Critical success factors of mobile application development

WC Okonkwo

24908363

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Supervisor: Prof HM Huisman

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Abstract

The development of mobile applications is fast growing and many mobile applications are being evolved into the software world every year. There are significant differences between the successes of these mobile applications. Similar to social media applications which started with instant messaging, to Facebook, and WhatsApp. All these applications have different degrees of success. In this research the researcher attempted to determine the critical success factors of mobile application development. To achieve this aim, we conducted review of previous literatures on mobile application development, description of current state of mobile application and how it is performed in South Africa, Nine success factors were identified through thorough review of some previous research reports includong: open source technology, individual development skill, software development kit, functionality, portability, system development methodology, mobile devices specifications, back-end integration and web to network integration. Survey research method was applied and questionnaire was used to collect the needed quantitative data. Descriptive statistics was performed to detaermine the critical success factors of mobile application. The result obtained showed that individual development skill is the most critical success factor while open source technology is not a critical success factor of mobile applications development.. Each level of importance to mobile application development was ranked. Furthermore, T-test analysis was performed and the result indicated practical significant difference in the use of system development methodology in mobile application development; mostly larger organizations make use of system development methodologies during mobile applications' development. Also perform is the analysis of variance and the obtained results indicated that different business entities perceived the important of these factors in different ways. The outcome of this research will add to the knowledge in academic environment and helps in the development of of succeful mobole applications.

***Keywords**: Mobile application development; critical success factors; platform; software developers; system development methodology.*

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Abbreviations

BEI:	Back-end integration
CSF:	Critical success factors
IDS:	Individual development skills
IS:	Information system
MAD:	Mobile applications development
MDS:	Mobile devices specifications
OST:	Open source technology
SDK:	Software development kit
SDM:	System development methodology
WNI:	Web to network integration

Chapter 1. Problem statement

1.1. Introduction

Mobile applications are the computer programs used in mobile devices for different activities including: entertainment, banking, social communications education and others. The development of mobile applications involves some process and procedures which are influenced by some factors for successfulness. This chapter gives the description of mobile applications development, its importance, rate of usage, issues and finally, defines the main problem to tackle in this study.

Many authors, write-ups and web pages have defined mobile application development in different and similar manners with regards to their knowledge and understanding. Considering these definitions:

According to Charland & Le Roux, (2011), Mobile application development is a process used to compile native codes in varying degrees of compatibility and success to be used in mobile devices. Rosado *et al.,* (2008) stated that mobile application development is a development method used to design applications for small, portable and wireless computing and communication devices. From a software engineering development perspective, Roman *et al.,* defined mobile application development to be the study of systems in which computational components may change location (Roman, 2000). Therefore, mobile applications can be defined as a set of processes and procedures involved in writing computer program for wireless handheld mobile devices like smartphones, tablet computers and personal digital assistants.

It is without doubt that in recent times, mobile devices have evolved from their usage solely for voice communication to a point where they provide a wide range of additional advanced services for everyday usage. Mobile application development provides a platform for creating applications that combine the functionality of the mobile telephone as a traditional communication device with the information systems' functionality of computing which include data collection, data processing, information access and information management. In addition, mobile applications provide communication functionalities such as transmission of text, voice and graphics (Gebauer & Shaw, 2004). This has undoubtedly led to the increased usage of mobile applications and hence the need for everyday development of applications to meet the needs of mobile phone users. It therefore became imperative for application developers to concentrate on creating mobile applications that provide similar applications that used to be run

on PC's for mobile devices. Increasingly, organizations are looking to improve their productivity and competitiveness through the use of mobile computing by providing their employees with mobile devices.

Currently, in South Africa, the mobile industry has become an economic development enabler. Mobile applications services have enveloped almost every business sector including: banking, education, healthcare, social and even agriculture and are widely expanding rapidly (Beger & Sinha, 2012).

There are two primary models for mobile applications: online applications and occasionally connected smart client applications. These are briefly described in chapter 2.

Mobile applications can be pre-installed on phones during manufacturing, downloaded by customers from various mobile software distribution platforms, or delivered as web applications using server-side or client-side processing (e.g. JavaScript) to provide an "application-like" experience within a Web browser. Mobile applications help improve accessibility of essential applications, by making them available on portable mobile devices which facilitate ease of usage in any location, usually where a mobile network is available.

Mobile applications are developed for various purposes which intrinsically determine the nature of the application. Some major application areas of mobile development include in e-learning (Carpretz & Alrasheedi, 2013); business purposes, social networking, and entertainment (Gebauer & Shaw, 2004), applications.

Mobile application development (MAD) is undoubtedly an important area in software development. The use of mobile phones globally has increased dramatically with an estimated 75% of the population of the USA being mobile phone users, with the UK having a 92% mobile phone usage rate, 87% in Australia, 89% in Singapore (Lee & Lee, 2007) and in South Africa, more than 75% of the country’s population are mobile phone users (Peyper, 2013; Smith, 2013). Due to the competitive nature of today’s business environment, organizations continually seek for competitive advantages in all areas of their business. They constantly seek to improve their productivity and competitiveness, through the use of mobile computing. This involves providing their employees with mobile devices and their clients with new improved mobile applications. As a result the modern workforce is becoming increasingly mobile with business processes being carried out using mobile devices (Chen, 2004). With the increase in adoption of mobile devices, the demand for mobile applications inevitably also increases. As a result mobile

applications are developed more frequently on a large scale. With the introduction of various platforms such as Android, IOS and Windows mobile platforms, developers are regularly producing and improving mobile applications to perform required functions for day-to-day activities (Cameron, 2011; Cording, 2012).

Software application development has been steadily growing and is of great importance to the advancement of information systems and communication technology of present age. The development of mobile applications involves formalized methods or system development methods which are a combination of approach, method, process and techniques (Huisman & Iivari, 2006).

As for generic software development, quite a number of system development methodologies are employed in developing mobile applications. They are different, based on the requirements of the software development environment including:

- Mobile D (Abrahamsson *et al*., 2004).
- Dynamic Channel Mode (Afonso et al., 1998).
- Mobile Application Software Based on Agile Methodology (MASAM) (Jeong et al., 2008).
- Agile methodology (Abrahamsson, 2003; Holler, 2011; Flora & Chande, 2013).
- Hybrid methodology (Rahimin and Ramsin, 2008).
- Chen, M. methodology (Chen, 2004).
- M Compass (Abrahamsson, 2003).

Currently, mobile application development is significantly higher than ever before. As a result, software development companies are constantly seeking for suitable development platforms for mobile application development which can support the current and future needs of their projects (Olavsrud, 2012). Some common examples of mobile application development platforms are:

- Android Mobile Operating System (Cording, 2012; Sales, 2006).
- Apple iOS mobile operating system (Apple, 2014).
- Symbian (Sales, 2006; Cinque *et al.,* 2007).

- Blackberry (Mahmoud & Dyer, 2007).
- Window (Cameron, 2011).

There however exist a number of issues with mobile application development. For instance, the dynamic, ever changing mobile application development environment provides unique challenges for mobile application development teams, with different development and technical requirements for various applications (Zhang & Adipat, 2005). Also, there are frequent modifications in customer needs and expectations. The changing needs and expectations make the mobile application development arena more complex (Flora & Chande, 2013). Also factors such as rapidly emerging standards, volatile platforms, intermittent connections, varied devices, and inconsistent user-interface and input technology also affect mobile application development environments (Holler, 2013).

Despite the fact that some of these problems are highlighted, there have been a wide variety of mobile applications that have been a great success and have a widespread impact within the mobile device environment. Examples would be the Android apps, the iOS apps, iPhone apps, Facebook apps and Twitter apps (Canny, 2012). Unfortunately, it is not known what factors contributed to the success of the mobile applications.

There are many research works regarding mobile application development but within our knowledge, not much related research work on 'critical success factors of mobile application development' has been done. Hence, the researcher deemed it necessary to work on this topic. In the context of present study, some factors have an influence on mobile application development and these factors will be investigated to determine if they must be present for a successful mobile application software development. If so, these factors may be considered as critical success factors (CSF) for mobile application development. These include the following and the details are discussed in chapter 2.

- Open source technology (; Rodrigues *et al.*, 2010; Littlefield, 2015).
- Individual development skills (Huntley, 2010).
- Software development kit (Rodrigues *et al*., 2010).
- Portability (Gebauer & Shaw, 2004; Papanikolaou & Mavromoustakos, 2006).
- Functionality (Papanikolaou & Mavromoustakos, 2006; Sybase, 2007; Mohamed & Tsinakos, 2014).
- System development methodology (Schwaber & Beedle 2001; Serena, 2007).
- Back-end integration (Spriestersbach & Springer, 2004; Sybase, 2007).

- Mobile devices specifications (Sauer, 2004; Sybase, 2007; Zhou, 2010).
- Web to network integration (Ahern, 2009; Zhou, 2010).

The problem we intend to investigate therefore is to identify the critical success factors of mobile applications development, which the developers could use as a guide in their daily activities. This may have great benefits to organizations both financially and otherwise. It would also increase our knowledge on the topic in academic environments.

1.2. Research aims and objectives

The main aim of this study is to determine the critical success factors of mobile applications development.

To achieve this aim the following objectives have to be attained:

1. Conduct a literature review of mobile application development.
2. Review literatures on success factors of mobile application development (if available) and other related literatures.
3. Describe the current state of mobile application use in business in South Africa.
    - History of MAD
    - Primary motivation: to know the main reason/purpose of developing mobile applications.
    - Duration: how long the organization has been into mobile applications development.
    - Number of mobile applications developed by the organization
    - Application success: how successful is the developed mobile application.
4. Investigate how mobile application development is performed in South Africa in terms of:
    - Systems development methodology
    - Platforms of development
5. Determine the perceived importance of the success factors identified amongst mobile application developers.

1.2. Method of investigation

There are three main research approaches including: positivist approach, interpretive approach and critical social approach (Healy & Perry, 2000; Mackenzie & Knipe, 2006). The positivist approach will be used for this study because it entails a scientific method of surveying a population for collection of the desired data by using a questionnaire. The data will be statistically analyzed for results purpose and can be scientifically verified. In other words, the topic under study '*Critical success factors of mobile applications development*' required a quantitative method of inquiry in which its study data is based upon quantifiable results of questionnaire data. The structure of this study is as showed in figure 1.1.

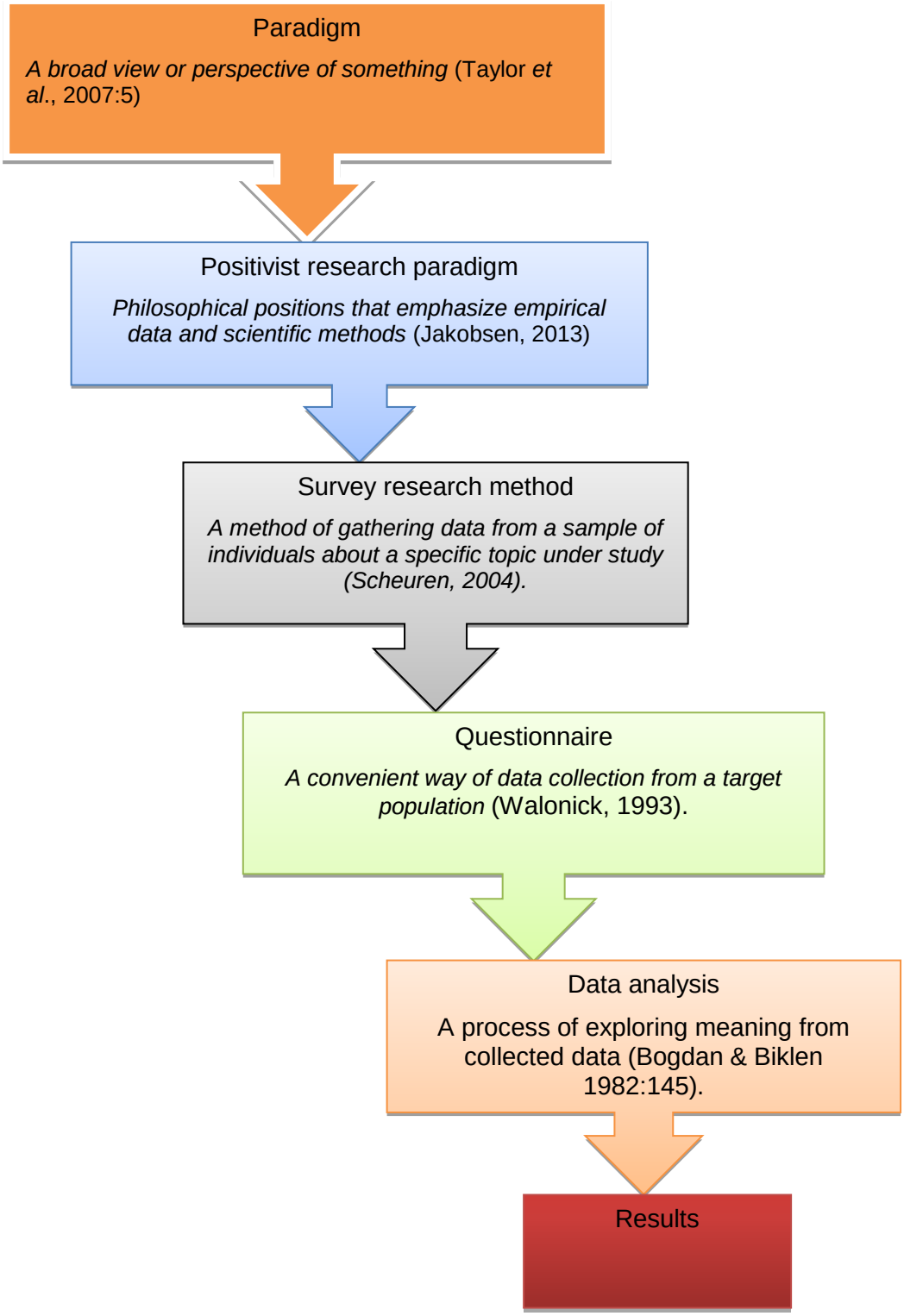

Figure 1.1. Methodological structure of the study

The above research methodology will be discussed in detail in chapter 3. The nature of the research required the application of the positivist paradigm. A Survey research method was used as the research strategy to collect data from the chosen sample of individuals. These individuals are information and communication technology experts. The survey was spread across many organizations but only 39% response was obtained. Moreover, the content of the survey is a set of logical questions associated with the research objectives put together in paper and electronic format as a questionnaire.

The questionnaire contained a total of 32 questions including closed-ended and open-ended questions divided into three sections including: background information, mobile application development and critical success factors. Closed-ended questions are multiple choice questions and open-ended questions needed the respondent to supply the answer. The questionnaire was systematically designed to ensure that it collects the required data from the chosen sample population.

The collected data involved both quantitative and qualitative data which were captured and analyzed using statistical analytical methods such as descriptive, reliability, T-test, ANOVA etc. to draw constructive conclusions about the critical success factors of mobile applications development.

1.4. Structure of the dissertation

Chapter 1 – Problem statement

This chapter will contain an introduction to the topic and background of the study to be conducted. It will cover the definition of the research problem and describe the importance of the research study together with its relevance. Furthermore, the research methodology will also be expanded upon in this chapter which will be concluded by outlining the structure of the dissertation.

Chapter 2 - Literature review

This covers the extracts from previous related studies concerning the research topic. In this chapter, the following are discussed:

- Mobile application development.
- Platform of mobile applications development.
- System development methodologies used in mobile application development.

- Identified success factors of mobile application development.

Within this chapter, a review of existing literature related to the topic will be conducted which will serve as a theoretical knowledge base for the study to be conducted.

Chapter 3 – Research Methodology

This chapter covers the research methodology used for the study and how it is applied including:

- Positivistic research paradigm.
- Survey research method.
- Questionnaire method of data collection.
- Description of the sample/respondents.
- Statistical data analysis.

Chapter 4 - Research findings

This covers the research results based on the outlined research methods. It provides:

- Analysis of data including: supporting tables, figures, diagrams etc.
- Use of statistical analysis to interpret findings, validity and reliability of the data.

Chapter 5 – Conclusions

This chapter contains:

- Drawn conclusions on research findings.
- Recommendations for further studies.
- Limitations of the study.

1.5. Chapter summary

This chapter gives the brief description of mobile application development and identified the problem statement of this research "*to determine the critical success factors of mobile applications development*" which is the aim of this study. Some of these factors are identified from previous research work. The method of inquiry for this study was depicted and chapters' break down was provided.

Chapter 2 focuses on a detailed review of previous work related to the topic under study.

Chapter 2. Literature review

2.1. Introduction

In this chapter, a review of the literature surrounding mobile application development, its platforms, development methodologies, software engineering issues, state of art mobile applications in South Africa and success factors are presented. The research into mobile phone applications, technologies, and infrastructures is not new but limited in this particular topic. As documented by Holzer and Ondrus (2010), researchers have been interested in these topics since the early 1990s. One prominent research in the early days is that of Formana and Zahorjan (1994), in which they discussed the challenges of mobile computing on a general scale. Even though Mobile Applications have been developed for over one decade, the intensity has increased since the launching of the iPhone Application Store (aliased as AppStore) in July 2008 (Wasserman, 2010).

Since this advancement of the market for mobile phone applications, device manufacturers such as Blackberry, Android, Nokia and Windows Phone have revolutionized the art of mobile applications' development. In 2010, Wasserman reported that there were over 250,000 mobile applications being deployed and running on different platforms, and today, this number has exponentially increased, with Smartphones and PDAs changing the game, (Holzer and Ondrus, 2010).

The Moore's law "is the observation that the number of transistors in a dense integrated circuit doubles approximately every two years", has also played a role in the advancement of mobile applications as the growth in mobile computational power, storage, and other hardware sophistication became a crucial vehicle that has driven advancement to the current day status (Moore, 1998).

The commercialization of mobile applications enabled developers to get their applications sold via online outlets such as AppStore. Figure 2.1 shows the distribution process of mobile applications as described by Holzer and Ondrus (2011).

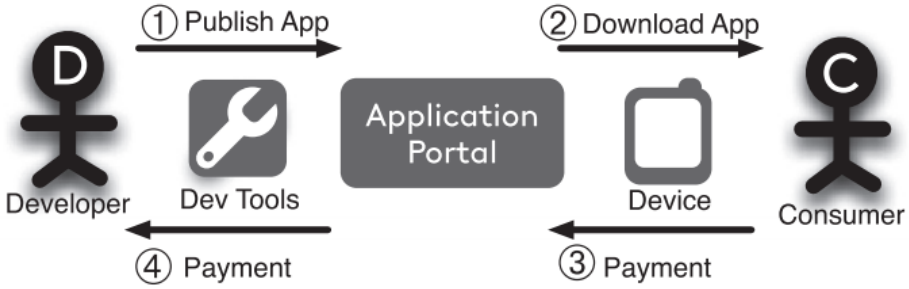

Figure 2.1. Distributing mobile devices (Holzer and Ondrus, 2011)

One major consideration in the development of mobile applications from the developer's perspective is the diversity of screen sizes, input devices and hardware specifications. This has also led to the mobile application software market being very competitive.

The remainder of this chapter is organised as follows: Section 2.2 presents the definition of terms and background information about the domain of mobile application development. Section 2.3 covers mobile applications models, Section 2.4 offers a review of existing platforms and cross-platform technologies used in mobile application development. Section 2.5 zooms down on the existing development methodologies employed by mobile software developers, companies and developers. Section 2.6 discusses the software engineering issues in this domain. Section 2.7 takes a look at the South African market and discusses the state of the art devices? Section 2.8 highlights the critical success factors of mobile application development, and Section 2.9 concludes this chapter.

2.2. Preliminaries and Definition of Terms

In this section, the definition of some key terms in this domain has been presented and preliminary concepts were discussed to a reasonable detail.

2.2.1. Mobile Device

A Mobile Device is a little electronic device that possesses almost (if not all), the functionalities of a computer and may be used for many computing activities (Questia, 2008: Hanson, 2011). Mobile devices often come with a touch screen or tiny keyboard as the input device. Well known

manufacturers of these types of devices are: Blackberry, Apple, Sony, Samsung, LG, Motorola, and HTC. One major component of any mobile device is an operating system which interfaces between the hardware and the application software installed on it. Other conventional functionalities include: Bluetooth, Wi-Fi, and GPS that facilitate communication between a local mobile device and the internet or other similar devices.

Multimedia functionalities are often embedded in mobile devices such as cameras for image and video recording, and they are also powered with rechargeable lithium batteries.

2.2.2. Mobile Operating Systems

This is an operating system (OS) designed for a portable device such as mobile devices, smartphones, personal device assistants (or PDAs) and tablets. This type of OS often use the full functional design of computer OS with an addition of mobile features such as Bluetooth, touchscreen, Wi-Fi, etc. The two-tier design allows some possible vulnerability which can be exploited for malicious attacks (Holwerda, 2013).

2.2.3. Mobile Application Development:

Mobile application development is a development method used to design applications for small, portable and wireless computing and communication (Rosado *et al*., 2008)

2.2.4 System development methodology

Methodology is a specific set of procedures of developing mobile applications. It involves a body of methods, rules, processes, techniques and principles that stand as guidelines for creating and designing mobile applications (Merriam-Webster).

2.2.5. Critical success factors (CSF)

These are skills or resources a business can invest in, in order to make an observable difference in the product of that business, thus making the business' outputs successful. In mobile application development, these are factors which, if applied in development of mobile applications; the developed applications will be very successful in the market. In other words,

critical success factors of mobile application development are the very important factors needed to develop a successful mobile application (Grunert & Ellegaard, 1992).

Furthermore, Grunert and Ellegaard stated four different ways in which the words critical success factors can be used. They are:

1) CSFs can be used as essential elements in a management information system.
2) They can be used as specific features of an organization.
3) They can be used as heuristic tools for managers to sharpen their thinking.
4) They can also be used as description of the key skills and resources required to be successful in a given market.

In this study the terms 'critical success factors' are used as important skills and resources needed to be successful in a mobile applications development market.

2.3. Mobile application models

Two primary models of mobile applications exist in the market (Sybase, 2007):

- Online applications and
- Occasionally connected smart client applications.

2.3.1. Online applications model

Online applications are the type of mobile applications model that require an active network connection to a back-end enterprise data source and they are usually browser-based. These applications do not store data or application logic on the mobile devices, they only connect to the data whenever needed. Thus constant network connection is required for online applications. Mobile devices connect to these applications through wireless connections (WIFI or WAN) during data transmission.

The major advantage of this model of mobile applications is no storage of data or application on the mobile devices. An organization's data center is the only storage unit. If a user requests either data or an application, it is retrieved directly from the enterprise's data store. The key disadvantages are the failure in users' expectations and inconsistent network coverage, especially when the user is in a rural area where the network connection is weak (Sybase, 2007).

2.3.2. Occasionally connected smart client applications model

Occasionally connected smart client applications are characterized by a local data store and local application, and do not require a constant network connection. It doesn't need a constant network connection for users to access information. Information is kept in a local database for users to access at any time.

Occasionally connected smart client applications have some advantages such as: applications are usable anywhere and anytime; quick access to data and no network connection is required for data access. The development, deployment and maintenance of the applications are the key disadvantages (Sybase, 2007).

The choice of model usually depends on the usage specifications and functions that the mobile application will perform. For instance, a mobile application that requires access to real time live information e.g. weather information, stock share prices for financial related applications etc., may have to be built on the online model. A problem with the online mobile application model is the constant need to have network connectivity, and network issues such as high network delay, limited bandwidth or dropped connections can affect the effectiveness of these applications, (Spriestersbach & Springer, 2004).

2.4. Mobile Application Platforms

The development of mobile phone applications was a very challenging task about a decade ago. Abrahamsson *et al*., (2004) reported on the difficulty of this task stating the demands and technical limitations of mobile phone technology as hindrances of progress. The issues identified by Abrahamsson are:

- urgent market demands with short project timeline.
- disjoint requirements across different mobile platforms.
- portability across many platforms.
- diverse standards and network protocols.
- The rate of change and introduction of new devices.

As time passed, many of these issues were overtaken by technological advancements. Mobile application development is more important to the enterprise than ever before. Development organizations are increasingly looking for a Mobile Application Development Platform (MADP)

that can support their needs for both current and future projects, (Olavsrud, 2012).

Quite a number of development platforms exist for mobile applications. These platforms can be perceived as operating systems for the mobile applications. Essentially, these platforms provide the core mobile software for mobile devices. All other mobile applications are developed over this underlining core software and rely on rules set for development on the platforms. Each platform is unique and exhibits different features, capabilities and behavior based on the specifications and functionalities required by the developers of the platform. Therefore, a platform for specific mobile application development has to conform to the rules stipulated for its environment (Hall & Anderson, 2009; Yonathan, 2012). Some common examples of mobile application development platforms are:

2.4.1. Android Mobile Operating System

The Android platform is a mobile device platform/operating system based on Linux. It is a free open-source mobile platform which is made available for use on any form of smartphone developed by any manufacturer. Due to its open-source implementation, Android framework allows hardware manufacturers to build customized user friendly interfaces to suit their individual requirements. However, the android platform ensures all applications developed have equal access to most of the core applications and hardware functionalities of the device. This allows for maximum exploitation of the Android-handset combination (Cording, 2012; Burnette, 2009). Android operating system suite provides memory management, process management, network model, driver model, security and an abstraction between mobile hardware and the higher level mobile device applications (Hall & Anderson, 2009; Yonathan, 2012).

2.4.2. Apple iOS mobile operating system

iOS is a proprietary operating system developed solely for Apple mobile devices such as the iPhone, iPod touch, and the iPad. The iOS mobile platform comes with advanced features of Voice over IP, multitasking, threading, folders, a unified mailbox and other features. iOS provides a set of well-defined system interfaces for application developers to write mobile applications that can be integrated into the Apple devices. The iOS uses a layered system architecture with lower and higher level layers. The lower layers contain fundamental services and technologies. Higher-level layers build upon the lower layers and provide more

sophisticated services and technologies with object-oriented abstractions that make it easier to write application codes for IOS (Apple, 2014).

2.4.3. Symbian

Symbian is a mobile application development platform designed to work on a stand-alone portable device. It was designed to be an open source platform for open standards based apps development with equal and fair licensing. Symbian was designed to accommodate event-driven, graphical and cross-platform technological patterns with a client server model on top of providing facilities like streaming, data persistence together with battery optimization fixtures. It was developed using C++ and uses small system architecture to optimize mobile applications performance on a constrained device. The Symbian mobile platform was very successful in its early days but with the introduction of newer platforms like IOS and Android, Symbian has lost popularity (Cinque, 2007; Sales, 2006).

2.4.4. Blackberry

The BlackBerry is a line of wireless handheld devices and services designed and marketed by BlackBerry Limited, formerly known as Research in Motion Limited (RIM). The Blackberry smartphone came with a different approach to other mobile device platforms. It was developed to cater for business professionals that require constant email services and business functionalities on the go using a mobile device (Mahmoud & Dyer, 2007). RIM developed the Blackberry platform to run an integrated service between RIM, telecom operators and the smartphone. This was achieved using thorough development of a BlackBerry's enterprise solution architecture. With this architecture, BlackBerry smartphones use telecom carrier's network to connect to RIM's Network Operating Center (NOC). The BlackBerry Enterprise Solution (BES) provides a means to access corporate emails and business critical applications (Yonathan, 2012).

2.4.5. Windows Phone

The Windows Phone is a mobile phone platform developed by Microsoft, with a C# framework (Cameron, 2011). It was launched in 2010 as Windows phone 7 and a successor of Windows mobile though incompatible with each other. Several phone manufacturing companies like

HTC, LG, Nokia and Samsung are developing Windows phone devices (Okediran *et al.,* 2014). The architecture of Windows phone comprises of three class libraries including (Stott, 2012): Application model, user interface model and cloud integrations.

The application model handles application management, user interface model handles user interface management and the cloud integration model handles web search activities. Also the architecture involves a phone kernel which controls the device driver access, networking, storage and basic security. The Windows phone architecture is showed in figure 2.2.

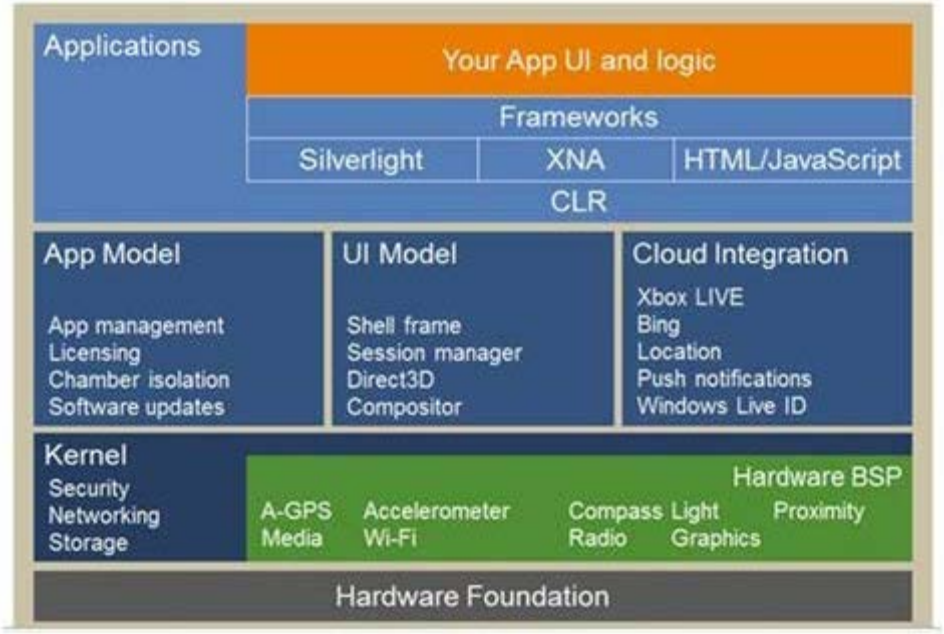

Figure 2.2. Microsoft windows phone architecture (Stott, 2012)

2.4.6. Cross-platform

However, cross-platform development tools that allow development of applications that can be used across different platforms are also available (Viswanathan, 2012)**.** These cross platform tools include:

1) RhoMobile, an open source framework based on ruby which allows the developer to create mobile applications for Android, Windows Mobile, Symbian, iPhone and RIM, platforms.

2) MoSync is a mobile application development tool which provides an SDK environment. It allows the integration of various compilers, libraries, runtimes, and device profiles from different platforms thus enabling development of tools for multi-platform integration. MoSync offers support for several types of OS', including Windows Mobile, Android, Symbian, Moblin, mobile Linux, iPhone OS and BlackBerry.

3) PhoneGap is another cross platform mobile application development tool which focuses more on mobile application development for the web 2.0 environment. It also allows development of applications for Android, Palm, Symbian, BlackBerry, and IOS environments which include iPhone, iTouch and iPad devices.

4) WidgetPad is a collaborative, open-source environment for development of smartphone apps. This program uses standard web technologies, such as JavaScript, HTML5 and CSS3. IOS, Android OS and Web OS.

2.5. Type of Development Methodologies for Mobile Applications

Similar to generic software development, quite a number of methodologies are employed in developing mobile applications. They are different, based on the requirements of the software development environment and these include:

- Mobile D methodology.
- M Compass.
- Agile methodology.
- Mobile Application Software Based on Agile Methodology (MASAM).
- The Hybrid Methodology.
- Chen, M. Methodology.
- Dynamic channel mode.

The above mentioned mobile applications development methodologies are briefly described as follows:

2.5.1. Mobile D Methodology

It is based on a combination of the extreme programming in terms of practices, Crystal methodologies in respect of scalability, and the rational unified process in terms of life cycle coverage. The methodological approach is meant for a maximum of ten people and is of the

form that if multiple teams are involved in developing different parts of the application, there must be a day for integration (Abrahamsson *et al*., 2004).

It initially adopts five phases of development methods which are stated by Abrahamsson *et al.,* 2004 as set-up, core, core2, stabilize, and wrap-up while VTT Electronic, 2006 referred to the phases as; Explore, Initialize, Productionize, Stabilize and System test and fix. Spataru, 2010 in his thesis, added an extension to the phase called Evolve, hence totally six phases of development.

The Explore stage is the planning phase which involves evaluating the project requirements and defining goals for the mobile app development including deadlines, development environment to be employed and choosing of active team members to complete the task. In the next stage called the Initialize stage, requirements for developing the mobile application are evaluated and technical and human resources are prepared. This stage can only begin after the first stage (Explore) is completed. The productionize stage is the third stage and here the principal functionalities of the mobile application is implemented. The Stabilize stage allows the project team to finalize the implementation and documentation of the mobile application. In addition, the quality of the mobile application can be improved on and verified at this stage. The system and fix stage is used to test the system based on its documentation, and system bugs are fixed to enable delivery of an error free mobile application. Finally, the new Evolve phase deals with continuously incorporating end users' responses on the delivered product into future releases (Abrahamsson *et al*., 2004; Spataru, 2010).

The process model is iterative while the tools and techniques are phasing and pacing, architecture line and pair programming (Abrahamsson *et al*., 2004). Figure 2.3 illustrates the difference phases of mobile D methodology.

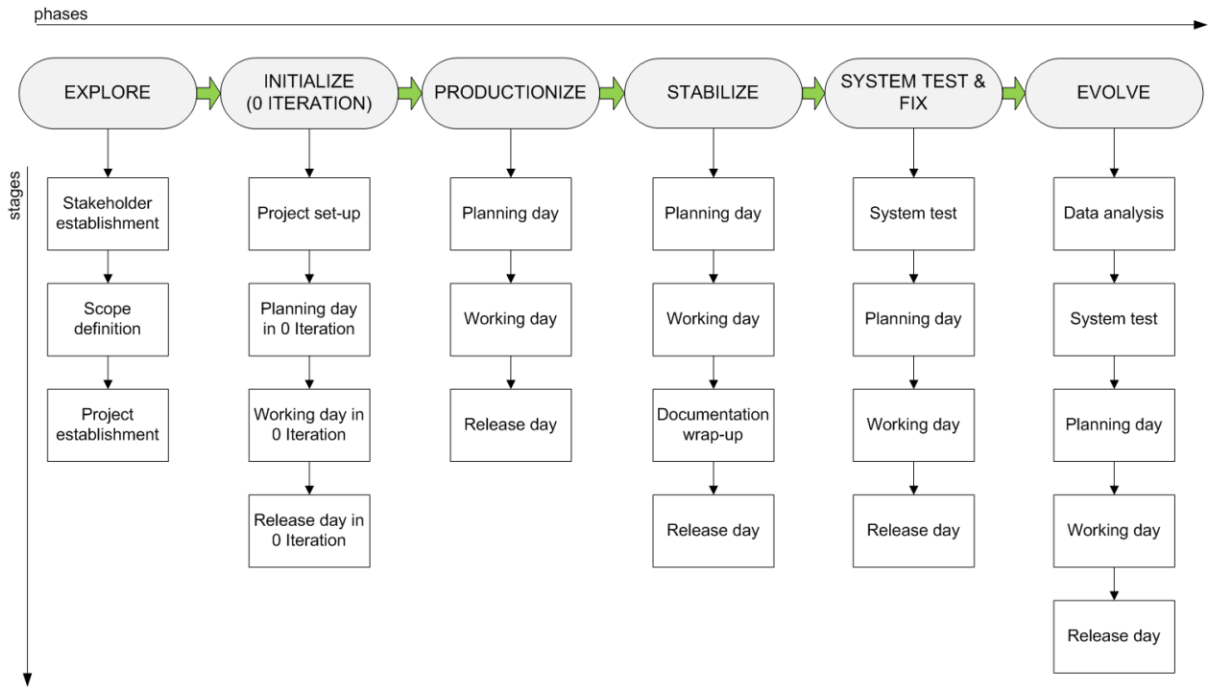

Figure 2.3. Mobile-D with added Evolve phase (VTT Electronics, 2006)

2.5.2. M-Compass*

The M-Compass app development methodology from Osellus Mobile is a tried and tested approach for developing cross-platform mobile apps. M-Compass dramatically reduces development time and results in engaging and attractive apps for users.

M-Compass is built on a hybrid unified-agile methodology that balances agility and speed with solid project governance. M-Compass breaks down a mobile application project into multiple time-boxed iterations that are spread across four distinct phases. This results in early versions of the app development life cycle, which gives ample opportunity for responding to the unexpected.

What makes M-Compass unique is the incorporation of platform-specific considerations and best practices in every phase of the project life cycle.

M-Compass includes both platform-specific best practices and methods that are common

across the iOS, Android, BlackBerry and Windows Phone platforms. Each version of your app will look unique and native on its target platform, while maintaining the overall project cost at a reasonable level (Abrahamsson *et al*, 2003)**.**

2.5.3. Agile Methodology

The mobile telecommunications industry comprises a highly competitive, dynamic and uncertain environment. The agile approach is seen as a natural fit for mobile application development and studies carried out for the application of the agile development approach to mobile application development indicates the need for software development processes tailored to suit the mobile application requirements (Flora, 2013; Holler, 2011). It has been recommended that agile practices are the best choice which assures different phases of software development life cycle and to solve the mobile application development issues more efficiently. It makes use of an iterative design model in development and different components of the mobile application are developed in each of the iterations (Abrahamson *et al*., 2003)**.**

2.5.4. Mobile Application Software Based on Agile Methodology (MASAM)

MASAM is a mobile application development methodology based on agile methodology, especially XP programming and mainly emphasised on rapid development. Its objective is to provide ease, simple and fast development and deployment processes. It also includes several developers and high customer participation during development. It comprises of four phases of development including: development phase, embodiment phase, product development phase and commercialisation phase. The development phase involves the definition and preparation of the project development in relation with grasping product (product summary and pre-planning) and product concept and sharing (user definition and initial product analysis). The embodiment phase brings out the prototype of development for user confirmation in relation with user needs' understanding and project architecture. It covers story card workshop, user interface design, non-functional requirement analysis, architecture definition and pattern management. In the product development phase, the application is developed and each cycle is released to the client for confirmation. The last phase of commercialisation involves testing and market selling of the application. The process models of MASAM comprises of sequential and iterative characteristics while the tools and techniques are test driven, eg., product summary, story cards and pair programming (Jeong *et al*., 2008).

2.5.5. The Hybrid Methodology

This is a mobile application development methodology proposed by Rahimian & Ramsin, (2008) using the method engineering approach. According to Brinkkemper, (1996), method engineering is ‘’the engineering discipline to design, construct, and adapt methods, techniques and tools for the development of information systems”. Method engineering comprises of the following approaches (Ralyté *et al*., 2003):

- Ad-hoc: Constructing a new methodology from scratch;
- Paradigm-based: Instantiating, abstracting or adapting an existing meta-model to produce the target methodology;
- Extension-based: Enhancing an existing methodology with new concepts and properties;
- Assembly-based: Constructing the methodology through assembling method fragments retrieved from a repository.

The Hybrid methodology design was developed based on the unique requirements of mobile application development and the knowledge gathered from existing methodologies and process patterns /metamodels (Ulrich & Eppinger, 2004; Ramsin, 2006; Ramsin & Paige, 2008). The method of development proposed in this methodology comprises of four iteration phases: instantiation phase, artefact-oriented phase, composition phase, and integration phase. The iteration phase deals with the expansion of the basis and the Integration phase incorporates concepts and techniques directly from existing methodologies. The last two phases of artefact-oriented and composition introduce ideas from adaptive software development to improve the development process engine and involve the addition of prototyping as a development pattern to the methodology respectively. The process model of the methodology is a top-down iterative-incremental process and the tools and techniques used are existing SDLC, analysis, adaptive software development (ASD), new product development (NPD) and commercialisation (Highsmith, 1997; Ambler, 1998; Rahimian & Ramsin, 2008). Figure 2.4 illustrates the general phases of hybrid methodology.

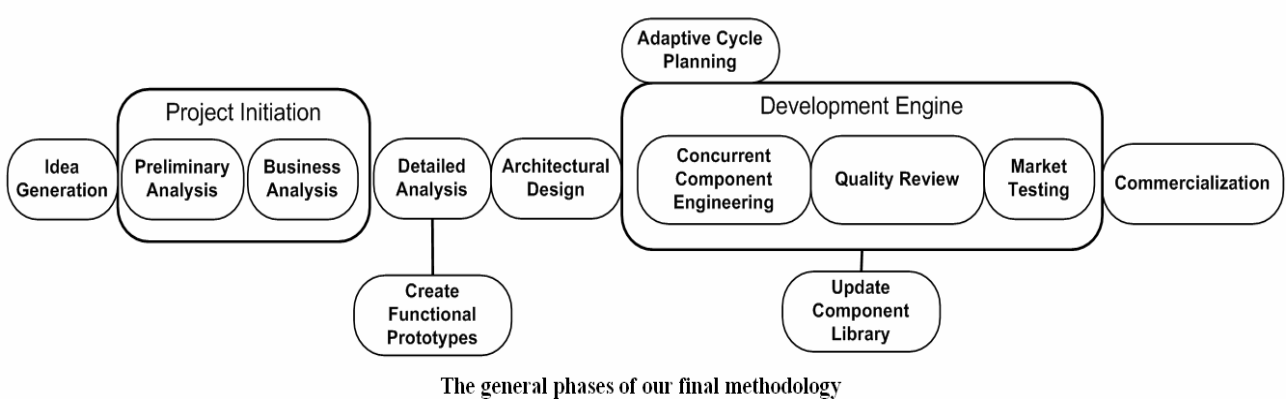

Figure 2.4. Phases of development of hybrid methodology (Rahimian and Raisin, 2008)

2.5.6. Chen, M. Methodology

A mobile applications development methodology created mainly for building of enterprise-wide mobile computing applications. The creator stated that the methodology: "should be seen as a mere suggestion and guideline which organisations can be used to develop an enterprise-wide mobile application." The approach involves performing various actions iteratively and simultaneously across the system life cycle with the purpose of getting a fast prototype and to gather responses within a specified period. It comprises of five developmental phases including; Develop enterprise wide mobile strategies; Analyse the mobility of the business process; Develop an enterprise-wide mobile technical architecture, Build mobile applications and Deploy mobile applications.

The first phase defines the plans for the development based on the organisation's existing system with consideration to their policies and objectives. The second phase deals with detail analysis of the project and its impact to the improvement of the organisation business relations. The third phase brings out the project design with reference to the previous two phases. The fourth phase deals with development of the system and the last phase covers the release of the application together with training and support services (Chen, 2004). See figure 2.5.

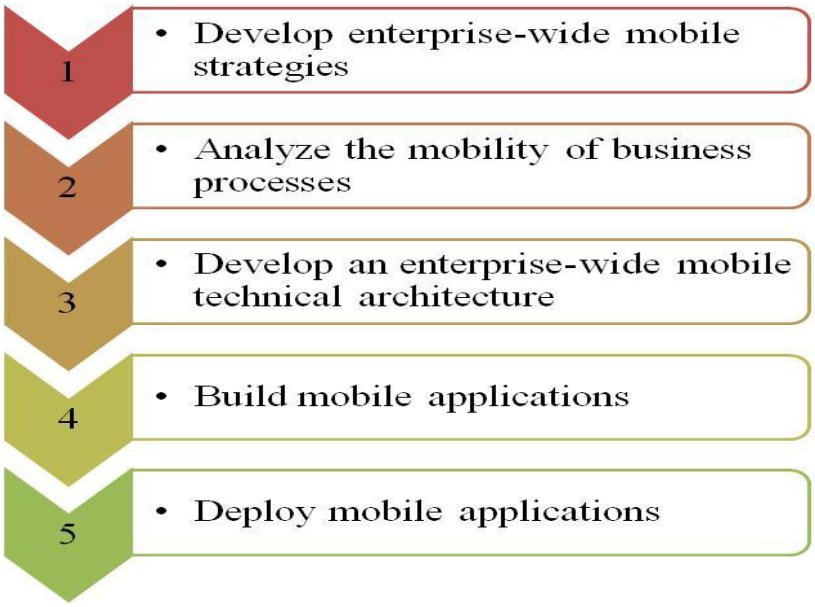

Figure. 2.5. A Methodology for Building Enterprise-Wide Mobile Applications (Chen, 2004).

2.5.7. Dynamic channel mode

A mobile applications development methodology created by Afonso, Silva and Regateiro. The methodology uses object-oriented approach and its development support depends much on analysis and design. The methodology is made up of three phases including: analysis, object design and implementation. The technique of this methodology is object modelling.

Analysis phase involves gathering of system requirements and the definition of key domain classes in the system. During this stage, the channel of the system is described with regards to the explanation of use-cases and customization of a meta-model for the information channel. The first activity in analysis is to outline scenarios that describe the functional requirements of the channel system. Next is the customization of a channel meta-model to define the key domain classes. According to the creators, '*meta-model is a model which can represent any particular channel*'. This model also serves as a class diagram.

Object-oriented design involves description of the solution to the problems identified during the analysis stage.

Implementation phase, also refers to as construction phase, involves creating the program codes for the designed solution of the analysis problem. Figure 2.6 shows the development activities of the methodology (Afonso et al., 1998).

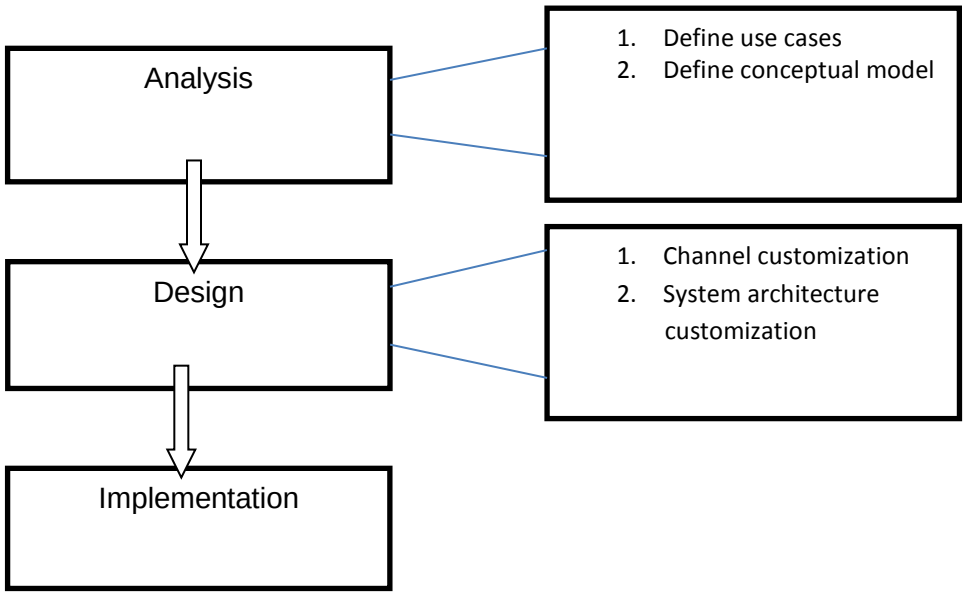

Figure 2.6. Dynamic channel development methodology - development activities (Afonso *et al.,* 1998).

2.5.8. Differences and similarities of the SDMs

There are some differences and similarities among the SDMs used for mobile applications development as discussed above.

The methods of development are similar to such an extent that all the SDMs involve different phases of development. The number of phases varies between 3 to 5 phases of development. In terms of the process models, all the SDMs use an iterative process model, except the Dynamic Channel Mode that follows a sequential process.

Their main difference is the tools and techniques applied in development. They all use different techniques of development, though all tend towards mobile application development. The most unique techniques are found in M compass and Chen M methodologies. The incorporation of platform-specific considerations and best practices in every phase of the project life cycle gives

M compass a unique technique while Chen M uses an enterprise architecture technique.

2.6. Some issues of software engineering

Mobile applications face some challenges which adversely oppose their usability. Most of these issues are as a result of advent in technology, increase in mobile application usage and new invention of mobile devices models and specifications. According to these authors, Wasserman (2010), Păvăloaia, (2013) and Kumari (2014), these challenges include:

Connection issues: the unstable connection of the internet especially in some areas and positions, creates concern in the mobile application usability. The strength of signal is mostly poor in rural areas, inside tunnels and inside buildings with massive walls which affect mobile applications' performance.

Processing capability: the size of the processing unit of mobile devices is small, hence it limits the type and size of application that can be installed and used in the devices. This conditioned the mobile application to be of small size and portable.

Screen size and data entry unit: the small size of the screen and tiny keypads of mobile devices pose some difficulty in mobile application usability especially when fast operation is needed. Though, advent in technology eases it with the introduction of voice and handwriting recognition.

Security issues: as a result of many networks which are interconnected, users of mobile applications can be attacked through the network connection. Therefore mobile application usability needed some high levels of precaution over the networks to avoid being attacked.

Display resolution: the screen size of mobile devices affects the quality of image resolution of the applications.

Environmental and weather conditions: environments and objects around it cause distractions to mobile application usage and poor weather conditions hinder signal transmission strength which affects the reception capability of mobile devices.

2.7. State of art of mobile applications in use in South Africa

The most significant technological advancement in South Africa happened within the era of mobile sphere, resulting to every adult having and using at least one mobile phone with network connection (UNICEF, 2012).

According to a study conducted by Steve Esselaar and Christoph Stork on *Mobile Cellular Telephone: Fixed-line Substitution in Sub- Saharan Africa* in 2005, about 56.7% of South African households have ownership of mobile phones. Statistics South Africa (2007) and Research ICT Africa (2011) confirmed this claim in their research that there has been a significant increase in mobile phone usage in South Africa: from 2001 to 2007 as mobile phone usage has increased from 32.3% to 72.9%. This indicates that the growth of mobile applications and ICT is higher in South Africa than in its neighbouring countries. The report of African observatory (2011) also indicates that South Africa has the third largest mobile subscriber percentage after Nigeria and Egypt in the African continent.

UNICEF (2012) reported that as usage of mobile devices have increased, new opportunities are opened mostly for young people in South Africa in accessing and consuming digital information via online platforms like Mxit, Facebook and Twitter.

Internet browsing has also become a normal life activity of every South African using a mobile phone and is increasing in rate. A survey conducted by Tande Dibussi in 2011 indicated that 39% of urban dwellers and 27% of rural dwellers are browsing the internet through mobile phones.

Mobile applications have embraced all activities going on in South Africa, with the result that one can now sit comfortably at home or elsewhere and perform business activities like banking, purchases and payment of bills. According to Bryson (2013), a student claimed and said “I use my cell phone for everything”. This is a university student who said that with her multi-function smartphone, she can download and watch movies, access and pay bills, and perform banking transactions online.

Mobile applications have proven to be very effective in banking business (Beger & Sinha, 2012). In 2004 and 2005, WIZZIT and MTN developed mobile banking applications that addressed customers’ financial needs online. It was a remarkable achievement because WIZZIT does not have a physical office address in South Africa; they only collaborated with the post office and ABSA bank to achieve this purpose. Customers can withdraw money from any ATM machine with their debit cards and deposit money through banks in South Africa. Today, the evolution of mobile application has immensely improved banking operations in South Africa not only making it easy and convenient but adding new operational activities in the banking system. Thus, all banks both in South Africa and the rest of the world are totally involved in online operations.

Talk of social media, mobile applications have made social communications easy, less costly

and comfortable. Mobile applications like Mixit, Facebook, Twitter and WhatsApps have completely changed the mode of communication to a better form. In 2009, a survey conducted by TNS on South Africans of the age from 16 and above, indicates that 75% of the participants are users of social network applications: 82% use Facebook, 29% use Mixit, 28 use Twitter, 18% use MySpace and 14% use LinkedIn (TNS, 2009).

2.8. Critical Success Factors

Critical success factors are very important elements needed for the success of mobile applications' development. These factors must be considered for the successful development of mobile applications. Through thorough review of previous research reports some of the success factors were identified for investigation under this study. These include:

2.8.1. Open Source Technology

The advent of open-source technology has encouraged the creation of various applications by developers. Developers can create a wide variety of mobile applications which can easily be integrated into any of the open source platforms and published for intending users to download and use or for mission critical implementations. As a result, a wide influx of mobile applications began and mobile applications are being created and regularly made available on repositories for interested users to download and make use of. Platforms such as android mobile platform and the IOS mobile platform provide an open source SDK (software development kit) that enables developers to create their applications for android devices. An important consideration however is the application design frame work, which differs for each platform. For instance, the UI and UX conventions, the touch points and menus are different for the IOS and Android applications (Rodrigues *et al.*, 2010; Littlefield, 2015).

2.8.2. Individual development skills

According to Huntley, it requires innovative skills of developers to design and develop mobile applications on multiple platforms (Huntley, 2011). Software development requires interactions between developers' perceptions of users' needs and users' perception of their wants (Carpretz,

2003). In addition, a good software designer leads software development to a success while a bad designer ends with disaster and software development requires a skilful developer that is up-to-date with techniques. Moreover, the structure of program codes depends on the mental arrangement of the design (Ahmed *et al*., 2013). In addition, Siau et al (2010) stated that information system is designed and created by a team of software experts and a team staffed with good individuals are more productive.

2.8.3. Software development kit

In recent times various software development kits (SDK) have been made available which provide tools for the development community to use in creating their mobile applications. This has led to the influx of various applications both as upgrades to existing applications and new unique applications developed by independent developers (Rodrigues *et al.,* 2010; Huntley, 2011). SDK is important in understanding, handling and scheming software development processes (Pfleeger & Fitzgerald, 1991). According to Wasserman (2010), SDKs provide the required device resources to developers during mobile applications development.

2.8.4. Portability

Due to advancement in technology and cross platform implementation of mobile applications, portability has been increasingly enhanced. The fact that mobile applications can be ported successfully from one device to another using a common platform makes it very acceptable by the community of users. Cross platform implementations of mobile applications are also becoming quite popular among mobile application developers. This allows for applications to be made available on devices running different platforms and enables wider acceptability and usage of the mobile applications (Gebauer & Shaw, 2004; Wasserman, 2010). Mobile applications should have the portable capability to be installed and run by different mobile devices and adaptable to different environments (Papanikolaou & Mavromoustakos, 2006).

2.8.5. Functionality

The functionality aspect can be perceived as a form of task/technology fit. Users especially in business environments, want technology to help perform the tasks they require by using their mobile devices. They therefore tend to veer towards applications that provide them with what

they need. The ability of mobile applications to meet the functional requirements of the users makes it a preferred option considering its portability and mobility features (Mohamed & Tsinakos, 2014; Sybase, 2007). Every mobile application has a required function(s) /task(s) and all the necessary features needed to achieve the function /task should be included in the development Papanikolaou & Mavromoustakos, 2006).

2.8.6. Back-End Application Integration

Another critical success factor in mobile application development according to Sybase, (2007) is how well the application can be made to integrate organizations' existing applications and database infrastructure and provide a similar and very efficient, effective, user friendly implementation to the existing application. It is further perceived that a well-designed mobile application can enable an organization's employees to be more productive and deliver improved customer service while reducing operating costs. Innovative approaches must be employed in developing mobile devices for performing critical business operations and data management (Spriestersbach & Springer, 2004).

2.8.7. System development methodology (SDM)

To achieve success from a developer's point of view, it is important to adopt a software development life cycle model that best suits the needs and requirements of the organization. In recent times, the agile software development has often been adopted as the preferred source (Schwaber & Beedle 2001). It provides an iterative, repetitive model for carrying out software development. It has been proven to be a very efficient method as against the native methods such as the waterfall model. The use of development models such as Agile, Scrum etc. help a developer achieve improved efficiency in mobile application development (Serena, 2007). Correal et al (2013) points out that mobile applications development requires a defined development process. As mobile applications advances with modern technologies, it is important to employ an SDM that addresses more aspects of mobile applications development process than are covered by agile development process (Wasserman, 2010).

2.8.8. Mobile Device Specification Issues

Development organizations and teams that build mobile applications are challenged with their

own unique array of complexities. Unlike traditional client-server and web-based software development shops, mobile developers are faced with very strict boundaries (memory, screen size, input devices, etc.), short application lifecycles, and extreme usability requirements. These are in addition to the inherent environmental volatility previously referred to. The storage capacity and processing power of the mobile devices also influence the mobile application development process (Sauer, 2004; Sybase, 2007; Zhou, 2010). Mobile devices' constraints should be considered during the development processes of mobile applications (Papanikolaou & Mavromoustakos, 2006).

2.8.9. WEB and Network Integration

Web based mobile application integration allows usage of online applications on mobile devices**.** This was a limitation to mobile applications' development until the mobile web was tackled with the help of service providers and now online mobile applications can be effectively run on mobile devices without much challenge (Vrechopoulos *et al.,* 2004)**.** One of the ways to also distribute the mobile application software is through the websites, which allow users to retrieve information or access services via their handheld devices (Hung *et al.,* 2003). The degree of efficiency and productivity of a software application is derived from the usage (Ahern, 2009). It is therefore expected that mobile service providers deliver real time information and services to their users through these sites. Therefore**,** improvement of system quality, information quality and service quality for web integration enhances user satisfaction (Zhou, 2010).

The present research will focus on the in-depth discussion of the CSF for mobile application development. We are going to study all the related literatures and MAD methodologies, perform reliability analyses on those factors and consolidate them into the final CSF of MAD.

2.9. CSFs assumptions

The identified success factors are assumed to be critical to mobile applications development as stated below.

1. Open source technology enables the environment for peer programming by collaboration of general public developers, making the source code free to be used, modified and improved on. Open source is a critical component to achieve agility in mobile application development.

2. Developer's skills and experience contributes immensely towards the development of new mobiles' applications and upgrade of existing ones (Huntley, 2011; Ahmed et al., 2013).
3. Software development kit provide tools for the development community and the required resources to developers during mobile applications development (Rodrigues et al., 2010; Wasserman, 2010).
4. The fact that mobile applications can be ported successfully from one device to another using a common platform makes it easily accepted by the community of users; hence portability has a significant effect on mobile applications' development (Papanikolaou & Mavromoustakos, 2006; Wasserman, 2010).
5. The functionality of a mobile application requires that it must meet the functional requirements of the users (Papanikolaou & Mavromoustakos, 2006; Mohamed & Tsinakos, 2014).
6. The development of a mobile application requires the integration of the new application to the organisation's existing ones and database infrastructure to produce similarly efficient, effective, user friendly implementation of the existing application, hence back end integration (Spriestersbach & Springer, 2004; Sybase, 2007).
7. Adoption of a system development methodology is highly necessary in a mobile application development (Wasserman, 2010; Correal et al., 2013).
8. One of the ways to distribute the mobile application software is through the websites, which allow users to retrieve information or access services via their handheld devices, therefore web and network integration is a critical component of mobile application development (Ahern, 2009; Zhou, 2010).
9. Mobile application developers are faced with very strict boundaries of mobile devices' specifications. In developing a mobile application the specifications of the mobile devices must be considered (Papanikolaou & Mavromoustakos, 2006; Zhou,2010).

The above assumptions were derived from the identified success factors of mobile applicationdevelopment in literature and will be measured in this study to determine their degree of importance to the success of mobile applications' development. Figure 2.7 shows the conceptual model of the critical success factors of mobile application development.

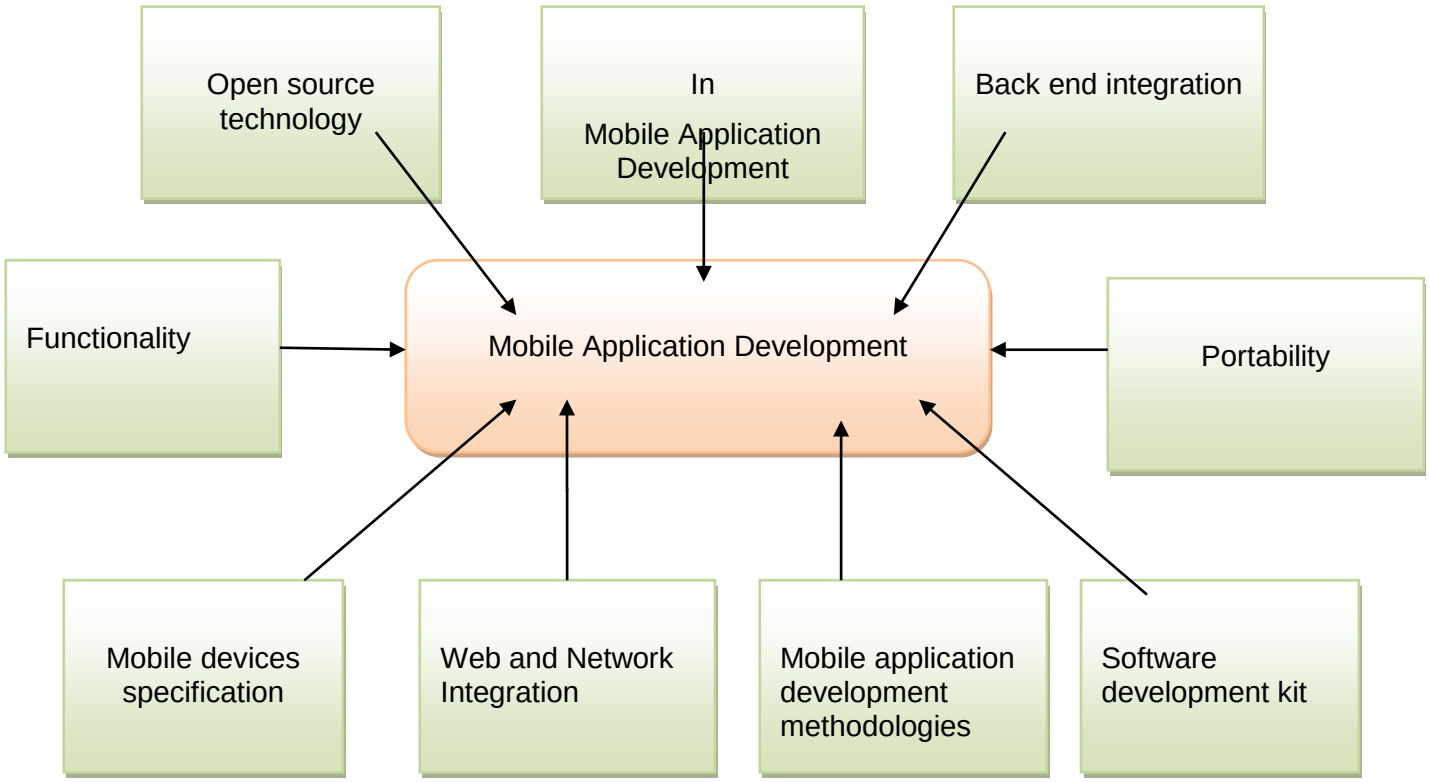

Figure 2.7: Conceptual model of CSF of mobile application development

2.10. Chapter summary

In this chapter we discussed mobile application development in detail covering the definitions, mobile application models, platforms of development, cross-platforms, and types of methodologies used in mobile application development, and software engineering issues. The state of art of mobile applications' usage in South Africa was also discussed with regards to their applications to different business areas.

Lastly, success factors of mobile application development were identified from review of previous research reports.A brief description of each success factor and a conceptual model of their importance to mobile application development was presented.

Chapter 3 will focus on the detailed description of the research methodology applied to conduct the study.

Chapter 3. Research methodology

3.1. Introduction

The study on critical success factors of mobile applications' development started by stating the research aim and objectives and theoretical overview of the topic under study. These have contributed to the description of the research topic.

The overview and background of this study was covered in chapter one, while a review of related literatures on the topic of study was conducted to obtain the theoretical knowledge of the topic under study as discussed in chapter two.

In this chapter the research methodology used for the study and how it is applied will be discussed, including the research paradigm, research method, data collection method, and data analysis as showed in the figure 3.1.

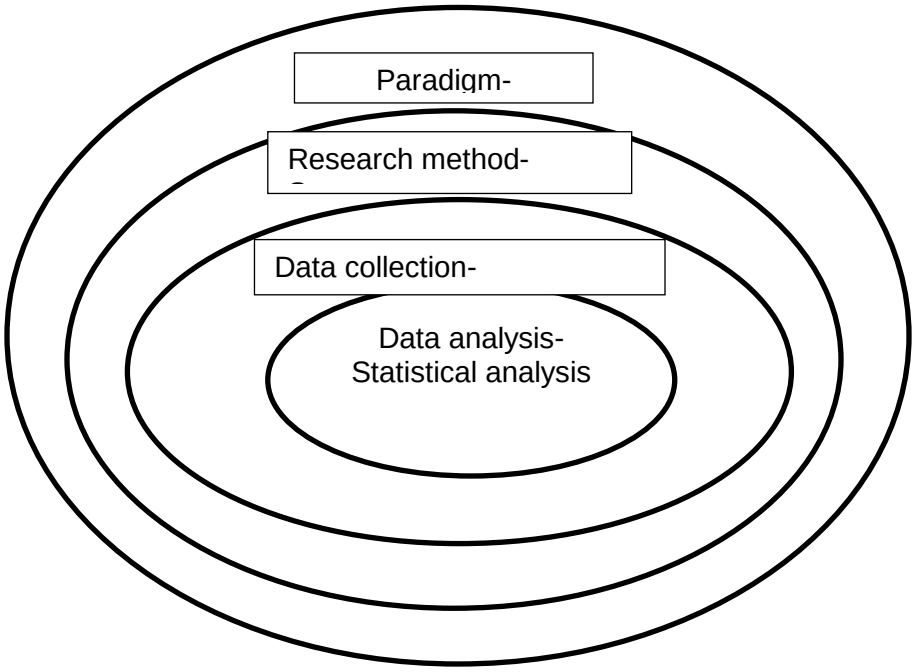

Figure 3.1. Research design outline

3.2. Paradigm

Paradigm is a classic form or an organized structure of conducting research. According to Merriam-Webster (2011), paradigm is referred to as: "a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated". It is a free combination of rationally associated assumptions, perceptions and plans which cause for more thinking and investigation (Mackenzie & Knipe, 2006). It involves knowing about a particular problem in life and having organized plans of how to investigate the particular problem

Paradigm comprises of three major types, including:

- Positivist (Scientific-positivism).
- Interpretivist.
- Critical.

According to Haworth (1984:344), each of the paradigms is associated with a set of assumptions including:

- Cosmology: entails the way the world is structured and humans' position within the world.
- Ontology: entails different ways of viewing the nature of the word and nature of humans in it.
- Epistemology: entails the unique way of inquiry to obtain a particular knowledge from the nature of the world.
- Ethics or Axiology: entails the philosophical field of study based on social norms and values.
- Acknowledgement of other philosopher's lexicon, e.g., aesthetics, metaphysics.

Furthermore, Haworth (1984:344) stated that without these contextual assumptions, human minds cannot be involved in the construction of theories about less inclusive portions of natural processes. Every research work follows a specific type of paradigm which influences the study and final outcome(s) of the research. The three major types of paradigm will be briefly discussed as follows:

3.2.1. Positivist paradigm

Positivist paradigm is based on science and it makes use of a scientific approach in investigating a topic under study. Hughs (2001), stated that this paradigm is based on static universal laws. With knowledge of these laws; we can understand and explain everything that happens around us. Positivism adopts theories of reality and knowledge about nature, for which we can use sense and reasoning to create knowledge about the reality of the world (Hume, 1993; Descartes, 1998). This paradigm emphasizes much on empirical observation of real events that can be rationally analyzed for clarification and experimentation which reduces the complications of the outside world. It comprises of two forms of approaches; exploratory and confirmatory. Exploratory involves observations and patterns to develop a theory while confirmatory involves using hypothesis to test a theory. Some features of positivist paradigm are as follows (Coolican, 2004; Oates, 2006:286; Stahl, 2008):

- Observation and data collection.
- Searching for patterns and creating theory.
- Making use of hypothesis to test and confirm any theory through research.
- Provides room for adjustment of theory.
- Believes that research is independent and purely objective.
- The world is based on universal laws and everything that happens around the world can better be explained with knowledge of these laws.

These features can be represented in a cycle as showed in figure 3.2.

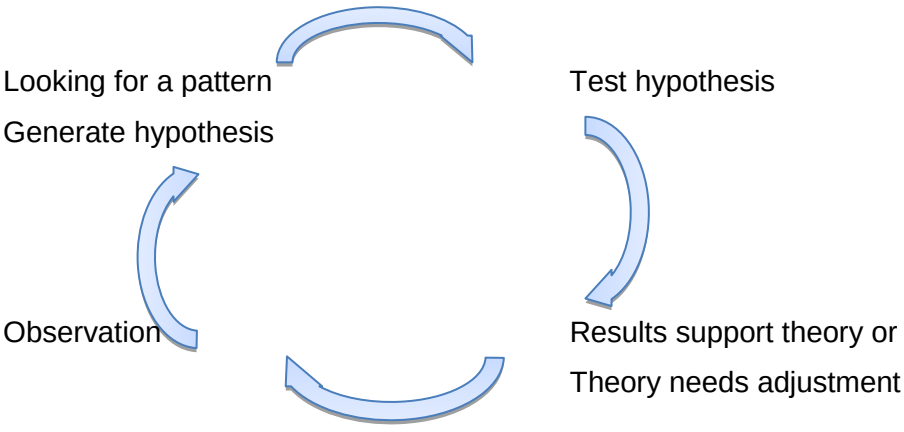

Figure 3.2 Research cycle of positivist paradigm

3.2.2. Interpretivist paradigm

Interpretivist or constructivism paradigm is anti-positivist and was created as a result of disagreement to positivism. The main argument of the interpretivist is that research should be conducted subjectively and not objectively, from the inside not the outside through direct interactions and experiences of the people. It studies events in their natural settings trying to make meaning from people's viewpoint (Joubish *et al*., 2011). Cohen *et al*., (2007:19) stated that with the interpretivist paradigm the researcher needs to: "understand, explain, and demystify social reality through the eyes of different participants". Interpretivism believes that social reality is known by many people and through communication with multiple participants; one can obtain different perspectives about an event. A need also exists to consider the subjective interpretations and perceptions of people in order to gain more understanding of the social life phenomenon (Ernest, 1994:25). The nature of research with this paradigm is qualitative and uses more of text to deduce knowledge from the social world. This paradigm is characterized with the following:

- Understanding people's perception is its key purpose
- Its reality is dynamic in nature because of changes in people's perceptions
- Its viewpoint is based on the knowledge of the people
- Subjective data based on people's perceptions
- The primary source of data is the people.

3.2.3. Critical paradigm

Critical social research paradigms, involves research initiatives that aim to dissuade conventional knowledge bases, which could either be quantitative or qualitative that portray scientific objectivity. It attempts to showcase the socio-historical specificity of knowledge and to shed light on how particular knowledge reproduces structural relations of inequality and oppression (Muncie, 2006). This paradigm is characterized with the following;

- Emancipation - (Stahl, 2008) suggests that the most important defining features of critical social research is its intention to promote emancipation.

- Criticism of Tradition - It projects a mindset that encourages researchers not to accept social conventions but to ask questions that produce constructive responses which lead to better arguments. Critical social research argues that you cannot continue to apply the

investigative logic developed by the positive social sciences to new topics and expect to develop new critical results (Comstock, 1982; Muncie, 2006).

- Non performativity Intent – Critical research looks to develop results that are objective and not necessarily always positive. This also aims at avoiding streamlining of research findings to suit the interests of benefactors such as financiers (O'Brien, 2001; Keiko, 2007).
- Critique of technological determinism - It advocates that technology should rely on the input of people and not the other way round (Thomas, 2006).
- Reflexivity - By adopting a reflexivity approach the entire research process can be evaluated from an objective perspective to ascertain a confidence level in the results obtained process (Somekh and Lewin, 2006).

3.3. Research paradigm applied in this study

This study involves the investigation of the relationship between factors. In other words, the research is to examine the identified success factors which are quantifiable variables and determine if they are critical to the success of mobile applications' development; therefore positivist paradigm is the most suitable approach and is used in this research. All the aspects of positivist paradigm including: the research method, data collection method, techniques and principles would be applied to justify the research quality. These aspects are discussed in detail in subsequent sections.

3.3.1. Scientific method

The positivist paradigm, also referred to as scientific method, is the oldest among the three main paradigms and is mostly used in research projects. A French philosopher Auguste Comte (1798 – 1857) introduced the positivist philosophy according to his belief that the truth about reality can only be known through a scientific method. It has been reviewed for improvement by many scholars and considered to be the research approach that gives the most accurate result (Schwandt, 2007). During the early 20th century, the Vienna Circle proved it to be the leading scientific method for research purposes (Neurath, 1973).

Furthermore, Oates (2006:283) stated that positivism involves two basic assumptions including:

- The world we live in has a form of order which is simply not random.

- The world can be investigated objectively.

These assumptions mean that: First, in the world we live, a particular situation will always give the same results wherever it may be. For instance, a stone thrown up in the open air surface must surely fall down as a result of gravitational force. Secondly, simple implies that research should be objectively and rationally conducted irrespective of the researcher's experience.

This study is centered on objective investigation in which the participants will freely complete the questionnaire based on their experience on mobile applications' development without any interference from the researcher.

3.3.2. Techniques of scientific method

There are three basic techniques applicable to scientific method (Hjørland, 2005; Creswell, 2007:.20). These are reductionism, repeatability and refutation.

- Reductionism – this involves breaking down of complex system into smaller parts for easy study.
- Repeatability – this involves repeating research experiment to confirm if it can give the same results.
- Refutation – this involves disproving a research experiment when repeated and does not give the same results.

In order to gather the quantitative data needed for this study, we broke mobile application development down into three major parts including:

- Background information of the participants – to obtain detailed information of the participants.
- Mobile applications' development process – to gain knowledge of how mobile applications are being performed in South Africa.
- Critical success factors. – to investigate the identified success factors.

Therefore, only the reductionist technique is applicable to the research work.

3.3.3. Principles of scientific inquiry

According to Feuer and Towne, there are six fundamental principles of scientific methods of research applicable to different kinds of scientific research. These principles create a well-defined approach to research with regard to questioning, investigating, reasoning and thinking (Feuer & Towne, 2002). These include:

- Positioned important questions that can empirically be examined: *The research question "Determine the critical success factors of mobile applications" can be empirically examined by verification of the quantitative data collected.*

- In scientific inquiry, research is connected to theory: *In this study some conceptual ideas associated with the research objectives were put together to form the theory for scientific investigation. These ideas made up the conceptual model of the study.*

- The research methods allow straight examination of questions: *Application of survey research method on this study provides a clear format for proper examination of the research questions.*

- There is provision for rational reasoning: *The questionnaire used for this study was logically designed in such a way that the participants would have a clear understanding of it and respond properly.*

- There is provision for generalization and reproduction of ideas: *This principle is applicable to random sampling but in this study we used convenience sampling.*

- The research process is transparent and permits scholarly debate: *The findings and conclusions of this study will be made clear to the scientific community.*

3.3.4. Advantages and disadvantages of positivist paradigm

3.3.4.1. Advantages

The aspects of positivist paradigm that gives it an edge over other paradigms are the research approach and research structure. Some scholars point out the advantages and disadvantages

as follows (Johnson & Onwuegbuzie, 2007; Cohen *et al*., 2007; Houghton, 2011; Johnson, 2014):

- It uses scientific methods in its research.
- It is based on quantitative data with a high degree of reliability.
- It delivers objective information which enables the researcher to make scientific assumptions.
- It is possible to make future predictions from quantitative data obtained.
- Accuracy of the Parsimony aids in making it valuable for studying large numbers of people therefore it saves time.
- It uses a definite structure in conducting research and discussions. That is, it follows a set of rules /guidelines in its studies.
- The structure creates room for variable changes during the study and this makes the study special through experiments which are more accurate.

3.3.4.2. Disadvantages

- Empiricism and objectivity is not suitable for research in social natural settings, especially when testing human behaviors.
- There is no flexibility in positivism, positivist believe that ecerything can be measured and calculated. They perceive things as they are and do not accept unsolved phenomenon.
- Inability to give account of a particular capability of one's practices and represent it to others.
- Generalized knowledge may not be applicable to a particular case.

3.3.5. Research strategies associated with positivist paradigm

The research methods associated with positivist paradigm include:

- Survey research method.
- Experimental research method.
- Design and Create research method.
- Correlational research method.

Survey research method – is a research method that involves the data collection from responses of a targeted population either through verbal or written communication (Mathiyazhagan & Nandan 2010).

Experimental research method –Experiments are operations or procedures carried out under controlled circumstances in an attempt to discover an unknown effect or law, to test, confirm, or establish a hypothesis, or to illustrate a known law (Merriam-Webster, 2011)

Correlational method – is a research method used to test for relationships between two variables in a situation where an experiment seems to be difficult or impossible (Lomax, 2013).

Design and create - This method focuses on developing new ICT products and the strategy of design and creation is by making awareness, suggestion, development, evaluation and conclusion (Richey & Klein, 2005).

3.4. Research method used in this study

In this study data is needed from a specific set of people (Information and communication professionals) in order to determine the critical success factors of mobile application development. Thus, the survey research method is used in this study.

3.4.1. Survey

Survey is a research method used in collecting quantitative data or information from a group of individuals known as ‘a sample’. In other words, survey is a method of accessing people’s minds and views over a unique topic under study. It is a research method commonly connected to positivism (Oates, 2006:93).

The idea of a survey is that one will obtain the same kinds of data from a large group of people in a standardized and systematic way. One then looks for patterns in that data to generalize to a larger population than the group that has been surveyed.

3.4.1.1. Advantages and disadvantages of using survey research method

There are some advantages and disadvantages of survey-based research as stated by (Oates, 2006:104; Marshall, 2005:132).

Advantages of using the survey research method include:

- Survey produced quick and large results at low cost compared to other methods.
- It makes provision for replication of the results from time to time.
- It provides a broad coverage of people or events, so that the results are more likely to be representative of the wider population.
- It is a suitable method for people with low communication and inter=personal skills.

Disadvantages:

- A survey tends to concentrate on quantifiable cases that rely on statistical analysis
- It lacks depth.
- It does not establish cause and effect.
- It provides or covers a particular point in time, rather than observing ongoing practices and change.
- When internet or postal survey is used, there is no physical contact with the respondent, thus the accuracy of the response cannot be judged through observation.

In planning and designing of the survey used for this study, these advantages and disadvantages were considered especially to minimize the effect of the disadvantages as described in the next section.

3.4.2. Planning and designing of survey

Six significant activities are involved in planning and designing of the questionnaire. These activities must be properly considered because the design of the questionnaire affects the data collected which affects the research outcomes (Oates, 2006:94; Brace, 2008:35-44; Oppenheim, 2000:49-82). These activities include:

- Data requirements.
- Data generation method.
- Sampling frame.
- Sampling technique.
- Response rate and non-responses.
- Sample size.

Below is a brief explanation of these activities with regard to their application to the topic under study.

3.4.2.1. Data requirements

This involves the type of data required to conduct the research. It can either be directly or indirectly related to the topic under study. Participants have only a single chance to respond, thus the survey should be clearly designed to collect the required data for the study. In this study, the required data is quantitative data that can enable us to determine the critical success factors of mobile application development. The survey has to be designed in a way to collect data from an organizational background, how mobile applications' development is done in South Africa and the importance of the identified factors. Table 3.1 indicates how the data requirements were addressed in the survey.

Table 3.1. Indicate how the data requirements were addressed in the survey.

Variable	**Linked to**	**Number of items investigated**
Section A – Background Information		
Core business area	Obj. 3	1 (list with 9 options)
Location of organization	Obj. 3	1 (participant to specify)
Size of organization	Obj. 3	1 (list with 5 options)
Number of developers in the organization	Obj. 3	1 (list with 5 options)
Role within organization	Obj. 3	1 (list with 5 options)
Section B – Mobile application Development		
Organization year in existence	Obj. 3 & 4	1 (list with 4 options)
Primary motivation	Obj. 3 & 4	1 (list with 4 options)
Number of mobile applications developed	Obj. 3 & 4	1 ((list with 5 options)
Most successful mobile application developed	Obj. 3 & 4	1 (participant to specify)

Table 3.1. Indicate ho**w** the data requirements were addressed in the survey (*contd*).

Development platform	Obj. 3 & 4	1 (list with 7 options)
Application success	Obj. 3 & 4	1 on 5-point Likert scale
Use of software development methodology	Obj. 3 & 4	1 with YES/NO
Section 3 – critical success factors		
Open source technology	Research aim and obj.1, 2 & 5	5 on 5-point Likert scale
Individual development skills	Research aim and obj.1, 2 & 5	4 on 5-point Likert scale
Software development kit	Research aim and obj.1, 2 & 5	4 on 5-point Likert scale
Portability	Research aim and obj.1, 2 & 5	4 on 5-point Likert scale
Functionality	Research aim and obj.1, 2 & 5	4 on 5-point Likert scale
Back-end integration	Research aim and obj.1, 2 & 5	4 on 5-point Likert scale
System development methodology	Research aim and obj.1, 2 & 5	3 on 5-point Likert scale
Mobile application devices	Research aim and obj.1, 2 & 5	3 on 5-point Likert scale
Web and network integration	Research aim and obj.1, 2 & 5	4 on 5-point Likert scale

3.4.2.2. Data generation method

This involves the method used to collect data from the participant(s) including: questionnaire, interviews, documents and observations. With regard to the research topic, most suitable method will be chosen. In this study, data will be gathered from large population and questionnaire method is most suitable.

Survey research method involves various data collection techniques including (Bell 1987; Oates, 2006:36).

- Interviews – this is a purposeful conversation between the researcher and the participant in which a set of preplanned questions are used to quiz the participant. It can be one-on-one or a group interview.
- Observation – this involves looking at people and listening to them talking in order to obtain information or infer meanings from their actions. That is, observing all activities of the people for information gathering purposes.
- Documents review – reviewing already existing documents that contain information related to the research topic including electronic bulletin boards, diagrams, videos etc.
- Questionnaire – this is a set of preplanned questions arranged in a particular order. It may be open-ended or closed-ended questions. Sometimes it involves both types. A closed-ended question is the type that allows the participant to choose an answer from a list of choice, e.g. multiple choice questions. An open-ended question is an unstructured type of question in which the participant answers in his/her own words. It normally starts with why, how, in your own opinion etc.

Selecting a technique for data collection depends on the sample, environment and type of data required in relation to the researcher's preference. Each of the techniques is suitable for a particular environment and a specific case. The research output can also be influenced by the data collection technique used in conducting the research.

3.4.2.3. Sampling frame

This is a set of individuals within the entire population that may be part of the survey, from which a sample will be selected. The sampling frame for this study covers all business areas where there is mobile application development interest within the real-world. These include several Information and communication technology experts from several related business areas such as

software development companies, financial institutions, telecommunication, education and engineering.

A search was conducted through the internet and a list of related organizations, their physical addresses and telephone numbers were obtained but there is no particular directory that contains all the organizations. Some of the targeted organizations like education, financial institutions and some telecommunications companies are already known. The web search only provided information about the software development companies and some other telecommunication companies. A long list was obtained, among which 392 organizations that have the most relevant background, which were chosen and contacted.

3.4.2.4. Sampling techniques

Sampling technique involves the process of selecting the sample which will be the representative of the population. There are two common types of sampling techniques: probability sampling and non-probability sampling techniques.

Probability sampling technique – One in which each sample has the same chance or probability of being selected and can accurately reflect the whole population including:

- Random sampling.
- Stratified sampling.
- Cluster sampling.
- Systematic sampling.

Non-probability sampling – One in which each sample does not have an equal chance or probability of being selected and the researcher is not sure if the sample accurately reflects the whole population. This includes:

- Purposive sampling.
- Snowball sampling.
- Self-selection sampling.
- Convenience sampling.

In this study a convenience non-probabilistic sampling technique was used because it is not possible to get a complete and comprehensive register or directory that contains a list of ICT

companies in South Africa. The selected sample is a list of companies that are involved in mobile applications' development within South Africa.

3.4.2.5. Response and nonresponse rates

In the survey, the number of returned responses and nonresponses matters a lot. There must be a defined strategy to be used in order to get the maximum number of responses else the participants may ignore the questionnaire. In this study, a letter of introduction was written and attached to the questionnaire to serve as a conviction to participants that it is a real study. Also when the companies were physically approached, emphasis was placed on the benefits of completing the questionnaire, namely that it will enrich their knowledge. With this strategy a reasonable number of responses were obtained.

3.4.2.6. Sample size

Sample size refers to the number of participants involved in the survey. It can either be a designated sample size or a final sample size (Shapiro, 2008). A designated sample size is the total number of participants contacted for the survey while a final sample size is the total number of participants that responded to the survey. In this research the designated sample size was 392 participants and the final sample size was 152 responses (39%). The response rate is satisfactory as it is expected from a questionnaire based survey.

3.4.3. Data collection techniques

In this study the questionnaire data collection technique was used because we needed quantitative data. There are some advantages and disadvantages of using the questionnaire method for data generation. These include (Marshall 2005:132; Oates, 2006:229):

3.4.3.1. Advantages of Questionnaire

- It is more convenient for participants to respond to because of the pre-defined answers.
- It is more economical in comparison with other data collection types.

- There are many ways of questionnaire distribution, as a result little or no geographical limitations exist during questionnaire distribution.
- Self-administration questionnaires do not need extra skills more than that of the researcher.

3.4.3.2. Disadvantages of Questionnaire

- There is no room for correction or explanation of misunderstandings in the questions.
- Incomplete answering of questions could result in poor or weak results in some cases.
- It is not suitable for people with poor literacy skills and visual handicaps to respond to a self-administered questionnaire.
- The validity of answers cannot be controlled by the researcher.

To minimize the effect of these disadvantages, the questionnaire was carefully designed and thoroughly examined and piloted before they were sent to the participants who are literate and experienced ICT experts.

The questionnaire was systematically designed to capture the required data in order to determine the critical success factors of mobile applications' development (see Appendix A). It contains three sections: background, mobile applications development and critical success factors. The background section of the questionnaire aimed to capture the background information of the participants including: core business area, location of the organization, organizational size in terms of number of employees, number of software developers in the organization and the role of the participant(s) in the organization. Section 2 aimed to capture information about how mobile application development is being performed in South Africa and the information collected include: how long has the organization been busy with mobile application development, the primary motivation for mobile application development, the number of mobile applications developed, the most successful mobile application developed, the platform of development and system development methodology used (if applied). Section 3 deals with the critical success factors. Nine important factors were identified and the participants were asked to rate the significance of these factors in a Likert scale of 1-totally disagreed to 5-totally agreed. Also added are explanatory statements attached to each factor to test the participants' understanding of the particular factor. This is to determine the degree of importance of each factor to the mobile application development. The summary of the items investigated by each variable is shown in Table 3.2

The questionnaire was piloted and changes /or corrections effected with regard to feedback obtained from the pilot survey. Most of the corrections involved rephrasing of questions for proper understanding and grammatical corrections made. The final copy was produced and sent out to a sample frame. This survey was conducted in South Africa between May 2014 and September 2014. A list of likely participants was obtained through internet searches together with their physical addresses and contact numbers. The participants were contacted by means of phone calls, e-mail messages and physical approach, after which questionnaires were sent to them. Participants were called on a weekly basis to remind them of responding to the questionnaire and responses were received gradually until no more responses were received. A drop-off approach was used to distribute the questionnaires especially to physically contacted participants. The latter method was effective with high response rates. All the responses were arranged together, thoroughly examined and data was captured for analysis.

3.4.4. Description of the sample used in this study

3.4.4.1.. Background information

In this section we will provide a description of the respondents that form part of the sample. The first section of our survey is the background information; here we are trying to gain more understanding about the respondent's core business area, business location, organization size in terms of employees, number of developers in the organization and the particular role of the respondent in the organization.

To achieve this, we created five questions in which four are multiple choice questions and the respondent has to select one out of the listed options. One question is an open-ended question, '*the location of the organization*' and the respondent has to supply the answer.

3.4.4.2. Core business area

This covers the major business area of the participant's organization and to gather this information options are provided including; Software Development Company, financial institutions, manufacturing, administrative services, retail/wholesale, education, telecommunication, engineering and others.

Descriptive analysis was performed on the collected data and the results obtained are as follows: software development companies (55.92%), financial institutions (11.84%), education

(13.82%), telecommunication (12.50%) and engineering (5.92%), manufacturing, administrative services, retail/wholesale and others have no responses. Though software development companies dominate the data, the result is satisfactory because the research is based on mobile application development. This is as shown in Table 3.2.

Table 3.2. Core business area

Core business area	**Number of participant N = 152**	**Percent**	**Cumulative percent**
Software development company	85	55.92	55.92
Financial institutions	18	11.84	67.76
Education	21	13.82	81.58
Telecommunication	19	12.50	94.08
Engineering	9	5.92	100.00
Manufacturing	0	0	0
Administrative services	0	0	0
Retail/Wholesale	0	0	0

3.4.4.3. Location of the organization

This question was asked in order to know in which province of South Africa the company is located. The following results were obtained: Gauteng province (98.03%) and Cape Town (1.97%). This is satisfactory because Gauteng province is the core business center in South Africa. Almost all the organizations have an office in Gauteng. The analysis is shown in Table 3.3.

Table 3.3. Location of the organization

Location	Number of participant N = 152	Percent	Cumulative percent
Gauteng	149	98.03	98.03
Cape Town	3	1.97	100.00

3.4.4.4. Organizational size

This determines the size of the organization of the participants. That is, knowing the total number of employees from all locations of the organizations. We provided number-ranged options from which the respondent has to select only one. The descriptive statistics of the result obtained are: 1-10 employees (24.34%), 10-50 employees (22.37%), 50-100 employees (8.55%), 100-200 employees (7.89%) and above 200 (36.84%). Table 3.4 shows the representatives of all organizational sizes.

Table 3.4. Size of the organization

Number of employees	Number of participants N = 152	Percent	Cumulative percentage
1-10	37	24.34	24.34
10-50	34	22.37	46.71
50-100	13	8.55	55.26
100-200	12	7.89	63.16
Above 200	56	36.84	100.00

3.4.4.5. IS department size

This provides the information about the total number of software developers in an organization. The results obtained with regards to different options are: no developers (5.92%), 1-5 developers (33.55%), 5-10 developers (21.05%), 10-50 developers (21.71%), 50-100 developers (5.26%) and above 100 developers (12.50%). The detail is shown in Table 3.5.

Table 3.5. Software developers in organizations

Number of developers	Number of participant	Percent	Cumulative percent
0	9	5.92	5.92
1-5	51	33.55	33.55
5-10	32	21.05	60.53
10-50	33	21.71	82.24
50-100	8	5.26	87.50
Above 100	19	12.50	100.00

3.4.4.6. Role of participants

This determines the particular role of the participant in the organization. Options involved are managing director, chief information officer, IT manager, project leader, system administrator, programmer/developer, system analyst and others. The descriptive statistics of the result obtained is: Managing director (11.18%), IT manager (15.13%), system administrator (13.82%), programmer/developer (51.97%), system analyst (3.29%) and others (4.61%). The detail is shown in Table 3.6.

Table 3.6. Role of participant

Role	Number of participant N = 152	Percent	Cumulative percent
Managing director	17	11.18	11.18
IT manager	23	15.13	26.32
System administrator	21	13.82	40.13
Programmer/developer	79	51.97	92.11
System analyst	5	3.29	95.39
Others	7	4.61	100.00

3.5. Data analysis

All the responses were thoroughly examined to extract the data and a statistical analysis was performed to determine the critical success factors (CSF) of mobile applications development. On the part of CSF, multiple items were used to examine the research variables.

A descriptive analysis was performed to describe the frequency and percentage of responses from the study population. A Pearson correlation analysis was performed to determine if a linear relationship existed (O'Rourke N. *et al.,* 2013). Also performed was a Cronbach alpha reliability analysis used to compute reliability coefficients for each of the examining variables (Sethi & King, 1991; Nunally, 1978). To determine if inter-correlations exist among variables, Kaiser's measure of sample adequacy (MSA), was computed (Tabachnick, 2001). In addition, the data was categorized and T-test analysis and analysis of variance (ANOVA) were performed to determine if there is any difference or similarity between the categories.

Since we used convenience sampling not random sampling, the mean comparison was done according to Cohen's effect sizes and the guidelines for effect size (d values) are as follows (Cohen, 1988):

d = 0.2 (small effect); d = 0.5 (medium effect) and d ≥ 0.8 (large effect or practical significant)

The criterion for Cronbach's coefficient alpha for reliability is $\alpha \geq 0.6$ Sethi & King, 1991; Nunally, 1978). That is if the obtained $\alpha \geq 0.6$ then the data obtained of that particular item is reliable.

For T-test if p-value ≥ 0.5, it indicates significance; p-value > 0.5 < 0.8, it indicates medium significance and p-value ≥ 0.8, it indicates practical significance.

For ANOVA, if p-value ≤ 0.05, there is statistical significance and if p-value ≥ 0.05, there is no statistical significant

3.6. Chapter summary

This chapter covers the research methodology used to conduct the study. Three main research paradigms were examined including: positivist, interpretivist and critical research paradigms. The most suitable paradigm for the study is positivist which was further detailed in terms of techniques, principles, advantages /disadvantages, research methods and data collection methods.

A survey research method was applied in which a questionnaire was used to collect quantitative data. Various statistical analytical methods including: descriptive statistics, correlational analysis, Cronbach coefficient alpha, ANOVA, T-test and cluster analyses were used for data analysis to determine the critical success factors of mobile application development.

Chapter four gives details of data analysis and research results indicating the critical success factors of mobile applications development.

Chapter 4. Results of statistical analysis

4.1. Introduction

In this chapter we report on the critical success factors of mobile application development which is the aim of this dissertation. The results will be presented according to all research objectives:

1. Conduct literature review of mobile application development.
2. Review literatures on success factors of mobile application development (if available) and other related literatures.
3. Describe current state of mobile application use in business in South Africa including:
    - History of MAD.
    - Primary motivation.
    - Duration.
    - Application success.
4. Investigate how mobile application development is performed in South Africa in terms of;
    - Systems development methodology.
    - Platforms of development.
5. Determine the perceived importance of the success factors identified amongst mobile application developers.

The objectives 1 and 2 stated above were treated in chapter 2 which covers the theoretical overview of the topic under study. As reported in chapter 3, the study started with survey design, with use of a questionnaire through convenience sampling, responses were obtained from respondents. The survey covers three sections including: investigation of background information of the respondent, information on the mobile application developed by the respondent and the critical success factors of MAD.

4.2. Current state of mobile application development (MAD) in South Africa

In this section, we investigated the current state of mobile application development in South Africa. We investigated how long the organization has been doing MAD, what is their primary motivation for MAD, the total number of mobile applications developed by the participating organizations and how successful is the most successful mobile application developed.

4.2.1. History of MAD in participating organizations

This determines how long the organization has been doing MAD. We provided number-range options and the descriptive statistics of the results obtained are: 1-5 years (15.13%), 5-10 (33.55%), above 10 years (43.42%) and never at all (7.89%). It indicates that 77% of participating organizations have been developing mobile applications for 5 years and longer. This is detailed in Table 4.1.

Table 4.1. History of MAD

Duration (years)	**Number of participant N = 152**	**Percent**	**Cumulative percent**
Never at all	12	7.89	7.89
1-5	23	15.33	15.33
5-10	51	33.55	48.68
Above 10	66	43.42	100.00

4.2.2. Primary motivation for MAD

This defines the reason/purpose of mobile application development in participating organizations. Several options were provided for the respondent and the descriptive statistics result obtained is: profit (58.55%), extension of company portfolio (53.29%), brand recognition (2.63%) and others (8.55%). It should be observed that some participants selected more than one answer but clearly the most primary motivation for MAD is profit. This is shown in Table 4.2.

Table 4.2. Primary motivation for MAD

Motivation	Number of participant N = 152	Percent
Profit	89	58.55
Extension of company portfolio	81	53.29
Brand recognition	4	2.63
Others	13	8.55

4.2.3. Number of mobile applications developed by organizations

In this, we report on total number of mobile applications developed by each participant organization. Number-range options were also provided and the descriptive statistics of the result obtained is: 1-10 apps (43.71%), 10-50 (22.52%), 50-100 (11.92%), above 100 (19.87%) and none (1.99%). This indicates that only 31.79% of the organizations have developed more than 50 applications. The detail is showed in Table 4.3.

Table 4.3. Number of mobile applications developed by organizations

Mobile application	Number of participant N = 152	Percent	Cumulative percent
None	3	1.99	1.99
1-10 apps	66	43.71	43.71
10-50 apps	34	22.52	66.23
50-100	18	11.92	78.15
Above 100	30	19.87	100.00

4.2.4. Mobile application success

The participants were asked to state how successful their mobile applications are; using the scale rating of 1-5 (1 is very unsuccessful and 5 very successful). The descriptive statistics of results obtained is: very successful (53.02%), successful (46.31%) and average (0.67%). No one indicated that their mobile application is not successful which indicates that participants are very satisfied with the mobile applications they developed. The detail is as showed in Table 4.4.

Table 4.4. Mobile application success

Rating (1-5)	**Number of participants N – 152**	**Percentage**	**Cumulative percentage**
1	0	0	0
2	0	0	0
3	1	0.67	0,67
4	69	46.31	46.98
5	79	53.02	100.00

4.3. How MAD is performed

This section of the survey investigates the mobile application development to know how MAD is performed especially in South Africa in terms of the platform of development and system development technology used in MAD.

4.3.1. Development platform

This is the operating system of a mobile application. In order to determine the platform of development by different organizations, we provided an optional list of different platforms in

which more than one can be selected. The options included: iOS, Android, Blackberry, Symbian, Windows and Mac OS. The response from the participants is as shown in Table 4.5.

Table 4.5. Platform of development

Platform	**Number of participants (users): N = 152**	**Number of participants (non-users): N = 152**
IOS	129 (87.16%)	19
Android	148 (99.33)	1
Blackberry	104 (70.27%)	44
Symbian	3 (2.03%)	145
Windows	95 (63.76%)	54
Mac OS	0 (0%)	149
Others	0 (0%)	0

From Table 4.5 above, It was observed that the platforms (iOS, Android, Blackberry, and Windows) are widely used in mobile application development while Symbian and Mac OS are rarely or not used at all. In addition the most popularly used platform is Android and it is clear that combinations of platforms are used in MAD.

4.3.2. Usage System development methodology (SDM)

The participants were asked about the general usage of system development methodology in their development of mobile applications. The options provided are simply ‘’YES’’ or ‘’NO’’. The descriptive statistics of the results obtained shows that 6.29% of participants indicated “NO” and 93.71% of participants indicated “YES”. This indicates that SDMs are widely used during the development of mobile applications. The detail is shown in Table 4.6.

Table 4.6. Usage of SDM

Usage SDM	Number of participants N = 152	Percentage	Cumulative percentage
YES	134	93.71	93.71
NO	9	6.29	100.00

4.3.3. Type of SDM

In completion of the above question, the participants were asked to specify the type of SDM they have used in mobile application development. The following options were provided: Mobile D, Dynamic channel mode, Mobile engineering, MASAM, Agile methodology, Hybrid, Chen M., M Compass, Mobile RAD, none and others. The participants can choose more than one option and Table 4.7 shows the detail of their responses.

Table 4.7. SDM used in MAD

SDM	Number of participants (users): N = 152	Number of participants (non-users): N = 152
None	9 (6.12%)	138 (93.88%)
Mobile D	31 (21.09%)	116 (78.91%)
Dynamic channel mode	1 (0.68%)	146 (99.32%)
Mobile engineering	0	147
MASAM	3 (2.04%)	144 (97.96%)
Agile methodology	135 (91.84%)	12 (8.16%)
Hybrid	3 (2.04%)	144 (97.96%)
Chen M.	0	147
M Compass	0	147
Mobile RAD	15 (10.20%)	132 (89.80%)
Others	1 (0.68%)	145 (99.38%)

Table 4.7 shows that developers of mobile applications applied the use of SDM in their development. It clearly indicates that the Agile methodology is used more than every other one and 7 participants do not use SDM in MAD. SDM that were specifically developed for MAD are not being used very often.

4.4. Critical success factors (CSF)

In this section the researcher investigated the perceptions of developers regarding success factors of mobile applications development. Some CSFs with some explanatory statements in relation with each factor were listed. The participants were asked to rate the importance of these CSF and their explanatory questions /statements on a scale of 1-5 (1 is totally disagreed and 5 totally agreed). These explanatory questions/statements were added in order to investigate the participant's understanding of the identified CSFs. The identified CSFs include the following: open source technology (OST), individual development skills (IDS), software development kit (SDK), portability, functionality, back-end integration (BEI), system development methodology (SDM), mobile devices specifications (MDS) and, web and network integration (WNI). In addition participants were asked to suggest other CSF not listed in the survey.

The mean of descriptive statistics of the responses on the CSFs and their rank are shown in Table 4.8. The analysis of quantitative data obtained showed that 8 out of 9 identified success factors emerged as significant factors with regard to mobile application development while one did not. The significant factors are individual development skills, software development kit, portability, functionality, system development methodology, mobile devices specifications, back-end integration and web to network integration and a non-significant factor is open source technology. The factors were rated on a 5-point scale (1 – strongly disagree to 5 – strongly agree), meaning that a mean value ≥ 3 indicates that the respondents agree that the particular factor has a significant influence to mobile application development. It can be seen that 8 factors have minimum response mean ≥ 3.68. This compares very well to the published report of Papanikolaou & Mavromoustakos who stated that mobile devices, portability and functionality are critical success factors of mobile e-learning applications (Papanikolaou & Mavromoustakos, 2006). The degree of importance of each factor can be seen from the ranking which shows that the individual development skill is most significant and system development methodology is least significant (Table 4.8). The result is satisfactory and not surprising because it is in line with

previous related literatures (Gebauer & Shaw, 2004; Papanikolaou & Mavromoustakos, 2006; Sybase, 2007; Serena, 2007; Zhou, 2010; Rodrigues *et al*., 2010; Mohamed & Tsinakos, 2014).

Table 4.8. Mean descriptive statistics of CSFs

Variable	**Mean N = 152**	**Std. Dev.**	**Scale rating**					**CSF Rank**
			1	**2**	**3**	**4**	**5**	
OST	2.89	0.99	13 (8.61%)	38 (25.17%)	58 (38.41%)	36 (23.84%)	6 (3.97%)	9
IDS	4.60	0.99	0	0	0	61 (40.13%)	91(59.97 %)	1
SDK	4.00	0.76	0	0	1 (0.66%)	61 (40.13%)	90 (59.21%)	4
Portability	3.84	0.80	0	9 (5.92%)	36 (23.68%)	78 (51.32%)	29 (19.08%)	6
Functionality	4.55	0.57	0	1 (0.66%)	3 (1.97%)	59 (38.82%)	89 (58.55%)	2
BEI	3.89	0.71	0	3 (1.97%)	38 (25.00%)	83 (54.61%)	28 (18.42%)	5
SDM	3.68	0.63	0	4 (2.63%)	49 (32.45%)	89 (58.94%)	9 (5.96%)	8
MDS	4.20	0.62	0	0	17 (11.18%)	87 (57.24)	48 (31.58%)	3
WNI	3.76	0.79	0	9 (5.92%)	42 (27.63%)	77 (50.68%)	24 (15.79%)	7

4.4.5. Unpacking Table 4.8

The investigation of the CSFs was done at two levels: a general statement of the CSF combined with explanatory statements for the CSF. Before we can unpack Table 4.8, we need to determine if these explanatory statements are a reliable measurement of the general CSF. In order to do that, we need to perform a reliability analysis.

It is important to test the reliability of the CSFs with regard to the corresponding research variables. Conger stated that reliability is the degree of error free of a measured tool (Conger, 1994). When a tool is given to the same set of people on different occasions to measure, the same results would be achieved. This means that the tool of measurement is reliable. In order to confirm the reliability of items of each factor under investigation, a reliability analysis was performed on the explanatory questions of each of the factors identified using Cronbach coefficient alpha. The least threshold criterion of 0.6 is the recommended value for exploratory research (Nunally, 1978; Sethi & King, 1991). The Cronbach coefficient alpha values obtained are shown in Table 4.9.

Table 4.9. Reliability analysis on CSF items

Construct	Cronbach coefficient alpha
OST	0.91
IDS	0.83
SDK	0.98
Portability	0.97
Functionality	0.96
BEI	0.95
SDM	0.93
MDS	0.93
WNI	0.98

From Table 4.9, the least Cronbach alpha coefficient is 0.83 and the highest is 0.98 which indicated that the CSF items data is reliable. The detailed description of the contents of Table 4.8 is as follows:

4.4.1. Open source technology (OST)

Open source technology was considered as one of the CSF of MAD and the participants were asked to rate its level of importance to the development of a mobile application. One general question and four explanatory statements were provided. The general question is “Open source technology is important in mobile application development”. The descriptive statistics of the result obtained is: totally disagreed (8.61%), disagreed (25.17%), average (38.41%), agreed (23.84%) and totally agreed (3.97%). The detail is showed in Table 4.10.

Table 4.10. Open source technology

Scale rating	Number of participants	Percentage	Cumulative percentage
1	13	8.61	8.61
2	38	25.17	33.77
3	58	38.41	72.19
4	36	23.84	96.02
5	6	3.97	100.00

Explanatory statements. Four explanatory statements are associated with OST and the descriptive statistics results obtained are showed in Table 4.11. The participants agreed with the first 2 statements about free access, but not with the last 2 statements regarding CSF for MAD.

Table 4.11. Explanatory statements of OST

Item description	mean N = 152	Std. dev.	Scale rating				
			1	2	3	4	5
OST allows free access to source code	3.43	0.68	0	11 (7.28%)	68 (45.08%)	67 (44.37%)	35 (3.31%)
OST application is free of charge	3.43	0.68	0	11 (7.28%)	68 (45.08%)	67 (44.37%)	35 (3.31%)
OST influenced mobile application development	2.92	0.95	13 (8.61%)	34 (22.52%)	60 (39.74%)	40 (22.49%)	4 (2.65%)
OST is CRF in your most successful mobile application development	2.89	0.94	13 (8.61%)	35 (23.18%)	61 (40.40%)	40 (22.49%)	2 (1.32%)

4.4.2. Individual development skills (IDS)

This factor was investigated using a general question and three explanatory questions. The general question is “In general, individual development skills are an important factor that affects mobile applications development”. The result obtained from descriptive statistics is: agreed (40.13%) and totally agreed (59.87%). The detail is showed in Table 4.12.

Table 4.12. Individual development skill

Scale rating	No. of participant	Percent	Cumulative percent
1	0	0	0
2	0	0	0
3	0	0	0
4	61	40.13	40.13
5	91	59.97	100.00

Explanatory statements: Three explanatory statements are associated with IDS and the descriptive statistics' results obtained showed that the response means of all the explanatory statements are very high, indicating that the factor IDS has strong effects on MAD. Table 4.13 details the statistics results.

Table 4.13. Explanatory statements of IDS

Item description	mean (N = 152)	Std. dev.	Scale rating				
			1	2	3	4	5
Developers' experience is important to mobile	4.58	0.49	0	0	0	63 (41.45%)	89 (58.55%)
Your organization has enough skilled developers for creating and developing mobile applications	4.18	0.96	3 (1.97%)	12 (7.89%)	4 (2.63%)	69 (45.39%)	64 (42.11%)
Availability of skilled developers is a critical success factor of mobile application development	4.59	0.51	0	0	1 (0.66%)	61 (40.13%)	90 (59.21%)

4.4.3. Software development kit (SDK)

The investigation of this factor also involves a general question and 3 explanatory statements. The descriptive statistics of the results obtained are shown in Table 4.14.

Table 4.14. SDK is an important factor of mobile application development

Scale rating	No. of participant	Percent	Cumulative percent
1	0	0	0
2	4	2.63	2.63
3	30	19.74	22.37
4	80	52.63	75.00
5	38	25.00	100.00

Explanatory statements: Three explanatory statements are associated with SDK and the descriptive statistics' results obtained showed high response mean of the explanatory statements indicating positive significance to MAD. Detailed results are showed in Table 4.15.

Table 4.15. Explanatory statements SDK

Item description	mean N = 152	Std. dev.	Scale rating				
			1	2	3	4	5
SDK helps and guide users in MAD	4.00	0.73	0	4 (2.63%)	28 (18.42%)	83 (54.61%)	37 (24.34%)
SDK eases and enhances MAD	3.98	0.72	0	4 (2.63%)	29 (19.08%)	85 (55.92%)	34 (22.37%)
SDK has a significant influence on MAD	3.96	0.73	0	4 (2.63%)	31 (20.39%)	84 (55.26%)	33 (21.71%)

4.4.4. Portability

Investigation of the importance of this factor to mobile application development was done using one general question and three explanatory questions /statements. The descriptive statistics' results obtained are showed in Table 4.16.

Table 4.16. A good mobile application should be portable

Scale rating	No. of participant	Percentage	Cumulative percentage
1	0	0	0
2	9	5.92	5.92
3	36	23.68	29.61
4	78	51.32	80.92
5	29	19.08	100.00

Explanatory statements: Three explanatory statements are associated with portability and the descriptive statistics results obtained showed that the response means are above average which is also significant to MAD. Table 4.17 shows the results.

Table 4.17. Explanatory statements of portability

Item description	mean N = 152	Std. dev.	Scale rating				
			1	2	3	4	5
The mobile application is portable	3.82	0.81	0	9 (5.92%)	38 (25.00%)	76 (50.00%)	29 (19.08%)
The mobile application can implemented across different platforms	3.88	0.82	0	8 (5.26%)	37 (24.34%)	72 (47.37%)	35 (23.03%)
Portability is critical success factor of mobile application development	3.85	0.84	0	9 (5.92%)	39 (25.66%)	70 (46.05%)	34 (22.37%)

4.4.5. Functionality

Functionality as a factor of mobile application development was investigated using one general question and three explanatory statements. The results obtained from descriptive statistics are showed in Table 4.18.

Table 4.18 Functionality is a critical success factor to be considered in mobile application development.

Scale rating	No. of participant	Percent	Cumulative percent
1	0	0	0
2	1	0.66	0.66
3	3	1.97	2.63
4	59	38.82	41.45
5	89	58.55	100.00

Explanatory statements: Three explanatory statements are associated with functionality and the descriptive statistics results obtained showed high response means of the explanatory statements indicating a significant effect to MAD. Table 4.19 details the results.

Table 4.19. Explanatory statements of functionality

Item description	mean N = 152	Std. dev.	Scale rating				
			1	2	3	4	5
The application performed the task it was intended for	4.42	0.53	0	1 (0.66%)	0	85 (55.92%)	66 (43.42%)
The application satisfied the users' needs	4.41	0.53	0	1 (0.66%)	0	87 (57.24%)	64 (42.11%)
The mobile application met the functional requirements of the users	4.35	0.54	0	1 (0.66%)	2 (1.97%)	90 (60.40%)	56 (37.58%)

4.4.6. Back-End Integration

This factor was also investigated with one general question and three explanatory statements and the descriptive statistics obtained are showed in Table 4.20.\

Table 4.20. The integration of a new mobile application to existing ones is given serious consideration during application development.

Scale rating	No. of participant	Percent	Cumulative percent
1	0	0	0
2	3	1.97	1.97
3	38	25.00	26.97
4	83	54.61	81.58
5	28	18.42	100.00

Explanatory statements: Three explanatory statements are associated with back-end integration and the descriptive statistics results obtained showed that all the response means are high indicating that factor BEI is significant to MAD. The results are detailed in Table 4.21.

Table 4.21. Explanatory statements of back-end integration

Item description	mean N = 152	Std. dev.	Scale rating				
			1	2	3	4	5
The application can be easily integrated into existing ones in an organization	3.94	0.75	0	3 (1.97%)	38 (25.00%)	75 (49.34%)	36 (23.68%)
The mobile application improves productivity	4.00	0.75	0	3(1.97%)	33 (21.71%)	77 (50.66%)	39 (25.66%)
Back-end integration was a critical success factor of mobile application development.	3.85	0.74	0	4 (2.63%)	42 (27.63%)	79 (51.97%)	27 (17.76%)

4.4.7. System development methodology

The importance of this factor was investigated using one general question and two explanatory statements/questions. The descriptive statistics results obtained are showed in Table 4.22.

Table 4.22. Generally, it is good to use system development methodologies in mobile application development.

Scale rating	No. of participant	Percent	Cumulative percent
1	0	0	0
2	4	2.63	2.63
3	49	32.45	35.10
4	89	58.94	94.04
5	9	5.96	100.00

Explanatory statements: Two explanatory statements are associated with SDM and the descriptive statistics results obtained showed that the response means of the exploratory are above average indicating also positive significance to MAD. The results are showed in Table 4.23.

Table 4.23. Explanatory statements of system development methodology

Item description	mean N = 152	Std. dev.	Scale rating 1	2	3	4	5
Use of formalized SDM enhanced software development	3.67	0.63	0	5 (3.31%)	48 (31.79%)	90 (59.60%)	8 (5.30%)
SDM was adopted in the development of the application.	3.70	0.63	0	3(1.99%)	50 (33.11%)	87 (57.62%)	11 (7.28%)

4.4.8. Mobile devices specifications

Investigation of the importance of this factor to mobile application development was done using one general question and two explanatory questions/statements. The descriptive statistics results obtained are showed in Table 4.24.

Table 4.24. Mobile devices' specification is a critical success factor of mobile application development.

Scale rating	No. of participant	Percent	Cumulative percent
1	0	0	0
2	0	0	0
3	17	11.18	11.18
4	87	57.24	68.42
5	48	31.58	100.00

Explanatory statements: Two explanatory statements are associated with MDS and the descriptive statistics results obtained showed that the response means of the explanatory statements are high indicating very a significant effect with relation to MAD. The results are showed in Table 4.25.

Table 4.25. Explanatory statements for mobile devices' specifications

Item description	mean N = 152	Std. dev.	Scale rating				
			1	2	3	4	5
Most successful mobile applications are compatible with different mobile devices' specifications.	4.28	0.58	0	0	10 (6.58%)	88 (57.89%)	54 (35.53%)
Mobile devices' specifications were considered during the application development.	4.21	0.64	0	0	18 (11.84 %)	84 (55.26%)	50 (32.89%)

4.4.9. Web and network integration

The importance of this factor was investigated using one general question and three explanatory statements. The results obtained from descriptive statistics are shown in Table 4.26.

Table 4.26. Integration of mobile application to web and network services is very important.

Scale rating	No. of participant	Percent	Cumulative percent
1	0	0	0
2	9	5.92	5.92
3	42	27.63	33.55
4	77	50.66	84.21
5	24	15.79	100.00

Explanatory statements: Three explanatory statements are associated with web and network integration and the descriptive statistics' results obtained showed that the response means are above average indicating a positive effect on MAD. The results are shown in Table 4.27.

Table 4.27. Explanatory statements for web and network integration

Item description	mean N = 152	Std. dev.	Scale rating				
			1	2	3	4	5
The most successful application runs as a web application	3.67	0.81	0	11 (7.24%)	47 (30.92%)	72 (47.37%)	22 (14.47%)
Web integration enhanced user satisfaction	3.73	0.80	0	9 (5.92%)	46 (30.26%)	73 (48.03%)	24 (15.79%)
Web and network integration is a critical success factor	3.68	0.75	0	9 (5.92%)	47 (30.92%)	79 (51.97%)	17 (11.18%)

4.5. Further analysis

The descriptive results obtained from the investigation of CSFs indicated that 8 of the listed success factors are significant to MAD and only one OST was not identified as a CSF of MAD. We decided to investigate the CSF further. We wanted to determine if the perceived relevance of the CSF could be influenced by some of the background variables, for example the use of a SDM and business area.

Furthermore, T-test analysis and analysis of variance (ANOVA) were performed on the data. Creech (2003) defined the analyses as follows:

T-test is a statistical analysis used to test the difference in the mean of two independent populations or samples. It can only compare means of the two different groups.

ANOVA is a statistical analysis used to compare the mean of dependent variables. ANOVA compares the extent of difference between groups with the extent of difference within groups. . It can be used to compare up to 3 or more groups of variables.

T-test analysis

In this study, a T-test analysis was done on 2 groups (use/non-use of SDM) with organizational size (A3), the total number of software developers in the organization (A4), how long has the organization being doing development (B1), the number of applications developed (B3), how successful is the application (B6) and the listed CSFs. The result obtained is showed in Table 4.28.

Table 4.28. T-test analysis between two groups (users of SDM and non-users of SDM)

Construct	Group (1 and 2)	Number of respondents	Mean	Std. dev.	p-value	d-value
Organizational size	Gr1	9	1.56	0.73	0.0001**	1.05^^
	Gr2	134	3.29	1.65		
Number of developers in the organization	Gr1	7	1.43	0.53	0.0008**	0.80^^
	Gr2	129	2.5	1.39		
Organizational years of existence	Gr1	7	1.43	0.53	0.0027**	1.31^^
	Gr2	126	2.37	0.72		

Table 4.28. T-test analysis between two groups (users of SDM and non-users of SDM) (*contd*)

Number of applications developed	Gr1	9	1.33	0.50	0.0006**	0.70^
	Gr2	132	2.17	1.20		
Application success	Gr1	9	4.11	0.60	0.0521	0.80^^
	Gr2	133	4.57	0.50		
OST	Gr1	8	3.38	0.79	0.4225	-0.31
	Gr2	134	3.13	0.72		
IDS	Gr1	9	3.96	0.59	0.0311**	0.88^^
	Gr2	134	4.48	0.54		
SDK	Gr1	9	4.26	0.66	0.2346	-0.40
	Gr2	134	3.97	0.73		
Portability	Gr1	9	3.78	0.67	0.6834	0.12
	Gr2	134	3.33	0.80		
Functionality	Gr1	9	4.37	0.48	0.8896	0.05
	Gr2	134	4.39	0.52		
BEI	Gr1	9	3.93	0.52	0.9872	-0.00
	Gr2	134	3.92	0.71		
SDM	Gr1	8	2.94	0.56	0.0035**	1.50^^
	Gr2	134	3.78	0.56		
MDS	Gr1	9	4.00	o.56	0.1863	0.46
	Gr2	134	4.28	0.60		
WNI	Gr1	9	3.67	0.67	0.7706	0.09
	Gr2	134	3.74	0.78		

Note: Gr 1 is the total number of non-users of SDM and Gr 2 is the total number of users of SDM.

p-value obtained when random sampling is assumed

****** Statistically significant at 0.05 levels according to t-test results for independent groups

^^ Practically significant difference

^ Medium significant difference

From Table 4.28, there was a practical significant difference between the organizational sizes of the uses of SDM in mobile application development with those that do not use SDM. This indicates that those with SDM have practical significance of more employees than those without SDM.

There was also a practical significant difference between the numbers of developers in an organization that uses SDM in mobile application development with those that do not use SDM. This indicates that those with SDM have practical significance of more mobile applications developers than those without SDM.

In addition, there was a practical significant difference between years of existence of an organization that uses SDM in mobile application development with those that do not use SDM. Thus SDM is mostly used in mobile application development by organizations that have being long into software development.

In addition, there was a medium significant difference between the numbers of applications developed by an organization that uses SDM in mobile application development opposed to those that do not use SDM. It implies that those organizations that uses SDM have developed more mobile applications than those that without SDM.

Moreover, there is a practical significant difference in the use of SDM among developers. It was indicated that those that use SDM in MAD acquired more skills than those that do not use SDM in MAD.

A practical significant difference also exists in the success of applications developed, which shows that mobile applications developed with SDM tends to be more successful than those developed without SDM.

The table also indicated that the usage of SDM in mobile application development has a practical significant difference with development without SDM.

Analysis of variance (ANOVA)

Also, ANOVA analysis was performed on 4 groups of the core business area and the CSF items which are dependent variable and the result obtained is showed in Table 4.29.

Table 4.29. ANOVA analysis on core business area and CSF items

CSF items	Core business area (Grp 1-4)	No. of respondents	Mean	Std. dev.	F-value	p-value	Tukey significance and d – value for the Groups			
							1	2	3	4
OST	Grp. 1	85	3.17	0.69				0.17	0.05	0.02
	Grp. 2	18	3,29	0.56	0.53 (3:136)	0.80			-.0.09	0.06
	Grp. 3	21	3.21	0.84						0.15
	Grp. 4	16	3.34	0.85						
IDS	Grp. 1	85	4.49	0.47				0.28	-.0.04	-0.03
	Grp. 2	18	4.65	054	0.54 (3:136)	0.6532			-0.32	-.0.30
	Grp. 3	21	4.48	0.51						0.01
	Grp. 4	16	4.48	0.56						
SDK	Grp. 1	85	4.10	0.70				-0.41	-0.90	0.03
	Grp. 2	18	3.81	0.68	5.15 (3:136)	0.0021 *			-0.50	0.39
	Grp. 3	21	3.48	0.60						0.82
	Grp. 4	16	4.13	0.79						
Portability	Grp. 1	85	3.82	0.81				0.55	0.15	0.20
	Grp. 2	18	4.26	0.64	1.66 (3:136)	0.1788			-0.41	-0.36
	Grp. 3	21	3.94	0.78						0.05
	Grp. 4	16	3.98	0.78						
Functionality	Grp. 1	85	4.37	0.48				0.39	-0.58	0.53
	Grp. 2	18	4.56	0.47	5.26 (3:136)	0.0018 *			-0.98	0.15
	Grp. 3	21	4.10	0.30						1.17
	Grp. 4	16	4.63	0.45						
BEI	Grp. 1	85	3.80	0.75				0.69	0.18	0.88
	Grp. 2	18	4.31	0.58	5.97 (3:136)	0.0008 *			-0.66	0.25
	Grp. 3	21	3.94	0.55						0.90
	Grp. 4	16	4.46	0.58						

Table 4.29. ANOVA analysis on core business area and CSF items (*contd*)

SDM	Grp. 1	85	3.61	0.61			0.60	0.64	0.29
	Grp. 2	18	3.97	0.61	3.82 (3:136)	0.115		0.05	-0.32
	Grp. 3	21	4.00	0.45					-0.38
	Grp. 4	16	3.78	0.58					
MDS	Grp. 1	85	4.17	0.54			0.34	0.18	0.79
	Grp. 2	18	4.42	0.73	2.94 (3:136)	0.0353 *		-0.18	0.24
	Grp. 3	21	4.29	0.62					0.49
	Grp. 4	16	4.59	0.49					
WNI	Grp. 1	85	3.58	0.70			0.57	-0.01	1.04
	Grp. 2	18	4.07	0.85	6.13 (3:136)	0.0006 *		-0.58	0.28
	Grp. 3	21	3.57	0.87					0.85
	Grp. 4	16	4.31	0.56					

Grp. 1 – software development. Grp. 2 – Financial institutions, Grp. 3 – Education and Grp. 4 – Telecommunication.

F-values obtained when random sampling is assumed

p-values obtained when random sampling is assumed

- Significant level is 0.05 according to ANOVA
- ** Statistically significant at 0.05 levels according to t-test results for independent groups
- ^^ Practically significant difference
- ^ Medium significance difference

It can be seen from Table 4.29 that business areas like software development companies, financial institutions, education and telecommunication organizations have different views of how importance a CSF is in the development of mobile applications.

A statistical difference in perception exists with relation to the use of SDK by different business areas. Software development companies and telecommunication companies perceived the use of SDK in MAD to be of greater statistical significance than the way financial institutions and education perceived it. Thus organizational and institutional views on SDK in MAD vary.

With respect to functionality, although all the business areas perceived it to be important in MAD, there is a statistical significance difference in perception of telecommunication and financial institutions to compare with other business areas. Telecommunications and financial institutions believed that mobile applications must be completely functional in order to be successful. A similar perception is seen in back-end integration, mobile devices specifications and web to network integration.

Other CSFs including individual development skill, portability and the use of SDM shows no practical significance difference in their effect to MAD.

Furthermore, Cohen stated the d-values for effect size as follows: d = 0.2 (small effect); d = 0.5 (medium effect) and d ≥ 0.8 (large effect or practical significant).

Effect size simply means the magnitude or size of effect of the statistical difference between the means of the compared groups. It is a true measure to quantify and measure the significance difference between two groups.

Small effect – this means that there is a significant difference between the compared means of the groups involved but can only be seen through careful study.

Medium effect – this indicates that avaerage significant differenece exists between the groups compared.

Large effect – this shows that there is a practical significant difference between the compared means of the groups. It is a big difference that can easily be noticed even with naked eyes which implies that one of the group strongly agreed to that the particular CSF than the other group.

The use of SDK in MAD indicated some differences among the groups as follows and the difference between:

Group 2 (Financial institutions) and group 4 (Telecommunication companies) (small effect). Group 3 (Education) and group 4 (Telecommunication companies) (large effect). Telecomunication companies strongly agreed on the importance of SDK in MAD than education sector as a result there exists a big practical significance difference between the groups.

The CSF ‘portability’ showed another difference within two groups and the difference between:

Group 1 (Software development companies) and group 2 (Financial institutions) (medium effect). There is average significance difference on the effect of CSF ‘portability’ on mobile applications development between these two groups.

Group 1 (Software development companies) and group 4 (Telecommunication companies) (small effect).

Also functionality showed some difference among groups and the difference between:

Group 1 (Software development companies) and group 2 (Financial institutions) (small effect).

Group 1 (Software development companies) and group 4 (Telecommunication companies) (medium effect).

Group 3 (Education) and group 4 (Telecommunication companies) (large effect). Telecommunications companies strongly agreed that functionality is a CSF of MAD than education sector resulting to a practical significance difference between the compared groups.

Back-end integration also showed some differences among the groups and the difference between:

Group 1 (Software development companies) and group 2 (Financial institutions) (medium effect).

Group 1 (Software development companies) and group 4 (Telecommunication companies) (large effect). Telecomunication companies strongly agreed on the importance of back-end integration in MAD than sofware development companies as a result there exists a big practical significance difference between the groups.

Group 3 (Education) and group 4 (Telecommunication companies) (large effect). Also telecommunication companies percieved back-end integration to be of high important in MAD than education sector resulting to a practical significance difference between the compared groups..

System development methodology indicated some differences as follows: between

Group 1 (Software development companies) and group 2 (Financial institutions) (medium effect).

Group 1 (Software development companies) and group 3 (Education) (medium effect).

Group 1 (Software development companies) and group 4 (Telecommunication companies) (small effect).

Mobile devices specifications also indicated some differences between groups as follows:

Group 1 (Software development companies) and group 2 (Financial institutions) (small effect).

Group 1 (Software development companies) and group 4 (Telecommunication companies) (medium effect).

Group 2 (Financial institutions) and group 4 (Telecommunication companies) (small effect), and

Group 3 (Education) and group 4 (Telecommunication companies) (small effect).

Web to network integration indicated some difference among the groups as follows:

Group 1 (Software development companies) and group 2 (Financial institutions) (medium effect).

Group 1 (Software development companies) and group 4 (Telecommunication companies) (large effect).

Group 2 (Financial institutions) and group 4 (Telecommunication companies) (small effect).

Group 3 (Education) and group 4 (Telecommunication companies) (large effect). Web to network integration is perceived to be very important in MAD by telecommunication companies than education sector resulting to a practical significance difference between the compared groups.

4.6. Chapter summary

This chapter focused on statistical analysis and research findings. The data was thoroughly extracted and statistical analysis performed in order to obtain the desired results. Various statistical analysis methods like descriptive, Cronbach's coefficient alpha, T-test and analysis of variance (ANOVA) were applied in the analyses. The descriptive statistics showed that 8 out of 9 identified success factors were critical to mobile applications dvelopment and the reliability of the CSF items were confirmed using Cronbach's coefficient alpha. The T-test and ANOVA dipict the difference in perceptions of the CSFs by different organizations and differeces among the statistical means respectively. Lastly the obtained results were discussed.

Chapter 5. Summary and conclusions

5.1. Introduction

This chapter deals with the research results, its contributions and conclusions. To start with, the research aims and objectives with regards to the results obtained will be reviewed after which the final summary of the study will be made. The limitations encountered during the course of this study and limitations that may occur during its implications will be stated. A few suggestions that can be considered for future research work will be made.

5.2. Summary of the research results

The main research aims and objectives were listed in chapter 1. To review, these aims were:

1. Conduct a literature review of mobile application development.

2. Review literatures on success factors of mobile application development (if available) and other related literatures.

3. Describe the current state of mobile application use in business in South Africa.
   - History of Mobile applications development.
   - Primary motivation.
   - Duration.
   - Application success.

4. Investigate how mobile application development is performed in South Africa in terms of;
   - Systems development methodology.
   - Platforms of development.

5. Determine the perceived importance of the success factors identified amongst mobile application developers.

In chapter 4 the research results obtained with regards to research aims and objectives indicates the following:

1. Conduct literature review of mobile application development.

    - Mobile application development is referred to as a process used to write computer programs for mobile devices.
    - It is an important process because it provides a platform for creating applications that combine the functionality of the mobile telephone as a traditional communication device with the information systems functionality of computing which include data collection, data processing, information access and information management.
    - Mobile applications are used in different aspects of life including banking as a means for online banking, education for e-learning and business for online purchases.
    - Mobile application development has some issues including: dynamic nature of development environment, varied mobile devices, volatile platforms and intermittent connections.
    - It is a successful process with successful products like Twitter, Facebook, Whatsapp, etc.

2. Review literatures on success factors of mobile application development (if available) and other related literatures.

    - Mobile applications development involves different platforms, cross-platforms and system development methodologies.

    - 9 success factors were identified including: open source technology, individual development skills, software development kit, portability, functionality, system development methodology, back-end integration, mobile devices specifications and web to network integration.

3. State of mobile application use in business in South Africa

    - It was observed that most of the participating organizations have good experience in mobile application development.

    - The main purpose of mobile application development business is for profit. 58.55% of the participants indicated that their primary motive for developing mobile applications is profit, although some do it for profit and extension of the company portfolio.

- Participants indicated that they are satisfied with the mobile applications they have developed. The reason is that 53.02% of developed applications were very successful, 46.31% were successful and 0.67% was at an average level.

2. How mobile application development is performed

- With regards to platform of development: 87.16% of total participants use Apple iOS, 99.33% use Android, 70.27% use Blackberry, 3% use Symbian and 95% use windows mobile platform. This indicates that Android development platform is mostly used in mobile applications' development, although combinations of platforms are also used in mobile applications development. This compares well to Gartner's press release on worldwide mobile devices shipment by operating system. Android (48.61%), iOS (11.04%), windows (14.0%) and others 26.34% (Gartner, 2015).

- A total of 93.71% of all participants indicated that they make use of systems development methodology during mobile applications development. This indicated a significant effect of system development methodology in mobile applications development. and compares well to a published report of Serena (2007) which stated that the use of SDM helps a developer achieve improved efficiency in mobile application development and in line with Schwaber & Beedle's (2001) report that the agile software development method has often been adopted and preferred for software development.

- It was observed that 91.84% which amounts to 135 out of 152 participants use Agile development methodology in mobile applications development. It indicates that the Agile methodology dominates other types of system development methodology in use. This implies that developers simply adopt the rapid development method instead of applying proper MAD SDM. It is imperative to create more awareness for MAD SDMs so that mobile application developers will gain more understanding about the proper system development methodology to use for a particular application of MAD.

3. Importance of success factors identified

- There is statistical evidence which showed that 8 out of 9 identified factors are significant to mobile applications development. These factors are individual development skills (Huntley, 2011; Ahmed *et al*., 2013), software development kit (Rodrigues *et al*., 2010; Wasserman, 2010), portability (Papanikolaou & Mavromoustakos, 2006; Wasserman, 2010), and functionality (Papanikolaou & Mavromoustakos, 2006; Mohamed & Tsinakos, 2014), mobile devices specification (Papanikolaou & Mavromoustakos, 2006; Zhou,2010), back-end integration (Spriestersbach & Springer, 2004; Sybase, 2007), system development methodology (Wasserman, 2010; Correal *et al*., 2013) and web to network integration (Ahern, 2009; Zhou, 2010) while open source technology is not significant. The statistical mean value obtained for significant factors is (≥ 3.68 ≤ 4.60).
- The degree of significance of the success factors differs to such an extent that individual development skills is the most significant factor with a statistical mean of 4.60 while open source technology is the least significant factor with 2.89 statistical mean value. The rank of the success factors is stated in Table 5.1.

Table 5.1. Rank of each factors level of importance to MAD

Variable	**Mean$_{N=152}$**	**Std. Dev.**	**CSF Rank**
Open source technology	2.89	0.99	9
Individual development skills	4.60	0.99	1
Software developmnt kit	4.00	0.76	4
Portability	3.84	0.80	6
Functionality	4.55	0.57	2
Back-end integration	3.89	0.71	5
System development methodology	3.68	0.63	8
Mobile devices specification	4.20	0.62	3
Web to network integration	3.76	0.79	7

An additional analysis was done to determine if the perceived relevance of the critical success factors could be influenced by the some of the background variables, for example the Use of a system development methodology, business area.

Research results also indicated a number of other significant findings; some of these can be summarized as follows:

- A practical significant difference exists between the perceptions of the group of organizations that make use of system development methodology in mobile applications development and those that do not apply system development methodology in mobile applications development with regards to organizational size, number of developers in an organization, years in existence of the organization and the amount of mobile applications developed.

  This indicates that the use of system development methodology in mobile applications development has a positive effect on the development of mobile applications. It was clearly observed that organizations that use system development methodology in mobile applications development have more progress than those that do not use system development methodology.

- The perception of the importance of success factors differs between participants from different business areas.
  - A statistical difference in perception of the use of software development kit in mobile applications development by different business areas is clear. Software development companies and telecommunication companies perceive software development kit to be more important in mobile applications development than other organizations.
  - A statistical difference was also observed in functionality of mobile applications. Telecommunication organizations and financial institutions perceived that the crtical success factor ‘functionality’ is more important in mobile applications development than in other business areas. Similarly, the same perception was observed on CSFs like back-end integration, mobile devices specifications and web to network integration.
  - There is no statistical difference in perception of other factors like individual development skills, portability and use of system development methodology.

- Open source technology has the least perception of importance.

Although these critical success factors are important in mobile applications development, different business areas value them differently. This is as a result of the nature of their business and their need for mobile applications.

5.3. Contribution

The results obtained in this research will add to the knowledge in the academic field while it will improve productivity in business environments. Business sectors, especially software development companies are advised to give these critical success factors serious consideration during mobile applications development and they will see good improvement in their mobile applications development.

5.4. Limitations

The major limitation encountered during this research which affected its true potential is the unresponsiveness of people contacted or approached to complete the associated questionnaire. The returned responses were low compared to expectation. As a result of poor response, some or other important critical success factors may be omitted.

5.5. Future work

Suggestions for further research would be:

i) To identify new factors that may emerge as technology advances, and
ii) Expand the scope of this study to other countries.

5.6. Conclusions

The aim of this research is to determine the critical success factors of mobile application development. Nine success factors of mobile application development were identified through review of previous literatures related to the topic of this study. These include: open source technology, individual development skills, software development kit, portability, functionality, system development methodology, back-end integration, mobile devices specifications and web

to network integration. Positivistic research paradigm was used in the investigation and survey research method was applied, using questionnaire to gather the quantitative data used. The colleted data was thoroughly analysed and the reliability confirmed. Investigation of these factors shows that 8 out of nine are important factors of mobile application development. Individual development skill is the most significant and open source technology is not a critical success factor of mobile application development. This indicates that the research aim was met.

The findings from further analysis depicts that the use of system development methodology in mobile applications development has a practical significant difference with respect to organizational size, number of software developers in an organization, how long an organization has been into mobile applications development and number of mobile applications developed by an organization. In addition, there are significant differences in perception of these factors by different business entities as a result of the nature of their businesses and motivation for mobile applications development.

Appendix a. Research questionnaire

Research Questionnaire

A. Background Information

1. What is the core business area of your organization?

☐ Software development company ☐ Financial/Banking/Insurance

☐ Manufacturing ☐ Administrative services ☐ Retail/Wholesale

☐ Education ☐ Telecommunication ☐ Engineering

☐ Others? (Please specify) ……

2. In which province of South Africa is your company located? (e.g. Gauteng)
Click here to enter text.

3. What is the total number of people employed in your organization? (Total from all locations)?

☐ 1 – 10 ☐ 10 – 50 ☐ 50 - 100 ☐ 100 - 200 ☐ 200 and above

4. What is the total number of software developers in your organization?

☐ 1 – 5 ☐ 5 – 10 ☐ 10 – 50 ☐ 50 --100 ☐ 100 and above

5. What is your role in your organization?

☐ Managing Director ☐ Chief Information Officer ☐ IT Manger

☐ Project Leader ☐ System Administrator ☐ Programmer/Developer

☐ System Analyst ☐ Others? (please specify) ……..

B. Mobile application development

6. How long has your organization been into mobile applications development?

☐ 1 – 5 years ☐ 5 – 10 years ☐ 10 years and above ☐ never at all

7. What is your company's primary motivation for mobile application development?

☐ Profit

☐ Extension of Company portfolio to attract more external clients/requests

☐ Brand recognition

☐ Others? (Please specify) .....

8. How many mobile applications have your organization developed?

☐ 1 - 10 apps ☐ 10 – 50 apps ☐ 50 – 100 apps ☐ 100 and above ☐ None

9. What is your most successful mobile application developed?

Name of the application ……

Release date ……

Brief detail of the application

Click here to enter text.

10. Which platform(s) does the above application operate in?

☐ iOS ☐ Android ☐ Blackberry ☐ Symbian ☐ Windows ☐ Mac OS

☐ Others? (Please specify) …….....

11. How successful is the application? (Use the scale 1-5 where 1 – unsuccessful and 5 - very successful)

Unsuccessful Very Successful

1	2	3	4	5

12. Generally in your development, do you use a formalized plan (software development methodology) in your design?

☐ Yes ☐ No

13. Which system development methodology did you used in your most successful mobile application design?

☐Mobile D ☐ Dynamic Channel Mode ☐ Mobile Engineeringl

☐MASAM ☐ Agile Methodology ☐ Hybrid ☐ Chen, M

☐M Compass ☐ Mobile RAD ☐ None ☐ Others? (please specify)…….

C. Critical Success Factors

These are factors that have great influence in development of mobile applications and must be present for the success of mobile applications development. Please use scale 1-5 (1 – totally disagreed and 5 – totally agreed)

14. Open source technology (OST) is important in mobile application development.

Totally disagreed Totally agreed

1	2	3	4	5

15. Open source software is by definition, software for which users have access to the source code. To what extent do you agree/disagree with the following statements about open source technology (OST) on your most successful developed mobile application?

	Totally disagreed				Totally agreed
Users have free access to the source code	1	2	3	4	5
Application free of charge to users	1	2	3	4	5
OST influenced the application development	1	2	3	4	5
OST is a critical success factor in your most successful mobile application development	1	2	3	4	5

16. In general, individual development skills are an important factor that affects mobile applications development.

Totally disagreed Totally agreed

1	2	3	4	5

17. To what extent do you agree to these statements regarding skills and experience of developers as applied to your most successful mobile application development

	Totally disagreed				Totally agreed
Developers experience is important to mobile application development	1	2	3	4	5
Your organization has enough skilled developers for creating and developing mobile application	1	2	3	4	5
Availability of skilled developers is a critical success factor of mobile application development	1	2	3	4	5

18. Software development kit (SDK) is an important factor of mobile application development.

Totally disagreed				Totally agreed
1	2	3	4	5

19. SDK was used in the development of your most successful mobile application development, which implies that:

	Totally disagreed				Totally agreed
SDK helps and guide developers in mobile applications development	1	2	3	4	5
SDK eases and enhances mobile applications development	1	2	3	4	5
SDK is has a significant influence to mobile application development	1	2	3	4	5

20. The fact that mobile applications can be ported successfully from one device to another using a common platform makes it very much accepted by community of users, hence a good mobile application should be portable.

Totally disagreed				Totally agreed
1	2	3	4	5

21. How true are these statements regarding the portability of your most successful application development?

	Totally disagreed				Totally agreed
The mobile application is portable	1	2	3	4	5
The mobile application can be implemented across different platforms	1	2	3	4	5
Portability is a critical success factor of mobile application development.	1	2	3	4	5

22. Functionality is a critical success factors to be considered in mobile application development.

Totally disagreed				Totally agreed
1	2	3	4	5

23. How true are these statements regarding the functionality of your most successful mobile application development?

	Totally disagreed				Totally agreed
The application perform the task it was intended for	1	2	3	4	5
The application satisfied the users need	1	2	3	4	5
The mobile application met the functional requirements of the users.	1	2	3	4	5

24. The integration of new mobile application to existing ones is given a serious consideration during application development.

Totally disagreed				Totally agreed
1	2	3	4	5

25. To what extent do you agree to these statements regarding back-end integration of your most successful mobile application development?

	Totally disagreed				Totally agreed
The application can be easily integrated into the existing one in an organization	1	2	3	4	5
The mobile application improves productivity	1	2	3	4	5
Back-end integration was a critical success factor of mobile application development	1	2	3	4	5

26. Generally, it is good to use systems development methodologies in mobile application development.

Totally disagreed				Totally agreed
1	2	3	4	5

27. Systems development methodology is an organized plan for developing and executing an application. With regards to your most successfully mobile application development, how true are these statements?

	Totally disagreed				Totally agreed
Use of a formalized system development methodology enhanced software development	1	2	3	4	5
A system development methodology was adopted in the development of the application.	1	2	3	4	5

28. Mobile devices specification is a critical success factor of mobile application development.

Totally disagreed				Totally agreed
1	2	3	4	5

29. There are different specifications of mobiles devices which must be considered in the development of your most successful mobile application. How true are these statements?

	Totally disagreed				Totally agreed
Most successful mobile applications is compatible with different mobile devices specifications	1	2	3	4	5
Mobile devices specifications were considered during the application development.	1	2	3	4	5

30. Integration of mobile application to web and network services is very important.

Totally disagreed				Totally agreed
1	2	3	4	5

31. Mobile applications are online applications that run through web and network integration. Considering your most successful mobile application development, how true are these statements?

	Totally disagreed				Totally agreed
The most successful application runs as a web application	1	2	3	4	5
Web integration enhanced user satisfaction.	1	2	3	4	5
Web and network integration is a critical success factor.	1	2	3	4	5

32. What other factors do you consider to be critical to mobile application development? Please specify and indicate its importance on a scale of 1 -5

	Totally disagreed				Totally agreed
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5
	1	2	3	4	5

Thank you for your participation!

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