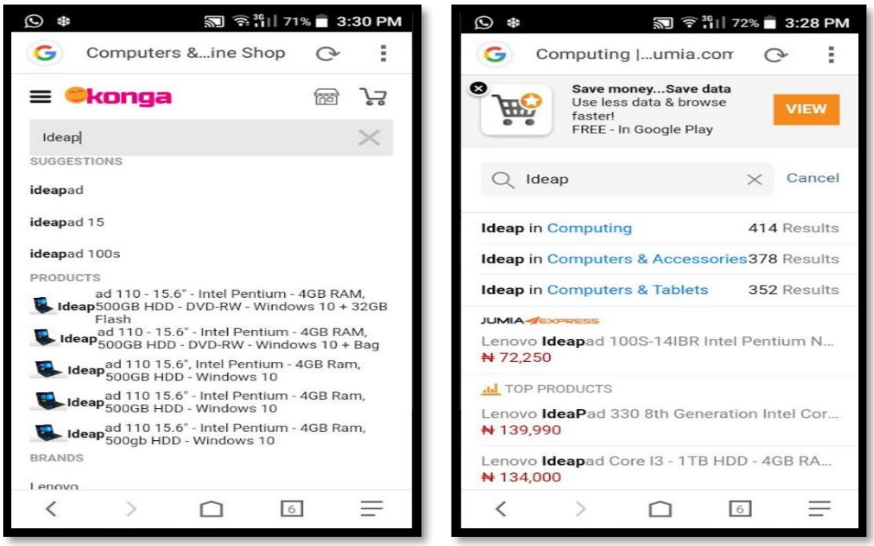


Figure 7.3: Samples of within the Category Product Search

Unavailability of the product during a within-category search of said product could lead users abandoning websites. Users' behaviour thus constitutes a crucial aspect of website usability and functionality. A separate search field and search scope could address this problem sufficiently.

2. ***Design (The websites' product categories should be visually displayed on the homepage):*** New users, or those with limited experience in using a website, heavily relied on the homepage content to identify the type of M-commerce website they were visiting. From the report generated through the Loop11 testing tool, 70% of users scrolled up and down on the homepage of websites when they visited the selected M-commerce websites. Figure 7.4 shows the home page content of two of the selected M-commerce websites. The home page of Jumia (left image) shows 8 product categories while Dealdey (right image) M-commerce website does not show any product category when accessed on five inch mobile phones.

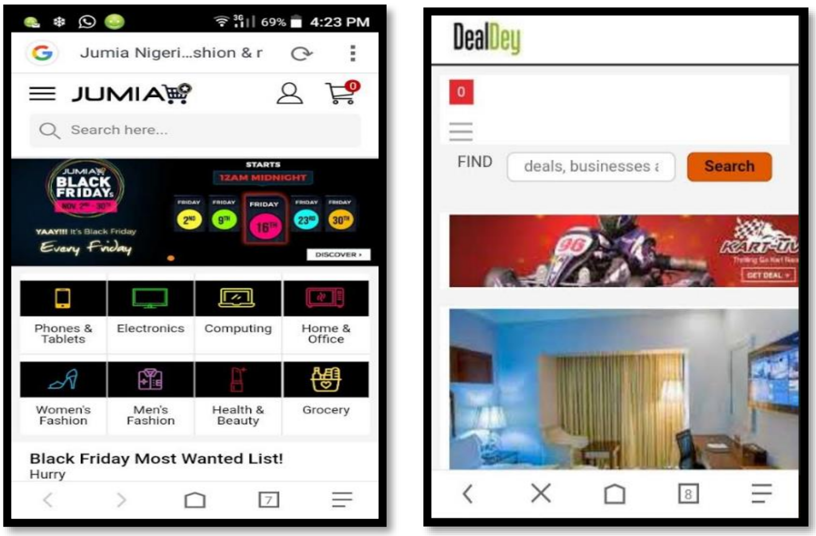


Figure 7.4: Product Categories on M-commerce Website Homepages

This is a problem which occurred in 75% of the tested websites because the visibility of product types on the homepage is limited. Mobile shoppers consequently perceive the selection offered on the website to be more restricted than it actually is. This is especially true for mobile websites as main navigation menus are often collapsed. Users must thus rely on visual content to determine product types. A minimum of 30 to 40% of popular product categories should, therefore, be visible on the homepage, whether directly or indirectly.

3. ***Purchasing Process (Sign-in should be collapsed and 'Guest Checkout' should be displayed at the top):*** It is expected that all M-commerce websites have an option whereby mobile shoppers can check out as *guests*. Surprisingly, none of the evaluated website had this important feature. The four evaluated websites only provided shoppers the option to log in via Facebook, Google accounts or to register as new users. This may result to many users abandoning the websites, as illustrated in the left image of Figure 7.5

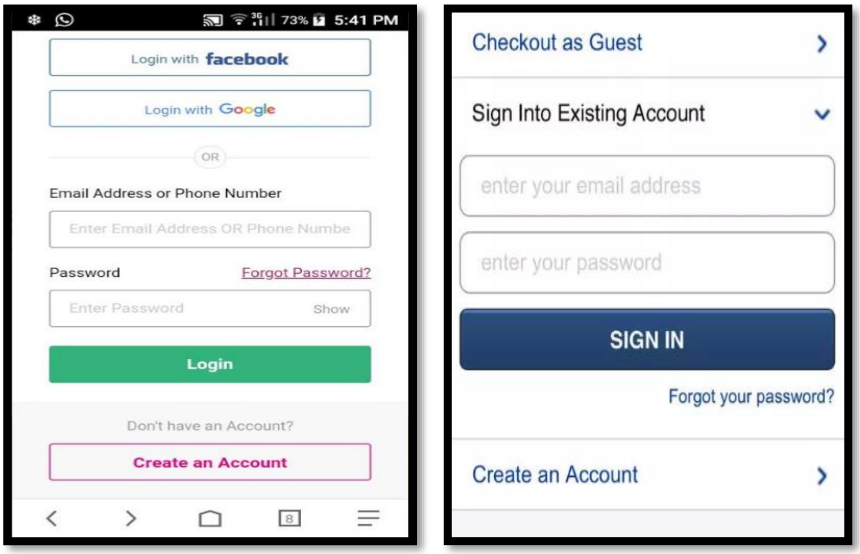


Figure 7.5: Sample of a Mockup Guest Checkout Option

Therefore, the current research suggests that a 'Guest Checkout' option should be provided and that it must not be in form of page layout. The 'Guest Checkout' option needs to be positioned at the top of the checkout page to avoid mobile shoppers possibly missing this button and thus thinking that it is not available. The account selection process should collapse the three options, 'Sign-in', 'Create Account' and 'Guest', to afford mobile shoppers an overall view, as presented in the right image of Figure 7.5. It is, therefore, posited that if this option is properly implemented, as suggested, it will reduce users' frustration with form fields as they demand too much attention during the account selection process.

4. ***Content (Auto-rotating homepage carousels should not be used):*** Despite being the cause of major problems on many touch-screen devices, all the selected M-commerce websites contained auto-rotating carousels on their homepages. User participants were continuously being disrupted when trying to concentrate on particular slides and, consequently, they would open the wrong slides. In most cases, carousel content is ignored as it mimics usual advertisements. Figure 7.6 presents a typical sample of images on the homepage of the Konga mobile website, displaying auto-rotating carousel contents.

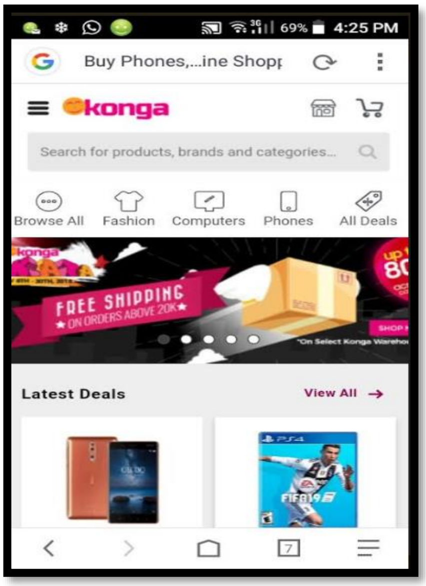


Figure 7.6: Sample of Auto-Rotating Carousels on Homepage

Even on desktop websites the use of auto-rotating carousels tends to generate negative responses. In the case of mobile websites, these carousels should be absolutely avoided. Not all touch devices have a mouse-hover state and carousels are notoriously difficult to navigate due to severe interaction problems. The best alternative is to display important slides as static content on the homepage of the M-commerce website.

5. ***Accessibility of Product Image (Image zooming gestures are important):*** Mobile device users often attempt to use gestures (pinching or double tapping) to zoom in on the images of products (Katsuragawa *et al*., 2019: 1–26).

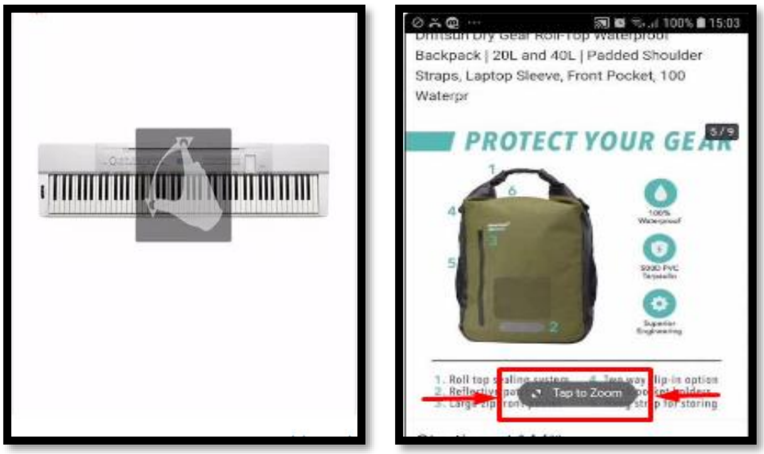


Figure 7.7: Mock-ups of product image zooming gestures

However, the selected M-commerce websites did not allow for the use of gestures, such as swiping to view different views of products, as shown in Figure 7.7. Even in instances where this feature is available, many M-commerce websites fail to inform mobile shoppers about the availability of zooming gestures and their functionality, as per the right image of Figure 7.7.

A feature must exist which would enable mobile shoppers (especially visually impaired shoppers) to expand the product image in order to obtain a better view (Yan & Ramachandran, 2019: 26–28). A larger image can afford mobile shoppers a better idea of how a product *appears*, but it does not help to ascertain the quality of the materials used and/or their texture, amongst other features. This means that it is crucial for E-commerce websites displayed on mobile devices to allow users zoom functionalities in order to inspect products closely. Ideally, websites should allow both *double-tapping* and *pinching* to facilitate this function.

If an M-commerce website complies with all the proposed guidelines in Phase 1, this research work suggests that the website should be evaluated with MCOM heuristics as a snapshot evaluation method, employing 2 or 3 evaluators, in order to identify some of the potential usability problems. The reason for this is that the application of MCOM heuristics in the usability evaluation of the four selected M-commerce websites discovered 63.9% of the total usability problems, as discussed in section 6.4.5, Chapter 6. In addition, a careful study of Table 7.2 shows that MCOM heuristics outperformed asynchronous testing in navigation, design, content and accessibility problem sub-areas, while the asynchronous testing method outperformed MCOM heuristics in only the *purchasing process* problem sub-area. A prior study shows that heuristic evaluation is a cost effective and a discount usability evaluation method (Nielsen, 1994a: 59).

7.4.2.2 Phase 2: Selection of Evaluation Method/s

Table 7.2 lists the usability problems of 10 main areas, as well as the sub-areas which correspond to them. It also indicates which method is best to facilitate said correspondence. Table 7.2 will significantly help managers of M-commerce companies to make decisions in terms of which evaluation method is most appropriate. If, for example, a problem occurs with navigation, it is the responsibility of the evaluator to determine whether the mistake occurred as a result of confusion or dead-end webpage link/s. If the former, the table shows that the asynchronous testing is the best course of action, while, if the latter, the table shows that the best method to employ is that of MCOM heuristic evaluation method.

However, if the problem occurred due to both factors, it should be investigated through the implementation of both the asynchronous user testing *and* MCOM heuristic evaluation methods. Through implementing this approach, specific usability problems can easily be identified for each website. Furthermore, the framework incorporates the MOSAD model, as presented in Figure 7.2, illustrating the essential attributes which need to be considered during the use of remote asynchronous user testing.

7.4.2.3 Phase 3: Redesign

Phase 3 involves the redesigning of the M-commerce website in order to heighten users' satisfaction. This phase will help address the usability problems identified in Phase 2. The *quick check guidelines* provided in Phase 1, regarding the website's conformity to stated guidelines, are very important and need to be considered carefully (Damala, Ruthven & Hornecker, 2019: 2–19). The application of both, or either, of the evaluation methods in Phase 2, will help the website manager, or usability professional/s, to ascertain potential problems and so action the necessary improvements, or redesigning, of the website (Charfi *et al.,* 2014: 116). The overall goal of the M-commerce website in Phase 3 is to enhance mobile shoppers' total satisfaction and subsequently improve the financial performance of the M-commerce website.

7.5 Conclusion

In this chapter, a framework is presented which can be used when conducting usability evaluation/s related to particular usability problem areas in M-commerce applications. In order to understand and analyse the framework, the research presented a three-phases framework for the usability evaluation of M-commerce websites. The framework includes five guidelines as pre-check guides for M-commerce usability as well as best practices to employ. These guidelines were identified after four leading M-commerce websites were evaluated with the aid of MCOM heuristics and asynchronous testing methods. Therefore, the proposed framework will prove useful to both *established* as well as *new* M-commerce providers in helping usability professionals decide which evaluation method they should use for a specific usability problem area in the evaluation of M-commerce websites.

Chapter 8: Conclusions and Recommendations

8.1 Introduction

The identification of usability attributes for M-commerce applications is one of the objectives of this study. This research work also sought to propose and validate appropriate UEMs for M-commerce websites. The research was carried out by carefully reviewing relevant past resources in this study genre as presented in Chapters 2, 3 and 4 of the thesis. In addition, to validate the proposed domain-specific evaluation method, an empirical study was carried out to measure the usefulness and effectiveness of the evaluation method.

As mentioned before, this research work developed a proposed framework that can be used for the usability evaluation of M-commerce websites. The framework included the updated MOSAD model and MCOM heuristics for usability evaluation of M-commerce applications. The framework is proposed based on the analysis of the research findings during the applications of remote asynchronous testing and MCOM heuristics methods on the four selected M-commerce websites.

The current research study complied with ethical standards, as discussed in section 5.8. An approval to conduct the study, along with an ethical clearance certificate, was granted as per Appendix 14. Vulnerable participants were not included in the research. The methods to be used during the study were explained to the participants. The participants were also informed that participation was completely voluntary and that they could withdraw from the research at any time, even *after* having completed the informed consent. Participants' personal information was regarded as strictly confidential. Descriptions and findings obtained in the study may be used in research publications and to help improve the selected websites. The research work conducted usability evaluations on four M-commerce websites through the use of two UEMs: remote asynchronous testing and the MCOM heuristic methods.

Therefore, this chapter draws conclusions with regards to, firstly, the effectiveness of the selected UEMs used in the study and how the desired aims and objectives were achieved. Secondly, the limitations associated with the research are presented in addition to certain recommendations and suggestions for future studies.

8.2 Accomplishment of the Research Objectives

One of the fundamental aims of this research was to develop a domain-specific heuristic evaluation method which could then be used to investigate the area of *usability* as associated with the four selected M-commerce websites. In addition, the study identified and proposed the essential attributes of a *usability model* to enhance UX in the context of M-commerce websites. This will assure the future of M-commerce and WAP platforms, by helping to increase the number of mobile shoppers that will ultimately use these services. This section will discuss how the research objectives had been achieved.

8.2.1 Objective 1: To determine which essential attributes of the usability model are most appropriate in the context of M-commerce websites.

It has been noted that earlier models were traditionally tailored towards desktop websites and, as such, have some limitations in their applicability to mobile websites. For example, some of these models focus on the design and development of telecommunication systems which differ from computer software. The emergence of mobile devices present significant challenges for usability professionals as these devices are difficult to evaluate and model with traditional usability models (Lettner & Holzmann, 2012: 119; De Lima Salgado & Freire, 2014: 179).

In order to address the literature gap, the current research proposed a *mobile usability model* to be considered in the design and development phases and whilst evaluating the usage of mobile websites in general, and M-commerce websites in particular. The approach adopted in developing the proposed model follows the pattern used for developing the PACMAD model for the usability evaluation of mobile applications in general, as discussed in section 2.8. The developed PACMAD model is beneficial for evaluating the usability of mobile applications and has been used by many scholars in usability evaluations, producing positive results (Park, Goh & So, 2014: 31; Cata & Martz, 2015: 66; Saleh & Ismail, 2015: 234; Serra *et al.*, 2015: 350; Chintapalli *et al.*, 2016: 2). However, the PACMAD model fails to address imbalances inherent to existing mobile applications and thus it not suitable to evaluate M-commerce applications.

Therefore, the proposed MOSAD model reveals the typical components of mobile websites which relate to the user, technology, tasks and the environment. In addition, the MOSAD model presents the main usability attributes that should be considered when conducting a usability evaluation of M-commerce websites. Satisfaction, trust, retention, loyalty and adoption, amongst others, are closely linked to M-commerce usability.

Most of the literature reviewed indicated that the existing usability models fail to consider the need for mobility and the essential attributes relevant to M-commerce websites as well as the impact of these on UX/s. This complicates the work of usability professionals who need to explicitly define task model inclusion in the context of mobility of mobile devices. Therefore, the result of the current study addresses this literature gap in which the determined attributes for the MOSAD model should enhance user acceptance and adoption of M-commerce websites. This, in turn, will lead to greater economic growth in the M-commerce sector. Therefore, this objective is achieved through identifying the essential attributes of a usability model that can enhance UX in the context of M-commerce websites.

8.2.2 Objective 2: To propose a landscape of usability evaluation methods, in respect of when to use which evaluation method/s in the context of mobile applications

In order to achieve Objective 2, the current study reviewed some relevant usability studies, as discussed in Chapters 2 and 3, from which 19 UEMs were identified in the context of mobile applications. Usability professionals are often familiar with a number of these methods, they tend to use either one or two usability methods. In an effort to understand which method/s to use, and when to use them, the current study categorised the methods using a 3-dimensional approach with axes, as discussed in Chapter 3. The three identified dimensions (qualitative versus quantitative, attitudinal versus behavioural and product context of use) differ from one another.

Qualitative studies provide useful and quality data regarding user attitudes, or behaviours, based on direct observation. *Quantitative* research studies, on the other hand, collect data regarding attitudes, or behaviours, indirectly using survey or analytical tools. However, user perceptions in quantitative research studies are generally determined through mathematical analysis. Data collection instruments, such as log files or surveys, gather large quantities of data which can be numerically coded. Qualitative research methods are more suited to usability problem questions like ***why?*** or ***how to fix?*** whilst quantitative research methods address questions like ***how many?*** and ***how much?*** in a usability evaluation. The great amount of data collected assist in resource prioritisation by allowing the researcher to focus on problems which have the most impact.

The attitudinal and behavioural dimensions assist in differentiating between studies which address different types of questions and are considered suitable for their own unique reasons.

The difference can be expressed by contrasting: *what users do* and *what users say*. In most cases, these two differ as illustrated in Figure 3.2, Chapter 3. It is important to note that usability professionals focus on *behavioural* methods which employ self-reported data information sheets which prove useful tools for designers or usability professionals. For example, *card sorting* is rarely used in the context of mobile applications. It, however, provides a mental model of user perception and assists in garnering the best and most reliable information architecture for applications or websites.

Survey, as a tool, measures and classifies attitudes and aids in the collection of self-reported data which track major problems that require attention. *Focus group* is not used often for the purpose of usability, however, in mobile usability evaluations it has attracted the attention of usability professionals because it provides information as to the general perception of people in a group setting. For *what users do* with the brand or product, *eye tracking,* as a tool attempts to uncover the way in which users interact with the product interface. However, one of the most popular methods used is the *in-lab study* (Castro *et al.*, 2011: 371) which employs a combination of behavioural and self-reported data. This data tend to slant either to the attitudinal or behavioural dimensions. It is, however, recommended that in-lab studies should favour the behavioural dimension.

The third dimension explores how the subjects in the usability study use the product, or software application. The descriptions are: usage of the product in a *natural* or *close to natural* context and usage of the product in a *scripted* form. The study did *not use* the product and *hybridization* as discussed in Chapter 3. All the identified UEMs, as depicted in Figures 3.2 and 3.3, can move toward one or more dimensions. Some move during the study period when different goals are being addressed. For example, field studies can deal with what people do (extensive observation) or what people say about a product (ethnographic interview). In addition, card sorting and desirability studies, in most cases, can have quantitative and qualitative versions whilst eye tracking methods may be scripted and at the same time unscripted. Therefore, based on the analysis of the findings and the ability to place each evaluation method into different dimensions, the current study achieved Objective 2. This is because each evaluation method was presented within the landscape context of mobile applications.

8.2.3 Objective 3: To develop appropriate domain-specific heuristic evaluation method for evaluating the usability of M-commerce websites.

The heuristic evaluation developed by Nielsen and Molich (1990: 225) is characterised as a valuable and an inexpensive expert-based method which is professionally used for the evaluation of software usability. Heuristic evaluation has been traditionally developed and used for desktop software (Neto & Pimentel, 2013: 93). A prior survey conducted by the UPA shows that the second most utilised usability evaluation method by usability professionals is the heuristic evaluation method. As mentioned before in section 4.1, the survey was based on responses from 1 318 respondents from 34 countries (UPA, 2009: 16). The importance of this method is thus highlighted. It further underlines the fact that the method is well received to evaluate the usability of software products in order to deliver the required end-UX. However, consequent to the unique characteristics of mobile devices, usability methods and skills developed to ascertain the usability of desktop websites may not yield the required results (Fetaji & Fetaji, 2011: 178).

Different domain-specific heuristics have been developed in the past few years. Amongst them are *playability heuristics* used for evaluating mobile games. These have proven to be effective when compared to traditional, or Nielsen desktop-based heuristics (Korhonen & Koivisto, 2006: 15–16). Omar and Jaafar (2010: 192) developed a modified version of playability heuristics, which showed promising results, for the evaluation of an educational computer game.

M-commerce website developers have created M-commerce content with the defined purpose of enabling the purchase of any item, or product, as desired by mobile shoppers (Kurkovsky & Harihar, 2006: 229; Gündüz & Pathan, 2013: 116; Inostroza *et al*., 2013: 24). Shopping on mobile devices, or smartphones, presents its own unique challenges. These include: lack of trust, fear of security lapses, limited screen sizes, difficult input mode and poor screen resolution, amongst others (Hillman *et al*., 2012: 115). Therefore, the implementation of traditional usability heuristics in M-commerce websites is not appropriate and their usage would lead to the omission of significant parts of M-commerce websites which should be investigated.

The current study addresses the significant literature gap in the development of domain-specific heuristics for evaluating the usability of M-commerce websites to test the efficiency, effectiveness and satisfaction associated with user interfaces. Following the review of mobile empirical studies in this research, it was noted that the major usability testing methods with respect to M-commerce websites are the questionnaire survey (Sadi & Noordin, 2011: 495), focus group (Sieger & Möller, 2012: 2–4), observation and interview methods (Djamasbi *et al.*, 2014: 304). M-commerce researchers and developers are faced with some difficulty in this genre of study. Though, heuristics exist for general mobile websites (Inostroza *et al.*, 2013: 26–27; Neto & Pimentel, 2013: 95; Mi *et al*., 2014: 357–361) and for E-commerce websites (Rababah & Masoud, 2010: 3–4), they are *not* suitable for the evaluation of M-commerce websites.

However, based on the extensive study and critical analysis of relevant literature, this thesis used Nielsen's heuristics (Nielsen, 1994b: 153) as a baseline for developing the proposed MCOM heuristics for M-commerce websites. In addition, the research work used the *guidelines approach,* adopted by different scholars (Mi *et al*., 2014: 357; Neto & Campos, 2014: 489; Orlandini *et al.*, 2014: 196; Xu *et al.*, 2014: 3), in their development of domain-specific heuristics for different mobile websites. Thus, this thesis addresses the dearth in literature by developing domain-specific methods for evaluating the usability of M-commerce websites. The proposed MCOM heuristics were validated by conducting mobile empirical usability evaluations on four selected M-commerce websites. This provided promising results, as evident in the study. The initial set of the proposed MCOM heuristics have been published in the ACM digital library (Ajibola & Goosen, 2017: 3–8). The third objective was thus achieved as the research developed a usability evaluation method (MCOM heuristics) which can be used to examine M-commerce websites' conformity to usability principles

8.2.4 Objective 4: To determine the effectiveness of the proposed domain-specific evaluation method in the usability evaluation of M-commerce websites

An earlier study compared newly developed E-commerce heuristics with user testing and Google Analytics (Hasan, Morris & Probets, 2013: 337). Findings showed promising results which serve as a guide for usability professionals in the usability evaluation of E-commerce applications. As discussed in Chapter 5, this study used a multiple case-study design to display the characteristics of usability problems identified by the MCOM heuristics and remote asynchronous testing methods.

To achieve the fourth objective, the researcher listed the common problem areas associated with usability, as identified by the five separate evaluation methods discussed in Chapters 5 and 6. The methods comprised three different user testing methods including: qualitative and quantitative data from the questionnaire, observation report and performance data from Loop11 in addition to two heuristic evaluation methods (quantitative and quantitative data from the heuristic checklist).

The usability problems identified by the MCOM heuristic evaluation method were compared to a combined list of the problems found by conducting remote asynchronous user testing. The comparison resulted in the generation of a standardized list of problematic areas, and sub-areas, associated with website usability. This comparison pinpointed the most suitable methods for identifying major and minor usability problem areas relevant to the 10 main usability problem areas and 44 sub-areas, as discussed in Chapter 6. The research also explained the number and levels of severity associated with each problem, relating to the 44 sub-areas separately, as identified by the various evaluation methods.

The results of this structured comparison provide evidence that remote asynchronous testing with the Loop11 tool can yield quicker, easier and cheaper indications of possible usability problem areas, associated with the selected M-commerce websites. This can provide an idea as to these potential problem areas or help to identify specific webpages with usability problems. However, from the results, it was observed that the three identified problem areas (absence of privacy and security, lack of capabilities and inconsistent design) could not be identified accurately. Furthermore, the research showed that the method did not identify some of the problems related to the 44 sub-areas of usability problems.

However, a comparison of the various methods showed that the MCOM heuristic evaluation, and user testing methods, identified specific problems related to the 44 specific sub-areas of usability problems. The current study shows that the three different methods of user testing (qualitative and quantitative data from the questionnaire, observational report and performance data from Loop11) are complementary. The user testing method identified 29 of the 44 usability sub-areas reported in the current study for M-commerce websites.

The user testing method proved to be most successful in pointing 55 major usability problems in the areas of: design, purchase procedures, internal search, content, customer service and accessibility as well as navigation. However, a significant drawback is that this method was unable to detect minor usability problems related to the eight problematic areas.

From the results obtained, it was noted that qualitative data obtained from MCOM heuristic evaluators were useful in highlighting specific usability problems, while quantitative data, from the heuristic checklist, were unable to reveal specific usability problems. The results also show that qualitative data obtained from the MCOM heuristic evaluators identified the majority of the minor usability problems (132) associated with all the problematic areas. The crucial nature of privacy and security problems was highlighted by the MCOM heuristic evaluators. Essentially, the results demonstrated that heuristic evaluators cannot, while evaluating the selected M-commerce websites, fulfil the role of actual users to identify actual problems which end users may face in real life (Moses, Pakravan & MacCarty, 2019: 155–162).

In spite of the lengthy period of time allocated to the MCOM heuristic evaluations, in terms of recruiting appropriate experts with an understanding of the subject matter and with requisite skills in the application of the heuristic guidelines for data collection and analysis, the overall time spent was less than the time consumed in the user testing method. However, in redesigning the website, there will be considerable expenses incurred due to the high level of severe usability problems which had not been discovered by the heuristic evaluators. The preceding discussion thus shows that the fourth objective was met.

8.3 Contributions of the Study

This thesis presents the culmination of a comprehensive study journey. The researcher conducted an extensive literature review, one of the major contributions of the thesis. The researcher presented a new model, the so called MOSAD model, as well as new MCOM heuristics for experts' evaluation of M-commerce websites. The current study extensively compared the proposed MCOM heuristic method and asynchronous user testing of four M-commerce websites. Therefore, the thesis offers the following seven major contributions:

1) The scientific presentation of the results (attributes and evaluation methods) of the literature review in the context of mobile and M-commerce websites.
2) The presentation of the suggested landscape of UEMs for M-commerce websites.
3) The development of a proposed MOSAD model for evaluation of M-commerce websites
4) The development of MCOM heuristics for evaluation of M-commerce websites.
5) The scientific presentation of the results of asynchronous user testing of four M-commerce websites.
6) The comparison of the results garnered by the evaluation of the newly developed domain-specific method (MCOM heuristics) and remote asynchronous user testing.
7) The development of a framework for the evaluation of M-commerce websites.

8.4 Validation of Methods

Before the MCOM heuristic evaluation, the new draft set of heuristics developed in Chapter 4 were subjected to review by usability professionals to obtain experts' opinions regarding each of the heuristics discussed in section 5.4.6.2, Chapter 5. The UX experts reviewed the proposed MCOM heuristics via a customised online survey.

Therefore, to ensure validity, the recruited experts in the heuristic evaluation individually determined usability problems. However, the researcher organised the analysis of both user testing data and heuristic evaluation data emanating from the respective tests. Selection problems were considered during the recruitment process and participants' characteristics for each method of user testing were based on the user profiles obtained from pre-test questionnaires. Furthermore, all the experts who had taken part in MCOM heuristic evaluation had comparable amounts of experience in heuristic evaluation. Unanticipated features were not included in these tests.

The reliability of an evaluation technique is connected to how well the technique generates similar, or exact, findings in distinct events under comparable conditions (Leimeister, 2010: 10; Cronholm & Göbel, 2015: 471). For instance, as regards user testing, reliability is concerned with whether or not the same results can be collected if the assessment was to be repeated (Nielsen, 1994a: 57–71). Due to certain time constraints it was not possible to employ the same methods twice in order to investigate whether similar results would be obtained in the research. However, the current study used certain techniques, described in detail in section 5.7 of Chapter 5, to test *reliability* in this research.

8.5 Research Limitations

Numerous limitations, some having the potential to influence the research results, had to be addressed in the course of this research. These limitations have been listed below to inform future research work:

1. Though the researcher strove to include all relevant research resources in mobile empirical usability studies, some relevant research papers may have accidentally been omitted during the process.
2. The use of the convenience sampling method for the selection of four M-commerce websites may have affected the results. These websites were *not* chosen based on their number of usability problems, but rather on their availability. This may have influenced

the pattern of problems uncovered in the MCOM heuristics guidelines and may not have been an accurate representation of all M-commerce companies.

3. Prospective mobile online shoppers have more time at their disposal than the limited time period provided for data collection from the selected website. This may have influenced the accuracy of the results.
4. The developed MCOM heuristics cannot be considered a comprehensive benchmark to traditional heuristics in the usability evaluation of the selected M-commerce websites. Therefore, in an effort to reduce time and costs, the assessment of the MCOM heuristics was, in some instances, lacking.
5. This research was carried out with a limited number of participants. If more participants had been involved, it would have provided enhanced results and an improved understanding as to potential usability problems.
6. Since the research experts hailed from different geographical locations, their cross-cultural differences and context may have affected the findings. In addition, these cultural differences could also account for the differences in usability problems which the methods highlighted.
7. The snowball sampling approach, which was employed to select the research participants, resulted in the researcher having very limited insight as to the actual population distribution in the sample. It is thus difficult to determine potential sampling error/s and to draw statistical inferences, or generalisations, from the population sample. Hence, the samples obtained through the snowball technique may not always be considered representative of society (Sharma, 2017: 752).
8. The tasks did not include an actual purchase, which might alter the motivation of participants to use, or navigate, the selected M-commerce websites. If users had been required to make a real purchase, they would have used the additional features of the websites more frequently and this would have increased their interactions.
9. Both the MCOM heuristics and asynchronous remote evaluation methods' guidelines were applied in the evaluation of the M-commerce sector. It is suggested that future research studies might benefit from applying these methods to other sectors of the economy.
10. A conclusion as to the performance of the two evaluation methods were based on the results obtained. The traditional in-lab testing method was not used, or compared, with these methods. It would be beneficial to the research if the two evaluation methods had been compared to a benchmark usability testing method.

8.6 Recommendations for Further Study

In order to overcome some of the limitations, the following recommendations are suggested:

1. With respect to the identified *usability problems*, further research should be conducted using the same number of evaluators and users and checking the impact this would have on the usability problems identified.
2. Research should be conducted to test the MCOM heuristics guidelines. This will consider the identified areas of the M-commerce websites which appear to be affected by usability problems and, in doing so, ensure that test tasks are adequately designed for the user testing method.
3. The current study could be potentially extended if the owners of the four websites decided to apply the suggested recommendations. Future research could examine the impact of the improved websites on usability and performance.
4. As based on the experience of the researcher with the asynchronous participants, future research will benefit from arranging a briefing session between the researcher and participants in which test procedures are explained. This will ensure that participants are less nervous during the actual test.
5. Good internet connection/s play a vital role when conducting asynchronous testing. Therefore, asynchronous tests should be done with a high-speed internet connection.
6. The stability of the targeted websites should be thoroughly checked by the researcher before the test commences.
7. The proposed framework for usability evaluation of M-commerce websites needs to be tested in order to obtain both quantitative and qualitative feedbacks in terms of the framework's effectiveness and usefulness from the perspective of the M-commerce providers.

8.7 Conclusions

Chapter 8 presented the summaries, conclusions and recommendations of the research study based on the results of the user-based usability testing and MCOM heuristic evaluation methods. The guidelines have been framed to assist in improving the quality of UXs when interacting with M-commerce websites. This chapter concludes the research work and emphasises, firstly, the effectiveness of the selected UEMs employed in the study and how the research aims and objectives have been achieved. Secondly, the chapter explained the research limitations and presented relevant recommendations and suggestions for future studies. This research study has both theoretical and practical applications. The findings in this research study will contribute significantly to the HCI and UX fields of study through theoretical and empirical means. Similarly, conclusions derived and recommendations made, will have practical applications to the identification of usability problems for usability professionals in this genre of study.

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Appendix 1: Letter to the Website Owner

Dear Sir / Madam,

Request for Permission to Conduct Usability Test

My name is Sunday Ajibola and I am a PhD student at the University of South Africa (UNISA). My research area is mobile E-commerce usability, which involves testing of some mobile E-commerce websites. I found out that your website is one of the popular mobile E-commerce sites in Nigeria.

Usability testing investigates the ease with which an average person can use software, or the website, to achieve his or her specific goals.

The purpose of the study is to test how easy the website is to use when prospective customers interact with the website interface. The participants will be asked to perform some simple tasks such as attempting to make a purchase of a particular item/product. They will also complete a questionnaire.

Participation in this usability study is voluntary. All information will remain strictly confidential. The descriptions and findings may be used as recommendations to help in improving the website. However, at no time will the name of the participants or any other identification be used. The participants can withdraw from this study at any time, even after having signed the informed consent form.

I would be very grateful if you would kindly grant me permission to conduct the study on your website. Should you wish to obtain further information regarding the test, please do not hesitate to contact myself (ajibolasunny@gmail.com) or my supervisor (xxxx@unisa.ac.za).

Thank you

I have read and understood the information in this letter and I hereby grant permission for the test to be done.

____________________________ ________________

Signature of website owner Date

____________________________ ________________

Signature of usability researcher Date

Appendix 2: Task Scenarios for M-commerce Websites

Website 1

Task Scenarios

Task 1: Search for a similar laptop to the one you lost

You recently lost your Lenovo laptop (Ideapad, 750GB of HDD, i5 and 4GB RAM) which cost N110K and you are planning to replace it with the same type. Search the site to see whether you can get the same type of laptop (with the same specifications and price). Try to add it to your shopping cart. Try to amend the shopping cart content to 4 pieces.

Task 2: Search for a particular type of hand-held Digital Camera

You will be travelling abroad next month and you are looking for a good-sized digital camera that you can use to take memorable pictures of the places you will be visiting. Search for a Canon digital camera (price N35K / colour Black) and try to add it to your shopping cart. Try to change the item's shipping address to one which differs from the address your registered with. Try to look for shipping information.

Task 3: Locate the name of the sales assistant

Suppose you are experiencing difficulty with your transaction and would like to gain advice from a sales assistant. You do not, however, know whom to contact regarding the problem/s. Using the selected websites, find the name of an assistant to contact.

Task 4: Check how to log refund complaints

You have just bought an item from the selected site and you have made a payment using your debit/credit card. You have, however, received bank alerts that the amount has been charged twice by the store. Check the online store to ascertain how to log a complaint and how to obtain a refund.

Website 2

Task Scenarios

Task 1: Search for a similar laptop to the one you lost

You recently lost your Dell laptop (1TB of HDD i5 and 4GB RAM), which cost N120K and you are planning to replace it. Search the site to ascertain whether you can buy the same type of laptop to the one you lost. Try to add it to your shopping cart. Try to amend the shopping cart content to 4 pieces.

Task 2: Search for a particular type of Shoe

You will be travelling abroad next month and you are looking for a good-sized pair of shoes that you can wear as the country you will be visiting is very cold. Search for the shoe labelled "Italia" in a size medium (price N8K, colour Black). Try to add it to your shopping cart. Try to change the item's shipping address a different address than the one with which you registered. Try looking for shipping information.

Task 3***:*** **Find the name of the sales assistant**

Suppose you are encountering transaction difficulty and would like to seek advice from a sales assistant. However, you do not know whom to contact regarding the problem/s. Using the selected website, locate the name of an assistant to contact from the website.

Task 4: Check how to log refund complaints

You have just bought an item from this selected site and you have paid with your debit/credit card. However, you received bank alerts that the amount has been charged twice by the store. Check the online store for the correct procedure to log a complaint/s and enquire as to the possibility of a refund.

Website 3

Task Scenarios

Task 1: Search for a similar lost Samsung Tablet

You lost your Samsung Tablet recently (7 inches, 1GB of RAM and 32GB HDD) which cost N45K. You are planning to buy a new one. Search the site and see if you can get the same type of Tablet with the specifications given above and try to add it to your shopping cart. Try to amend the shopping cart content to 4 pieces.

Task 2: Search for a particular type of Jacket

You will be travelling abroad next month and you are looking for a good-sized Adidas jacket that you can wear because the weather will be cold. Search for the jacket labelled "Adidas", size medium, price N6K in blue. Try to add it to your shopping cart. Try to change the item’s shipping address to another address which differs from the one your registered with. Try to obtain shipping information.

Task 3: Find the name of the sale assistant

Suppose you are encountering difficulty with your transaction and you would like to seek advice from a sales assistant. However, you do not know whom to contact regarding the problem/s. Using the selected websites, locate the name of an assistant to contact.

Task 4: Check how to log refund complaints

You have just bought an item from this selected site and you paid with your debit/credit card. However, you received bank alerts that the amount has been charged twice by the store. Check the online store for information regarding how to log your complaint and enquire as to a refund of the money.

Website 4

Task Scenarios

Task 1: Search for a similar Smart Phone

You have recently lost your Techno Smart Phone X7 (1 GB of RAM and 8GB HDD), which cost N25K and you are planning to buy a new one. Search the website to ascertain whether you can obtain the same type of smart phone as the one you have lost. Try to add it to your shopping cart. Try to amend the shopping cart content to 4 pieces.

Task 2: Search for a particular type of Shoe

You will be travelling abroad next month and you are looking for a good-sized shoe that you can wear because it will be cold in the country you will visit. Search for the shoe labelled "Italia", size medium, price N10K and colour Brown. Try to add it to your shopping cart. Try to change the item's shipping address to an address which differs from the one you registered with. Try to look for shipping information.

Task 3: Find the name of the sales assistant

Suppose you are encountering difficulty with your transaction and you would like to seek advice from a sales assistant. However, you are not aware of whom to contact regarding the problems. Using the selected websites, locate the name of an assistant to contact.

Task 4: Check how to log refund complaints

You just bought an item from this selected site and you paid with your debit/credit card. However, you received bank alerts that the amount had been charged twice by the store. Check the online store for how to log a complaint/s and enquire as to a refund.

Appendix 3: The Announcement Used to Recruit Participants

Research Testing Participants Needed

If you have experience in the use of the internet, as well as a computer, and you are at least 18 years old, the researcher would like to ask you to participate in this study in order to collect design feedback on selected websites.

It will take around three hours to complete, and the evaluation will be done in your own environment (e.g. your home or office). A set of normal tasks will be given to you and you will be asked to complete the questionnaires which the researcher will provide.

To show his appreciation for your time and effort in participating in this exercise, the researcher will give you N100 airtime voucher. Please email x@x.com before dd/mm/yyyy, if you are interested in participating.

Appendix 4: Participants' Profile in Asynchronous Testing

GENDER		
Website	**Male**	**Female**
Site 1	12	8
Site 2	12	8
Site 3	12	8
Site 4	12	8
Average	12	8
Approximate No. of Users	**48**	**32**

ACADEMIC QUALIFICATIONS						
Website	**SSCE**	**OND/NCE**	**HND/BSC**	**PGD**	**MBA/MSc**	**PhD**
Site 1	2	4	5	4	4	1
Site 2	1	5	5	4	4	1
Site 3	3	3	3	6	5	0
Site 4	2	4	7	2	3	2
Average	2	4	5	4	4	1
Approximate No. of Users	**8**	**16**	**20**	**16**	**16**	**4**

AGE OF PARTICIPANTS							
Website	**18-25**	**26- 30**	**31-35**	**36-40**	**41-45**	**46-50**	**Above 50**
Site 1	1	3	4	4	4	3	1
Site 2	1	2	4	4	3	4	2
Site 3	2	4	5	5	4	2	0
Site 4	1	3	4	4	5	2	1
Approximate No. of Users	**5**	**12**	**15**	**17**	**16**	**11**	**4**

COMPUTER EXPERIENCE			
Website	Below 1 year	Between 1-3 years	Above 3 years
Site 1	1	8	11
Site 2	1	8	11
Site 3	1	8	11
Site 4	1	8	11
Average	1	8	11
Approximate No. of Users	**4**	**32**	**44**

Internet Experience			
Website	Below 1 year	Between 1-3 years	Above 3 years
Site 1	1	9	10
Site 2	1	9	10
Site 3	1	9	10
Site 4	1	9	10
Average	1	9	10
Approximate No. of Users	4	36	40

Appendix 5: Pre-Test Questionnaire

Section 1: Background and Experience **Personal Information**		
1	**Age**	
	18-25	☐
	26-30	☐
	31-35	☐
	36-40	☐
	41-45	☐
	46-50	
	Above 50	
2	**Gender**	
	Male	☐
	Female	☐
3	**Education**	
	Secondary School Certificate	☐
	Diploma/NCE	☐
	HND/BSc	☐
	PGD	☐
	MSC/MBA	☐
	PhD	☐
Computer Experience		
4	**How long have you been using a computer?**	
	Less than 1 year	☐
	Between 1 and 3 years	☐
	Above 3 years	☐
5	**How many hours a day do you use a computer to complete your tasks?**	
	Around 1 hour	☐
	Between 2 and 4 hours	☐
	Above 4 hours	☐
Internet Experience		
6	**Which internet browser do you frequently use?**	
	Google Chrome	☐
	Mozilla Firefox	☐
	Opera Mini	☐
	The Internet Explorer/Microsoft Edge	☐
	UC Browser	☐
7	**How long have you been using the Internet?**	
	Less than 1 year	☐
	Between 1 and 3 years	☐
	Above 3 years	☐

8	**How many hours a week do you use the internet?**				
	Less than 2 hours				☐
	Between 2 and 4 hours				☐
	Above 4 hours				☐
9	**Have you ever interacted with any of the below websites?**				
	www.konga.com	Yes	☐	No	☐
	www.kaymu.com	Yes	☐	No	☐
	www.jumia.com	Yes	☐	No	☐
	www.dealdey.com	Yes	☐	No	☐
10	**Have you ever used the internet to buy a product?**				
	Yes				☐
	No				☐
	If your answer to the above is No, go to Q36				
Section 2: Mobile Shopping Experience					
11	**How often do you buy product/s with your Smartphone?**				
	Once a week				☐
	Once a month				☐
	Once in a year				☐
12	**When was the first time you used your Smartphone to purchase a product?**				
	About a year				☐
	About 2 or 3 years				☐
	Over 3 years				☐
13	**What was the last product you used your Smartphone to buy online?**				
14	**Name the website that you used to buy the product?**				
15	**Indicate the payment method you used when buying the product.**				
	Debit Card				☐
	Credit Card				☐
	Bank Transfer				☐
	PayPal				☐
	Cash on delivery				☐
	Others				☐

PURCHASING PROCESS										
			7	6	5	4	3	2	1	
16	It saves time to buy items online.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
17	I prefer to buy online from a well-recognised website.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
18	The website search feature is helpful while buying online.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
19	Personally, I find buying online is cheaper when compared to going to the store.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
20	Personally, I find the full description/s of the product when online unimportant.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
21	I used to buy online because the products are cheaper.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
22	Before I purchase anything, I would rather do detailed research on the product/s.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
23	Due to the fact that I am able to purchase items whenever I want, I prefer to shop online.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
24	Because I can buy products worldwide, I like to shop online.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
25	When I shop online, I find it hard to recall passwords.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
26	Usually, the company delivers products within the time frame that they had promised.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
27	Websites accurately represent their products and I am usually happy with what I get using Internet shopping.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
28	I believe that delivery costs are irrational.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
29	Online companies usually provide adequate customer service.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
30	Usually, the online prices are lower than they would be in other places.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
31	If sites have a clear return and refund policy, I feel encouraged to shop online.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
32	A shopping site should be able to deliver items to a different address, other than mine.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
33	If a website keeps me informed regarding the status of my order, it makes me feel like it is more reliable.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
34	If a site provides alternative types of ordering/delivery/payment, I prefer to shop from that website.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
35	The fact that some websites contain very specific or restricted areas for product delivery frustrates me.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
Section 3: Online Shopping Perceptions										
			7	6	5	4	3	2	1	
36	Using the internet is usually not too expensive.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**

37	If a company presents their information on their website/s, I ignore it.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
38	If a site has user-friendly navigation, I prefer to use that site.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
39	If a website is well-organised, I would enjoy using it.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
40	I get frustrated with completing compulsory registration when I shop online.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
41	Whenever I want to purchase items from the internet, I am concerned about my financial details' safety.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
42	Whenever I want to purchase items from the internet, I am concerned about my personal information's privacy.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
43	The lack of legal regulations which manage online transactions worries me.	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**

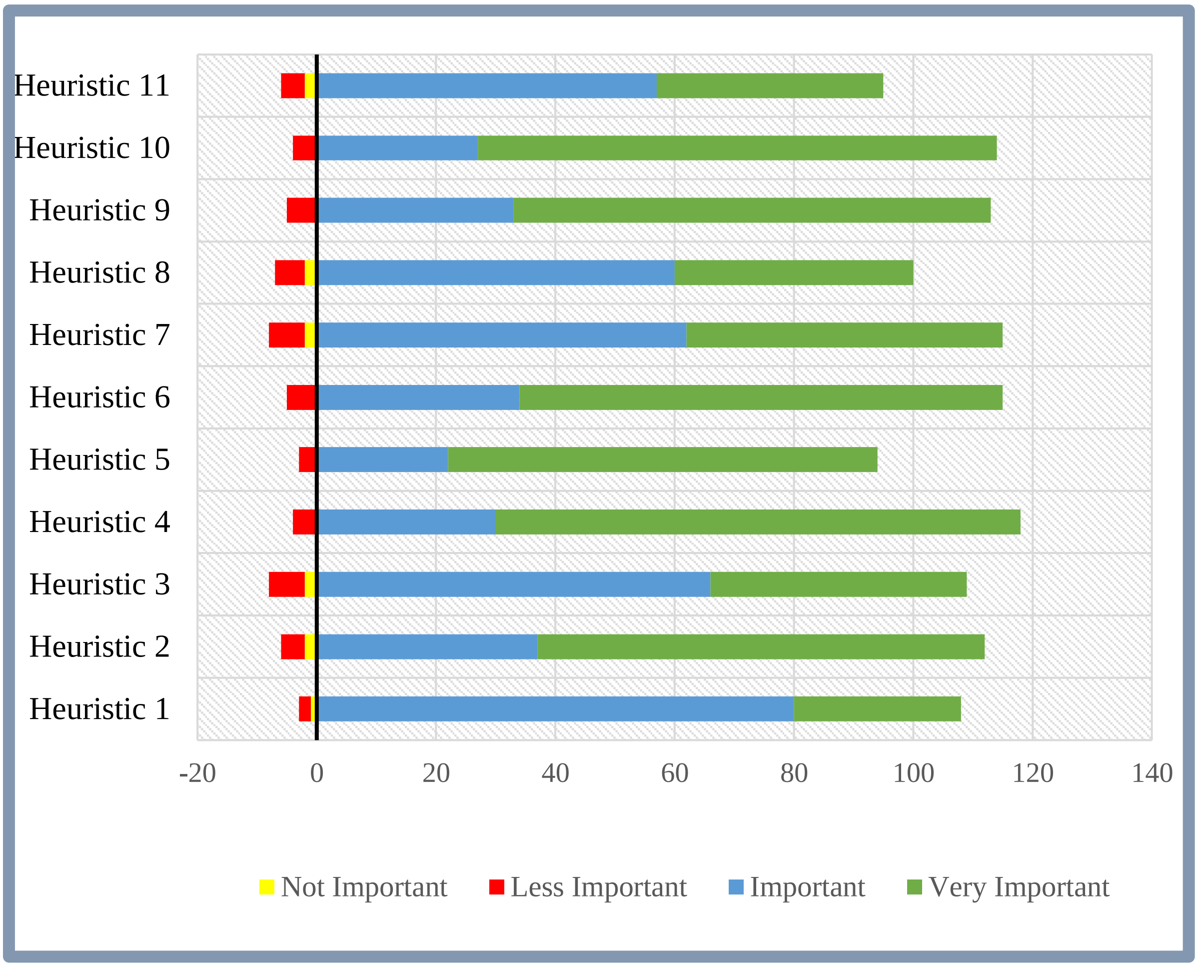
Appendix 6: Standardised Questionnaire: System Usability Scale (SUS)

John Brooke developed SUS as a 10 item usability questionnaire, which has 5 response options and is regarded as a "quick and dirty" usability system rating scale. SUS provides an overview of subjective measurements of usability with a non-complex ten-item scale and is judged as a reliable usability evaluation method for any system in comparison to the industrial standard.

As a participant in this exercise, you can withdraw your consent from this study, even after having signed the inform consent form. Kindly rate your level of agreement, or disagreement, to the following statements. All items need be checked.

			1	**2**	**3**	**4**	**5**	
1	I think that I would like to use this website frequently.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**
			1	2	3	4	5	
2	I found the website unnecessarily complex.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**
			1	2	3	4	5	
3	I thought the website was easy to use.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**
			1	2	3	4	5	
4	I think that I would need the support of a technical person to be able to use this website.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**
			1	2	3	4	5	
5	I found the various functions in this website to be well integrated.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**
			1	2	3	4	5	
6	I thought there was too much inconsistency in this website.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**
			1	2	3	4	5	
7	I would imagine that most people would learn to use this website very quickly.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**
			1	2	3	4	5	
8	I found the website very cumbersome to use.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**
			1	2	3	4	5	
9	I felt very confident using the website.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**
			1	2	3	4	5	
10	I needed to learn a lot of things before I could get going with this website.	**Strongly Disagree**	☐	☐	☐	☐	☐	**Strongly Agree**

Appendix 7: Quantitative Data from Usability Professionals' Survey



Appendix 8: Modification to the Draft Set of MCOM Heuristics

No	Heuristic	Usability Professionals Comments
2	Be aware of users' fear of losing data	Some experts believe that it is important to make this heuristic more actionable, such as ensuring that the user receives feedback which affirms that their data have been saved and that it will be safe, even from session to session, unless the user asks to forget it. Or even that there is a 'recent items' button so the user can see things they forgot to put in the cart, and a 'view cart' button so that they can quickly confirm that their items are there.
3	Include primary button under each product page	The experts suggest that the 'Add to Cart' button needs to be added below every product page, in statement order, to avoid a misinterpretation of the cart buttons. Many reviewers suggest that since *heuristic* is implying that the 'primary button' is always 'Add to Cart' then it is necessary to include it in the title. The reviewers suggest that having the button always 'below' can be an problem. It needs to be clearly visible on the screen. 'Below' could result in the user needing to scroll to see it.
5	Be careful of adding images, or product information, on different subpages	Some of the experts reported that the heuristic needs to clearly indicate the *path* back to the main listing from a product-details page, even if only partial breadcrumbs are shown.
6	Be careful in the arrangement and design of account-selection options	The experts agreed with the heuristic, however, they requested more descriptive information.
9	Allow the verification of inputted day and date	Most of the reviewers agreed that day of the week should always be shown along with the day of the month, to ensure that users do not make a mistake. In addition, they suggested that address, shipping option, number of cart items etc. should be allowed to be verified before the check-out process.
11	Ensure that users' privacy and security concerns are addressed	Few experts suggested that the description of this heuristic is too general and not specific enough to M-commerce applications. Therefore, the researcher modified the descriptions in order to make it specific to M-commerce applications.

Appendix 9: Final Set of Developed MCOM Heuristics

No	Heuristic	Descriptions
1	Make the home page easy to view at a glance	The home page should be easy to scan by users so that they can obtain an overview of the whole website. If this does not occur, mobile shoppers will fail to engage and may take the wrong paths in the process of executing their tasks while interacting with the application.
2	Be aware of users' fear of losing data	Users of mobile applications fear the loss of inputted data because typing on mobile devices is cumbersome. Users should receive feedback that their data have been saved, and that it will be safe, even from session to session unless the user indicates that is should be *forgotten*. A 'recent items' button will help users to see that which they have forgotten to add to the cart. A 'view cart' button can help them to quickly confirm that their items are present.
3	Make primary button ('Add to Cart') visible on each product page	The 'Add to Cart' button needs to be visible on every product page in order to avoid a misinterpretation of cart buttons. Some websites have two similar 'Add to Cart' buttons (one at the top or middle and a second at the bottom of product page), which may, in many cases, confuse users. Therefore, the 'Add to Cart' button needs to be clearly visible on every product webpage.
4	Be careful with the inclusion of animated carousels	In most cases users find it difficult to identify the reason why a carousel is important which makes it difficult to interact with carousels, especially on small devices. Some carousels frequently change without allowing users enough time to read and understand or to select an appropriate option.
5	Be careful of adding images, or product information, on different sub-pages	Users may experience difficulties when trying to understand the scope of a product sub-page. To gain a full understanding of the current page's scope on a mobile device is problematic because of the limited screen size of mobile devices. Page-scope clues are available on full size pages, like the complete set of current page overview, breadcrumbs and full URL paths. These, however, are lacking in mobile pages. It is necessary to clearly indicate the path back to the main listing from a product-details page, even if only partial breadcrumbs are shown.
6	Be careful in the arrangement and design of account-selection options	Ensure that users understand the 'Guest Checkout' feature including field relationships, option selection and account-selection steps. M-commerce applications should include visible cues. If users can swipe something then swiping ambiguity should be avoided. In addition, the application should use expandable menus sparingly and incorporate menu labels which clearly show that they have various options beneath them.
7	Ensure that the auto-correction of the dictionary is disabled when needed	Ensure that the auto-correction function of the dictionary is working; otherwise this could lead to user frustration. In most cases, auto-correction does not work well for some acronyms, e-mail addresses, street names and words that are not included in the dictionary.
8	Ensure that fields are big enough to display common data in full (Add label at the top of the field)	It should be easy for users to notice errors and to correct them (error prevention and recovery). In the case of question and answer interfaces, the application should have minimal typing requirements. In addition, the application should show field labels above list fields and to the left of fields that are single. It is essential that the application use dialog boxes as well as data entry screens which indicate the number of character spaces available in each field.
9	Allow for the verification of inputted day, date and shopping details	Avoid the use of text fields for dates as this causes needless mental processing and can lead to vital selection errors. In most cases, users encounter problems with drop-down menus or simple text field dialog in the selection of the date. It is necessary that the day of the week should always be shown along with the day of the month, to ensure users don't make a mistake. In addition, users' address, shipping option and number of cart items, to name a few, should be verified before the check-out process.
10	Ensure that each hit area and list item are clearly identified and demarcated	Ensure that different lists do not confuse users about where to tap when trying to select a product. The major problem users face is where to tap in order to choose a particular item in the product page. Pertinent questions that arise are: Can the user tap the whole 'element'? Or the title of the product? Can the thumbnail be tapped? This problem usually occurs when the list of

		items is more than half screen size, as recommended. However, M-commerce applications that have limited list items are faced with this problem when the hit areas are not clear enough, which may lead to product abandonment.
11	Ensure that users' privacy and security concerns are addressed	The M-commerce application must be able to protect users' private and/or personal information and ensure that mobile shoppers' trust is protected while using the applications. In addition, the M-commerce applications should be able to answer pertinent questions like: (1) Is it impossible to access areas which are protected? (2) Is it possible to access confidential or protected areas using a particular password? and (3) Does the website contain adequate information regarding the protection and copyright of content? The M-commerce applications should avoid permanently signing in users on applications if the device is used by more than one user and should afford users the option whether to remain logged in while keeping them informed of the risks.

Appendix 10: The Procedure of the User Testing

The researcher would like to acknowledge his appreciation for your willingness to participate in the current research. In this document, I would like to elaborate on the reasons for requesting your input.

This study will examine the usability of four distinct M-commerce websites in Nigeria in order to determine which aspects have room for improvement, which is why I have asked for your assistance. Everything done by you in the current research will be treated as an anonymous matter. You participate on a voluntary basis, meaning that you can quit the study at any point, or choose *not* to answer any one of the questions in it.

The duration of the test should be about three hours. One website should take up about 45 minutes of your time. You will complete a series of typical tasks across a range of four sites. Do not rush these tasks, work at a comfortable and normal pace and do not feel as if you are writing a test – this is very important for this exercise.

When the site/s require you to register as a new client, you do not need to enter any real personal information. You do not have to enter your own personal Credit/Debit Card details when the tasks asks you to buy various products where Credit/Debit Card is an option for payment. When you reach the page requiring confirmation, you can stop, and you can enter fictional financial details – nothing will cost you any money and you do not have to buy anything. Please, note that you can halt any activity and continue with the next task, or if you do not think that you can perform a certain task.

If you experience any difficulties, or problems, please do not hesitate to write your observation comment on the open window of the screen. A questionnaire has been prepared for you to complete *after* you have tested each of the sites, and another online post-evaluation questionnaire will be made available to you once you have finished testing all four websites. In this session, please give an honestly reflection as to your feelings and experience of each of the website.

If you have no further enquiries, please fill out the pre-test questionnaire and sign the consent form.

Thank you

Appendix 11: Questionnaire for Post-Test

Website name: ---

From your experience in completing tasks on the website, indicate the level of ease/difficulty:										
			7	6	**5**	4	3	2	1	
1	Acquiring information connected to tasks	**Very Easy**	☐	☐	☐	☐	☐	☐	☐	**Very Difficult**
2	Locating the products I wish to buy	**Very Easy**	☐	☐	☐	☐	☐	☐	☐	**Very Difficult**
3	Making use of the site's internal search facility	**Very Easy**	☐	☐	☐	☐	☐	☐	☐	**Very Difficult**
4	The site's registration process is	**Very Easy**	☐	☐	☐	☐	☐	☐	☐	**Very Difficult**
5	Buying one of the items	**Very Easy**	☐	☐	☐	☐	☐	☐	☐	**Very Difficult**
6	Flexibility of the site to allow change of customer information	**Very Easy**	☐	☐	☐	☐	☐	☐	☐	**Very Difficult**
7	Adding or removing items from shopping carts.	**Very Easy**	☐	☐	☐	☐	☐	☐	☐	**Very Difficult**
What is the level of your agreement/disagreement with the following statements:										
8	The website organises information well	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
9	It was difficult to move around the site without becoming confused	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
10	A helpful table of contents can be found easily	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
11	The search function quickly yielded results	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
12	The internal search's results were accurate	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
13	The internal search's results were inaccurate	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
14	A small number of links broke or failed to work	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
In case you wish to register before paying for the products on the website, then continue with question 15, otherwise continue from question 16:										
			7	6	5	4	3	2	1	
15	It was convenient to use compulsory registration on the site	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
16	Before buying items, I prefer to register	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
17	All the expected capabilities and functions were present on the site	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
In case you do not agree with question 17, respond to question 18. Otherwise, continue to question 19:										
18	On this site, state any functions or capabilities you found lacking?									
Questions related to the website's overall navigation and appearance:										
			7	6	5	4	3	2	1	
19	The interface of this site was good	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
20	The website gives detailed information to help me complete buying tasks	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**

21	It was a challenge to return to the home page from any of the site's pages	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
22	The website's colour choice was suitable	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
23	The site was easy to read/text size was adequate	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
24	The site used easy-to-understand terms throughout	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
25	This website's interface was attractive and pleasant	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
26	It was easy to use the site	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
27	All pages on the site were clear and easy to find	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
28	I would be happy to recommend this site to friends	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
Questions related to the site's privacy and security:										
29	I trust companies that say they will not abuse my personal information	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
30	I feel that my financial information is secure whenever I buy from this site	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
31	This website makes me feel confident to buy from it	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
The following questions are related to your personal feelings and perceptions regarding the site:										
32	Which five attributes of the site did you like?									
	1									
	2									
	3									
	4									
	5									
33	Which five attributes of the site did you *not* like?									
	1									
	2									
	3									
	4									
	5									
34	In the future, what would make you want to buy anything from this site?									
	1									
	2									
	3									
	4									
	5									
35	In the future, what would make you *not* want to buy anything from this site?									
	1									
	2									
	3									
	4									
	5									

Appendix 12: Heuristic Categories, Sub-categories, and their Descriptions

Heuristic Areas and Sub-areas	Descriptions
ARCHITECTURE AND NAVIGATION	
Consistency	Throughout the website, justification is done, fonts, navigation positioning and so on are consistent as well as the style and layout of pages. Furthermore, it uses consistent colours and navigation and information design, like background colours, font colours and standard link colours. The terms the site uses are consistent, and across all languages, content is consistent as well. The navigation and information design of the site is suitably organised.
Navigation support	It is easy for any user to explore and navigate the site easily because navigational links, like the index, site map, table of contents or navigation bar are easy to find and use.
Internal search	The site's internal search function works well, because its results are easy to interpret, fast and accurate.
Working links	The user knows what to expect from destination pages because the site's links work properly, are distinctive and do not mislead them.
Resourceful links .	Links to useful external links are provided and the site is resourceful and informative.
No orphan pages	Pages' positions on the site are clear and it is easy to go to the homepage from any of the site's sub-pages.
Logical structure of site	Structuring of the site is done properly because the architecture is not too deep, products are categorised well and information is grouped accordingly.
Simple navigation menu	The site is easily understandable because menu choices are logically ordered and the navigation menu is straightforward.
CONTENT	
Up-to-date information	Users are informed when the site adds new information and it is updated often.
Relevant information	Content is not redundant or grinding, nothing is lacking or overcomplicated and the information is relevant to the user.
Accurate Information	All provided information, like services and prices, is correct.
Grammatical Accuracy	There are no grammatical errors within the content.
Information about the Company	Corporate profiles are easy to access.
Information about the product	The website provides suitable information concerning its products such as: prices, pictures, availability and descriptions.
ACCESSIBILITY AND CUSTOMER SERVICE	
Easy to find and access website	Search engines allow users to find the site easily, pages download in an appropriate amount of time and it is easy to remember the URL.
Contact us information	It is easy to communicate with the company because the site displays useful information like: 'contact us' details, FAQs and feedback forms.

Help/customer service	Customer service and assistance is easy to find and navigate with a distinct, clear layout, and concise, well-written information.
Compatibility	Different monitor resolutions and browsers run the site equally well.
Foreign language and currency support	More than one currency is used and content is shown in various languages.
Product image accessibility	There must be a feature that will enable mobile shoppers (especially the visually impaired) to expand the product images in order to obtain a proper view of the product.
DESIGN	
Aesthetic design	Potential clients are impressed because the website is appealing and looks attractive.
Appropriate use of images	There are not any broken images, they are of a good quality, they are not used unnecessarily and they are of a relevant size.
Appropriate choice of fonts and colours	The website uses easy-to-read fonts, appropriate colours for all features and an appropriate combination of colours.
Appropriate page design	Headings are unambiguous, pages are not chaotic, there are no pages which contain a lot of whitespaces and they do not require the user to scroll too often. All pages have sufficient page margins and titles.
PURCHASING PROCESS	
Easy order process	It is easy to log on or register, change information, order and change what is in the user's shopping cart.
Ordering information	It is easy to access complete ordering information. The following are clearly indicated: cancelling orders, what the return and refund policy is, terms and conditions, how to order and available payment options.
Delivery information	It is easy to find information on order delivery including costs, areas, address options, problems and delivery times.
Order/delivery status provision	The user is kept informed about the status of their order by the company, through confirmation e-mails or by using a tracking system which the user can easily access online.
Alternative methods of ordering/payment/ delivery are available	The website supports different ways of paying and ordering so that users can choose the method they prefer.
Security and privacy	Secure payment methods which are recognised, or socket layering, is used to keep users' transactions safe. Privacy policy and security information are easy to find on the site.

Appendix 13: Heuristic Evaluation Checklist

Kindly indicate the level of your agreement or disagreement with the statements below:										
NAVIGATION AND ARCHITECTURE										
			7	6	**5**	4	3	2	1	
1	There is consistency in the page layout	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
2	There is consistency in text justification	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
3	There is consistency in all the fonts	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
4	There is consistency in the colours	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
5	Standard link colours were used by the websites	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
6	There is consistency in the terms/terminologies	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
7	There is consistency in contents among all language interfaces	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
8	It is easier to navigate on the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
9	Finding information about the tasks are easier	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
10	The locations of the table of contents, or navigation bar, site map and index are suitable	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
11	Using internal search is good with regards to response time	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
12	Internal search results are helpful and appropriate	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
13	The website links are clear/obvious	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
14	The website broken links are few	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
15	The page names and the link names are the same	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
16	The external resources have an appropriate number of links	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
17	Returning to the home page is easy and clear from any website sub-page	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
18	The position of each page on the website is clear	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
19	The structure of the website is straightforward and simple	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
20	There is a group of related information on the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
21	The products' categorisation is good and helpful	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
22	A limited number of clicks are required to reach destination page	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
23	There is straightforward and simple navigating menu	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
24	There is a logical arrangement of menu choices	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**

CONTENT										
			7	6	5	4	3	2	1	
25	The website contains current and up-to-date information	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
26	There is a clear display as to the last updated date	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
27	The website contains clear and visible new information	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
28	The use of terms and terminologies are simple and easy to understand	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
29	The contents is concise	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
30	The number of pages “under construction” is limited	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
31	There is accurate and precise information	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
32	There is no presence of grammatical error in the contents	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
33	Company suitable information is displayed	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
34	The description of each product is accurate	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
35	The products’ photographs are displayed adequately	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
36	The status (e.g. out of stock, available or in stock) of each product is adequately displayed	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
37	The product’s price is adequately displayed	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
CUSTOMER SERVICE AND ACCESSIBILITY										
			7	6	5	4	3	2	1	
38	Using search engines to access the website is good	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
39	The website name is domain-related	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
40	Remembering the URL is easy and not complex	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
41	It is fast to download pages	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
42	The contents of FAQs are adequate and helpful	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
43	The ‘Contact Us’ information is clearly displayed (e.g. fax and telephone numbers, physical address and names)	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
44	Customers are allowed to send comments on the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
45	It is easy to locate customer service/help on the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
46	The layout of help/customer service on the website is clear and distinct	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
47	It is easy to search for customer service/help	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
48	It is easy to navigate to customer service/help	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
49	The help/customer service contained adequate information	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**

50	The website is compatible with various internet browsers	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
51	The website is compatible with various screen resolutions	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
52	Different foreign languages are supported by the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
53	Appropriate currencies are supported by the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
DESIGN										
			7	6	5	4	3	2	1	
54	The website is appealing, attractive and aesthetics	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
55	The displayed images are of an adequate quality	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
56	The number of broken images is limited	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
57	The help and contents of the websites are related to the images	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
58	Most images contained alternative text	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
59	The effect of the image sizes on loading time is minimal	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
60	It is easy to read the fonts	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
61	The colours of the selected fonts are good	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
62	The website contained suitable background colours	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
63	The selected fonts and background colours are suitably combined	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
64	The websites contain uncluttered pages	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
65	The websites contain clear headings	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
66	There are sufficient, or suitable page margins	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
67	Scrolling is required for only a few long pages	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
68	The page contents and company name are adequately described by page title	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
PURCHASING PROCESS										
			7	6	5	4	3	2	1	
69	It is easy to register on the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
70	It is easy to change customer information	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
71	It is easy to login to the websites	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
72	It is easy to order products from the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
73	It is easy to change shopping cart content	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
74	Shopping cart's information is accurate	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
75	The content of the shopping cart is vividly displayed	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**

76	There is adequate information on how to order	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
77	There is adequate clarification as to payment options	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
78	The website adequately explained the process to cancel an order	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
79	The website adequately explained refund and return policy	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
80	It is easy to understand the terms and conditions	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
81	The explanations as to delivery times are adequate	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
82	The explanations as to delivery costs are adequate	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
83	The details about delivery areas are adequate	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
84	There is adequate clarity regarding delivery options	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
85	Options to deliver order/s to another address are available	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
86	There is adequate clarity regarding delivery problem/s (e.g. late delivery, non-delivery or wrong address)	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
87	Shopping customer received confirmation e-mails after order had been placed	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
88	Shopping customer received dispatch notification e-mail after order was dispatched	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
89	Online order tracking is supported by the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
90	Various ordering methods are available and supported by the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
91	Various payment methods are available and supported by the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
92	Various delivery methods are available and supported by the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
93	Secure socket layer is used by the website	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
94	The secured payment methods used are well recognised	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
95	There is adequate and clear information explaining and guaranteeing security	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**
96	There is adequate and clear information about privacy policy	**Strongly Agree**	☐	☐	☐	☐	☐	☐	☐	**Strongly Disagree**

Appendix 14: Research Ethics Certificate Issued by UNISA

UNISA college of science, engineering and technology

Dear Mr. Ariyo Sunday Ajibola (49133241)

Date: 2016-07-28

Application number: 024/ASA/2016/CSET_SOC

REQUEST FOR ETHICAL CLEARANCE: Usability Attributes and Evaluation Methods for Mobile E-Commerce (Humans involved)

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

Adele da Veiga

Dr. A Da Veiga
Chair: Ethics Sub-Committee School of Computing, CSET

Prof I. Osunmakinde
Director: School of Computing, CSET

Prof I. Alderton
Executive Dean (Acting): College of Science, Engineering and Technology (CSET)

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2016 -07- 29
Office of the Deputy Executive Dean
College of Science, Engineering & Technology

University of South Africa
College of Science, Engineering and Technology
The Science Campus
C/o Christiaan de Wet Road and Pioneer Avenue, Florida Park, Roodepoort
Private Bag X6, Florida, 1710
www.unisa.ac.za/cset

UNISA college of science, engineering and technology

Appendix 15: Informed Consent Form for Usability Test – Remote Asynchronous Usability Testing

Dear Sir / Madam,

My name is Sunday Ajibola and I am a PhD. student at the University of South Africa (UNISA). My research area is mobile E-commerce usability, which involves testing some mobile E-commerce sites. I am requesting your participation in this study.

The purpose of the study is to ascertain how easy the site is to use by you, the prospective customer, while trying to make a purchase. You will be asked to perform some simple tasks such as attempting to purchase a particular item, or product, and also to complete questionnaires.

Participation in this usability study is voluntary. All information will remain strictly confidential. The descriptions and findings may be used to help improve the website. However, at no time will your name or any other identification be used. You can withdraw your consent from this study, even after having signed this form.

Each participant in the remote asynchronous test will be compensated with the equivalent of N100 airtime of your respective service provider.

If you have any questions, please contact me at ajibolasunny@gmail.com or my supervisor – at xxx@unisa.ac.za.

Thank you

I have read and understand the information in this letter and all of my questions were answered.

____________________________ ________________

Participant's Signature Date

____________________________ ________________

Usability Researcher's Signature Date

Appendix 16: Informed Consent Form for Heuristic Evaluation

Dear Sir / Madam

My name is Sunday Ajibola and I am a PhD student at the University of South Africa (UNISA). My research area is mobile E-commerce usability, which involves the testing of some mobile E-commerce sites. I am requesting your participation in this study.

The purpose of the study is to test the ease of use of the site through newly developed domain-specific heuristics, and also to complete some questionnaires. All the necessary details for this experiment will be provided.

Participation in this usability study is voluntary. All information will remain strictly confidential. The descriptions and findings may be used to help improve the website. However, at no time will your name, or any other identification is used. You can withdraw your consent from this study even after having signed this form. You can choose to leave the study at any time.

Each expert evaluator in the heuristic evaluation will receive a $5 Amazon Gift Card.

If you have any questions, please contact me at ajibolasunny@gmail.com or my supervisor – at xxx@unisa.ac.za.

Thank you

I have read and understand the information in this letter and all my questions were answered.

Participant's Signature	Date
Usability Researcher's Signature	Date

Appendix 17: Post evaluation questionnaire

1	Please identify the site which appeared the most professional and indicate what had attracted you to its interface.
2	On which website is it the easiest to find items? Please give reasons for your choice.
3	On which website is it the easiest to order products? Please give a reason for your choice.
4	On which website is it the easiest to find help for editing the shopping cart or continuing shopping?
5	Of the websites, which do you find most trustworthy? Please give a reason for your choice.
6.	In terms of finding information linked to tasks, which site had the simplest route? Please give a reason for your choice.
7	In terms of changing customer information, which site was the easiest to use?

Appendix 18: Specific Usability Problems Discovered during Heuristic Evaluation

S/N	Heuristic Name	Usability Problem Descriptions
1	The home page should be easy to view at a glance	The top image seems to take up more space than needed. It is not balanced with the rest of the content. There was not an easy way to return to the home screen after advancing deeper into the product pages.
		User should be able to easily figure out that the site is for both buying and selling.
		‘Search for items’ contains too many steps, icon is only on the homepage - not a text entry form.
		Listing Icon in upper left is unclear … list most frequently used categories here perhaps…
		The words “sell, shop, smile” should be prominently displayed with ‘Kaymu’ site name and should not hidden.
2	Be aware of users’ fear of losing data	Difficult to create an account as USA was not listed as a country. When the evaluator selected a different country the phone number entered was not accepted as valid for the country selected.
		Sign up process did not indicate if all fields were required and did not specify what the password requirements were.
		Cannot buy an item without logging in - if user does not want to create an account this ends the opportunity for the product to be sold.
		Problem for vendors: Description of items is clipped off in category display. Enable vendors to name the item as first entry and to show size, range or price per unit.
3	Make ‘Add to Cart’ button visible on each product page	System crashed repeatedly when user attempted to drill down on a specific item without using the ‘Buy’ button.
		No ‘Add to Cart’ button in group displays. User has to drill down to individual item and then ‘Buy’ - user would prefer a “browse/compare” basket function before buying.
4	Be careful of including animated carousels	Home page has 3 rotating images - they are a little distracting and move too quickly. The text on the image is so small it is difficult to read.
		Homepage includes carousel which can apparently not be stopped and drilled down on it.
5	Be careful of adding images or product information on different sub-pages	The full-size product images are available but the close icon “X” did not appear. Only after the evaluator had tapped the image did it appear. This could confuse users.
		Sub-pages seem to display a single vendor’s items, when this was not a user’s selected request.
		A single vendor may offer all kinds of different items which will not fit a buyer’s requested product category.
		Recently viewed items should be delisted once items are in the shopping cart during the same session making it possible for the user to easily find item/s he/she had previously studied but not yet added to the cart.
6	Be careful as to the arrangement and design of account-selection options	Guest checkout is hidden - it was not clear that the user had to enter an e-mail to register. The evaluator presumes to enter e-mail and create a password but was not allowed to do so, except for existing users.
		System requires registration before user can buy. System log-in status is not readily apparent when not yet logged in or not yet subscribed/registered.
7	Ensure that the auto-correction of the dictionary is disabled when needed	Category selection from drop down menu should override search text entered.
		A search box could be available for category menu listings - more like a category look-up.
8	Ensure that fields are extensive enough to display common data in full (Add label at the top of the field)	Only after user had submitted information to sign up did he/she realise that he/she had miss-entered a phone number. From the verification code screen there was no way to return to the previous screen to correct the mistake. The user was stuck on the “Verify Code” screen. The only way to recover was to return to the home screen.

		When the user tapped the 'Forgot Password' link and entered an e-mail, not registered yet, the message displayed was not user friendly. Currently, it says "Failure! E-mail does not exist".
		Search box should be fully displayed to enable one to directly enter text information.
		Search box was not extensive enough to contain prompt: "Search for a product, category, or br". Brand Name was cut off in the search display.
9	Allow verification of inputted day, date and shopping details	Use of New labels on products for sale are ambiguous and should provide detailed date/time metadata when requested by users.
		Use of date may show when displaying allowable return date ("7 days" versus Return before September 20, 2016).
10	Ensure a clear distinction of each hit area and list item	Not all areas tapped responded in the same speed - this caused some confusion and the user tried tapping repeatedly.
		The website is not clear enough as the users basically assume that all items are clickable.
		Hit symbology area for slide display is non-functioning and ambiguous.
11	Ensure that users' privacy and security concerns are addressed	No evidence that the website is secure.
		Terms and conditions and privacy policy is not available prior to registration. Some problems concerning copyright for photograph content exist.
		The users wish to see questions and answers in simple, non-legal language.

Appendix 19: The asynchronous testing data and the identified problem areas and sub-areas, and the website's locations with corresponding test tasks

Usability Problems' Areas		Website 1	Website 2	Website 3	Website 4
The Main Area	**The Sub-Area**	**Identified Problems & Website's Location**	**Identified Problems & Website's Location**	**Identified Problems & Website's Location**	**Identified Problems & Website's Location**
Navigation	**Confusing webpage Links**	'checkout' link at any product's page. Task 2 'Buy now' link at add to Cart end page. Task 2	'Go' link at shipping page Task 2	'our services' link at website home page. Task 4	Whole Website - Register' and 'sign in' links at top menu. Task 3&4
		Whole Website - Register' and 'sign in' links at top menu. Task 3&4 Whole website ('advanced search' link). Task 4	'address book' link at my account page. Task 3	'our services' link at home page of the website Task 4	'address book' link at my account page. Task 3
	Unclear webpage links	Whole website (The link at 'shopping cart'). Task 3	Whole website (The link at the 'shopping cart'). Task 3 'Home page' link at order Preview page. Task 4	Any product's page ('complete order' and 'shopping basket' links). Task 2 Whole website (The link at 'shopping basket)'. Task 3 'online catalogue' link at the website's home page Task 4	Whole website ('shopping cart link'). Task 3
	Poor navigational supports	Order Preview webpage (no link to be directed to home page. Navigation from one webpage to others are difficult menus) Task 3&4	Not Available	Order webpage (no link to be directed to home page). Navigation from one webpage to others are via difficult menus Task 3 Shopping Cart webpage (no link to be directed to home page. Navigation from one webpage to others are difficult menus) Task 2&3	Not Available
Content	**Unsuitable content (Present of unsuitable auto-rotating carousels content)**	Shipping Information webpage (There were frequent displayed of misleading error message). Task 2&4	Not Available	There were products displayed that unavailable to be sold at online catalogue subsection Task 1&4 Website 'under construction' were displayed at search webpage Task1&4	Not Available
Design	**Confusing images**	Order Preview webpage (site's logo). Task 3	Not Available	Whole website (site's logo). Task 3	Not Available
	Unsuitable webpage design	Not Available	The website login webpage section (The 'current and new customer's fields'). Task 1,2&4	The products' descriptions at any product's webpage were not appropriate Address webpage ('shipping and billing' fields) Task 2.	Login page ('new and current customer' fields). Task 1,2&4

Appendix 19: Continued

Usability Problem Area	Usability Problem Sub-Area	Website 1	Website 2	Website 3	Website 4
		Identified Problems & Website's Location	Identified Problems & Website's Location	Identified Problems & Website's Location	Identified Problems & Website's Location
Architecture	**Structural problem**	Not Available	Not Available	Whole website Task 1,3&4	Whole website Task 3&4
Internal Search	**Wrong Results**	Whole website (product search) Task 4	Whole website (product search) Task 4	Not Available	Whole website (product search) Task 4
Purchasing Process	**Problem in completing some required fields**	(Shipping coupon field) The webpage at shipping coupon Task 2	The 'gift certificate code' at shipping webpage Task 2	Not Available	Not Available
	Problem in differentiating between fields (required and non-required)	Not Available	'password' field at login webpage. Task 2 some required fields at address webpage) Task 2	Personal Information page (some required fields) Task 2&3	Address page (some required fields) Task 2
	Problem in knowing the required web links to be tapped	Shopping Cart page ('update order' link) Task 3	Not Available	Shopping Cart page ('ok' link) Task 3	Not Available
	Sessional problems	Not Available	Not Available	Webpage at personal Information (users' information were missing) Task 3&4	Missing previous users' information Task 3&4
	Present of illogicality of the required fields	The local government area and state fields at registration webpage) Task 2	State and country fields at address webpage) Task 2	Not Available	Registration page ('state/LGA's field) Task 2
	Lack of required information when products are added to the cart	The end webpage at add to cart. Task 2&4	Not Available	Product webpage Task 2	The end webpage at add to car. Task 2&4
Customer service & accessibility	**Locating helpful information in customer support/ help section is difficult**	Whole website Task 3	Whole website Task 3	Whole website Task 3	Whole website Task 3
	The provided information via Customer Service/Help section are inappropriate	Not Available	Not Available	FAQ page Task 3	Not Available

Appendix 20: Results of Likert Scores (post-test questionnaire) and Mann-Whitney test for expert and novice participants in respect of the four selected websites

No.	Website 1			Website 2			Website 3			Website 4		
	Likert Score		Mann-Whitney Test (Two tailed) N1=10, N2=10	Likert Score		Mann-Whitney Test (Two tailed) N1=10, N2=10	Likert Score		Mann-Whitney Test (Two tailed) N1=10, N2=10)	Likert Score		Mann-Whitney Test (Two tailed) N1=10, N2=10
	Novice Users	Expert Users	Are expert and novice groups significantly different?	Novice Users	Expert Users	Are expert and novice groups significantly different?	Novice Users	Expert Users	Are expert and novice groups significantly different?	Novice Users	Expert Users	Are expert and novice groups significantly different?
Q1	**5.1**	**6.6**	(U = 18.500, p=.015) Yes	**4.5**	**5.8**	(U=22.500, p=.035) Yes	**3.1**	**2.8**	(U=48,500, p=.912) No	**5.7**	**6.3**	(U=34.500, p=.247) No
Q2	**5.6**	**6.6**	(U=24.000, p=.052) **No**	**5.7**	**6.3**	(U=34.500, p=.247) No	**2.6**	**2.6**	(U = 44.500, p=.684) No	**5.0**	**6.2**	(U = 26.500, p=.075) No
Q3	**5.7**	**6.5**	(U=27.000, p=.089) **No**	**5.0**	**6.2**	(U=26,500, p=.075) No	**N. A.**	**N. A.**	**N. A.**	**N. A.**	**N. A.**	**N. A.**
Q4	**5.2**	**6.5**	(U=20.500, p=.023) Yes	**4.9**	**6.1**	(U=28.500, p=.105) No	**3.7**	**2.0**	(U=27.500, p=.089 No	**4.5**	**5.8**	(U=22.500, p=.035) Yes
Q5	**5.9**	**6.1**	(U=45.000, p=.739) No	**5.4**	**5.8**	(U=43.500, p=.631) No	**4.4**	**3.9**	(U=41.000, p=.529) No	**5.7**	**6.5**	(U=27.000, p=.089) **No**
Q6	**4.9**	**5.7**	(U = 39.000, p=.436) No	**4.6**	**5.8**	(U = 33.500, p=.218) No	**3.8**	**2.9**	(U = 37.500, p=.353) No	**4.9**	**6.1**	(U = 28.500, p=.105) **No**
Q7	**4.3**	**5.6**	(U = 28.000, p=.105) No	**4.4**	**5.5**	(U = 29.500, p=.123) No	**4.2**	**3.4**	(U = 39.500, p=.436) **No**	**4.6**	**5.8**	(U = 33.500, p=.218) **No**
Q8	**5.5**	**6.6**	(U = 22.000, p=.035) Yes	**5.1**	**5.9**	(U = 32.500, p=.190) No	**3.4**	**2.0**	(U = 25.500, p=.063) **No**	**4.9**	**5.7**	(U = 39.000, p=.436) No
Q9	**5.9**	**5.4**	(U = 49.000, p=.971) No	**3.5**	**4.8**	(U = 31.500, p=.165) No	**2.7**	**2.4**	(U = 40.500, p=.481) No	**4.4**	**5.5**	(U = 29.500, p=.123 **No**
Q10	**4.9**	**6.3**	(U = 23.000, p=.043) Yes	**5.1**	**6.3**	(U = 29.000, p=.123) **No**	**4.1**	**3.3**	(U = 39.500, p=.436) No	**3.4**	**2.0**	(U = 25.500, p=.063) **No**
Q11	**5.2**	**6.4**	(U = 27.000, p=.089) **No**	**5.4**	**6.1**	(U = 35.500, p=.280) **No**	**N. A.**	**N. A.**	**N. A.**	**5.9**	**5.4**	(U = 49.000, p=.971) No
Q12	**5.6**	**6.5**	(U = 22.000, p=.035) Yes	**5.4**	**6.1**	(U = 37.500, p=.353) No	**N. A.**	**N. A.**	**N. A.**	**N. A.**	**N. A.**	N. A.
Q13	**5.4**	**5.9**	(U = 35.500, p=.280) No	**5.8**	**5.6**	(U = 37.500, p=.353) No	**N. A.**	**N. A.**	**N. A.**	**N. A.**	**N. A.**	**N. A.**

Appendix 20: Continued

No.	Website 1			Website 2			Website 3			Website 4		
	Likert Score		Mann-Whitney Test (Two tailed) N1=10, N2=10	Likert Score		Mann-Whitney Test (Two tailed) N1=10, N2=10	Likert Score		Mann-Whitney Test (Two tailed) N1=10, N2=10)	Likert Score		Mann-Whitney Test (Two tailed) N1=10, N2=10
	Novice Users	**Expert Users**	**Are expert and novice groups significantly different?**	**Novice Users**	**Expert Users**	**Are expert and novice groups significantly different?**	**Novice Users**	**Expert Users**	**Are expert and novice groups significantly different?**	**Novice Users**	**Expert Users**	**Are expert and novice groups significantly different?**
Q14	**4.5**	**5.8**	(U = 25.000, p=.063) No	**4.5**	**5.6**	(U = 32.000, p=.190) No	**3.9**	**3.1**	(U = 37.500, p=.353) **No**	**N. A.**	**N. A.**	**N. A.**
Q15	**3.4**	**3.1**	(U = 46.500, p=.796) No	**2.0**	**3.5**	(U = 26.500, p=.075) No				**5.4**	**5.9**	(U = 35.500, p=.280) No
Q16							**2.0**	**2.5**	(U = 40.500, p=.481) No	**5.4**	**6.1**	(U = 35.500, p=.280) No
Q17	**4.7**	**6.2**	(U = 26.500, p=.075) **No**	**3.9**	**4.8**	(U = 35.500, p=.280) No	**2.5**	**2.0**	(U = 40.500, p=.481) No	**2.0**	**3.5**	(U = 26.500, p=.075) No
Q19	**5.8**	**6.0**	(U = 49.500, p=.971) **No**	**5.6**	**5.2**	(U = 35.500, p=.280) **No**	**4.1**	**4.1**	(U = 49.500, p=.971) **No**	**3.4**	**3.1**	(U = 46.500, p=.796) **No**
Q20	**5.9**	**6.0**	(U = 44.500, p=.684) **No**	**5.8**	**5.2**	(U = 36.000, p=.315 **No**	**4.1**	**3.5**	(U = 40.500, p=.481) **No**	**4.5**	**5.6**	(U = 32.000, p=.190) **No**
Q21	**4.4**	**4.1**	(U = 47.500, p=.853) No	**5.7**	**4.8**	(U = 41.000, p=.529) No	**4.6**	**4.1**	(U = 46.000, p=.796) No	**3.9**	**4.8**	(U = 35.500, p=.280) No
Q22	**5.5**	**6.1**	(U = 47.000, p=.853) No	**4.4**	**5.6**	(U = 27.000, p=.089) No	**4.8**	**4.7**	(U = 43.500, p=.631) No	**4.7**	**6.2**	(U = 26.500, p=.075) No
Q23	**5.8**	**5.0**	(U = 40.000, p=.481) No	**4.7**	**5.5**	(U = 33.000, p=.218) No	**4.7**	**4.5**	(U = 49.500, p=.971) No	**5.8**	**5.2**	(U = 36.000, p=.315) No
Q24	**5.5**	**4.7**	(U = 45.500, p=.739) No	**4.5**	**4.6**	(U = 47.500, p=.853) No	**4.8**	**2.9**	(U = 25.500, p=.063) No	**5.9**	**6.0**	(U = 44.500, p=.684) No
Q25	**5.1**	**5.8**	(U = 34.500, p=.247) No	**4.0**	**4.7**	(U = 36.500, p=.315) No	**3.2**	**2.7**	(U = 41.500, p=.529) No	**5.7**	**4.8**	(U = 41.000, p=.529) No
Q26	**4.3**	**6.2**	(U = 18.000, p=.015) Yes	**4.3**	**5.2**	(U = 36.500, p=.315) No	**2.6**	**2.5**	(U = 50.000, p=1.000) No	**4.4**	**5.6**	(U = 27.000, p=.089) No
Q27	**5.2**	**5.3**	(U = 47.500, p=.853) No	**4.4**	**5.5**	(U = 36.500, p=.315) No	**3.1**	**3.4**	(U = 46.500, p=.796) No	**5.5**	**6.1**	(U = 47.000, p=.853) No
Q28	**4.5**	**5.6**	(U = 30.500, p=.143) No	**4.8**	**4.9**	(U = 49.500, p=.971) No	**3.5**	**2.0**	(U = 26.500, p=.075) No	**4.7**	**5.5**	(U = 33.000, p=.218) No

Q29	**5.7**	**5.9**	(U = 46.000, p=.796) No	**5.7**	**5.3**	(U = 43.500, p=.631) No	**5.2**	**5.0**	(U = 48.500, p=.912) No	**5.8**	**5.0**	(U = 40.000, p=.48) No
Q30	**5.5**	**4.9**	(U = 42.500, p=.579) No	**5.0**	**5.2**	(U = 47.500, p=.853) No	**5.0**	**3.7**	(U = 34.000, p=.247) No	**4.7**	**4.5**	(U = 49.500, p=.971) No
Q31	**5.5**	**5.3**	(U = 47.000, p=.853) No	**5.3**	**5.1**	(U = 45.500, p=.739. No	**4.6**	**3.4**	(U = 32.000, p=.190) No	**4.0**	**4.7**	(U = 36.500, p=.315) No

Appendix 21: Post-Test Questionnaire's Likert Scores and the Friedman Test's Results in Relation to the Four Selected Websites

No.	Post-Test Questionnaire's Statements	Websites' Likert Score				Friedman Test
		Site Number 1	**Site Number 2**	**Site Number 3**	**Site Number 4**	**Was the four selected websites statistically significant difference? (N=20)**
Architecture and Navigation						
Q1	Acquiring information connected to tasks is	**5.85**	**5.00**	**2.95**	**5.15**	X^2 (2) = 30.714, p=.000 **Yes**
Q2	Locating the product I wish to buy is	**6.10**	**5.65**	**2.60**	**6.00**	X^2 (2) = 34.125, p=.000 **Yes**
Q3	Making use of the site's internal search facility is	**6.10**	**5.00**	**N. A.**	**5.60**	**N. A.**
Q8	The information is adequately organised on the website	**6.05**	**6.00**	**2.70**	**5.50**	X^2 (2) = 35.273, p=.000 **Yes**
Q9	It was hard to move around the site without becoming confused	**5.65**	**5.30**	**2.55**	**4.15**	X^2 (2) = 25.015, p=.000 **Yes**
Q10	A helpful content can be found easily (table of contents)	**5.60**	**5.60**	**3.70**	**5.70**	X^2 (2) = 31.355, p=.000 **Yes**
Q11	The results were promptly displayed from the search function	**5.80**	**5.50**	**N. A.**	**5.75**	**N. A.**
Q12	Accurate results were displayed from the search function	**6.05**	**5.20**	**N. A.**	**5.75**	**N. A.**
Q13	Inaccurate results were displayed from internal search function	**5.65**	**5.45**	**N. A.**	**5.70**	**N. A.**
Q21	From any of the site's pages, it was a challenge to return to its home page	**4.25**	**4.10**	**4.35**	**5.25**	X^2 (2) = 17.644, p=.000 **Yes**
Q24	Small number of links failed to work	**5.10**	**4.25**	**3.85**	**4.55**	X^2 (2) = 15.796, p=.000 **Yes**
Content						
Q14	To help me complete the buying tasks, the website detail information is	**5.15**	**4.60**	**3.50**	**5.05**	X^2 (2) = 22.172, p=.000 **Yes**
Q27	The terms they used throughout the site were easy to understand	**5.25**	**4.50**	**3.25**	**5.05**	X^2 (2) = 22.116, p=.000 **Yes**
Design						
Q19	The interface of this site was good	**5.90**	**5.00**	**4.10**	**5.40**	X^2 (2) = 31.115, p=.000 **Yes**
Q20	This website's interface was attractive and pleasant	**5.95**	**5.10**	**3.80**	**5.50**	X^2 (2) = 33.323, p=.000 **Yes**
Q22	The website employed a suitable colour choice	**5.80**	**4.75**	**4.75**	**5.00**	X^2 (2) = 18.473, p=.000 **Yes**
Q23	The site was easy to read, because of the text's size	**5.40**	**5.00**	**4.60**	**5.10**	X^2 (2) = 12.792, p=.002 **Yes**
Q25	The pages on the site were clear and easy to find	**5.45**	**4.80**	**2.95**	**5.25**	X^2 (2) = 29.285, p=.000 **Yes**
Purchasing Process						
Q4	Website's registration process	**5.85**	**5.10**	N. A.	**5.50**	**N. A.**
Q5	Buying one of the items	**6.00**	**5.20**	**4.15**	**5.60**	X^2 (2) = 30.632, p=.000 **Yes**
Q6	Flexibility of the site to allow change to customer information	**4.95**	**4.75**	**3.35**	**4.95**	X^2 (2) = 9.033, p=.011 **Yes**
Q7	Adding, or removing, items from shopping carts	**5.30**	**5.00**	**3.80**	**5.20**	X^2 (2) = 24.824, p=.000 **Yes**

Q15	It was convenient to use the compulsory registration on the site	**3.25**	**2.85**	**N. A.**	**2.75**	**N. A.**
Q16	I prefer completing registration before buying any item on the website	**N. A.**	**N. A.**	**2.25**	**N. A.**	**N. A.**
Q29	I am more confident when companies give assurance as to the security of my personal information	**5.80**	**5.50**	**5.10**	**5.50**	X^2 (2) = 14.176, p=.001 **Yes**
Q30	I am confident that whenever I buy an item from the website that my private information is secure	**5.20**	**5.20**	**4.35**	**5.10**	X^2 (2) = 14.245, p=.001 **Yes**
Q31	I feel that I can confidently buy from this website	**5.40**	**5.00**	**4.00**	**5.20**	X^2 (2) = 26.655, p=.000 **Yes**
The Overall Evaluation of the Websites						
Q17	The expected capabilities and functions were present on the site	**5.45**	**4.37**	**2.25**	**4.35**	X^2 (2) = 37.014, p=.000 **Yes**
Q26	I found it easy to use the site	**5.25**	**4.25**	**2.55**	**4.75**	X^2 (2) = 25.401, p=.000 **Yes**
Q28	I am willing to recommend this website to my friends	**5.04**	**4.75**	**2.76**	**4.85**	X^2 (2) = 28.212, p=.000 **Yes**

Appendix 22: The identified usability problem areas from the post-test questionnaires - the qualitative data

Usability Problems		Usability Problems' Locations			
Main Areas	Sub-Areas	Website 1	Website 2	Website 3	Website 4
Navigation	**Confusing webpage Links**	Whole website - The 'register' and 'sign in' links at the top menu	Not Available	Not Available	Not Available
Navigation	**Unclear webpage links**	Not Available	The following webpages at the home page have problems: Shopping Cart page, Login page, Address page, payment and shipping page and Order Preview page	Not Available	Not Available
Navigation	**Poor navigational support**	Order Preview Webpage (No webpage links or navigational menus to the home page, amongst others)	Whole Website (While ordering item, left main menu failed to display on some webpages)	Not Available	Not Available
Navigation	**Orphan webpage links**	Not Available	Not Available	Webpage of online catalogue subsection and banner related links at search results webpage. Home page.	Online Catalogue Subsection Search Results page.
Navigation	**Dead-end webpage**	Not Available	Not Available	Very large products' image view at product image webpage.	Not Available
Content	**Unsuitable Content (unsuitable auto-rotating carousel content)**	Not Available	Not Available	Whole Website Many webpages have no precise content and repetitive. Carousels	Not Available
Content	**Incomplete Information**	'Out of stock' was displayed for product/s on products page	'Out of stock' was displayed for product/s on products page	Not Available	Out of stock was displayed for product on products page
Content	**Lack of products' information**	(Availability Problem) Most product's webpage	(Availability Problem) Most product's webpage	(Availability Problem). Most product's webpage	(Availability Problem). Most product's webpage
Design	**Unsuitable webpage design**	Entire product's category webpages (long pages with large number of images). Large number of product images, which make the webpage too long	Any product's page (inappropriate presentation of product's description)	Not Available	Not Available
Design	**Choice of unsuitable colours and fonts**	Not Available	Not Available	Whole website Font colour and size are not good. Links and background colour combination are not appropriate. The webpage contained small font size	Not Available
Architecture	**Structural problem**	Not Available	Not Available	Whole Website	Whole Website
Internal Search	**Wrong results**	Whole Website (product search)	Whole Website (product search)	Whole Website (product search)	Whole Website (product search)
Internal Search	**Restricted Options**	Not Available	Not Available	Whole Website (advanced and product search)	Whole Website (product search)

Appendix 22: Continued

Usability Problems		Usability Problems' Locations			
Main Areas	Sub-Areas	Website 1	Website 2	Website 3	Website 4
Purchasing (Checkout) Process	**Problem in differentiating between fields (required and non-required)**	Not Available	Login page ('password' field) Some required fields at address webpage	Some required fields at personal Information webpage	Not Available
	Lengthy ordering process	Checkout webpage at 'Add to Cart' webpage	Not Available	Not Available	Not Available
	Sessional problem	Not Available	Not Available	The website failed to 'remember customer' information at personal information webpage	Not Available
Customer service and Accessibility	**Supported only one language**	Not Available	Whole Website	Whole Website	Whole Website
Inconsistency	**Inaccurate layout/design/content**	Not Available	Not Available	Whole website (website contents are not responsive across all devices)	Not Available
Missing Capabilities	**Incomplete website capabilities/ functionalities**	Not Available	Not Available	The site did not have internal search	Not Available

Appendix 23: The Results of Heuristic Evaluation in Respect of the Identified Usability Problems and their Respective Website's Locations

Problem Area	**Problem Sub-Area**	**Usability Problems' Locations**			
		Website number 1	**Website number 2**	**Website number 3**	**Website number 4**
Navigation	**Confusing webpage links**	I. Buy now link; add to Cart II. Checkout link; any product's page III. Link tagged guaranteed sub-menu at home page IV. Register link and sign in links at top menu	I. Help link (Customer Service page) II. Whole website - customer service link at top Menu III. Whole website – Help link at bottom menu	I. Training link (More details link) at website home page II. Whole website - Message board message at left menu III. Whole website - Business support at left menu IV. Whole website - Quick search at left menu V. Whole website - Training Menu	I. Register link and sign in links at top menu II. Whole website - Quick search at left menu III. Whole website - customer service link at top Menu
	Unclear webpage links	Whole website at 'shopping cart link'	I. Address book link at my account webpage II. Home webpage link - Order Preview webpage III. The following have problem (Address webpage, Live chat web link and payment and shipping webpage Shopping cart webpage)	I. Complete order link at any product's page II. Shopping basket link at any product's page III. Whole website: The website links are not noticeable in which the font size and colour were the same. Click here for more information links on customer service and 'our membership' on our service page. IV. Online Catalogue link at website home page	Home webpage link - Order Preview webpage The following have problem (Address webpage, Live chat web link and payment and shipping webpage Shopping cart webpage)
	Poor Navigational support	No navigational menus in 'order preview' page to the home page and to other page	The left main menu was not available at some other webpages while performing ordering process	Whole website - Navigational menus for the following webpages were not available on the website: order page, payment and shipping page, and shopping page. Links to the home page were not available	Whole website - Navigational menus for the left main menu while adding to cart were not available
	Orphan webpage Links	Not Available	Not Available	I. A link on tell a friend at home page II. 'Contact us' page at home page	Not Available
	Dead-end webpages	Not Available	Not Available	I. Any product webpage with large size II. Favourite links webpage III. Glass and wood products webpages	Not Available

Appendix 23: Continued

Problem Areas	Problem Sub-areas	Usability Problems' Locations			
		Website 1	**Website 2**	**Website 3**	**Website 4**
Content	**Unsuitable content (unsuitable auto-rotating carousel content)**	The website frequently displayed misleading error message at shipping information webpage. Presence of unsuitable auto-rotating carousels content.	Help page (under construction page). Presence of unsuitable auto-rotating carousels content	I. Home page - The website was unable to display relevant information in respect of its major purpose II. Unavailable products were displayed at online catalogue sub-section III. Related Links page (web hosting reviews, blog, Add URL-free.com, web directory, art directory, free dictionary links) IV. Customers were not allowed to add feedback at testimonial webpage V. Presence of unsuitable auto-rotating carousels content	Whole website (many webpages had repetitive/ unprecise content) such as: "our services" webpages and "Home webpage" Presence of unsuitable auto-rotating carousels content
	Incomplete information	'Out of stock' for products was displayed in many products' webpage	'Out of stock' for product were displayed in many products' webpage	Ladies ware and household items (inaccurate product descriptions)	'Out of stock' for product were displayed in many products' webpage
	Present of grammatical errors	Home Page - Guaranteed Sub-menu	Whole website - Left Menu	Not Available	Bottom home page- Guaranteed sub-menu
	Lack of company's information	Not Available	About us page	About us page	Not Available
	Lack of products' information	Some product's page: their availability, fabric type, products length was missing and some products had large images and one size	Some product's page: their availability, fabric type, products lengths, widths were missing and some products had duplicated images	Some product's page: their availability, fabric type, products length was missing and some products had large images and no size guide	Any product's page: Displaying repetitive product images

Appendix 23: Continued

Problem Areas	Problem Sub-areas	Usability Problems' Locations			
		Website 1	**Website 2**	**Website 3**	**Website 4**
Design	**Confusing images**	I. Whole website - Live support image at live support sub-section is confusing II. Whole website - Debit card images at Guaranteed sub-menu is confusing	Whole website - Bottom Menu (credit card images)	Whole website (The program webpage images, website's logo and news webpage are confusing)	Website's logo on the 'add to cart' page is not appropriate Website's logo at order preview webpage is confusing
	Unsuitable webpage design	Unsuitable heading for shipping information webpage	Any product's page (unsuitable presentation of product's descriptions)	The content on the home webpage is clustered Whole website (Whenever users scrolled down, the left and top navigational menu disappeared).	Disordered content at home webpage. The products' images are too large with long webpages at product category webpages.
		The privacy policy webpage is too long. Some products are located at the bottom of the webpage and the most/best sellers' webpage appeared at bottom webpage	Privacy Policy webpage (long pages)	Very long webpage and clustered content at 'our service' webpage The terms and conditions on the webpage is too lengthy	Privacy policy is far at the bottom of the webpage and the webpage is too lengthy The shipping method and other preview webpages have inappropriate headings
	Poor aesthetic design	Whole website	Whole website	Whole website	Whole website
	Unsuitable image quality	Not Available	Not Available	Whole website (logo image, all images of the products)	Not Available
	Lack of alternative text	Not Available	Not Available	Whole website	Most Selling webpage. New arrival webpage
	Fragmented images	Not Available	Not Available	Banner - Online catalogue sub-section Some product webpages and online catalogue sub-sections have fragmented images	Not Available

Appendix 23: Continued

Problem Area	Problem Sub-Area	Usability Problems' Locations			
		Website number 1	Website number 2	Website number 3	Website number 4
Design	**Unsuitable colours and font choices**	Whole website - The links and background colour combination at guaranteed sub-menu are unsuitable	Whole website - The links and background colour combination at bottom menu are unsuitable The link colours at products category webpage are too dull Whole website - The menus font sizes and text are small and dull	Whole website - The font styles are not appropriate. The use of the bold style in some webpage paragraphs is not suitable	Whole website - The links and background colour combinations at guaranteed sub-menu are unsuitable The links and colour of the text are the same
	Unsuitable webpage titles	Whole website	Whole website	Whole website	Whole website

Appendix 23: Continued

Problem Areas	Problem Sub-areas	Usability Problems' Locations			
		1st Website	2nd Website	3rd Website	4th Website
Architecture	**Structural problem**	Not Available	Not Available	Whole website	Not Available
	Menu items' order not logical	Not Available	Whole website - Bottom Menu	Whole website - Main Left Menu	Whole website - Bottom Menu.
	Menu items' grouping not logical	Not Available	Not Available	Whole website - Main Left Menu	Not Available
Internal Search	**Inaccurate Results**	Whole website (product search)	Whole website (product search)	Whole website (Online Catalogue Subsection Search).	Whole website (product search).
	Restricted options	Whole website (advanced and products search)	Whole website (advanced and products search)	Not Available	Whole website (Advanced and products search)
	Search position not clearly visible	Whole website (product and advanced search)	Not Available	Not Available	Not Available
Security and Privacy	**Customers' fear about privacy and security**	Not Available	Privacy statement omitted	Privacy statement omitted and security guarantee policies in the website	Privacy statement omitted
Inconsistency	**Inaccurate content/layout/ design/**	Whole website (position of the navigation menu)	The customer service and bottom webpages are not consistent as well as items at left main menu The Wish List, Address Book and Order History webpages are not aligned Whole website - The left main menu links and navigational menu position are inaccurate	Whole website - The font styles, font colours, webpage layout, sentence format, products webpages, products image size, and content between heading webpage and navigational menu are not consistent	Whole website (position of the navigation menu)

Appendix 23: Continued

Problem Areas	Problem Sub-areas	Usability Problems' Locations			
		Website 1	**Website 2**	**Website 3**	**Website 4**
Purchasing Process	**Problem in completing some required fields**	Not Available	The gift code fields in the shipping webpage	Not Available	Not Available
	Lengthy ordering process	'Checkout' webpage and 'Add to Cart' webpage	Not Available	Not Available	Not Available
	Sessional Problems	Not Available	Not Available	The webpage - relating to personal information (the website failed to 'remember' customers' information)	Not Available
	Difficulty to log into customer's account	Whole website	Not Available	Not Available	Not Available
	No confirmation is displayed when users delete shopping cart item	Webpage in the 'Shopping cart'	Webpage in the 'Shopping cart'	Webpage in the 'Shopping cart'	Webpage in the 'Shopping cart'
	Lengthy webpage registration	The webpage in the registration process	Not Available	Not Available	Not Available
	Illogicality of the required fields	State and town address fields in the registration page	State and town address fields in the address page	Not Available	State and town address fields in the address page
Accessibility and Customer Service	**Locating the website from search engines is difficult**	Not Available	Whole website	Whole website	Whole website
	Supported only one language	Whole website	Whole website	Not Available	Whole website
	Supported only one currency	Whole website	Whole website	Whole website	Whole website
	The provided information via Customer Service/Help section is inappropriate	FAQ page	Not Available	FAQ page	Help page
	Customers' comments not supported	Not Available	Whole website	Whole website	Whole website
	Locating helpful information in customer support/ help section is difficult	Not Available	Whole website	Not Available	Whole website

Appendix 23: Continued

<table>
<tr><th rowspan="2">Problem Areas</th><th rowspan="2">Problem Sub-areas</th><th colspan="4">Usability Problems' Locations</th></tr>
<tr><th>Site 1</th><th>Site 2</th><th>Site 3</th><th>Site 4</th></tr>
<tr><td>Missing Functions</td><td>Incomplete website capabilities/ functionalities</td><td>The website has no links to external resources and website map

The website failed to include shopping cart information while navigating

Delivery time was not at the order preview webpage, delivery time not stated on the website</td><td>The website has no links to external resources and website map

The precise time to deliver the products are omitted in the order webpage.

Information about delivery problems are not available on the website</td><td>No other ordering method present in the website

No additional payment methods option present in the website

No other delivery method option present in the website

Information about delivery problems are not available on the website

Products' delivery information was not available

Detail information about ordering products is not available</td><td>There is no presence of flexible delivery method in the website (Possibility to deliver to alternative address is not allowed)

There is no presence of another delivery method in the website

There is no presence of another ordering method in the website</td></tr>
</table>

Appendix 24: Heuristic checklist's statements and the identified problem areas and sub-areas

Usability Problem areas	Usability Problem Sub-areas	Statement Number in the Heuristic Checklist	Websites' Likert Scores			
			Website 1	Website 2	Website 3	Website 4
Navigation	Poor Navigational support	8	N. A.	N. A.	2.60	N. A.
		10	N. A.	3.20	3.00	3.00
Internal Search	Wrong results	12	3.00	3.80	N. A.	3.60
Content	Unsuitable content. Unsuitable auto-rotating carousel content.	25	N. A.	N. A.	1.60	N. A.
		27	N. A.	3.20	1.00	3.00
		29	N. A.		3.20	N. A.
	Incomplete information	31	3.20	3.60	3.40	3.40
	Lack of company's information	33	N. A.	3.40	3.20	3.60
	Lack of products' information	35	N. A.	N. A.	3.00	N. A.
		36	2.40	2.20	1.20	2.00
Design	Unsuitable webpage design	18	N. A.	N. A.	1.80	N. A.
		59	3.00	N. A.	N. A.	N. A.
		67	3.20	N. A.	N. A.	N. A.
	Unsuitable webpage titles	68	3.60	3.20	3.40	3.40
	Poor aesthetic design	54	N. A.	N. A.	1.40	N. A.
	Unsuitable images' quality	55	N. A.	N. A.	3.60	N. A.
	Lack of alternative text	58	N. A.	N. A.	3.80	N. A.
Architecture	Structural problem	9	N. A.	N. A.	3.00	N. A.
		19	N. A.	N. A.	2.80	N. A.
		20	N. A.	N. A.	3.00	N. A.
		21	N. A.	N. A.	1.80	N. A.
		22	N. A.	N. A.	2.60	N. A.
	Menu items - order not logical	23	N. A.	N. A.	3.40	N. A.
	Menu items - grouping not logical	24	N. A.	N. A.	2.00	N. A.
Security and Privacy	Customers' fear about privacy and security	95	N. A.	N. A.	3.20	N. A.
		96	N. A.	N. A.	3.40	N. A.
Accessibility and Customer Service	Locating the website from search engines is difficult	38	N. A.	N. A.	2.20	N. A.
	The provided information via Customer Service/Help section are inappropriate	42	2.60	N. A.	3.20	N. A.
	Customers' comments not supported	44	N. A.	2.60	2.20	3.00
	Locating helpful information in customer support/ help section is difficult	45	N. A.	3.0	N. A.	3.40
		46	N. A.	2.80	N. A.	3.40
		47	N. A.	3.40	N. A.	3.80
		48	N. A.	2.60	N. A.	3.00
	Supported only one language	52	1.00	1.00	N. A.	1.00
	Supported only one currency	53	2.40	2.40	2.20	2.0

Appendix 24: Continued

Usability Problem areas	Usability Problem Sub-areas	Statement Number in the Heuristic Checklist	Websites' Likert Scores			
			Website 1	Website 2	Website 3	Website 4
Inconsistency	Inaccurate layout/design/content	1	N. A.	2.80	2.80	3.60
		2	N. A.	N. A.	3.60	N. A.
		3	N. A.	N. A.	3.40	N. A.
		4	N. A.	N. A.	2.60	N. A.
		6	N. A.	N. A.	3.20	N. A.
		7	N. A.	N. A.	2.40	N. A.
Missed Capabilities	Incomplete website capabilities/ functionalities	16	1.60	1.60	N. A.	1.40
		76	3.60	N. A.	3.20	N. A.
		78	N. A.	N. A.	3.80	N. A.
		85	2.40	N. A.	N. A.	N. A.
		86	N. A.	3.40	3.60	3.60
		90	3.00	N. A.	N. A.	N. A.
		92	2.80	N. A.	3.20	N. A.

Appendix 25: Heuristic checklist's Likert scores and the Friedman test's results for the four selected websites

No.	Heuristic Checklist's Statements	Checklist Likert Scores				Results (Friedman Test)
		Website 1	Website 2	Website 3	Website 4	Was the four selected websites statistically significant difference? (N=5)
	Architecture and Navigation					
1	There is consistency in the page layout	6.40	3.40	2.80	3.60	$X^2 (2) = 9.333$, p=.009 Yes
2	There is consistency in text justification	6.40	5.00	3.60	5.40	$X^2 (2) = 9.500$, p=.009 Yes
3	There is consistency in the font use	6.80	5.80	3.40	6.00	$X^2 (2) = 9.294$, p=.010 Yes
4	There is consistency in the colours	6.60	6.00	2.60	6.40	$X^2 (2) = 9.500$, p=.009 Yes
5	Standard link colours were used by the websites	6.00	4.00	2.80	3.60	$X^2 (2) = 7.600$, p=.022 Yes
6	There is consistency in the terms/terminologies	5.20	4.80	3.20	5.20	$X^2 (2) = 4.625$, p=.099 No
7	There is consistency in contents among all language interfaces	N. A	N. A	2.40	N. A.	N. A
8	It is easier to navigate in the website	6.20	5.80	2.60	6.00	$X^2 (2) = 9.500$, p=.009 Yes
9	Finding information about the tasks are easier	5.80	5.40	3.00	5.80	$X^2 (2) = 8.824$, p=.012 Yes
10	The locations of the table of contents or navigation bar, site map and index are suitable	5.40	3.20	3.00	3.00	$X^2 (2) = 6.421$, p=.040 Yes
11	Using internal search is good with regards to response time	6.40	6.00	N. A	6.40	N. A
12	Internal search results are helpful and appropriate	3.00	3.40	N. A	3.60	N. A
13	The website links are clear/noticeable	6.20	5.80	4.20	6.00	$X^2 (2) = 7.538$, p=.023 Yes
14	The website broken links are few	5.60	5.20	4.20	5.40	$X^2 (2) = 3.000$, p=.223 No
15	The page names and the link names are the same	5.80	4.60	4.40	4.40	$X^2 (2) = 10.000$, p=.007 Yes
16	The external resources have appropriate number of links	1.60	1.60	4.00	1.60	$X^2 (2) = 6.857$, p=.032 Yes
17	Returning to home page is easy and clear from any website sub-page	4.00	6.00	4.60	6.40	$X^2 (2) = 6.615$, p=.037 Yes
18	The position of each page within the website are clear	4.80	5.60	1.80	5.20	$X^2 (2) = 9.294$, p=.010 Yes
19	The structure of the website is straightforward and simple	6.00	6.00	2.80	6.20	$X^2 (2) = 7.538$, p=.023 Yes
20	There is a group of related information on the website	5.60	4.80	3.00	5.40	$X^2 (2) = 6.632$, p=.036 Yes
21	The products categorisation is good and helpful	6.00	5.40	1.80	6.00	$X^2 (2) = 7.895$, p=.019 Yes
22	Small number of clicks are required to reach destination page	5.60	5.60	2.60	5.40	$X^2 (2) = 7.176$, p=.028 Yes
23	Navigating menu is straightforward and simple	6.20	5.80	3.40	6.20	$X^2 (2) = 10.000$, p=.007 Yes
24	Logical arrangement of menu choices	6.00	5.40	2.00	6.00	$X^2 (2) = 9.294$, p=.010 Yes

	Content					
25	The website contains current and up-to-date information	5.60	3.60	1.60	4.20	X^2 (2) = 9.579 *p*=.008 Yes
26	Last updated date is clearly displayed	2.20	3.00	1.00	2.40	X^2 (2) = 3.714, *p*=.156 No
27	New information is clearly and visibly displayed	6.00	2.40	1.00	3.00	X^2 (2) = 9.333 *p*=.009 Yes
28	Terms and terminologies are simple and easy to understand	6.40	5.60	4.80	6.40	X^2 (2) = 6.857 *p*=.032 Yes
29	The contents are concise	6.20	5.80	3.20	6.00	X^2 (2) = 9.500 *p*=.009 Yes
30	The number of pages “under construction” are few	4.40	4.40	4.40	4.60	X^2 (2) = .143, *p*=.931 No
31	There is accurate and precise information	3.20	3.20	3.40	3.40	X^2 (2) = .154, *p*=.926 No
32	There are no grammatical errors in the contents	4.20	4.20	4.20	4.0	X^2 (2) = .118, *p*=.943 No
33	The company suitable information is displayed	6.20	4.20	3.20	3.60	X^2 (2) = 8.316 *p*=.016 Yes
34	The descriptions of each product is accurate	6.40	5.60	4.00	6.20	X^2 (2) = 9.500 *p*=.009 Yes
35	The product photographs are displayed adequately	6.20	6.20	3.00	6.40	X^2 (2) = 8.824 *p*=.012 Yes
36	The status (e.g. out of stock, available or in stock) of each product is adequately displayed	2.40	2.40	1.20	2.00	X^2 (2) = 3.714, *p*=.156 No
37	The prices of the products are adequately shown	5.40	6.20	5.20	6.60	X^2 (2) = 4.769, *p*=.092 No
	Customer Service and **Accessibility**					
38	It is easy to use search engines to access the website	6.00	3.60	2.20	4.40	X^2 (2) = 10.000 *p*=.007 Yes
39	The website name is domain-related	6.20	6.60	6.40	7.00	X^2 (2) = 4.667, *p*=.097 No
40	To remember the URL is easy and not complex	6.80	6.80	6.60	6.60	X^2 (2) = 1.000, *p*=.607 No
41	Pages download quickly	5.40	6.20	5.40	6.60	X^2 (2) = 7.412, *p*=.025 Yes
42	The contents of FAQs are adequate and helpful	2.60	5.40	3.20	5.20	X^2 (2) = 8.316, *p*=.016 Yes
43	The ‘Contact Us’ information is clearly displayed (e.g. fax and telephone numbers, physical address and name)	6.40	6.20	6.20	6.40	X^2 (2) = 2.000, *p*=.368 No
44	Customers are allowed to send comments on the website	7.00	3.60	2.20	3.00	X^2 (2) = 9.500, *p*=.009 Yes
45	It is easy to locate customer service/help on the website	6.60	2.60	N. A.	3.40	N. A.
46	The layout of help/customer service on the website is clear and distinct	6.00	2.60	N. A.	3.40	N. A.
47	It is easy to search for customer service/help	6.00	3.40	N. A.	3.80	N. A.
48	It is easy to navigate to customer service/help	6.20	3.40	N. A.	3.00	N. A.
49	The help/customer service contained adequate information	5.40	5.40	N. A.	5.20	N. A.
50	The website is compatible with various internet browsers	6.60	5.40	5.20	6.20	X^2 (2) = 6.615, *p*=.037 Yes
51	The website is compatible with various screen resolutions	6.40	6.40	5.00	6.20	X^2 (2) = 6.533, *p*=.038 Yes

52	Different foreign languages are supported by the website	1.00	1.20	6.20	1.00	X^2 (2) = 10.000, *p*=.007 Yes
53	Appropriate currencies are supported by the website	2.40	2.40	2.20	2.00	X^2 (2) = 3.713, *p*=.156 No
	Design					
54	The website is appealing, good-looking and aesthetic	4.20	3.40	1.40	4.00	X^2 (2) = 7.176, *p*=.028 Yes
55	The displayed images are of an adequate quality	6.00	6.00	3.60	6.40	X^2 (2) = 9.294, *p*=.010 Yes
56	The number of broken images are few	4.60	5.00	4.40	4.60	X^2 (2) = .125, *p*=.939 No
57	The help and the contents of the websites are related to the images	6.60	5.40	5.20	5.20	X^2 (2) = 4.667, *p*=.097 No
58	Most images contained alternative text	4.40	5.40	3.80	5.80	X^2 (2) = 7.000, *p*=.030 Yes
59	The effect of the image size on loading time is minimal	3.00	6.40	6.00	6.80	X^2 (2) = 9.333, *p*=.009 Yes
60	It is easy to read the fonts	6.60	6.40	5.00	6.00	X^2 (2) = 7.600, *p*=.022 Yes
61	The colours of the selected fonts are good	6.40	6.00	4.00	5.40	X^2 (2) = 7.429, *p*=.024 Yes
62	The website contained suitable background colours	6.20	5.40	5.20	5.80	X^2 (2) = 5.000, *p*=.082 No
63	The selected fonts and background colours have suitable combination	6.20	5.40	4.40	4.20	X^2 (2) = 6.632, *p*=.036 Yes
64	The websites contained uncluttered pages	6.40	5.80	4.80	6.20	X^2 (2) = 9.500, *p*=.009 Yes
65	The website contained clear headings	5.80	5.00	4.00	5.40	X^2 (2) = 5.778, *p*=.056 No
66	There is sufficient or suitable page margins	6.40	6.20	4.20	6.40	X^2 (2) = 6.857, *p*=.032 Yes
67	Scrolling is only required for a few long pages	3.20	5.40	4.40	5.80	X^2 (2) = 7.053, *p*=.029 Yes
68	The page contents and company name are adequately described by page title	3.60	3.20	3.40	3.40	X^2 (2) = 1.000, *p*=.607 No
	Purchasing Process					
69	It is easy to register on the website	4.40	6.00	N. A.	6.40	N. A.
70	It is easy to change customer information	4.60	6.20	1.60	6.60	X^2 (2) = 9.579, *p*=.008 Yes
71	It is not hard to log into the websites	4.40	6.20	N. A.	6.80	N. A.
72	It is easy to order products from the website	2.80	6.20	2.00	6.60	X^2 (2) = 9.294, *p*=.010 Yes
73	It is easy to change shopping cart content	5.40	5.80	2.40	6.60	X^2 (2) = 9.333, *p*=.009 Yes
74	Shopping cart's information is accurate and good	6.20	6.40	4.00	6.20	X^2 (2) = 6.533, *p*=.038 Yes
75	The content of the shopping cart is vividly displayed	6.60	6.40	4.40	6.80	X^2 (2) = 7.538, *p*=.023 Yes
76	There is adequate information on how to order	3.60	4.80	3.20	5.00	X^2 (2) = 7.176, *p*=.028 Yes
77	There is adequate clarification of payment options	6.00	5.40	5.00	5.80	X^2 (2) = 3.800, *p*=.150 No
78	The website adequately explained the process of cancelling an order	4.80	4.40	3.80	4.00	X^2 (2) = 2.667, *p*=.264 No
79	The website adequately explained refund and return policy	6.40	6.20	4.00	5.80	X^2 (2) = 6.000, *p*=.050 No

80	It is easy to understand the terms and conditions	5.60	5.40	4.20	5.20	X^2 (2) = 2.286, p=.319 No
81	The explanations on delivery time are adequate	6.60	6.00	4.00	5.00	X^2 (2) = 7.429, p=.024 Yes
82	The explanations about delivery costs are adequate	6.20	4.80	4.40	5.20	X^2 (2) = 5.636, p=.060 No
83	The details about delivery areas are adequate	5.60	5.20	4.60	4.60	X^2 (2) = 4.667, p=.097 No
84	There is adequate and clear information regarding delivery options	4.00	5.20	4.60	4.80	X^2 (2) = .875, p=.646 No
85	The option to deliver orders to another address is available	2.40	5.00	5.00	4.60	X^2 (2) = 4.667, p=.097 No
86	There is adequate clarity about delivery problems (e.g. late delivery, non-delivery, wrong address)	5.00	3.40	3.60	3.60	X^2 (2) = 7.625, p=.022 Yes
87	Shopping customer received confirmation mails after order had been placed	N. A.	N. A.	N. A.	N. A.	N. A.
88	Shopping customer received dispatch notification e-mail after sending the order out	N. A.	N. A.	N. A.	N. A.	N. A.
89	Online order-tracking is supported by the website	N. A.	N. A.	N. A.	N. A.	N. A.
90	Various ordering methods are available and supported by the website	3.00	5.20	4.60	4.60	X^2 (2) = 6.000, p=.050 No
91	Various payment methods are available and supported by the website	5.40	5.40	4.80	5.80	X^2 (2) = 3.714, p=.156 No
92	Various delivery methods are available and supported by the website	2.80	4.60	3.20	4.20	X^2 (2) = 6.615, p=.037 Yes
93	Secure socket layer is used by the website	5.60	5.40	N. A.	5.60	N. A.
94	The secured payment methods used are well recognised	5.20	5.20	4.60	5.40	X^2 (2) = .800, p=.670 No
95	There is adequate and clear information about security guarantee	6.00	6.20	3.20	6.60	X^2 (2) = 7.538, p=.023 Yes
96	There is adequate and clear information about privacy policy	6.20	5.80	3.40	6.00	X^2 (2) = 9.500, p=.009 No