A Mobile Applications Innovation Ecosystem Framework for Botswana

By

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Thesis Title: A Mobile Applications Innovation Ecosystem Framework for Botswana.

DECLARATION:

I declare that A Mobile Applications Innovation Ecosystem Framework for Botswana is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references

I further declare that I submitted the thesis to originality checking software and that it falls within the accepted requirements for originality

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

Signature ____________________

Date 2 July 2019

Acknowledgements

The thesis is dedicated to the multitudes of people without whom this study would not have been possible.

Firstly, to almighty God for giving me the courage to persevere with the study. To my daughter and wife for allowing me time to work while they were busy on their mobile apps. To my supervisors for their endless courage and unwavering support that kept me motivated and focused when the study's complexity heightened, a mere *thank you* would never be enough. A special thank you to all the students, lecturers, innovation officers, mobile application developers, government and parastatal officials who provided for the study, despite their busy daily schedules.

Abstract

The role that locally relevant services and content can play in the development of societies cannot be underestimated. The proliferation of mobile phones in Africa's developing countries is a significant enabler, which provides access to such locally relevant services and content. Mobile applications have the potential to support the development of the African continent through bolstering the main mechanisms of innovation, inclusion and efficiency. This has been demonstrated by instances of increased literacy, improved access to health care, banking, crowd sourcing and provision of farming and/or agricultural assistance. Successful cases of such mobile-based services include Kenya's M-Pesa, which has allowed millions of rural people, who do not have access to traditional banking facilities, to send and receive money as well as pay utility bills and school fees. The development of similar innovative and locally relevant mobile-based solutions, which is currently considered to be in its infancy, is key to improving the lives of people in developing countries. This study identifies the essential components of an innovation ecosystem, for the development and presentation of a Mobile Applications Innovation Ecosystem Framework for Botswana. An innovation ecosystem enables effective interaction amongst entrepreneurs, companies, universities, research organisations, investors and government agencies towards maximising economic impact and potential. To gain a practical understanding of the context in which locally relevant mobile-based services can be developed, the study adopted a pragmatic research approach. Through combining the 4Cs Framework for ICT and the systems theory's Triple Helix Model of Innovation, the study proceeded to develop the framework using a Design Science Research (DSR) methodology. DSR guided the identification of the components, which make up the mobile applications innovation ecosystem within government, industry and higher education sectors, as extracted from the literature review. This process facilitated initial framework designs, which were demonstrated to and evaluated by conveniently sampled stakeholders from relevant helices. Thereafter a synthesised framework was presented for evaluation by knowledgeable professionals from the mobile applications innovation ecosystem.

The study contributes to the theoretical knowledgebase by presenting a theoretical framework for understanding ICT4D innovation frameworks and mobile applications innovation components. The practical contributions of the study include a validated artefact which presents the components of a mobile applications innovation ecosystem, an understanding of the challenges faced by Botswana's higher education students in mobile application programming and the challenges and opportunities available for mobile application developers in Botswana.

Keywords: Mobile Applications Innovation Ecosystem Framework, ICT4D Innovation Ecosystem, Mobile Applications for Development, Innovation Ecosystem Framework Components

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Abbreviations and Acronyms

ADSL	Asymmetric Digital Subscriber Line
BIH	Botswana's Innovation Hub
BOCRA	Botswana Communications Regulatory Authority
BoFiNet	Botswana Fibre Networks Ltd
BTCL	Botswana Telecommunications Corporation Limited
BQA	Botswana Qualifications Authority
CDE	Collaborative Development Environments
CS	Computer Science
CVE	Collaborative Virtual Environment
DS	Development Studies
DSR	Design Science Research
EASSy	Eastern Africa Submarine Cable System
EDGE	Enhanced Data rates for GSM Evolution
EIG	Europe India Gateway
GPRS	General Packet Radio Services
GPS	Global Positioning System
HE	Higher Education
HEI	Higher Education Institution
HRDC	Human Resources Development Council
ICT	Information and Communications Technology
ICT4D	Information and Communications Technology for Development
IDE	Integrated Development Environment
IS	Information Systems
IT	Information Technology
ITU	International Telecommunications Union
KP	Knowledgeable Professional
LDCs	Least Developed Countries
LTE	Long-Term Evolution
M4D	Mobile (Cellular) Phones for Development
MAIE	Mobile Applications Innovation Ecosystem
MAP	Mobile Application Programming
MDG	Millennium Development Goals
MSP	Mobile Service Providers
NCQF	National Credit and Qualifications Framework
NGO	Non-Governmental Organisations
NSI	National System of Innovation
PTDA	Post- 2015 Development Agenda
PTO	Public Telecommunications Operator
QR	Quick Response

R & D	Research and Development
SCI	Social Collaborative Integrated Development Environments
SDGs	Sustainable Development Goals
SDK	Software Development Kit
SMS	Short Message Service
TEC	Tertiary Education Council
UNICEF	The United Nations Children's Fund
USB	Universal Serial Bus
WACS	West Africa Cable System

Publications

1. A. Nyamaka, A. Botha, J. Van Biljon and M. Marais, "Challenges Botswana’s Mobile Application Developers Encounter: Funding, Commercial and Technical Support," 2018 IST-Africa Week Conference (IST-Africa), Gaborone, 2018.

2. A. Nyamaka, A. Botha and J. Van Biljon, "Exploring Challenges to Mobile Application Programming at a Private Higher Education Institution in Botswana," IDIA2015 Conference, Zanzibar, 2015.

Chapter 1 Introduction

1.1 Background

Information and Communication Technology for Development (ICT4D) is a research area concerned with utilising Information Communication and Technology (ICT) as a means, and an end, to the developmental goals of communities (Tongia, Subrahmanian, & Arunachalam, 2005). Heeks, Thapa and Wall (2018) noted increased discussion as to the meaning of the “D” in ICT4D giving rise to diverse perspectives. These perspectives include the role ICT can play in the reduction of poverty and the facilitation of sustainable livelihood and economic growth, reiterating the view that development facilitates freedom, as illustrated by Lwoga and Sangeda (2018). The International Telecommunication Union’s (ITU, 2017a) broader perspectives regarding possible ways in which ICTs can address Sustainable Development Goals (SDGs) and how corporate services can utilise ICT to achieve SDGs through the smart management of water, energy, conservation, buildings and agriculture, amongst others (Ono, Iida, & Yamazaki, 2017), are also relevant examples. Heeks (2014) argues that ICT4D holds a place in the global development agenda as it plays an ever-increasing role in the socio-economic development of human life. Information and Communications Technology (ICT) can help realise developmental goals through facilitating sustainable innovation in the following four broad areas: (i) developing the required infrastructure in the form of computing devices, (ii) developing and ensuring connectivity of these computing devices, (iii) building the necessary human capacity to raise awareness of ICT whilst stimulating innovation and use, and (iv) developing/generating locally relevant content (Tongia et al., 2005) whilst addressing the sixteen international development priorities of ICT4D (Heeks, 2014).

The World Bank (2016) states that more than 40% of the world’s population has access to the Internet. In Least Developed Countries (LDCs) the phenomenon of mobile phones being widely adopted as computing devices which offer connectivity is evident with Africa showing an increase in the number of mobile telephone subscriptions from 10 in 2005 to 80 per 100 inhabitants in 2017 (ITU, 2017b). Innovations, which take advantage of the proliferation of mobile technologies, can result in the developing world becoming increasingly prosperous and inclusive by enabling poor and disadvantaged communities to access opportunities which had previously been out of reach (The World Bank, 2016). Developmental goals, as exemplified by the SDGs, are applicable to both *developing* and *developed* countries (Ono et al., 2017). The developmental agendas of developing countries should, therefore, focus on mobile technologies to provide poorer communities with developmental opportunities (The World Bank, 2016).

The services offered by mobile phones have grown from merely making and receiving phone calls, or sending and receiving messages, to complex and extensive mobile services. These services, research has shown, allow users to access various content from the health, agricultural, educational and business domains, even from remote areas. These mobile applications have the potential to assist in the development of the African continent by increasing literacy levels, improving access to health care and banking, crowd sourcing as well as providing farming or agricultural aid. Mobile technologies in Africa are therefore evolving from mere communication tools to service delivery platforms (Aker & Mbiti, 2010). Herselman and Botha (2016) support the argument that mobile technologies empower users and contributors with new abilities, and in the face of several infrastructural and interoperability challenges in mobile-based digital health innovation ecosystem, they present strategies, approaches and experiences in building a digital health innovation ecosystem. There are several instances of socio-economic and political developments utilising mobile technologies in Africa. In the socio-economic domain, Aker and Mbiti (2010) refer to Ghana farmers in Tamale enquiring as to the price of tomatoes and corn in Accra, 1 000 kms away, through the use of text messages. Rashid and Elder (2009) explain how HIV/AIDS patients in Malawi receive text messages which remind them to take their medicines, as per schedule, thus helping them to adhere to the treatment programme. Millions of rural people who did not previously have access to traditional banks can now send and receive money, pay utility bills and school fees using M-Pesa, a mobile banking system developed in 2007 in Kenya (Murugesan, 2013). Mobile technologies have resulted in better living conditions for many people in developing countries addressing areas such as crowd sourcing, farming, education and health. Anil, Parul, Rachan and Rita (2012) argue that mobile phones can be used, within the health context of developing countries, to: (i) create awareness by sending messages regarding health campaigns or reminders for medication, (ii) establish emergency services where mobile phones are used to send information before, during and after disasters in an effort to assist people and rescue teams, (iii) monitor patients' vital signs in real time, and (iv) collect community and health data. In South Africa, the MomConnect app provides crucial health information to mothers during pregnancy and in the early years of child rearing. This app is described as being very useful as it empowers women in their role as mothers (Skinner et al., 2018). Crandall (2012) notes that increased mobile penetration in Kenya has resulted in Short Message Service (SMS) based services being increasingly used to empower farmers through disseminating information regarding weather conditions, market updates and other relevant information. In the political realm, South Africa's official opposition party, the Democratic Alliance, had 111 000 subscribers to their app on the now defunct Mxit in 2012 (The World Bank, 2012) whilst Ghana used 1 000 independent locally trained parallel vote tabulation (PVT) observers to transmit voting results, via text messages, to a central office (Aker & Mbiti, 2010), thus increasing the transparency of the electoral process. The Ushahidi and Uchaguzi mobile app was developed during Kenya's 2008 elections to crowdsource and report on post electoral violence (The World Bank, 2016). These listed innovations were all created in response to identified inefficiencies in the society and, as such, contributed in addressing the developmental needs of communities.

The socio-economic and political relevance of mobile phones in Africa is evident. The development of more relevant mobile applications which, in turn, could generate social, economic and political benefits for the African continent can be achieved by creating an innovation ecosystem which fosters mobile application development.

1.2 Rationale

The rationale for developing a Mobile Applications Innovation Ecosystem (MAIE) Framework for Botswana stems from the realisation that, despite the wide adoption of, and the socio-economic developmental potential presented by mobile phones, Botswana and Africa's mobile applications industry is still developing (Adkins, 2013; Coetzee, 2013; "Hackathons," 2013; Pieters, 2014). The relatively new industry is thus limited by the lack of locally relevant mobile content and human capacity (Tongia et al., 2005), the mobile applications industry in Africa faces a shortage of skills (Pieters, 2014), numerous challenges faced by mobile application developers such as the high cost of mobile bandwidth, the high cost of smart phones, limited awareness of the importance of mobile applications identified by Kapinga and Mbise (2019), poor policy and regulations, lack of financial resources, poor ICT governance cited by Pankomera and Greunen (2018) and numerous financial and technical challenges stated by Drouillard, Taverner, Willianson and Harris (2014). Tongia et al. (2005) also noted that, within the developing countries context, most Information and Communications Technology (ICT) systems' content is not locally relevant and the lack of correct language and/or systems causes individuals to become passive *consumers* of information rather than producers thereof. To avoid wasting resources in an attempt to address developmental goals, it is necessary that ecosystems engage local communities in developing technologies and digital content in line with their societal needs (ITU, 2017a). The provision of locally relevant mobile content and services can result in the realisation of the developmental potential presented by digital technologies to African, and Botswana's communities, should the numerous challenges faced in mobile applications ecosystems be addressed.

The economic success of Africa thus requires innovative ecosystems as these systems generate new ideas and organisations (IBM Communications, 2013). *Innovation ecosystem* is the term used to describe the large number and diverse nature of components, such as participants and resources, necessary to facilitate innovation (Thomas & Walburn, 2017). These components include: *material/structural resources* such as funds, equipment and facilities; *human resource capital* such as students, faculty, staff, industry researchers and industry representatives within the various innovation ecosystem institutional entities such as the universities, colleges, business firms, venture capitalists, economic development and business assistance organisations, funding agencies and policy makers (Jackson, 2011). This study utilises the three perspectives of Higher Education, Industry and Government, as proposed by the Triple Helix Model of Innovation (Etzkowitz, Dzisah, Ranga, & Zhou, 2007; Leydesdorff, 2005). The research thus moves beyond the 'block' entities to investigate and present deeper and specific actor identities, missions, objectives and needs, as well as possible ways in which they influence interaction dynamics (Ranga & Etzkowitz, 2013). Innovation ecosystems therefore model complex economic relationships between actors in an ecosystem with the primary goal of enabling technological development and innovation (Jackson, 2011). Thomas and Walburn (2017, p. 13) state that "an effective innovation ecosystem therefore enables entrepreneurs, companies, universities, research organisations, investors and government agencies to interact effectively to maximise the economic impact and potential of their research and innovation". The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) facilitates a fine-grained view of innovation actors and roles, both institutional and individual, in addition to elucidating the relationships between them (Ranga & Etzkowitz, 2013). In many African countries role players in Higher Education, Industry and Government primarily operate in silos and consequently they do not create new business opportunities (Kimatu, 2016). The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) encourages closer interaction between these innovation role players and was thus adopted to guide the development of the innovation ecosystem framework in this research work. The development of an innovation ecosystem framework for mobile applications can provide a fertile environment which, in turn, encourages the production and consumption of mobile applications ultimately driving the developmental goals of societies.

This study sets out to explore, describe and evaluate the components, which together constitute a Mobile Application Innovation Ecosystem (MAIE) framework for Botswana. This process will be done through the use of: the Four C Framework for ICTs (Tongia et al., 2005) (see section 4.2.2); the three perspectives (Higher Education perspective, Government perspective and Industry perspective) articulated in the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) and a Design Science Research (DSR) methodology. The newly formulated MAIE framework would be able to assist governments, industry and academia in the development of a mobile application economy, thus driving society's developmental goals through mobile cellular-based Information and Communications Technology (ICT).

1.3 Purpose of the Study

The main aim of this research is to explore, describe and refine a Mobile Applications Innovation Ecosystem Framework for Botswana.

Johnson and Foote (1988, p. 2) describe a framework as "a set of classes that embodies an abstract design for solutions to a family of related problems, and supports reuse at a larger granularity than classes." Tomhave (2005, p. 9) notes that a framework is "a fundamental construct that defines assumptions, concepts, values, and practices, and that includes guidance for implementing itself." A framework can, in addition, be defined as a structure, or system, for the realisation of a defined result/goal without supplying the complete details (Verbrugge, 2016). In the software development field, a framework thus provides a basic system model for a particular application domain within which specialised applications can be developed (Berit, Baharak, & Branca, 2002). Although several commonalities are evident in the above definitions, this study adopted the definition presented by Johnson and Foote (1988). Further to the research aim, the following brief narrative descriptions frame the study.

Tracy (2012) defines *mobile applications* as applications that run on mobile, untethered devices. The World Bank (2012) defines mobile applications as software that runs on a mobile phone, or on a server, and which interacts with mobile phones, thus expanding on Tracy's (2012) definition to include software running on servers while interacting with mobile phones. This latter definition will be adopted in this study. Mobile applications therefore enable the delivery of content, or any service, via a mobile phone.

Within this context, the innovation ecosystem is comprehensively unpacked in sections 4.3 and 4.4. The study further aligns with the arguments presented by Thomas and Walburn (2017), who describe *innovation ecosystem* as the term used to denote the large number and diverse nature of components, such as participants and resources, necessary for innovation. The definition also ascribes to Jackson's (2011) view that such components include: material/structural resources (such as funds, equipment, facilities), human resource capital (such as students, faculty, staff, industry researchers and industry representatives) within various innovation ecosystem institutional entities (such as universities, colleges, business firms, venture capitalists), economic development and business assistance organisations (such as funding agencies and policy makers).

To achieve this aim, the following research objectives are outlined and contextualised in Figure 1-1:

- RO_1. To investigate the components, challenges and opportunities within the mobile applications innovation ecosystem from a Higher Education perspective.
- RO_2. To establish the components, challenges and opportunities within the mobile applications innovation ecosystem from an Industry perspective.

- RO_3. To establish the components and support opportunities available to the mobile applications innovation ecosystem from the Government perspective and to assess the uptake of this support.
- RO_4. To evaluate the proposed Mobile Applications Innovation Ecosystem.

1.4 Research Overview

The aim of this research is operationalised through answering the main research question, as presented in section 1.4.1.

1.4.1 Main Question

RQ_M: What are the components of a mobile applications innovation ecosystem framework for Botswana?

To answer this question, the following sub questions will be addressed:

1.4.2 Sub Questions

RQ_1. What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Higher Education perspective?

RQ_2. What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Industry perspective?

RQ_3. What are the components, support opportunities available to the mobile applications innovation ecosystem from the Government perspective, and what is the uptake of this support?

The following diagram maps the main research question to the sub research questions, the research contribution as well as the research strategy employed to operationalise it.

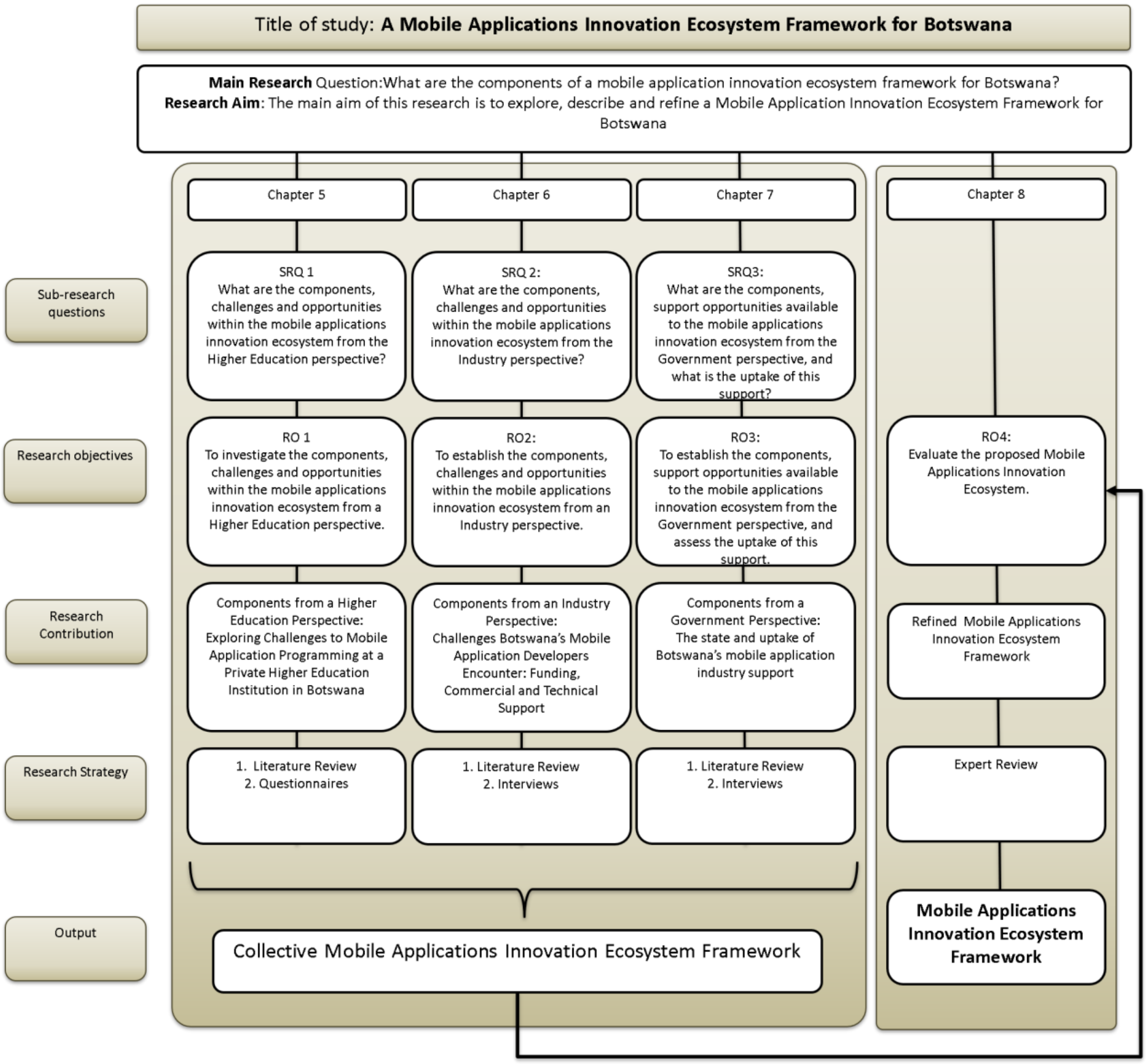

Figure 1-1: Research links and data gathering approaches

1.5 Scope and Disciplinary Context

This study explores, describes and refines a Mobile Applications Innovation Ecosystem Framework for Botswana. Whilst it does set out to interrogate the human capacity component of the 4Cs Framework (Tongia et al., 2005) from various Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) perspectives, the study does not engage with educational theories. Much literature exists on these theories, as well as their associated pedagogies, and the author acknowledges the discourse and work of many institutions and individuals in this regard. However, within the context of this study, an in-depth engagement is considered beyond the scope of research.

1.6 Research Design

The research, grounded in a pragmatic research philosophy, adopts a Design Science Research (DSR) methodology, operationalised through the Design Science Research process formulated by Peffers et al. (2006), as per Figure 1-3: Peffers' (2007) DSR process adapted for this study.

Hevner, March, Park and Ram (2004) presented a Design Science framework which centred on the building and evaluating IT artefacts. This Design Science framework was expanded into three design science research cycles, as per Figure 1-2. The *Relevance Cycle* links the environment of the research study with the design science activities. The *Rigor Cycle* ties the design science activities in with the domain's existing knowledge base whilst the *Design Cycle* iterates between the relevance and rigor cycles (Hevner, 2004).

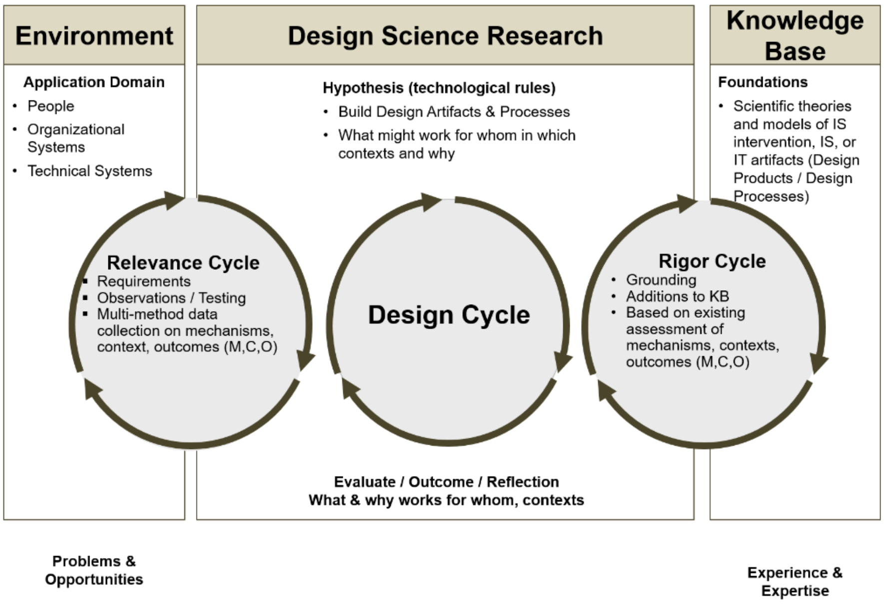

Figure 1-2: Design Science research cycles (Hevner, 2004)

These three cycles are briefly outlined and discussed in section 3.5.

1.6.1 Relevance Cycle

The *Relevance Cycle* outlines the implementation context needed to identify the requirements for the research. Hevner (2007) argues that the product created by the Design Science Research process should be utilised in the environment. This study has identified its research opportunity as the dearth of locally relevant (Africa, in general, and Botswana, in particular) Mobile Application Innovations. It is further posited that any innovation will only be as strong as the ecosystem which supports it (Botha et al., 2010). As such, not only is the process of developing mobile applications under consideration, but also the ecosystem into which they will be introduced. The relevance cycle is facilitated thought an in-depth narrative on Botswana (Chapter 2) and relevant literature reviews presented in sections 5.2, 6.2 and 7.2. This process is executed in line with the tenets of the adopted Design Science Research methodology, as follows:

- Chapter 5 aims to answer RQ_1 from a Higher Education perspective to thus explore and describe the components, from literature, applicable to a Mobile Applications Innovation Ecosystem.
- Chapter 6 is framed by RQ_2 and considers the Industry perspective when identifying components relevant to a Mobile Applications Innovation Ecosystem.
- Chapter 7 aims to address RQ_3. Components of a Mobile Applications Innovation Ecosystem are explored and identified from a Government perspective.

1.6.2 Rigor Cycle

The *Rigor Cycle* infuses the research project with existing knowledge towards ensuring innovation (Hevner, 2007). Additions to the knowledge base, resulting from the design science research process, may include extensions to the original theories and methods made during the research, new meta-artefacts (design products and processes) and all experiences gained from performing the research and field testing the artefact within the application environment (Hevner, 2007; Hevner et al., 2004).

The rigor cycle is facilitated through the construction, description and application of a Theoretical Framework for the study (as per Chapter 4) and the reflections and evaluations of the individual three perspectives, as well as the combined MAIE framework, presented in Chapter 8.

The theoretical lens through which this study is executed proposes an amalgamation of ICT's 4Cs Framework (Tongia et al., 2005) and the Systems Theory's Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005). This process is comprehensively described in Chapter 4.

1.6.3 Design Cycle

The *Design Cycle* of research activities iterates more rapidly between the development of an artefact, its evaluation, and subsequent feedback to refine the design further, than the *Relevance* and *Rigor Cycles* (Carlsson, Henningsson, Hrastinski, & Keller, 2011; Hevner, 2007).

The Design Cycle iterations aim to answer the main research question and are operationalised in two phases using Peffers' Design Science Process (2007), as per Figure 1-3.

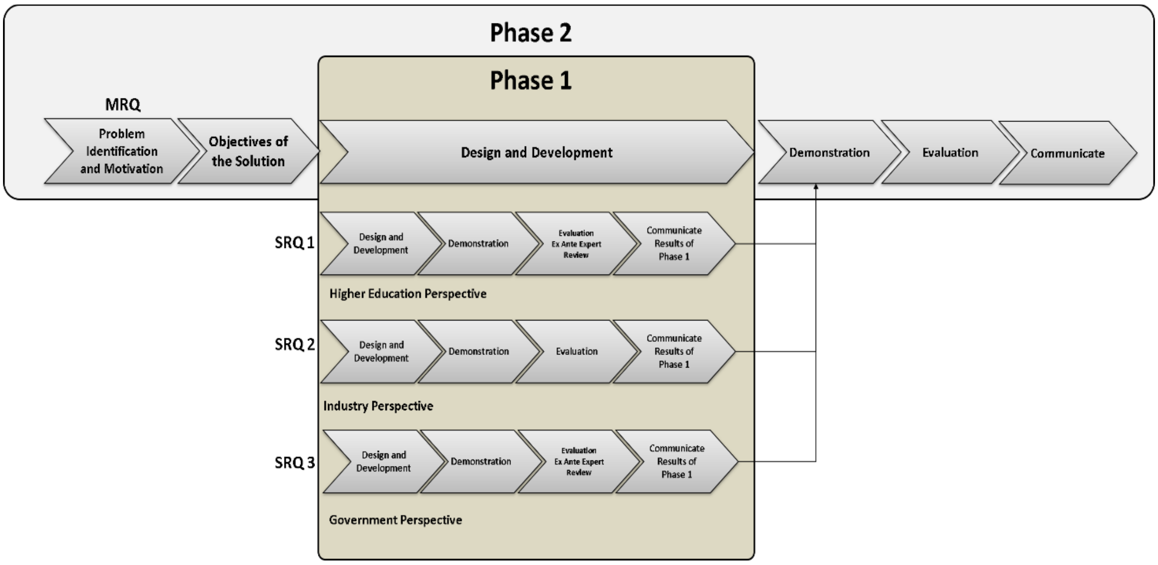

Figure 1-3: Peffers' (2007) DSR process adapted for this study

The *problem identification and motivation* and the *objectives of the solution* (both outlined in this chapter) remain the same for all the iterations and align with the research aim of the thesis.

The subsequent steps (*design and develop*, *demonstrate, evaluate* and *communicate*) are iteratively applied to each of the perspectives of the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) in Phase 1.

The research process, operationalised in Phase 2, is concerned with the design, development, demonstration and evaluation of the *collective MAIE Framework*, as guided by understanding of the three perspectives garnered from Phase 1. The second phase is, once again, framed by the overarching study objectives and solution.

The following section outlines each of these phases in more detail. In addition, they will be comprehensively addressed in Chapter 3, Research Methodology.

- **Phase 1** (presented in Chapters 2, 4 and 5 to 7) details the exploration and description of the component parts through three iterations, each addressing one perspective contained in the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005). The HE perspective is dealt with in Chapter 5, the Industry perspective is presented in Chapter 6 whilst the Government perspective is discussed in Chapter 7. The outcomes of each of the three perspectives are iteratively constructed through the DSR process, as part of the rigor and relevance cycles, framed by the contextual narrative of Botswana (Chapter 2), and then grounded by the Theoretical Framework (Chapter 4). Each of the three Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) perspectives (HE, Industry and Government perspectives) explores the components from literature reviews and consequently presents the design from the identified components evaluated by experts in the helix. The three interim framework designs are used to provide input for the DSR iterations in Phase 2.
- **Phase 2** (discussed in Chapter 8) presents the second phase of the DSR process in which the consolidated interim frameworks 1, 2 and 3 (each describing a separate perspective) were used to develop a synthesised framework. This conceptual framework is presented to, and evaluated by, knowledgeable professionals. The end result of this interactive process is the Final Mobile Applications Innovation Ecosystem Framework presented in Figure 8-9: Final Mobile Applications Innovation Ecosystem Framework.

1.7 Ethical Considerations

The following documents, included in the appendix, guided the research's ethical considerations:

- An ethical clearance letter granted by UNISA's College of Science, Engineering and Technology's (CSET) Research and Ethics Committee. (Appendix 11-1).

- An authorisation letter granted by the Research Department of Botho University, authorising the researcher to carry out the research at Botho University (Appendix 11-2).

- A research permit granted by the Ministry of Transport and Communication within the Botswana Government (Appendix 11-3).

- Introductory letter and consent form allowing for the gathering of data from HEI students regarding challenges faced in mobile application programming (Appendix 11-4).

- Introductory letter and consent form allowing for the gathering of data from Mobile Application developers within Botswana's mobile application ecosystem (Appendix 11-5).

- Introductory letter and consent form allowing for the gathering of data from Funding and Support agencies within Botswana's mobile application ecosystem (Appendix 11-6).

- Introductory Letter and consent form allowing for the gathering of data from knowledgeable professionals within Botswana's mobile application ecosystem (Appendix 11-7)

These documents, and actions detailed later, were further guided by conventional social science ethics' four principles namely: (i) informed consent, (ii) absence of deception, (iii) privacy and confidentiality, and (iv) accuracy, as outlined by Christians (2005).

1.7.1 Informed Consent

This principle requires that research participants be informed regarding the nature and consequences of their participation in the research (Christians, 2005). The introductory letters and consent forms implemented this principle.

1.7.2 Absence of Deception

This principle forbids deliberate misrepresentation and extends to criminals, children in schools and/or mentally incapacitated participants (Byrne & Alexander, 2006). To adhere to this principle, divergent meanings stemming from different languages, cultures, choice of words and experiences will therefore require a common understanding (Christians, 2005). The introductory letter clearly explained the purpose of the study in uncomplicated language and the questionnaire used terms which would be familiar to stakeholders and/or knowledgeable professionals.

1.7.3 Privacy and Confidentiality

Safeguarding participants' identities and data against unwanted exposure is addressed by this principle. The introductory letter and consent form explained that data would be collectively analysed, thus anonymising participants. Data hard copies were kept under lock and key in the researcher's office whilst soft copies were only shared with the supervisor via Dropbox.

1.7.4 Accuracy

This principle requires that the researcher ensures that data is accurate and no fabrications, fraudulent materials, omissions and contrivances are carried out (Christians, 2005). The researcher used a coding scheme to link each questionnaire to the data in the analysis software to thus ensure traceability. All data was collected from students, mobile application developers, mobile service providers, government representatives and members of various support organisations. All questionnaires were captured without omitting any responses.

1.8 Research outline

The thesis chapters of this research study are as follows:

Chapter 1: Introduction

This chapter introduces the study by briefly describing the role played by mobile applications within the context of ICT4D. It further presents the developmental challenges resulting from limited relevant mobile applications and motivates the role innovation ecosystems can play in the development of the African continent by supporting mobile applications.

Chapter 2: Contextualising the Research

The chapter introduces the application domain through a description of Botswana in terms of the adopted theoretical framework. It then presents Botswana's higher education system, mobile technologies in Botswana's mobile ecosystem industry as well as relevant governance structures.

Chapter 3: Research Methodology

The research methodology chapter presents the Design Science Research and case study strategies used to answer the research questions.

Chapter 4: Theoretical Framework

This chapter elaborates on the domain discipline of ICT4D and introduces the theoretical framework underpinning the study, namely an amalgamation of ICT's 4Cs Framework (Tongia et al., 2005) as well as the systems' theory Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005).

Chapter 5: Higher Education Components of a Mobile applications innovation ecosystem

This chapter presents the rigor cycle of the adopted Design Science research. It explains the literature component of the innovation ecosystem for mobile applications from the higher education perspective as well as presenting an initial framework design. The framework is evaluated, and challenges faced by, and resources available to, computing students at a conveniently sampled private University in Botswana introduce the relevance cycle of the Design Science Research. The initial framework version 1 is subsequently presented.

Chapter 6: Industry Components of a Mobile applications innovation ecosystem

Another DSR cycle is executed and presented in this chapter. During the rigor cycle, literature dealing with the components of a mobile applications innovation ecosystem from the second perspective (industry) from the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) is presented. The framework components from the industry perspective are evaluated and challenges faced by mobile application developers in Botswana are established. Consequently, framework version 2 is presented.

Chapter 7: Industry Components of a Mobile applications innovation ecosystem

The third perspective of the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005), namely the government's components of a mobile applications innovation ecosystem, are established in the third DSR cycle. This is achieved by a third rigor cycle during which components of a mobile applications innovation ecosystem, from the government's perspective, are used to formulate a third framework design. This design is then evaluated in accordance with the identification of support available to the mobile application development industry in Botswana from government and non-government organisations. The resulting third version of the framework is then presented.

Chapter 8: Evaluation of the Mobile applications innovation ecosystem Framework

This chapter presents the second DSR phase in which the *parts* of intermediate frameworks 1, 2 and 3 (comprising of the identified components from HE, Industry and Government) are finally synthesised to create a *whole* framework. This new synthesised framework then undergoes an evaluation, based on the IS artefact evaluation criteria (Prat, Comyn-Wattiau, & Akoka, 2014), by knowledgeable professionals hailing from each of the triple helix perspectives who have been active in Botswana's mobile ecosystem. A final, evaluated framework is then presented as the outcome of the study and in response to the main research question.

Chapter 9: Conclusion

This chapter presents reflections on the study and concludes the research.

1.9 Benefits and Significance of the Study

Research impact is a continuum which ranges from raising awareness of findings at the one end, through knowledge and understanding of the findings' implications, to changing behaviour, on the other end (Walter, Nutley, & Davies, 2003). The different points on the continuum of benefits, as depicted in this thesis, are discussed in the following sections.

1.9.1 Challenges to Learning Mobile Application Programming: A Case of Computing Students at Botho University in Botswana

The process of developing the framework will deliver a deeper understanding as to the challenges faced by HEI students in Botswana when engaged, or attempting to engage, in mobile application programming. This contribution will elucidate challenges and opportunities that HE students face when participating in Botswana's mobile application development ecosystem. This understanding will guide the creation of framework version 1.

1.9.2 The challenges faced by Botswana's mobile application industry

This contribution will present the challenges and opportunities (technical, financial and commercial) presented by the Mobile Application Development Industry in Botswana. This contribution will help academia, industry and government appreciate the current state of funding and technical support for Botswana's mobile application developers. This information will help contribute to the creation of a desirable environment for mobile application programming in Botswana.

1.9.3 The state of funding and other support available to mobile application developers in Botswana and its uptake

This contribution will present the state of funding and other forms of support available to mobile application developers in Botswana as well as the state of the uptake of such support. This contribution will shed light on the areas that the mobile applications innovation ecosystem needs to address in order to ensure adequate support for the developers of mobile applications in Botswana.

1.9.4 An evaluated Mobile applications innovation ecosystem Framework for Botswana

This contribution will present the components which facilitate mobile application development within a mobile application ecosystem. The mobile applications innovation ecosystem framework will be evaluated by knowledgeable professionals within Botswana based on the IS artefact evaluation criteria.

Chapter 2 Botswana – Research Context

This multi-disciplinary study was carried out in Botswana. In line with the principle of contextualisation (Myers & Klein, 1999), this chapter will sketch the context in which the research was carried out and, as such, it forms part of the *Relevance Cycle* (refer section 1.8), as described by Hevner's (2007) DSR three cycle model.

2.1 Introducing Botswana

Botswana is a developing sub-Saharan country with a population of 2.021 million in 2013 (Statistics Botswana, 2017). The country is landlocked between South Africa, Namibia and Zimbabwe as shown in Figure 2-1. A 2014 survey revealed that 94% of Botswana households had access to mobile phones and 40.6% of these households had access to the internet (Statistics Botswana, 2017). The Communications Regulatory Authority Act (CRA Act, 2012) lead to the establishment of the Botswana Communications Regulatory Authority (BOCRA) in 2013 in an effort to regulate the communications sector in the country, including internet and mobile services (BOCRA, 2016).

Figure 2-1: Map of Botswana (Source: https://tinyurl.com/ybodwacr**)**

The Botswana Communications Regulatory Authority (BOCRA) pegged the number of mobile telephone subscribers in March 2017 at over 3 million, thus showing a high mobile penetration rate of about 150%. At the same time, the number of ADSL users was estimated at 59 590 whilst mobile internet subscribers tallied 1.4 million. Thus, Botswana has about 23 times more mobile than ADSL internet users (BOCRA, 2018). Statistics Botswana (2015) earlier estimated the mobile penetration rate at a slightly higher 184% which is amongst the highest in Africa. Botswana's Vision 2036 aims "to transform Botswana from an upper middle-income country to a high income country by 2036" (The Vision 2036 Presidential Task, 2016, p. 1). Vision Pillar 1, entitled *Sustainable Economic Development*, considers, amongst others, a knowledge-based economy, human capital and Information and Communication Technology (ICT) as key concepts to achieving this vision. The vision's imperatives include, but are not limited to, innovation. The Vision 2036 Presidential Task (2016) has thus earmarked *innovation* an expectation for the country. This is in line with Vision Pillar 2, entitled *Human and Social Development,* which considers education and skills development as fundamental to human resource development (The Vision 2036 Presidential Task, 2016).

These statistics indicate that the people of Botswana have adopted mobile phones as computing and connectivity devices and, despite connectivity gaps, these mobile devices may potentially be used to help achieve Botswana's developmental goals. In accordance with the adopted theoretical framework the following sections present, within the context of Botswana, the higher education domain (section 2.2), the mobile industry sector (section 2.3) and governance of the mobile industry (section 2.4).

2.2 Botswana's Higher Education Sector

2.2.1 Overview of Botswana's Higher Education Sector

Botswana's higher education system started in 1964 with the establishment of the regional University of Basutoland, Bechuanaland and Swaziland, subsequently renamed the University of Botswana, Lesotho and Swaziland (UBLS) and the system currently includes both private and public institutions (Malete & Kobedi, 2012). Before the advent of the Botswana Qualifications Authority (BQA), public institutions were the responsibility of different ministries and departments of government while private institutions answered to the Tertiary Education Council (TEC), now known as the Human Resources Development Council (HRDC) (TEC, 2012). In 2012, 37 higher education institutions (24 public and 13 private) with 46 613 students were registered with the HRDC (Malete & Kobedi, 2012). Botswana envisages an increasing gross enrolment ratio (GER) reaching 25% by 2026, up from 17% in 2016, and private universities are considered key in this expansion (TEC, 2012). The BQA, a parastatal established by the Botswana Qualifications Authority Act (No 24 of 2013) under the Ministry of Tertiary Education Research Science and Technology, has been charged with the mandate of assuring quality education and managing the National Credit and Qualifications Framework (NCQF). This body had, by 2017, registered 788 Technical and Vocational Education and Training (TVET) education providers of 6 366 accredited learning programmes, 20 Higher Education providers of 546 learning programmes and no data on the General Education subsystem (Botswana Qualifications Authority, 2017). Botswana's higher education offers a variety of programmes and had an enrolment of 28 522 in 2017, with Information and Communication Technology programmes accounting for 10.2% of the total enrolment in the year 2017 (Botswana Qualifications Authority, 2017). Private institutions are considered more responsive to market needs while public institutions focus on addressing the human resource needs of the government, with the exception of the University of Botswana (Damane & Molutsi, 2013).

2.2.2 The Challenges faced by Higher Education in Africa

Jackson, Ellis and Postner (2012) argue that given the proliferation of mobile devices and with the many software development tools available, undergraduates can explore mobile application programming as part of their curriculum. Globally, mobile application development is a very relevant topic which appeals greatly to computing students. Such popularity can be used to attract, retain and motivate students (Alston, 2012). This popular appeal is as a result of the increasing popularity of smart phones and their accompanying applications (Gordon, 2013). Computer Science departments are beginning to realise the importance of offering mobile application development courses (Gordon, 2013).

Despite the importance of mobile application programming, some African higher education institutions, however, face financial constraints, shortages of published books, lack of basic teaching resources, lack of simple laboratory equipment and supplies to teach and do research in other countries as well as delays in salary payment (Teferra & Altbach, 2004). BQA identified the top challenges, as observed from quality assurance audits in Botswana, to be: unqualified lecturers, inadequate equipment, health and safety failures, poor internal quality assurance methods and poor policy implementation by education providers (Botswana Qualifications Authority, 2017). Although the government of Botswana provides funding to public tertiary education institutions for their recurrent and capital expenditures, Damane and Molutsi (2013) note that similar funding is not available to private higher education institutions in the country. This approach to funding results in private higher education institutions being more resource-constrained than their public institution counterparts.

Students attending higher education institutions are not only affected by their own personal challenges but also by the challenges faced by their institutions. In neighbouring South Africa, students face resource constraints which result in them living off campus, experiencing problems with transport and, consequently, missing classes as well as having to contend with the high cost of textbooks. All of these factors are exacerbated by a general academic unpreparedness for higher education (Biljon & Dembskey, 2011). In an effort to accommodate the escalating number of student enrolments between 2009 and 2016, the Botswana government spent about 5% of the Gross Domestic Product on tertiary (higher) education (Damane & Molutsi, 2013). Huge demands in other areas of government expenditure as well as dwindling diamond resources have eroded the financial resources of the country. The government, being the largest role player in student financing, has had to enforce stricter tertiary admission criteria in an effort to reduce the number of secondary school leavers eligible for government sponsorship, despite the planned increases in the gross enrolment ratio (GER). Student allowances have also been reduced, or stopped completely (Damane & Molutsi, 2013). These actions culminate in financial resource-constraints affecting both institutions *and* students.

2.2.3 Challenges Faced in Teaching Mobile Application Programming

The development of computer programmes or applications, also known as *programming* or *application development,* commenced at the same time as the invention of general-purpose computers. Evidence of the concept of a stored computer programme which could sort data was discovered amongst the notes of John von Neumann (1903 - 1957) (Gordon, 2013). While mobile application programming and traditional computer programming are similar disciplines, additional challenges come into play during mobile application programming (Gordon, 2013).

These unique mobile application programming challenges result from: varied network speeds inherent to different wireless connections, network failures, varying platform performance and varying screen sizes (Tracy, 2012). Gordon (2013) argues that mobile devices' small screens and their ability to change orientation, multiple sensors and touch input capabilities all present challenges which mobile application programmers must navigate. Mahmoud and Popowicz (2010) further identify bandwidth, processor speed, screen size and resolution, memory consumption, battery life and user input tools as characteristics which differentiate mobile programming from traditional computer programming environments. The advent of application environments, such as virtual reality and smart environments, adds to the challenges of developing applicable mobile applications for the latest environments (Ahmed & Rehmani, 2017).

2.2.3.1 *Differences: Mobile Application Programming and Computer Programming*

The development of apps for mobile devices differ from the development of traditional desktop apps, thus requiring students to take heed of the differences and resulting challenges. Gordon (2013) groups the differences between programming mobile devices and traditional computers into six categories:

***User Interface Design and Usability**:* This category refers to differences in screen size, changing orientation, sensors and touch screens. These phenomena can create challenges regarding the amount of information being displayed, thus necessitating developers to sub-divide their pages as well as cater for landscape and portrait orientation changes. In addition, tedious input keyboards mean that information cannot be extracted from the user as quickly as it would be if a computer was being used.

***Device Cooperation**:* This covers communication between the mobile device and other parts of the solution, such as remote servers, other devices or sensors and actuators using different technologies such as Wi-Fi and Bluetooth to control other devices like TVs.

***Hardware Issues**:* This category deals with hardware limitations and complexities brought about by mobile device hardware. Limited memory, bandwidth, storage and power supply have implications for programme design. Connecting and making use of

GPS and other sensors as well as employing connectivity features introduces new areas in programming mobile devices.

***Data Handling**:* Data can be stored on the local device, or remotely in some cloud service and this requires a certain understanding as to the trade-offs between the two options. Computers store data in files which can be accessed from programmes after having obtained the required permission. Mobile devises store data in application specific files, system wide preference files or application specific databases, thus giving rise to several challenges when attempting to share data among mobile apps.

***Application Interaction**:* Computers couple different programmes to achieve required tasks, therefore re-using programmes. Students should thus be able to use the services of other applications to achieve their application's goals, or to offer their functionality to other applications.

***Programming Issues**:* This category covers the general differences in cross platform development, life cycles, security, testing and debugging.

Developers/programmers of mobile applications must therefore be mindful of how their code affects, or is affected by, these challenges and characteristics.

2.3 Botswana's Mobile Industry

2.3.1 Introducing Mobile Ecosystems

Crandall (2012) argues that the existence of a phone *alone* is not sufficient to realise the developmental potentials brought about by mobile phones as several other factors have to be in place as well. These other factors are summarised in the mobile ecosystem/value chain.

The mobile ecosystem, or value chain of mobile services, consists of five major domains: infrastructure and support services, network operators, handset devices, distribution and content as well as services (Phillips, Lyons, Page, Viviez, & Maria, 2011). The Content and Services group is responsible for developing mobile applications and services. In Africa this group's contribution to the economy has been significantly lower than that of other groups, as depicted in Figure 2-2.

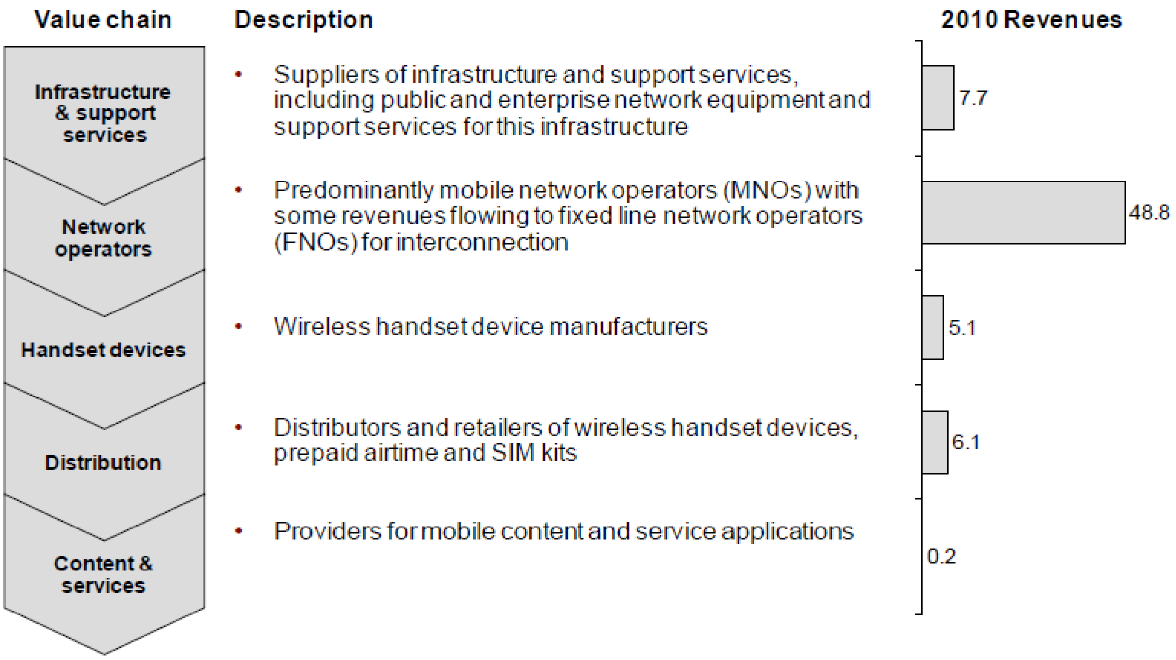

Figure 2-2: Mobile ecosystem description and size in Africa (2010, US$billions)(**Phillips et al**., **2011, p. 23)**

The Infrastructure and support services value chain will be discussed in section 2.4 seeing that the government plays a greater role within that section of the value chain.

2.3.2 Botswana's Network Operators

The Network Operators' section of the mobile ecosystem is made up of mobile as well as fixed network operators which provide connectivity (Phillips et al., 2011). Botswana's telecommunications market has four major players: Botswana Fibre Networks Ltd (BoFiNet) which is a wholesale provider and three Public Telecommunications Operators (PTO) namely Botswana Telecommunications Corporation Limited (BTCL), Mascom Wireless Botswana (Pty) Ltd (Mascom) and Orange Botswana (Pty) Ltd (Orange) (BOCRA, 2016). The PTO license holders in Botswana can operate fixed and mobile telephony services, with only BTCL offering both while Mascom and Orange offer only mobile services.

2.3.2.1 *Mobile Telephone Service in Botswana*

The mobile service market share in Botswana, as illustrated in Figure 2-3, shows that Mascom is the leader with a 53% market share whilst BeMobile, the mobile telephone section of BTCL, possesses 15% of the market share.

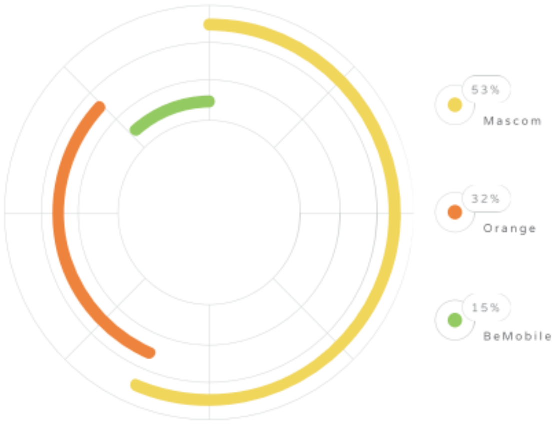

Figure 2-3: Botswana's mobile market share as at March 2016 (BOCRA, 2016)

The majority of the mobile service users in Botswana use *prepaid* (98%) with post-paid mobile telephone users accounting for the other 2%. This has not changed in the past 5 years (BOCRA, 2016). Mobile internet access is primarily via mobile smart phones and USB modems and, despite the fact that it is more expensive, these services have grown by 14.4% from March 2015 to March 2016. These services include technologies ranging from 3G and LTE, in urban areas, to GPRS and EDGE in other parts of the country (BOCRA, 2016).

2.3.2.2 *Fixed Telephone Service in Botswana*

The fixed telephone service in Botswana has one player namely BTCL. The market trend indicates that fixed telephone service demand may decline as consumers prefer mobile telephone services, this despite the 177% growth increase in fixed landline broadband between 2011 and 2016 and the 69% increase in fixed wireless broadband subscriptions over the same period (StatCounter, 2017).

2.3.3 Botswana's Handset Devices

The Handset Devices component of the mobile ecosystem comprises of the hardware manufactured by wireless handset device manufacturers (Phillips et al., 2011) including Samsung, Blackberry, Nokia, Apple, Huawei and HTC, amongst others. Botswana's mobile operating systems market share indicates that Android based mobile devices are most popular, accounting for 76% of mobile devices in May 2017 (an increase of 31% from January 2015) whilst Apple's iOS rose from 4 to 6% over the same period (Sanou, 2013). Although no data exists which specifically focuses on Botswana's mobile devices, smartphone adoption has been steadily increasing and it is expected, that by 2020, over half the connection base in sub-Saharan Africa will consist of smart phones (GSMA, 2014).

2.3.4 Mobile-based Content and Services in Botswana

The providers of mobile applications and services, which Phillips et al. (2011) refer to as the *Content and Services group* in the mobile ecosystem, play a crucial role in developing countries as they place ICT applications for education, health, government, banking, environment and business within the reach of all communities (Sanou, 2013). This group contributes the lowest economic value due to the limited prevalence of mobile application development in Africa. Within the mobile ecosystem value chain, the content and services group in Africa is the smallest with limited mobile content production due to the numerous challenges being faced by mobile application developers within the African mobile application ecosystem (Drouillard et al., 2014). This thesis argues that the growth of mobile-based content and services is essential to the sustained development, of not only Botswana, but also the African continent.

Several literature works discuss Botswana's mobile-based content and services. These, however, focus primarily on mLearning and telemedicine technology. Khengere (2012) explored the ways in which mobile technologies can be used to assist distance learners in Botswana whilst Yaqiang and Chakalisa (2011) argued for the integrated use of mobile technologies to promote learning and teaching in various education settings in Botswana. Littman-Quinn et al. (2011) and Littman-Quinn, Mibenge, Antwi, Chandra and Kovarik (2013) demonstrated the benefits of using mobile technologies, to specialist trainees, in the areas of clinical education, clinical decision making and patient adherence. Aileen et al. (2012) demonstrated how resident physicians at the University of Botswana School of Medicine managed to effectively utilise smart phones to access point of care medical information and self-directed learning while at home. Quinley et al. (2011) noted that in 89% of cases, midwives and an expert gynaecologist in Gaborone, Botswana, were able to correctly diagnose cervical cancer from images taken by mobile phones and transmitted via MMS. Schwartz et al. (2014) stated that 76% of the time, digital photographs of X-rays obtained via mobile phones were used to correctly diagnose common pathologies found in Botswana. A study by Esfalul et al. (2013) concluded that telemedicine could significantly improve patient management. Challenges experienced in using mobile technologies in Botswana include: devices malfunctioning, unreliable IT infrastructure, damage to devices and a misalignment of IT and heath care providers.

Realising the potential benefits of mobile technology and the need for locally developed mobile applications and services in the country, the Botswana Innovative Hub launched the first mHealth IT Innovative Competition on 29 January 2013. The competition aimed at encouraging the youth of Botswana to come up with ideas that could improve public health and health care delivery in the country as it faces a shortage of health workers and poor IT infrastructure in non-urban areas (Churu, 2014). The mHealth IT Innovative Competition has become an annual event in Botswana, with a grand prize of about US$15 560 in 2014 (Churu, 2015). The third competition (2015) was launched in February 2015 (Churu, 2015). In separate events, Orange Botswana (a mobile service provider) supported a once off Blackberry Jam developer session which aimed to provide insights into Blackberry 10 platform's strengths, vision and how developers could create apps for Blackberry users. The jam session, which was held in Botswana's capital city in May 2013, was attended by more than 180 developers ("Jam", 2013). These efforts underscore and acknowledge that the creation of locally relevant digital content and services, accessible via mobile gadgets, require that local mobile application developers master the necessary expertise and skills.

2.4 Botswana's Mobile Ecosystem Governance

2.4.1 Botswana's Mobile Ecosystem Governance

The mobile ecosystem in Botswana is governed by the Communications Regulatory Authority Act of 2012 (CRA Act). This act led to the establishment of the Botswana Communications Regulatory Authority (BOCRA) on the 1st of April 2013. This organisation is charged with the mandate to regulate the communications sector in Botswana and report to the Ministry of Transport and Communications (BOCRA, 2016). One of BOCRA's core business focus points is the development and promotion of appropriate strategies and policies to encourage infrastructure development and the use of ICT services aimed at driving the *knowledge society* key result area.

Botswana's ICT technology and services are licensed under several categories. These include Services and Applications Providers (SAPs) which are non-infrastructure-based service providers which deliver all forms of services and applications to end users through means *other* than broadcasting.

2.4.2 Botswana's Infrastructure and Support Services

The Infrastructure and Support Services domain comprises "suppliers of infrastructure and support services, including public and enterprise network equipment and support services for this infrastructure" (Phillips et al., 2011, p. 23). Botswana's mobile telecommunications infrastructure is managed by Botswana Fibre Networks Ltd (BoFiNet). BoFiNet is the sole wholesale provider of national and international telecommunication infrastructure. Their core mandate is to provide and operate a world class telecommunications backbone network infrastructure through the Eastern Africa Submarine Cable System (EASSy), linking East Africa to the rest of the world, the West Africa Cable System (WACS) undersea fibre optic cable connecting South Africa to London and the Europe India Gateway (EIG) undersea fibre optic cable. BoFiNet initiated service in October 2013 after having been issued with an interim Public Telecommunications Operator (PTO) license to provide wholesale services from 1 April 2013 (BoFiNet, 2016).

Locally, BoFiNet's national fibre infrastructure covers more than 6 000km. This system links cities, towns, villages and a transport network of 161 sites through the latest fibre optic based Dense Wavelength Division Multiplexing (DWDM), as well as older Synchronous Digital Hierarchy (SDH) equipped sites, together with a national IP core meshed topology network of which the routers link directly to undersea fibre cables (BoFiNet, 2016). All licensed telecommunications operators in Botswana are serviced by BoFiNet as its infrastructure allows for the offering of WIFI services, national leased lines and various internet products to the mobile network operators and other connectivity service providers in Botswana.

BoFiNet's current infrastructure allows for 3G and 4G connectivity across the country, offering high quality services to the retail segment at amongst the lowest prices in the region BOCRA (2016). The connectivity requirement for ICT4D is thus addressed.

2.5 Mobile Technology for Development in Africa

The developmental potential, through the promotion of inclusion, efficiency and innovation, presented by mobile technology in Africa is evident (The World Bank, 2016). Mobile technologies in Africa are slowly shifting from being mere *communication tools* to being *service delivery platforms* (Aker & Mbiti, 2010). This shift in focus is enabling digital dividends in the form of growth, service delivery and jobs within developing countries (The World Bank, 2016). Botha et al. (2010), Aker and Mbiti (2010), Murugesan (2013), Anil, Parul, Rachan and Rita (2012), Lwoga and Sangeda (2018), Ono et al. (2017), Nchise, Boateng, Shu and Mbarika (2012) and Crandall (2012) presented cases which illustrated how mobile technology was changing the way in which Africa conducts business and approaches general interaction. Despite Raiti's (2006) claim that ICT4D will *not* provide food, clean water, affordable health care, civil rights, or peace, which is true to some extent, the presented cases show how ICT4D has positively impacted on civil rights, health care and agriculture. Mobile technologies, therefore, show great potential in the development of Africa if one considers the high penetration rate of mobile phones and the steady growth in smart phone adoption. There is thus an abundance of fertile ground for potential mobile application programming in Africa which would ensure the creation of locally relevant content. Raiti (2006) acknowledges the documented ICT4D success stories of improvements in literacy levels amongst farmers and facilitated communal communication but maintains that ICT4D is not a cure-all for the complex needs of developing countries.

2.6 Summary

This chapter articulated and described the research environment through an introduction of the country, Botswana. Based on the adopted Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005), the chapter unpacked the higher education sector of the country and presented its mobile ecosystem industry as well as the mobile ecosystem regulatory influences which underpin it. An insight into the role of mobile technologies in the development of the African continent was also presented.

Chapter 3 Research Design

This chapter describes the research methodology adopted in developing a Mobile Applications Innovation Ecosystem Framework for Botswana. Saunders et al. (2016) describe the construct which they used to outline the research process as *a progression of elements*. These elements include: the research philosophy, research approach, research strategy, time horizon of research and, finally, data collection methods. They present these elements as a *Research Onion* (Saunders et al., 2016) which helps to facilitate a consistently rigorous research process. Gregor (2006) suggests that the nature of the theory, or the type of knowledge being contributed, should guide the choice of research philosophy, i.e. the ontology and epistemology. As convincing motivation for adopting a DSR research methodology exists, this study elected to consider the nature of the research problem and its knowledge contribution as the point of departure in articulating the study's research methodology.

3.1 Research Question

The main research question (RQ_M) to be addressed in this study is:

RQ_M: What are the components of a mobile applications innovation ecosystem framework for Botswana?

This main research question is supported by the following three sub research questions:

- RQ_1: What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Higher Education perspective?

- RQ_2: What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Industry perspective?

- RQ_3: What are the components, support opportunities available to the mobile applications innovation ecosystem from the Government perspective, and what is the uptake of this support?

Towards answering these questions, the following section articulates the research aim.

3.2 Research Aim

The main aim of this research is to explore, describe and refine a Mobile Applications Innovation Ecosystem Framework for Botswana.

The four research objectives are identified as:

- RO_1. To investigate the components, challenges and opportunities within the mobile applications innovation ecosystem from a Higher Education perspective.
- RO_2. To establish the components, challenges and opportunities within the mobile applications innovation ecosystem from an Industry perspective.
- RO_3. To establish the components, support opportunities available to the mobile applications innovation ecosystem from the Government perspective and to assess the uptake of this support.
- RO_4. To evaluate the proposed mobile applications innovation ecosystem.

It is argued that, as the MAIE Framework will extend over multiple organisations and domains, the research would need to:

- Engage with an initially ill-defined problem;
- Concern itself with a socio-technical system (Fischer & Herrmann, 2011) which includes technology, people and processes;
- Create a contextualised artefact which acknowledges the stakeholders and participants; and
- Be pragmatically useful.

These identified features necessitated the execution of a research process which could support them and thus facilitate the conceptualisation of the MAIE framework. Hevner et al. (2004) argue that there are two paradigms that characterise most Information Systems (IS) research: behavioural science and design science. It is argued that behavioural science is rooted in natural science research methods as it seeks to develop and justify theories which explain, or predict, organisational, or human, phenomena (Hevner et al., 2004). Hevner et al. (2004) further state that design science is fundamentally a problem-solving paradigm, rooted within engineering and artificial science research methods, which seeks to create innovations that define ideas, practices, technical capabilities and products. DSR focuses on developing new Information Technology artefacts that solve problems and, as such, it underscores the thrust of this research study. Hevner et al. (2004) broadly defined such Information Technology artefacts as: constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices) and instantiations (implemented and prototype systems). Gregor and Hevner (2010) argue that DSR uses *artefacts* to understand, explain and frequently improve the behaviour of social systems.

The research contribution of this study is a Mobile Applications Innovation Ecosystem Framework for Botswana. Gregor and Hevner (2010) identify three levels of contribution types in DSR, as per Figure 3-1. The outcome of this research qualifies as a Level 2 contribution as the framework will have an operational architecture.

Design Science Research Contribution Types

	Contribution Types	Example Artifacts
More abstract, complete, and mature knowledge	Level 3. Well-developed design theory about embedded phenomena	Design theories (mid-range and grand theories)
↕ ↕ ↕ ↕	Level 2. Nascent design theory—knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules.
More specific, limited, and less mature knowledge	Level 1. Situated implementation of artifact	Instantiations (software products or implemented processes)

Figure 3-1: DSR contribution types (Gregor & Hevner, 2010)

Design science projects are considered as *research* if they demonstrate academic qualities such as analysis, explanation, argument, justification and critical evaluation (Oates, 2012) which are demonstrated throughout this research. The research contribution, in terms of maturity of knowledge contribution (Gregor & Hevner, 2013), is presented in Figure 3-2.

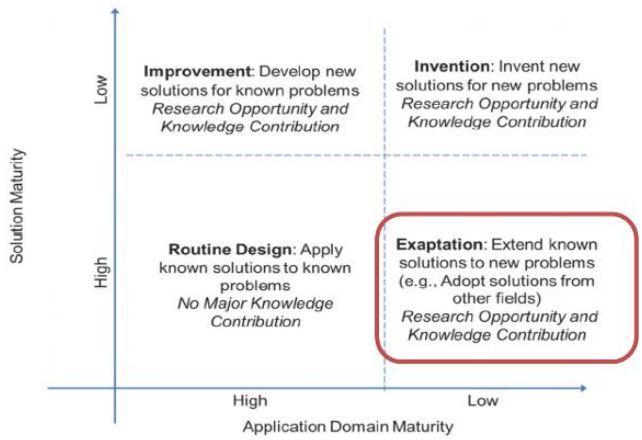

Figure 3-2: Research contribution (Gregor & Hevner, 2013, p. 345)

Gregor and Hevner (2014, p. 345) state, with reference to Figure 3-2, that “our framework focuses attention on the knowledge start-points (e.g. maturities) of the research project to support a clearer understanding of the project goals and the new contributions to be achieved”. The research study is an exaptation. Exaptation contributions extend known solutions in other fields (innovation ecosystems) to two new areas: (i) the problem of limited relevant mobile applications and (ii) the new context of Botswana.

3.3 Research Paradigm

The research paradigm guides the Research Approach and Research Method, as outlined in Figure 3-3.

Paradigm	**Ontology** *What is reality?*	**Epistemology** *How can I know reality?*	**Theoretical Perspective** *Which approach do you use to know something?*	**Methodology** *How do you go about finding out?*	**Method** *What techniques do you use to find out?*
Positivism	There is a single reality or truth (more realist)	Reality can be measured and hence the focus is on reliable and valid tools to obtain that	Positivism Post-Positivism	Experimental research Survey research	Usually quantitative, could include: Sampling Measurement and scaling Statistical Analysis Questionnaire Focus Group Interview
Constructivism /Interpretive	There is no single reality/truth. Reality is created by individual in groups (less realist)	Therefore, reality needs to be interpreted. It is used to discover the underlying meaning of events and activities.	Interpretivism (reality needs to be interpreted) Phenomenology Symbolic interactionism Hermeneutics Critical Enquiry Feminism	Ethnography Grounded Theory Phenomenological Research Heuristic Inquiry Action Research Discourse Analysis Feminist Standpoint research etc	Usually qualitative, could include; Qualitative interview Observation Participant Non-participant Case Study Life History Narrative Theme Identification etc
Pragmatism	Reality is constantly renegotiated, debated, interpreted in light of its usefulness in new unpredictable situations	The best method is one that solves problems. Finding out is the means, change is the underlying aim	Deweyan pragmatism Research through design	Mixed methods Designed-based research Action Research	Combination of any of the above and more, such as data mining, expert review, usability testing, physical prototype
Subjectivism	Reality is what we perceive to be real	All knowledge is purely a matter of perspective	Postmodernism Structuralism Post structuralism	Discourse theory Archaeology Genealogy Deconstruction etc	Autoethnography Semiotics Literary Analysis Pastiche intertextuality etc
Critical	Realities are socially constructed entities that are under constant internal influence	Reality and knowledge is both socially constructed and influenced by power relations from within society	Marxism Queer theory Feminism	Critical discourse analysis, critical ethnography Action research Ideology Critique	Ideological review Civil action Open-ended interviews Focus groups Open ended questionnaires Open ended observations, and journals

Figure 3-3: Paradigms in research (Patel, 2015)

Research paradigms describe research by making ontological, epistemological and axiological assumptions. The discussion below elaborates on the ***pragmatic*** philosophy adopted for the design science research.

3.3.1 Pragmatism

Pragmatic research aims to generate useful knowledge to inform practice and action. As clearly put forward by (McDermid, n.d.), *pragmatism* is concerned with the utility of the research artefact, and, rather than debating abstract issues of truth and reality, it focuses on solutions that bring about a better world. Godchild (2012, p. 2) argues that "pragmatism is concerned with action and change and the interplay between knowledge and action" thus making it ideal for "research approaches intervening into the world and not merely observing the world". Unlike Interpretivism, the role of the researcher is not to merely engage in understanding, but to engage in changing the world (Goldkhul, 2012). Pragmatism argues that the best research method to use is the one that solves the given research problem (Patel, 2015). Pragmatism thus encourages allows the researcher to adopt a pluralist position which allows him/her to mix whatever methods he/she deems suitable for the research study (Goldkhul, 2012; Goles & Hirschheim, 2000). Developing an Information Systems artefact, such as a mobile applications innovation ecosystem framework for Botswana, is an effort to change the status of the mobile applications industry by supporting an ecosystem that drives the development of more relevant mobile applications and can, therefore, be considered as pragmatic research. The study generates the knowledge needed to act and develop a mobile applications innovation ecosystem framework and, in this sense, it fits within the aim of pragmatic research. Vaishnavi and Kuechler (2004) also argue that a researcher who adopts a DSR methodology is a pragmatist, a view supported by Goldkhul (2012) and clearly illustrated by Patel (2015) in Figure 3-3.

3.4 Mixed Research Approach

Most research texts divide research into two approaches: *qualitative* and *quantitative* research (Knox, 2004). Qualitative and quantitative research can also be termed *inductive* and *deductive* research, respectively. Bordens and Abbort (2006) state that quantitative theory is expressed in mathematical terms, meaning the inputs and outputs of the research are numerically expressed. A hypothesis, or generalisation, is the starting point of a quantitative approach, and data is collected and analysed to prove, or refute, the hypothesis. Qualitative research, on the other hand, presents theories in non-numerical and often subjective terms. Having adopted a pragmatic research philosophy, this design science research study is thus positioned to use both qualitative and quantitative approaches, as illustrated in Figure 3-4, with both quantitative and qualitative data being collected. All interpretations, however, are done quantitatively.

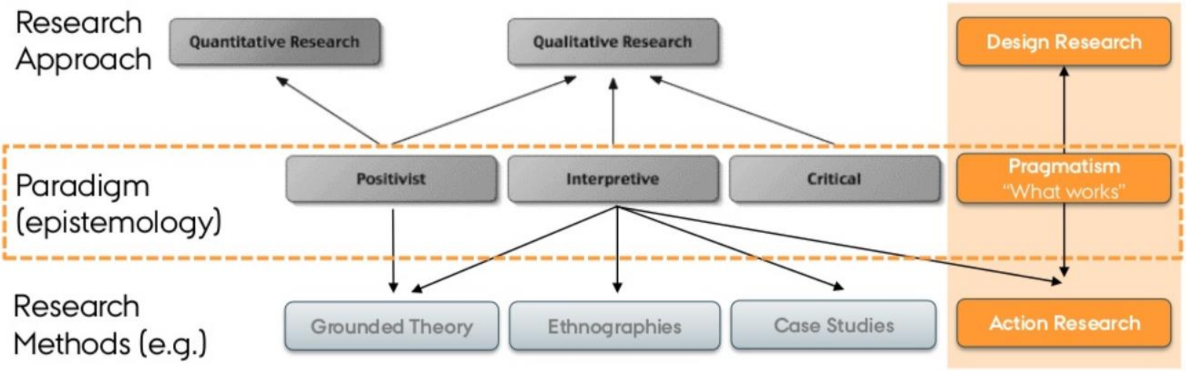

Figure 3-4: Qualitative and quantitative methods in Design Science Research, (Groskovos, 2015)

3.4.1 Quantitative Approach

Originating from natural sciences like Biology, Chemistry, Physics and Geology, domains concerned with investigating things that can be observed and measured objectively and repeatably, this approach has been adopted during most of the 20th century (Tuli, 2011). Hughes (2006) holds forth that quantitative research possesses characteristics such as control, hypothesis testing, replication and operational definition. This approach will thus be: replicable, enable the production of cause and effect relationships and allow for statistical analysis and precision. Several authors state that a quantitative approach flows forth from a positivist philosophy (Holden & Lynch, 2004; Saunders et al., 2003). This point is disputed by Tuli (2011) who holds a purist approach and thus considers the relationship between philosophy and approach as law. In this research work a quantitative approach (surveys and questionnaires) was used to collect data. The statistical analysis of the data is presented in Chapters 5 and 8.

3.4.2 Qualitative Approach

Hughes (2006) presents qualitative research as allowing the researcher to obtain an insider's view and thus discover issues which might be missed in the use of quantitative approaches. Qualitative descriptions allow for the discovery of possible descriptions of relationships. Interviews, a common qualitative data collection tool, were used to obtain information from mobile application developers and mobile application support organisations, as per Chapters 6 and 7. The data analysis was guided by both qualitative and quantitative approaches.

3.5 Design Science Research Method

Behavioural science addresses research through the development and justification of theories that help to explain, or predict, phenomena related to the needs of business. Design Science, however, addresses the building and evaluation of artefacts designed to meet business needs (Hevner et al., 2004). Hevner et al. (2004) propose seven guidelines to complement the IS research framework and to thus assist researchers, reviewers, readers and editors towards an understanding as to the requirements for effective DSR.

Table 3-1: Design Science Research Guidelines. Adapted from Hevner et al. (2004, p. 83)

Guideline	Description	Implications for this research
Guideline 1: Design as an artefact	Design Science research must produce a viable artefact in the form of a construct, model, method or instantiation.	The research produced a framework, the viability of which is assessed through KPs from the mobile ecosystem in Botswana.
Guideline 2: Problem relevance	The objective of Design Science research is to develop technology-based solutions to important and relevant business problems.	The developed framework incorporates literature and relevant student and mobile app developers' challenges and opportunities available to the mobile ecosystem in Botswana.
Guideline 3: Design evaluation	The utility, quality and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.	The refinement, efficacy and evaluation of the framework was done by KPs from Botswana's mobile ecosystem.
Guideline 4: Research contributions	Effective Design Science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies.	The primary research contribution, *a mobile applications innovation ecosystem framework*, is presented in addition to the communication from each DSR cycle. This includes the challenges and opportunities

Guideline	Description	Implications for this research
		faced by HE students and mobile application developers in mobile application programming as well as the support and opportunities available to Botswana's mobile application industry.
Guideline 5: Research rigor	Design Science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.	Rigor for the framework is provided by literature reviews to identify the components and the evaluation of the designs by: 202 higher education students, 41 mobile application developers, 20 government and NGO support organisations and 24 knowledgeable professionals.
Guideline 6: Design as a search process	The search for an effective artefact requires utilising available means to reach desired ends while satisfying laws in the problem environment.	Literature reviews were used to search for the initial components of the ecosystem and additional searches done from the stakeholders for relevance and contextualisation.
Guideline 7: Communication of research	Design Science research must be presented effectively, both to technology-oriented as well as management-oriented audiences.	The thesis aims to present information, as detailed in Guideline 4, to management and technology-oriented audiences.

The adopted DSR framework addresses the requirements for academic quality through the rigor, design, evaluation and relevance cycles, as detailed in this chapter. Figure 3-5: Design Science Research cycles. Adapted from Hevner et al. (2004) summarises the adopted DSR cycles in developing the mobile applications innovation ecosystem framework for Botswana.

3.5.1 Design Science Research Cycles

Hevner et al. (2004) present a combined behavioural and design science research framework to guide the understanding, executing and evaluating of Information Systems (IS) research. Hevner et al. (2004) suggest three inherent research cycles, as illustrated in Figure 3-5: Design Science Research cycles. Adapted from Hevner et al. (2004), namely: (i) the *Relevance Cycle* which links the contextual environment of the research project with the design science activities; (ii) the *Rigor Cycle* which associates the design science activities with the knowledge base that illuminates the research study; and (iii) the *Central Design Cycle* which "iterates between the core activities of building and evaluating the design artefacts and processes of the research" (Hevner, 2004, p. 88).

The *environment* (see Figure 3-5: Design Science Research cycles. Adapted from Hevner et al. (2004)) situates the Research Problem as comprising of: people, organisations and existing technologies. The *people* involved during the DSR phases will be the stakeholders from higher education, government and industry in Botswana. These individuals include HEI computing students, mobile application developers, funding and support agencies, mobile app tutors, mobile service providers, venture capitalists and other funding bodies and government and regulators who form part of the mobile ecosystem (made up of suppliers of network infrastructure, mobile network operators, mobile hardware manufacturers, distributors of mobile services and hardware as well as the developers of mobile content). The knowledge base is framed by ICT's 4C Framework (Tongia et al., 2005) and the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) as further explained in Chapter 4. The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) describes three perspectives namely: the Higher Education perspective, the Industry perspective and the Government perspective. Each of these perspectives are discussed in a chapter in the Relevance Cycle. The three perspectives are interrogated through an exploration guided by the 4C Framework (Tongia et al., 2005), of Computing, Connectivity, Content and Human Capacity.

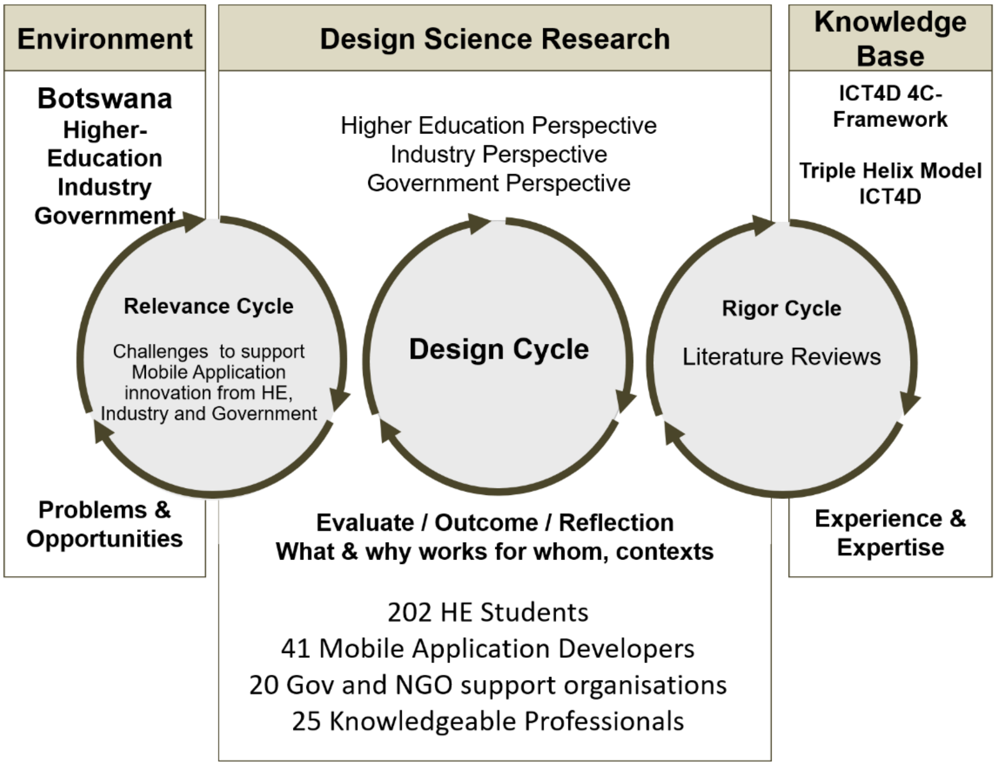

Figure 3-5: Design Science Research cycles. Adapted from Hevner et al. (2004)

3.5.2 The Relevance Cycle

The Relevance Cycle outlines the implementation context in an effort to identify the requirements for the research. In *general,* this study is contextualised within the African Mobile Innovation Ecosystem and it is *specifically* concerned with the mobile innovation ecosystem in Botswana. Chapter 2 presented a narrative description of Botswana, much needed background knowledge towards understanding the research activities outlined in this thesis.

Within this context, various stakeholders can be identified as contributing and/or influencing the Innovation Ecosystem. Literature Reviews are presented in Chapters 5, 6 and 7. The perspectives of the three chapters in the relevance cycle are garnered from the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005). These perspectives are further investigated using the four “Cs”, as articulated by ICT’s 4C Framework (Tongia et al., 2005). Chapter 5 discusses the Theoretical Framework in detail.

- Chapter 5: The literature review in Chapter 5 underpins the research activities which address RQ_1: *What are the components, challenges and opportunities within* *the mobile applications innovation ecosystem from the Higher Education perspective?* This chapter addresses a Higher Education perspective to explore and describe the components, from literature, applicable to a Mobile Applications Innovation Ecosystem.

- Chapter 6: This chapter's literature review is framed by RQ_2: *What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Industry perspective?* As such, it addresses an Industry perspective as to the identification of components relevant to a Mobile Applications Innovation Ecosystem.
- Chapter 7: This chapter aims to answer RQ_3: *What are the components, support opportunities available to the mobile applications innovation ecosystem from the Government perspective, and what is the uptake of this support?* Components of a Mobile Applications Innovation Ecosystem are identified and explored from a Government perspective.

3.5.3 The Rigor Cycle

Viewed within the context of the rigor cycle, this study is grounded in the section of ICT4D which deals specifically with the use of mobile (cellular) phones for development (M4D) and how a Mobile Applications Innovation Ecosystem Framework for Botswana can stimulate the development of locally relevant mobile-based content and services. The developmental potential presented by mobile phones is unpacked in terms of the three dimensions identified by the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) which provides a fine-grained view of innovation actors and roles, both institutional and individual, and the relationships between them (Ranga & Etzkowitz, 2013) is illustrated in Figure 3-6.

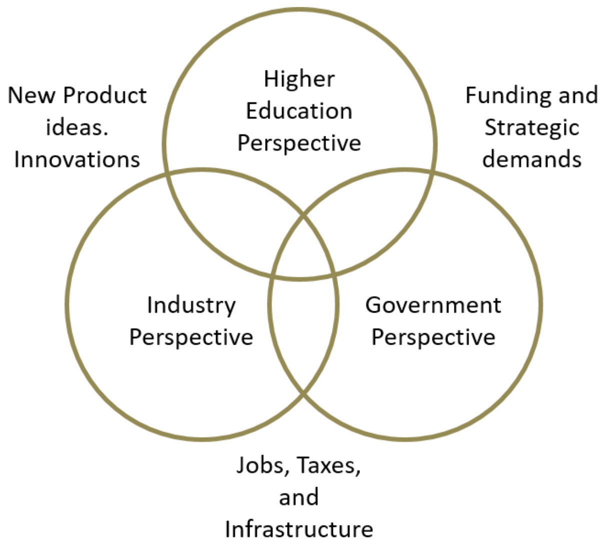

Figure 3-6: The Triple Helix Model representation (Kimatu, 2016)

The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) introduces three dimensions of a social system namely the:

- Knowledge dimension: represents the *universities* and *academia* who create and share new knowledge within the area. This dimension is referred to as the ***Higher Education perspective*** in this study;

- Economic dimension: represent *industry* and, as such, business entities that create economic activities in the area. This dimension is referred to as the ***Industry perspective*** in this study;

- Geographic dimension: represents the *government* who rules the area. This dimension is referred to as the ***Government perspective*** in this study.

The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) is discussed in detail in section 4.3.5, Chapter 4. Each of these dimensions, as identified from the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005), is interrogated by means of the components presented in Tongia et al.'s (2005) ICT4D four C Framework (refer to Figure 3-7: 4Cs Framework for ICT).

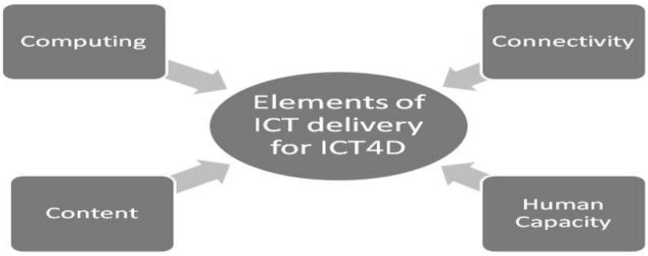

Figure 3-7: 4Cs Framework for ICT

These four components are briefly outlined in the following section (Tongia et al., 2005):

- Computing: Access to computing devices such as PCs or mobile phones is required to achieve ICT4D.

- Connectivity: ICT4D requires users to have access to content via data connectivity or internet access from their computing devices.

- Content: Locally relevant and meaningful content in the correct language must be provided to communities.

- Human Capacity: Communities must be made aware, literate, innovative and empowered to use ICT.

A full discussion of Tongia et al.'s (2005) ICT's 4C Framework (Tongia et al., 2005) is included in section 4.2.2.

Figure 3-8 presents a diagrammatic outline of the perspectives provided by the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) and the ICT's 4C Framework (Tongia et al., 2005), as they relate to this research study.

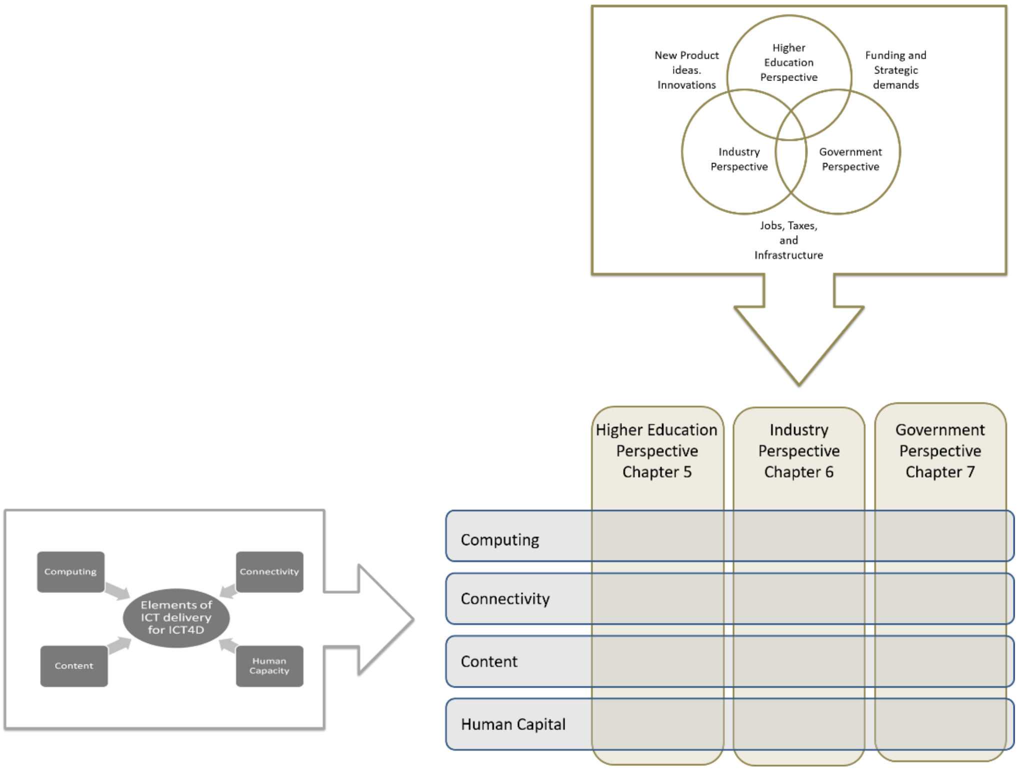

Figure 3-8: Application of the Triple Helix Model (Etzkowitz et al., 2007; Leydesdorff, 2005) and the ICT4D 4C Framework (Tongia et al., 2005)

3.5.4 The Design Cycle

During this cycle the researcher designs artefacts to address the research problem, through creativity and/or trial and error (Gregor & Hevner, 2013). This cycle is considered the heart of the DRS project as it involves iterations between the construction and evaluation of the artefact. Subsequent feedback is used to refine the design (Hevner, 2007). The designs are carried out within the three perspectives of Higher Education, Industry and Government, as per the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005). Each perspective (refer to Chapters 5, 6 and 7) is expanded upon, based on the ICT's 4C Framework (Tongia et al., 2005). In the first DSR phase each perspective leads to a design (sections 5.3, 6.3 and 7.3) which is then evaluated by stakeholders which hail from that relevant perspective (sections 5.4, 6.4 and 7.4). A second design is subsequently created by synthesising Phase 1 frameworks into a newly designed intermediate framework (section 8.1.1). Knowledgeable professionals from the three perspectives (section 8.4) once again evaluate the newly created framework. This process is repeated, finally resulting in the creation of the framework presented in section 8.6. Hevner (2007) suggests multiple iterations of the design cycle. This study undertook two iterations which are elaborated upon in sections 3.7 and 3.8.

3.6 Design Science Research Process

The Design Science Research Process operationalises the Design Science Research. Several processes exist in the knowledge base to assist the researcher in developing the framework (DSR artefact). Vaishnavi and Kuechler (2004) identified five iterative steps to design and creation namely: awareness, suggestion, development, evaluation and conclusion shown in Figure 3-9.

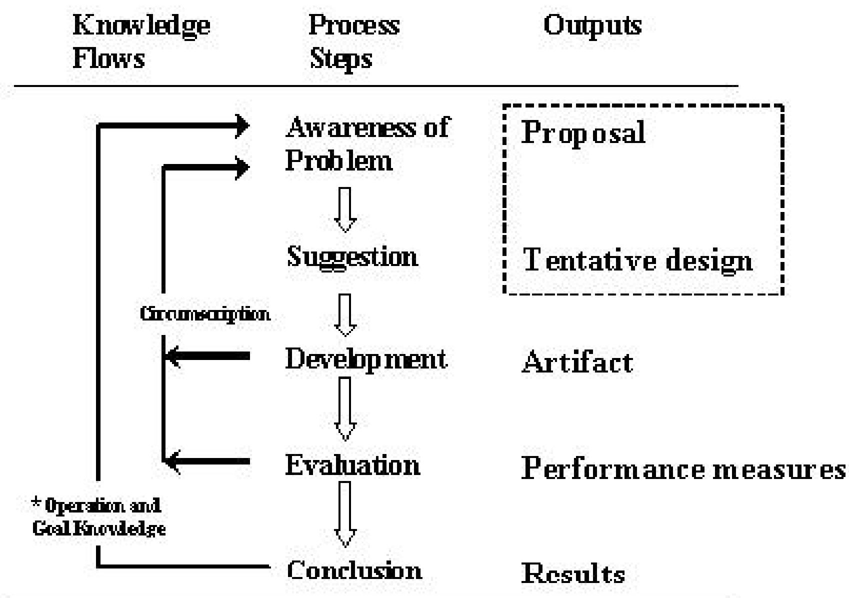

Figure 3-9: Design Science Research Process (Vaishnavi & Kuechler, 2004, p. 8)

Peffers et al. (2006) identified six steps in the DSR process, as per Figure 3-10.

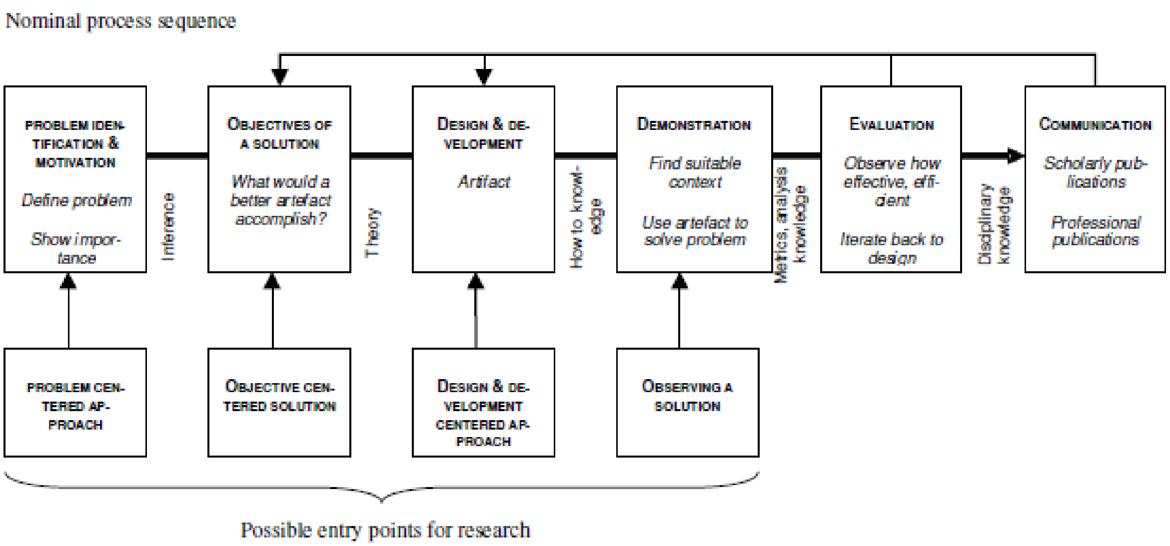

Figure 3-10: Design Science Research Process Model (Peffers et al., 2006, p. 93)

This research study acknowledges the DSR process of Vaishnavi and Kuechler (2004) and adapted the model suggested by Peffers et al. (2006) to help guide the research process. Peffers et al.'s (2006) DSR Process Model is implemented in two phases, as illustrated in Figure 3-11: Design Science Research Process for developing a Mobile Applications Innovation Ecosystem Framework

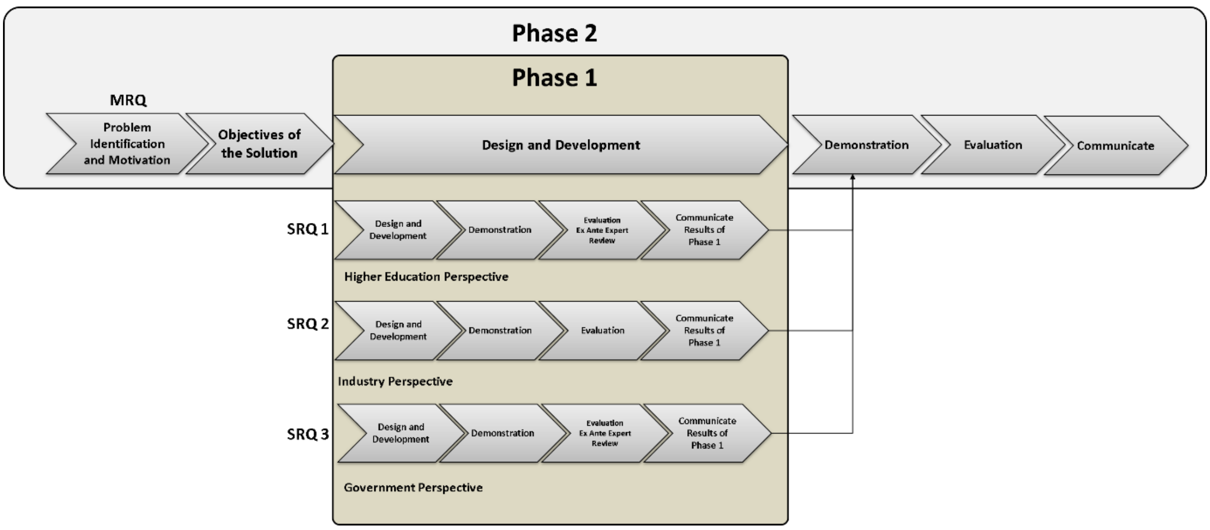

Figure 3-11: Design Science Research Process for developing a Mobile Applications Innovation Ecosystem Framework

3.7 Phase 1

This phase describes three rigor-design-relevance iterations of Design Science Research as guided by the main research question and the research objectives of the study.

Each of these three rigor-design-relevance iterations addresses a sub research question and corresponds to one of the three perspectives identified from the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) presented in section 4.3.5. Each of these are outlined below according to the Peffers et al.'s (2006) DSR process model (see Figure 3-11: Design Science Research Process for developing a Mobile Applications Innovation Ecosystem Framework).

3.7.1 Higher Education Perspective

3.7.1.1 *Design and Development:*

The initial design made up from components of the mobile applications innovation ecosystem framework (see Table 5-3: Higher Education Components for Mobile Application Programming), was derived from literature and guided by the unique theoretical framework presented at the end of Chapter 4. A literature review thus introduces rigor to the Design and Development phase.

3.7.1.2 *Demonstration and Evaluation:*

After the context of computing HEI students in a private university in Botswana had been established, evaluation of the higher education perspective of the MAIE framework was done ex-post naturalistically. This was done in 2015 using a questionnaire instrument which elicited 202 responses from participating HE students. Questionnaires, as descriptive surveys, were used since they are "establish what respondents believe, know, like, dislike, and think about the problem under investigation" (Tichapondwa, 2013, p. 126).

As mobile application programming is mainly a computing subject, the study population of HE students consisted of Botswana higher education students studying computing. Convenience sampling was employed, and the research instrument was given to any student, willing to participate, and attending the private Botho University in Botswana. Convenience sampling was used as the government pays tuition and maintenance allowances to students attending both private and public institutions in Botswana, regardless of their family background or geographic origin (Damane & Molutsi, 2013). Thus, students who attend public and private institutions such as Botho University, generally have access to the same resources and/or experience the same resource constraints. This allows for generalisation of all higher education students in Botswana. Generalisation beyond Botswana must, however, be considered as a limitation which could affect possible application/s of the framework.

The researcher broke the one-week data collection period down into discrete time slots and asked to complete the questionnaire. The following table indicates the discrete time units and the time slots (shaded in grey) used to administer the questionnaire.

Table 3-2: Time slots for questionnaire administration in classrooms

Monday		Tuesday		Wednesday		Thursday		Friday	
Slot	Time	Slot	Time	Slot	Time	Slot	Time	Slot	Time
1	07:00 - 09:30	1	07:00 - 09:30	1	07:00 - 09:30	1	07:00 - 09:30	1	07:00 - 09:30
2	09:30 - 12:00	2	09:30 - 12:00	2	09:30 - 12:00	2	09:30 - 12:00	2	09:30 - 12:00
3	12:00 - 14:30	3	12:00 - 14:30	3	12:00 - 14:30	3	12:00 - 14:30	3	12:00 - 14:30
4	14:30 - 17:00	4	14:30 - 17:00	4	14:30 - 17:00	4	14:30 - 17:00	4	14:30 - 17:00

The descriptive survey was conducted using an objective and standardised questionnaire containing both structured and unstructured questions. Most questions were structured as respondents prefer choosing from predetermined structured responses rather than describing a phenomenon (The World Bank, 2015). The questionnaire was administered at Botho University to students enrolled in computing courses in Gaborone, Francistown and Maun.

3.7.1.3 *Communication:*

The first paper publication from this study; “Exploring Challenges to Mobile Application Programming at a Private Higher Education Institution in Botswana”, was based on findings obtained from this initial DSR evaluation. Chapter 5 presents the complete contextualisation and feedback.

The research outcome of this higher education perspective rigor-design-relevance iteration is the MAIE for Botswana version 1, as presented in Figure 5-23: Higher Education Perspective: Mobile Applications Innovation Ecosystems Framework v1 .

3.7.2 Industry Perspective

3.7.2.1 *Design and Development:*

A literature review was conducted to identify the MAIE components from the Industry perspective to thus identify the Industry MAIEI components' design, presented in section 6.2, Chapter 6.

3.7.2.2 *Demonstration and Evaluation:*

Demonstration and evaluation sessions were conducted in 2017. Interviews with 41 mobile application developers in Botswana were evaluated and provided relevance to the Industry components of the MAIE framework. The details of this rigor-design-relevance iteration are presented in section 6.4, Chapter 6.

3.7.2.3 *Communication:*

The second paper publication from this study; “Challenges Botswana's Mobile Application Developers Encounter”, communicated demonstration and evaluation findings from the Industry perspective.

The research outcome of this Industry perspective’s rigor-design-relevance iteration is the MAIE for Botswana version 2, as presented in Figure 6-11: Industry Perspective: Mobile Applications Innovation Ecosystems Framework v2.

3.7.3 Government Perspective

3.7.3.1 *Design and Development:*

During this phase literature was used to identify components of a MAIE, from a government perspective, to formulate the Government MAIEI components design as presented in section 7.2, Chapter 7.

3.7.3.2 *Demonstration and Evaluation:*

Through conducting interviews with 20 individuals from governmental and non-governmental support organisations, the components of a MAIE from the Government perspective were evaluated. The findings and framework is presented in section 7.4, Chapter 7.

3.7.3.3 *Communication:*

Although the "State of Botswana's mobile application industry support" demonstrations and evaluation findings were not published, the relevant information is communicated in Chapter 7.

The research outcome of this Government perspective's rigor-design-relevance iteration is the MAIE for Botswana version 3, as presented in Figure 7-19: Government Perspective: Mobile Applications Innovations Ecosystems Framework.

3.8 Phase 2

Phase 2 aims to answer the Main Research Question. Using the DSR process, as suggested by Peffers et al. (2006), the frameworks of the three perspectives are combined to establish a MAIE Framework for Botswana.

The Phase 2 design presents a synthesis of the final designs created in Phase 1 to produce an intermediate MAIE framework as presented in section 8.1.1, Chapter 8.

3.8.1 ***Demonstration and Evaluation*:**

In 2018 the intermediate MAIE framework was evaluated, through questionnaires, by 25 KPs from the three perspectives in Botswana - Higher Education, Industry and Government. A final MAIE framework is presented in Chapter 8, thereby addressing the research question.

3.8.2 *Communication*:

The final framework, as result of the evaluation, is presented in Chapter 8.

The DSR approach, as previously detailed through an explanation of the DSR framework, DSR process and the DSR phases and iterations, presents the best strategy to develop the MAIE framework, thus addressing the research questions and achieving the research objectives.

The research outcome of Phase 2 addresses the main research question and presents the main research output, a final MAIE for Botswana presented in Figure 8-9 (Section 8.6)

3.9 Design Science Artefact Demonstration and Evaluation

3.9.1 Evaluation Methodology

The representation, or demonstration, of framework components is done through concept maps where *components* are presented as *concepts*. Concept maps, developed by Novak in 1972, are defined as “a graphical representation of the relationship among terms” (Vanides, Yin, Tomita, & Ruiz-primo, 2005, p. 27). Concept maps “are graphical tools for organising and representing knowledge”, (Cañas & Novak, 2009, p. 1). Cañas and Novak (2009) state that concept maps are made up of concepts, usually enclosed in circles or boxes. The relationship/s between these concepts are represented by a connecting line which links the related concepts. Concept maps aid in the understanding and organisation of information whilst facilitating efficient storage and retrieval of said information (Vanides et al., 2005).

In DSR, evaluation is concerned with the evaluation of design science outputs, including theory and artefacts, and it is this activity that injects the *science* into DSR (Venable, Pries-Heje, & Baskerville, 2012). A DSR artefact can be a product, process, technical or socio-technical artefact and these variables impact on the existing evaluation methods (Venable et al., 2012).

The adopted DSR process does not distinguish between *demonstration* and *evaluation* as the design was presented (demonstrated) to the research participants before they evaluated it. Peffers, Tuunanen, Rothenberger and Chatterjee (2007) indicate the relationship between *demonstration* and *evaluation* noting that demonstration is considered a light-weight evaluation to demonstrate that which the artefact can achieve and its purpose within a given context. Evaluation, however, is a more formal and extensive process which includes the collection of objective quantitative performance measures.

The evaluation in DSR has to be done employing informed methods within the knowledge base (Hevner et al., 2004). Such evaluation methods can be observational, analytical, experimental, testing and/or descriptive (Hevner et al., 2004). To help choose among the various evaluation methods and strategies, Pries-Heje, Baskerville and Venable (2008) and Venable et al. (2012) formulated a framework which guides the user in identifying that which needs to be evaluated as well as how and when it should be evaluated. In order to achieve internal validity, the framework is evaluated using naturalistic DSR evaluation (Pries-Heje et al., 2008). The framework is thus evaluated by real knowledgeable professionals and stakeholders within the mobile application ecosystem.

The following table outlines the integrated demonstration and evaluations in the DSR process, the participants involved as well as the section where the relevant evaluation is presented.

Table 3-3: Participants and methods of the Framework Artefacts demonstration and evaluation

Phase	Framework	Participants	Evaluation Method	Reference
Phase 1 (Design and Develop Framework)	HE Perspective	202 HE students	Likert scale, Component Evaluation via Questionnaires	Section 5.4
	Industry Perspective	41 mobile app developers	Likert scale Component Evaluation via Interviews	Section 6.4
	Government Perspective	20 stakeholders from governmental and non-governmental support organisations	Likert scale Component Evaluation via Interviews	Section 7.4
Phase 2 (Refine and validate framework)		25 knowledgeable professionals (7 from higher education, 8 from government, 9 from industry and 1 NGO KP)	Likert scale Component Evaluation via Questionnaire and IS Artefact Evaluation criteria by Prat et al. (2014)	Section 8.4

Hevner et al. (2004) suggest that the utility, quality and efficacy of a DSR artefact be rigorously demonstrated. They further suggest that the evaluated artefacts can be measured in terms of functionality, completeness, consistency, accuracy, performance, reliability, usability, fit within the organisation and other relevant quality attributes. This was, indeed, achieved in Phases 1 and 2 of the study through the use of Likert scale to evaluate each framework component. More comprehensive criteria for information systems artefact evaluation were used, after adaptation, in Chapter 8 (Phase 2), categorised into five dimensions, with criteria and sub criteria as proposed by Prat et al. (2014) as per Figure 3-12.

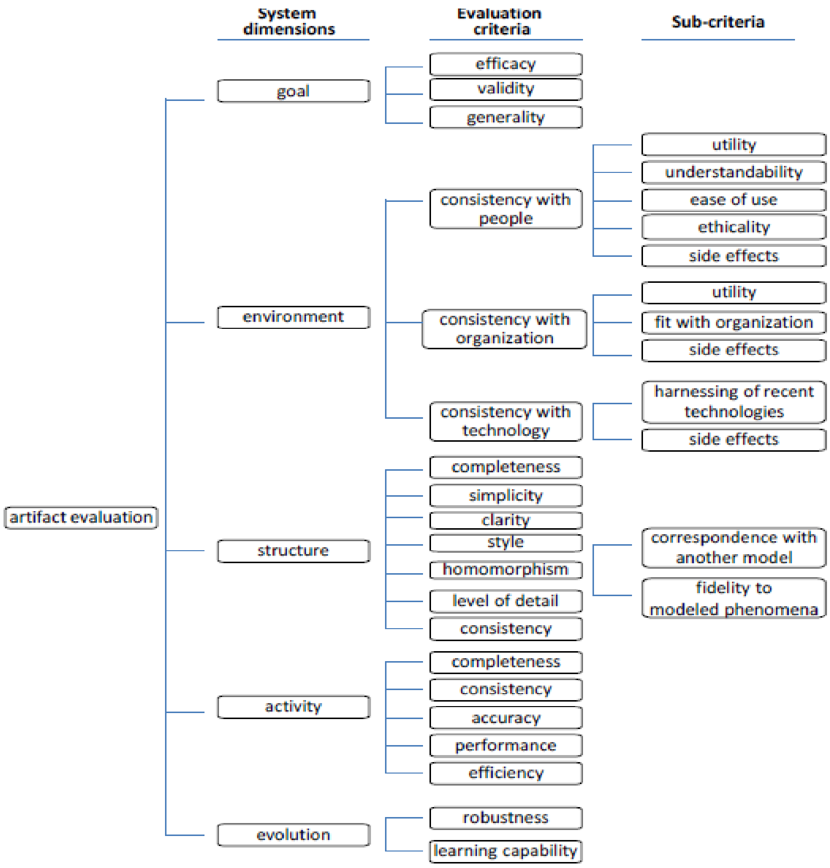

Figure 3-12: Hierarchy of information systems artefact evaluation criteria (Prat et al., 2014)

Prat et al.'s (2014) five dimensions indicate that artefact evaluation must appraise the system goal, consistency with the environment, structure, activity and the artefact's ability to evolve.

3.9.2 Evaluation Data Generation Methods

The following section presents the data generation methods used to obtain inputs to the DSR process (evaluation) as well as reflecting on the reliability of the research by investigating the ways in which participant/s and researcher errors and biases were minimised.

3.9.2.1 *Interviews*

Interviews are planned controlled conversations between people, with one person trying to gain information from the other in accordance to a specific agenda (Oates, 2012). Kothari (2011) attests that interviews involves the collection of data by presenting oral-verbal stimuli to obtain an oral-verbal response in a structured way. This can be done during a personal, face-to-face interaction or via a telephone. Interviews are suitable tools when attempting to obtain detailed information from a limited number of people and can be used, within the DSR strategy, to obtain framework evaluation data during the framework evaluation stages in Phases 1 and 2, as presented in sections 6.4 and 7.4.

3.9.2.2 *Questionnaires*

Kothari (2011) indicates that questionnaires, where a number of questions are printed in a specific order and then sent to respondents to supply answers, are the most popular data generation method when dealing with larger numbers of respondents. Oates (2012) presents a similar definition and adds that questionnaires are normally associated with a survey strategy. Kothari (2011) further argues that the low input cost and limited influence of the interviewer afford respondents time to think and formulate their answers and is thus especially suitable when dealing with educated people. The questionnaire method was used to generate data during the evaluation stage of the first phase (HE components) as well as the final phase when KPs evaluated the intermediate framework. The risk of a low rate of return was minimised as students were asked to complete the questionnaires during class and appointments were made with knowledgeable professionals. The research acknowledges Oates' (2012) comment that the information obtained from questionnaires depends on the quality of the questions. Questionnaires were used to obtained framework evaluation data during the framework evaluation stages in Phases 1 and 2, as presented in sections 5.4 and 8.4.

3.10 Research Limitations

The study identified numerous challenges faced by students during their studies which might indirectly impact on their ability to take part in mobile application development. The research focused exclusively on learning as well as economic and technological challenges faced by conveniently sampled Botho University HE students in Botswana on the basis that all students in private and public universities in the country receive the same financial support from the government. This sampling and nature of challenges explored could bring about bias and reduce the applicability of the research in other contexts. The research, however, acknowledge that social, political and other challenges may result in students exploring other avenues of study. Admittedly, this will limit the usefulness of the framework due to the selective nature of the considered challenges. Other challenges can be investigated in subsequent research studies.

The research did not engage with the users of mobile applications in the communities as this is considered the domain of the innovation stakeholders when they implement their ICT4D projects. This omission could have resulted in some components, challenge and opportunities from the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) being missed.

The developed framework provides components of a mobile applications innovation promoting environment based on the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) which does not allow for the full capture of political conditions and decisions faced by a country. These must be factored before applying the framework to other environments and can be studied in future research work.

The research was limited to Botswana's HE, Industry and Government sectors and thus limits the applicability of the framework to other countries.

3.11 Summary

The adopted DSR research methodology followed a two phased DSR process. The initial phase resulted in the development of framework designs from three perspectives (HE, Industry and Government perspective) through literature reviews (rigor and relevance cycles), framework design (design cycle) and the evaluation of the frameworks (relevance and design cycles). The HE perspective framework components were developed, from literature, and evaluated by HE students.

Communication of the MAIE from the HE perspective as presented Chapter 5 and a paper was published as per the last step of the DSR process model presented in Figure 3-10: Design Science Research Process Model (Peffers et al., 2006, p. 93). The Industry framework components were developed, from literature, and evaluated by mobile application developers. The findings were communicated via a research paper and is included in Chapter 6. The third perspective of Phase 1 focused on the government perspective and saw the development of a framework, from literature, and the framework's evaluation from government as well as other support organisations and communication of the MAIE was done in Chapter 7. The second and final cycle synthesised the frameworks originating from Phase 1's three frameworks, gained from the three perspectives, to develop an intermediate framework. This intermediate framework was evaluated by knowledgeable professionals from the three perspectives (HE, Industry and Government perspective) to thus produce the final MAIE framework for Botswana. This final framework is presented in section 8.9.

Chapter 4 Theoretical Framework

4.1 Introduction

The purpose of this chapter is to present the theoretical framework adopted in developing a Mobile Applications Innovation Ecosystem Framework for Botswana. This narrative form part of the rigour cycle of the DSR process, as outlined in section 3.5.3.

Unlike the positivist requirement that “a good theory should enable accurate prediction and control over events” (Downs & Mohr, 1979, p. 391), this study considers theory to be “a statement of relations among concepts within a set boundary and constraints” (Bacharach, 1989, p. 496) which thus helps to abstract the complexities of the natural phenomena under observation. The adopted definition is aligned to the fifth definition of theory, proposed by Abend (2008), as it focuses on enabling investigating, grasping and representing of a solution to an identified problem in the social world.

The exploration, description and refinement of a Mobile Applications Innovation Ecosystem Framework for Botswana was achieved through an original adopted theoretical framework - an amalgamation of the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) and the 4Cs Framework (Tongia et al., 2005) presented in section 4.5. The 4Cs Framework (Tongia et al., 2005) provides the ICT dimensions (Computing, Connectivity, Content and human Capacity) which should be addressed in any ICT4D project (Tongia et al., 2005) and which are explained in section 4.2.2. The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) provides a fine-grained view of innovation actors and roles, both institutional and individual, and the relationships between them (Ranga & Etzkowitz, 2013), as discussed in section 4.3.5. This chapter concludes with a representation of the adopted theoretical framework and justification for its adoption.

The amalgamated model and framework were chosen for their relevance in achieving the research objective of developing a Mobile Applications Innovation Ecosystem Framework for Botswana. The adopted theories were selected based on their ability to explain and guide the development of an innovation ecosystem from the ICT4D domain framework and the triple helix model of innovation.

4.2 The Domain Discipline: Information and Communications Technology for Development (ICT4D)

Information and Communications Technology (ICT) is considered both a means and an end to development (Mozelius, 2014). ICT is therefore required if development of a community is to occur and, yet, its existence indicates that development has taken place. This study considers the use of ICT through mobile applications as a means towards development. Information and Communications Technology for Development (ICT4D) refers to the opportunities provided by ICT as an agent of development (Heeks, 2008). ICT4D can therefore be viewed as an amalgamation of three key domains namely: Computer Science (CS), Information Systems (IS) and Development Studies (DS) (Heeks, 2008). The Computer Science domain attempts to establish what is *possible* with technology, the IS domain concerns itself with what is *feasible* with technology while the Development Studies domain seeks to determine what is *desirable* with technology to effect development. Despite Raiti's (2006) argument that, in the case of development, ICT4D is a piece of a larger puzzle, there is a growing body of evidence showcasing the role of ICT in the development of developing countries (Lwoga & Sangeda, 2018). Table 4-1 summarises the role that ICT can play in achieving Sustainable Development Goals (ITU, 2017b, p. 106).

Table 4-1: The contribution of ICT in attaining the SDGs (ITU, 2017b)

SDG Goal	**Ways in which advanced ICTs contribute to achieve SDG Goal**
Goal 1: End poverty in all its forms everywhere	ICTs help businesses to become part of the formal market economy; provision of better price information helps increase revenues and profits; mobile banking provides access to loans and microcredit; mobile payment systems reduce transaction costs; computer modelling and simulation can help develop better policies
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	Smart agriculture solutions to monitor soil and weather conditions allow increasing crop yield; better coordination of food supply chains reduce waste; better crop management can restore soil conditions and create more sustainable agriculture
Goal 3: Ensure healthy lives and promote well-being for all, at all ages	Internet of Things (IoT) allows innovative forms of low-cost health monitoring and diagnostics; ICTs can connect remote health workers with specialised diagnostic services; big data analytics allow forecasting of disease outbreaks
Goal 4: Ensure inclusive and equitable quality education and promote	ICTs allow access to online educational resources and learning communities; big data analytics help identify learning

SDG Goal	Ways in which advanced ICTs contribute to achieve SDG Goal
lifelong learning opportunities for all	challenges and create more effective instruction, allow continuing education and specialised training
Goal 5: Achieve gender equality and empower all women and girls	ICTs can provide women access to empowering information and education, and access to microcredit
Goal 6: Ensure availability and sustainable management of water and sanitation for all	Smart water management reduces losses; water quality monitoring enhances water safety; smart waste management reduces risks of contamination
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	Smart metering and smart appliances allow better energy use management; microgrids and smart grids allow for building more sustainable energy supplies while lowering the carbon footprint; green buildings reduce energy consumption
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	IoT and artificial intelligence have significant potential to increase productivity and economic growth while reducing the resource intensity and carbon footprint of production; additive manufacturing provides new opportunities for smaller scale, custom manufacturing
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation	ICT, IoT, big data and artificial intelligence contribute to smarter infrastructures; preventative maintenance and continuous monitoring increase resilience; the plasticity of advanced ICTs allows for accelerated learning, rapid prototyping and continuous innovation
Goal 10: Reduce inequality within, and among, countries	Advanced ICTs will allow further decentralised and localised production with the potential to reduce income inequality among countries; by improving education, they can contribute to reducing interpersonal inequality within countries
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	IoT applications allow for the creation of smart and energy-efficient cities; big data analytics and artificial intelligence can help in creating better urban transport systems, safer neighbourhoods and more accountable city government
Goal 12: Ensure sustainable consumption and production patterns	ICTs, in combination with IoT and big data analytics, can improve coordination between consumers and producers; additive manufacturing and just-in-time production will increase efficiency and sustainability
Goal 13: Take urgent action to combat climate change and its impacts	Big data analytics and artificial intelligence can help reduce the carbon footprint of production and consumption; information sharing and learning communities can develop and replicate better practices
Goal 14: Conserve and sustainably use the oceans, seas and marine resources so as to promote sustainable development	New sensing and monitoring technologies can help track oceanic resources; big data and artificial intelligence will facilitate better resource management practices and allow early warning systems
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably	Monitoring the use of land resources, deforestation and soil conditions can contribute to the preservation of resources

SDG Goal	Ways in which advanced ICTs contribute to achieve SDG Goal
manage forests, combat desertification, and halt and reverse land degradation, and halt biodiversity loss	
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	Big data analytics, combined with open data policies, can empower citizens; monitors and big data analytics may help to increase government transparency; direct trade relations may increase global tolerance and understanding
Goal 17: Strengthen the means of implementation and revitalise the global partnership for sustainable development	ICTs enable the formation of new communities of engaged citizens; big data analytics and artificial intelligence will allow advanced modelling of developments that can be shared rapidly and widely

The following section briefly describes the history of ICT4D.

4.2.1 ICT4D History

Heeks (2008) identified four phases in the evolution of ICT4D: ICT4D 0.0, ICT4D1.0, ICT4D 2.0 and ICT4D 3.0. The following section briefly describes these ICT4D development phases.

ICT4D 0.0: The ICT4D 0.0 era started with the installation of the first computer in a developing country (1956 in Kolkata, India) and lasted till the 1990s. Key players in ICT4D 0.0 were governments and huge multinationals who viewed IT, respectively, as a tool to handle internal administrative functions and to deliver economic growth (Heeks, 2008).

ICT4D 1.0: ICT4D 1.0 commenced with the advent of the Millennium Development Goals (MDGs) and when the internet, in the 1990s, sparked a renewed interest in ICT and the ways in which it could help developing countries (New Media Research in Uganda, 2011). Many non-governmental organisations (NGOs) and developmental organisations prioritised the application of ICT to achieve the MDGs. This process resulted in the adoption of quick, off-the-shelf solutions which could be replicated in the poor communities of developing countries. The idea of making information technology publicly accessible to people who had previously not been able to access it led to the deployment of various types of telecentres. These ranged from a box on the street containing a payphone to big rooms filled with computers facilitating internet access, fax and copy machines, telephones and libraries (Heeks, 2008). Such telecentres resulted in quick and tangible evidence of achievement in delivering information and communication services to poor communities (Sambasivan, Rangaswamy, Cutrell, & Nardi, 2009). In this era ICT4D was viewed as an emerging research area concerned with the twin challenges of addressing the Millennium Development Goals (MDGs) and designing technologies for resource-constrained environments (United Nations, 2014). The eight MDGs are presented in Figure 4-1.

Figure 4-1: United Nations Millennium Development Goals (United Nations, 2014)

ICTs played significant roles towards achieving these MDGs, as documented by Heeks (2008).

ICT4D 1.0 falls under the *pro-poor* mode of innovation whereby innovation occurs outside poor communities, but on their behalf (Heeks, 2008). The content generated within the ICT4D 1.0 era often had limited value as it was not in a digital form, not interactive and too broadly scaled, thus offering limited relevance (Mozelius, 2014). Additionally, telecentres, as non-profit entities, were not sustainable and scalability was limited (Mozelius, 2014). The failures of most ICT4D 1.0 projects resulted in several studies delving into the questions of how to ensure sustainability (increasing longevity), scalability (increasing the reach) and the objective evaluation of the ICT4D projects. Some of these challenges were addressed in ICT4D 2.0.

ICT4D 2.0: ICT4D 2.0 cannot be clearly distinguished from ICT4D 1.0, nor has consensus been reached as to a precise definition (Heeks, 2008). Coetzee (2010), however, indicated that ICT4D 2.0 occurs at a smaller scale and still adapts and/or applies ICT4D 1.0 technologies. ICT4D 2.0 argues that community members be the instigators and owners of ICT solutions (Coetzee, 2010). The depth, complexity and success of *"ICT for Society through Society"* projects depend on community members' technical prowess (ITU, 2010). Therefore, the need exists to develop technical prowess among community members to achieve "*ICT for society through society*". Young community members attending higher education institutions, if armed with appropriate skills, are ideal drivers for ICT4D 2.0 (Coetzee, 2010). This thesis, therefore, considers HE students as important role players in the mobile applications innovation ecosystem.

While acknowledging the role ICT plays in development, ITU stated that "As part of broader initiatives, ICTs can contribute to achieving each of the 17 SDGs" (ITU, 2017b, p. 94). In order for ICT to help achieve the previously mentioned and Post - 2015 Development Agenda (PTDA), now commonly referred to as the Sustainable Development Goals (SDGs), users must be able to find and access content which is meaningful to them. This process requires the provision of content which is relevant to the culture and language of the individuals (Bon & Akkermans, 2014). Locally developed mobile applications by local developers are therefore an essential prerequisite for ICT4D 2.0.

ICT4D 3.0: ICT4D 3.0 requires that the problems and developmental objectives addressed be defined and controlled by the *people and communities concerned*, not by an international persona (Bon & Akkermans, 2014). Such an ICT4D approach is thus: *inclusive* of the beneficiary of the initiative, *adaptable* to the local environment and social system agents, *discursive* in that it facilitates further action and research and finally supports self-organising action as it moves from the real world problem to the final product, all the while supporting existing endeavours (Bon & Akkermans, 2014). Van der Boor et al. (2014), in their study of global sources of innovation and diffusion in mobile banking services, revealed that 85% of the innovations in mobile banking originated within developing countries, with at least 50% of mobile financial services being initiated by users and around 45% being initiated by producers. The remaining innovations were developed jointly by users and producers. The role of users and developers, alone or in combination, leads to the creation of innovative solutions for developing countries. This research, therefore, advocates an ICT4D 3.0 approach. ICT4D 2.0 proposes that community members be *instigators* and *owners* of ICT solutions (Coetzee, 2010). This approach supports the notion of *users* as service innovators and *need* as a driver for innovation (van der Boor et al., 2014). The depth, complexity and success of the "*ICT for Society through Society*" projects depend on the community members' technical prowess (Coetzee, 2010). Computing students and established mobile application developers are candidate members of mobile application development strategies which, with the support of higher education, industry and government, could engage users.

4.2.2 The Domain Theory: 4Cs of Delivering ICT Functionality

The research is in line with ICT4D's three thrusts: (i) the sustainable development of the required infrastructure, (ii) building the required capacity of skills to develop, use and manage the technology and (iii) the provision of access to locally relevant digital content and services (Tongia et al., 2005). It has to be noted that the availability of ICT *alone* does not lead to development (Raiti, 2006). This is also noted by Tedre et al. (2011) when they indicate that addressing non-technical issues (such as teacher training, a support model, content in local languages, adaptation to local conditions, parental agreement and support, monitoring and evaluation, administrative support, and sustainability) is important after technical devices, such as laptops, had been issued. ICT can therefore enhance development and bridge the digital divide if innovation takes place in four key component areas namely *Computing, Connectivity, Content and Capacity*, or the 4Cs Framework (Tongia et al., 2005). The components for delivering ICT4D are described by the 4C Framework (Tongia et al., 2005), as illustrated in Figure 4-2.

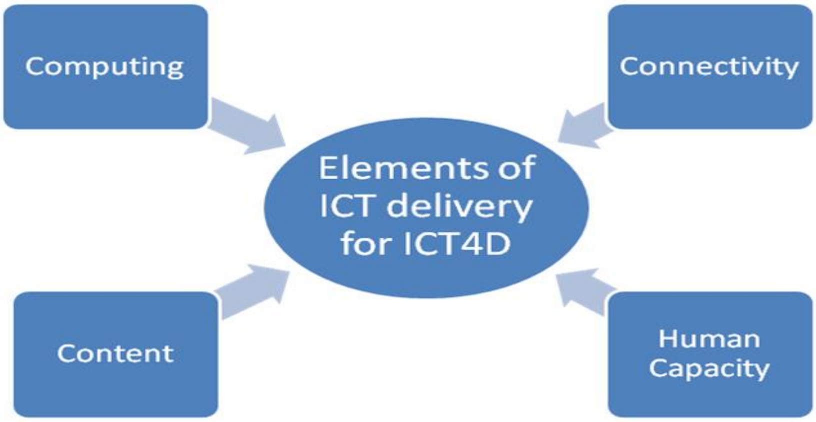

Figure 4-2: Components of delivering ICT for ICT4D. Adopted from Tongia, Subrahmanian and Arunachalam (2005; p. 29)

Figure 4-2 shows that for ICT4D to occur, communities must have access to: computing infrastructure, connectivity as well as relevant and meaningful content. In addition, communities must be aware of and literate enough to harness ICT for developmental purposes.

Computing: Computing devices are a prerequisite to promoting ICT4D (Tongia et al., 2005). Mobile devices have been widely adopted in Botswana, thus providing an existing and alternative computing infrastructure. Section 2.3.3 discussed mobile handsets in detail.

Connectivity: Connectivity allows content to be delivered to users via the mobile computing devices being used. The recent development of new mobile communication protocols, like 3G and 4G, have resulted in more bandwidth being made available to mobile users, thus making the internet more accessible (Tongia et al., 2005). With 1 444 207 subscribers, from a population of just over 2 million, having internet on their mobile phones, it can be concluded that connectivity exists in Botswana. Sections 2.3.2 and 2.4 discussed connectivity within the Botswana context.

Content: Tongia et al. (2005) comment that most content is not locally relevant and some systems result in people becoming *passive consumers* of information rather than *producers*. The relevance of content in local languages is also highlighted by Tedre et al. (2011). A discussion on development-related mobile applications in Botswana was presented in section 2.3.4.

Capacity: Users of ICT need to be aware, literate and innovative in order to harness the potential presented by ICT at a national, or community level. The execution of a successful ICT4D project requires more than just technology. Non-technical support such as teacher training, a support model, adaptation to local conditions, parental agreement and support, monitoring and evaluation, administrative support and sustainability of projects (such as one-on-one computing) are essential (Tedre et al., 2011). This study acknowledges that young community members attending higher education institutions are ideal drivers for "*ICT for society through society*", if armed with an appropriate skillset (Coetzee, 2010). Given the importance of empowering young community members, this study thus set out to achieve an understanding of the challenges and opportunities faced by higher education students, as well as mobile application industry stakeholders such as mobile application developers, whilst establishing an update as to the support availed to developers by government and non-governmental support organisations.

Each of the 4C Framework (Tongia et al., 2005) components requires innovation to enhance ICT4D. Owing to their tremendous uptake in low-income communities, mobile phones are often touted as the most promising platforms for ICT4D (Sambasivan, Rangaswamy, Cutrell, & Nardi, 2009). The relationship between the 4Cs Framework (Tongia et al., 2005) and research contribution is outlined in Figure 4-3.

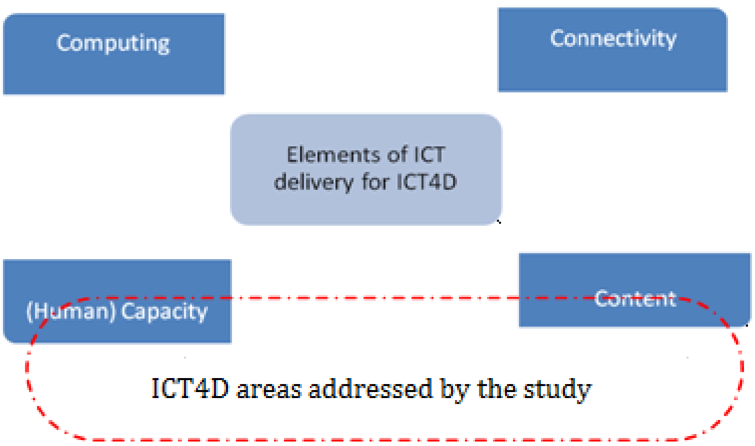

Figure 4-3: The relationship between the 4Cs Framework (Tongia et al., 2005) and Mobile Applications Innovation Ecosystem Framework

Figure 4-3 clearly shows that a mobile applications innovation ecosystem focuses on the development of an innovation ecosystem framework that will support the development (through human capacity) of locally relevant content and services to be accessed through the mobile phone as computing and connectivity medium.

4.3 Innovation Ecosystems

4.3.1 Introducing Innovation

Innovations can be new ideas, a scheme that challenges the present order, a formula, and/or a unique approach which is perceived as new by the individuals involved (Rodgers, 1983). Innovations can also be considered technical such as the development of new products, technologies and services, or new administrative procedures, policies and organisational forms (Patanakul & Pinto, 2014). Innovations can thus be considered the implementation of creative ideas in a beneficial way (Durst & Poutanen, 2013). The enhancement of Botswana's mobile applications ecosystem required a new approach to the ecosystem and therefore theories on innovation are discussed in section 4.3.4.

4.3.2 The Need for Innovation

Several factors have resulted in most emerging economies seeking ways to stimulate economic growth by advocating for knowledge-based economies. For Africa to experience a successful economic boom, and consequently join the ranks of the most successful emerging economies, the establishment of innovative ecosystems are imperative as these *are economic engines for creating new ideas and new companies* (Jackson, 2011). Several factors, including the current economic downturn and its associated high unemployment rates as well as low tax revenues, have resulted in governments seeking new ways of creating jobs. The impressive growth rates of most high-tech industries offer a strong incentive to develop and nurture innovative ecosystems which leverage higher education technology research (IBM Communications, 2013). These sentiments are also supported as innovation ecosystems. Due to their part social network and part business infrastructure they provide a much needed support web which enables the creation, and rapid growth, of new start-ups and, for established companies, they enable increased aggressive innovation, thus creating more companies and jobs (OECD, 1996).

The role of knowledge and technology in driving productivity and economic growth is reflected in the "new growth theory" (OECD, 1996). This theory calls for knowledge investments in research development, education and training and new managerial structures and knowledge distributions through both formal and non-formal networks (OECD, 1996). Botswana's Vision 2036 captures this new growth theory in "Vision Pillar 1 – Knowledge Based Society" (Vision 2036 Presidential Task Team, 2016). The increased production and focus on the use of technology, as well as the creation of knowledge intensive service sectors (such as education, communications and information research and development), are some indicators of knowledge based economies (Leydesdorff, 2010). To unravel the complex dynamics of a knowledge based economy in terms of its composing sub dynamics, the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) provides some analytical insight (Ranga & Etzkowitz, 2013). The growing movement towards knowledge-based societies requires countries to move away from dominant industry-government dyad relations to relations of an increasingly triad nature. These relations would include industry, government and the university, in this study broadened and termed Higher Education, as illustrated in the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005). Leydesdorff (2010) argues that organised knowledge production has added a third dimension in addition to economic exchange and political control. These sub-dynamics can be represented as functions of a knowledge-based economy: (i) wealth generation in the economy, (ii) novelty generation by organised science and technology, and (iii) governance of the interactions between these two sub dynamics by policy-making in the public sphere and management in the private sphere (Leydesdorff, 2010).

4.3.3 Introducing Innovation Ecosystems

4.3.3.1 *Ecosystems: An Ecological View of Innovation*

The term *ecosystem* has its origins in ecology and refers to the relationship between living things and their environment (Durst & Poutanen, 2013). Innovative ecosystems enable an understanding of the ways in which economic output can be increased, through the generation of new ways to obtain more output from the same input (innovation), through a contemplation of the various economic and non-economic role players and parts. To elucidate an innovation ecosystem, one would expect a conceptual analogy between a biological and an innovation ecosystem. A *biological ecosystem* includes all living organism (biotic factors) as well as the physical environment (abiotic factors) which function together as a unit and is characterised by one, or more, states of equilibrium to thus maintain a desirable population (Jackson, 2011). An *innovation ecosystem* is made up of more than tech companies and mobile service providers, it enables the development and upgrading of digital devices and services based on the needs of the community (ITU, 2017a). The equilibrium state is modelled by energy dynamics, such as predator-prey relationships, and due their complex nature where every part has a functional effect on the other, ecosystems have to be considered as a whole (Jackson, 2011).

Innovation ecosystem is the term used to describe the large number and diverse nature of components, such as participants and resources, which are necessary for innovation to take place (Thomas & Walburn, 2017). Such components include the material/structural resources (such as funds, equipment and facilities) as well as human resources capital (such as students, faculty, staff, industry researchers, universities, colleges, business firms, venture capitalists, economic development and business assistance organizations, funding agencies and policy makers) (Jackson, 2011). Unlike biological ecosystems, innovation ecosystems model the complex economic relationships between actors, or entities, such as material resources and human capital. These make up the institutional entities in an ecosystem which have the functional goal of enabling technological development and innovation (Jackson, 2011). Thus, two distinct economies are to be found in an innovation ecosystem: a *knowledge economy* led by fundamental research and a *commercial economy* driven by the market (Leydesdorff, 2010). Thomas and Walburn (2017) labelled these two economies *human* and *structural* capital, respectively. They also identified a third component, *relational capital*, which represents how well these two economies interact. Relational capital was cited along with human and structural capital by IBM Communications (2013). Cross (2015) suggests that the success of regional innovation ecosystems depends on their *ecological*, *economic* and *societal* attributes. Ecological attributes describe functions that span research to commercialisation within the ecosystem and how they relate to and support various components of that ecosystem. Economic attributes refer to characteristics necessary to facilitate commerce throughout the ecosystem. Societal attributes refer to the necessary relationships within the ecosystem to facilitate positive outcomes. The innovation ecosystem economies are presented in Figure 4-4.

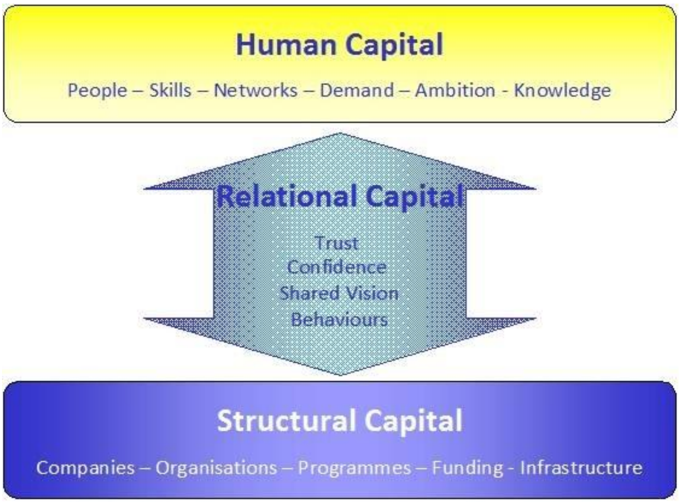

Figure 4-4: The interactions and relationships within the Innovation Ecosystem (Thomas & Walburn, 2017)

Besides the economic potential presented by innovation ecosystems, they may also help to elucidate the path forward (Martini, Tjakraatmadja, Anggoro, Pritasari, & Hutapea, 2012). It is therefore essential to understand the success factors which influence innovative ecosystems towards achieving economic potential and developing society by means of information and communications technology.

4.3.4 Innovation Theories

Innovation theories are reviewed in this section to enable the exploration, description and refinement of an innovation ecosystem framework for the development of mobile applications. The adopted theoretical framework is presented in section 4.5.

4.3.4.1 *Disruptive Innovation Theory*

The theory of Disruptive Innovation describes the process whereby a smaller entity starts off by providing a product, or service, which meets the needs of customers hitherto overlooked by incumbent companies. Later this smaller company gains a foothold in the higher market segments as it delivers more functionality (Christensen, Raynor, & McDonald, 2015). This theory is clearly explained when Christensen et al. (2015, p.32) indicated that “Specifically, as incumbents focus on improving their products and services for their most demanding (and usually most profitable) customers, they exceed the needs of some segments and ignore the needs of others. Entrants that prove disruptive begin by successfully targeting those overlooked segments, gaining a foothold by delivering more-suitable functionality—frequently at a lower price. Incumbents, chasing higher profitability in more-demanding segments, tend not to respond vigorously. Entrants then move upmarket, delivering the performance that incumbents' mainstream customers require, while preserving the advantages that drove their early success. When mainstream customers start adopting the entrants' offerings in volume, disruption has occurred".

Disruptive innovations originate in low-end, or new market footholds and these innovations do not catch up with mainstream customers until the quality of the innovation meets existing standards (Christensen et al., 2015). As disruptive innovators start with products and services generally assigned to the bottom of the pyramid, the disruptive innovation theory relates well to the 4Cs Framework (Tongia et al., 2005) for the ICT4D presented. The disruptive innovation theory has four key components: (i) incumbents in a market are improving along a trajectory of sustaining innovation, (ii) incumbents overshoot customer needs, (iii) incumbents possess the capability to respond to disruptive threats, and (iv) incumbents end up floundering as a result of the disruption (Christensen et al., 2015; King & Baatartogtokh, 2015). Agreement exists that a disruptive innovation can result in the floundering of an incumbent if it does not react timeously (Christensen et al., 2015).

The disruptive innovation theory is widely used and appeals to many leaders of small entrepreneurial companies as well as executives of large organisations which praise its guidance (King & Baatartogtokh, 2015). However, its validity and generalisability has not been tested in academic literature (Christensen et al., 2015). This concern is also shared by the original authors of the theory when they indicated that the theory's core concepts have not been widely understood, are frequently misapplied and thus wrongly used to describe any situation in which industry was shaken up, resulting in the failure of incumbents (Heylighen & Joslyn, 1992). Although this theory provides for prediction and control in the development of innovative mobile services for customers hitherto neglected by incumbent mobile applications and service providers, and even though it can guide strategies adopted by small mobile application developers to gain market entry, it does not ultimately provide guidance regarding the identification of actors and their roles in the development of an innovation ecosystem. This theory is thus not deemed suitable for use in this research study.

4.3.4.2 *Systems Theory approach to Triple Helix Mobile Applications Innovation Ecosystem*

The investigation into the components of a MAIE, as well as the challenges and opportunities faced by higher education and industry in Botswana, along with the support availed to mobile app developers in this country, intuitively led to the choice of a theory which recognises the components of, and relations between, such mobile application programming components. A systems theory approach to developing an innovation ecosystem was therefore adopted. The systems theory focuses on the arrangements of, and relations between, the parts which connect to create a whole (Heylighen & Joslyn, 1992). The *parts* are presented as the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) and the 4Cs Framework (Tongia et al., 2005) presented in Chapters 5, 6 and 7, whilst the *whole* is presented in Chapter 8. Mele, Pels and Polese (2010) summarised the features of systems as (i) interdependency of the parts of a system, (ii) the reference of any structure and process in a system to the environments of the system, (iii) equilibrium and adaptedness and continuous re-adaptations to environmental demands and others. Systems, therefore, operate within environments from which they obtain inputs which translate into processes for developing outputs, or for adaptation. The systems theory is applicable to a wide field of research and systems can be found in nature, science, society, economic contexts and in information systems (Mele, Pels, & Polese, 2010). In an effort to establish general principles applicable to all systems which, irrespective of fields, would lead to the development of the general systems theory, Mele et al. (2010) present the relations between system components as the focus area of systems theory. This constitutes a shift from the traditional scientific approach which focuses on reducing the whole and studying the components. Thus, the general systems theory focuses on interactions (Aronson, 1996).

A widely adopted approach to systems theory implementation is through *systems thinking* in which a study focuses on how the object being studied interacts with the other components of the system (Arnold & Wade, 2015). Systems thinking consists of three building blocks: (i) components and their characteristics, (ii) interconnections amongst the characteristics and how they relate and feedback to each other, and (ii) a function or purpose (Arnold & Wade, 2015). Arnold and Wade (2015) further proposed a system test to check for systems thinking fidelity, as based on these three requirements. Manzini (2012) highlighted areas in which systems thinking has proven valuable to address complex problems. These include instances where: role players are required to see the bigger picture and not just focus on their role; problems have been worsened by past attempts to fix them; actions affect, or are affected, by the environment and problems do not have obvious solutions.

The systems theory has been used to explain innovations through various innovation systems including the National Innovation System described by Jucevičius and Grumadaitė (2014) and the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005). Ranga and Etzkowitz (2013) show how the Triple Helix Model of Innovation systems (Etzkowitz et al., 2007; Leydesdorff, 2005) has been defined as a set of three, thus passing Arnold and Wade's (2015) Systems Test in relation to the following:

(i) Components: These are made up of the institutional spheres of higher education, industry and government. Each of these spheres has a wide array of role players such as computing students, mobile application development tutors, mobile application laboratories personnel, funders of mobile application development and mentors of mobile application developers, amongst others. This theme was also identified in national innovation systems as “a variety of institutions” (Manzini, 2012, p. 3)

(ii) Relationships between components: Termed “interactions” in national innovation systems (Manzini, 2012, p. 3), relations among the institutions of an innovation system take the form of technology transfer, collaboration and conflict moderation, collaborative leadership, substitution and networking. Relationships, such as mobile application development tutors developing the technical skills of computing students in mobile application laboratories while obtaining support in the form of funding, mentorship and other technical support from industry and the government, are further detailed in Chapters 5 to 7.

(iii) Functions: Bringing technological change to an economy, or facilitating technological learning, occurs as a result of the interaction among innovation institutions (Manzini, 2012). Generation, diffusion and utilisation of knowledge and innovations, which can lead to the creation of innovative mobile applications for societal benefit, is a function of the innovation system. The functions within a mobile applications innovation ecosystem are discussed in Chapters 5 to 7.

Jucevičius and Grumadaitė (2014) noted that academia was gradually shifting focus from innovation systems to innovation ecosystems and attributed this to innovation systems' inability to cater for complex social dynamics. They thus advocated that innovation systems be treated as complex systems with diverse role players giving rise to multiple and unpredictable interactions. These interactions hold the potential for disequilibrium when compared to complicated systems with diverse actors and predictable interactions and equilibrium state. This viewpoint is not shared by Stichweh (2010) who clearly shows, in one of his system features, that complexity is a trigger mechanism for system-formation.

Collins, Brown and Holum (1991) show how the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) systems accommodate both institutional and individual roles in innovation whilst providing a fine-grained view of innovation role players and the relationships between them within a dynamic, boundary-spanning and diachronic transition of knowledge flow systems. The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) is thus adopted for this study.

4.3.5 The Triple Helix Model of Innovation

The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) provides a fine-grained view of innovation actors and roles, both institutional and individual, as well as the relationships between them (Ranga & Etzkowitz, 2013) as shown in Figure 4-5.

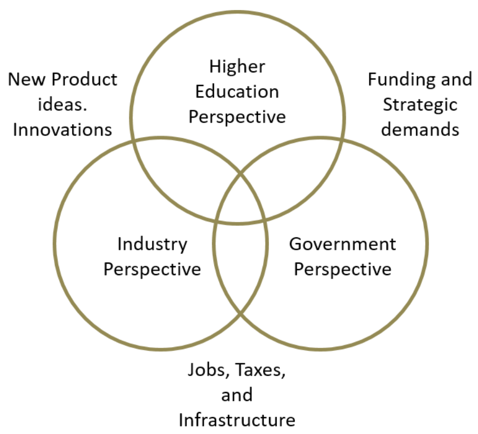

Figure 4-5: The perspectives adapted from the Triple Helix Model (Kimatu, 2016)

The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) introduces three dimensions of social systems: *Geography dimension* which represents the government responsible for the area; *Knowledge dimension* which represents the academia who create and share new knowledge within the area; and *Economy dimension* which represent the business entities that generate economic activities in the area (Ranga & Etzkowitz, 2013). A quadruple helix model has been formulated by adding the *Civic Society dimension* in order to capture the voice of the innovation user (Kimatu, 2016). This study, however, uses the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) and considers the role of civic societies addressed by the ICT4D 3.0 approach, as discussed in section 4.2.2. Innovation used to be limited to a single institutional sphere. In this way product development was limited to industry, policy making to government and new knowledge creation and dissemination to academia (Etzkowitz, 2002). This internal transformation within each sphere constitutes the first dimension of the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) with the second dimension being the influence which each helix exerts on another (Leydesdorff & Etzkowitz, 1998). These influences have led to a steady diffusion of the roles of each of the above three spheres. The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) elaborates on the interaction of these three spheres and has resulted in each sphere, to differing degrees, assuming the role of the other. Thus academia, for example, develops new products and helps in policy development while the government assumes industry roles such as starting and supporting business. An understanding of contemporary innovation processes thus requires an understanding of the overlap between these three relatively independent institutional spheres (IBM Communications, 2013). The evolution of strategic interactions between these three spheres leads to the creation of new institutions (multi-sphere) and new relationships between the three spheres. The function/s of each sphere is thus altered to promote the generation, diffusion and utilisation of knowledge and innovation. Although the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) is considered mature, thus drawing government, higher education and industry closer, the governments, higher education institutions and industries of third world countries operate in silos, thus not fostering innovation (Kimatu, 2016).

4.4 Innovation Ecosystems in Africa

To successfully initiate an economic boom in Africa, which will result in the continent joining ranks with successful emerging economies, the establishment of innovative ecosystems are paramount for they constitute the economic engines which create new ideas and companies (IBM Communications, 2013). Factors, such as the current economic downturn and its associated high unemployment rate as well as low tax revenues have resulted in governments seeking ways of creating new jobs. The significant growth rate of high tech industries offer a strong incentive to develop and nurture innovative ecosystems which leverage the technology research of universities (Jackson, 2011). Innovation ecosystems, due to the fact that they are part social network and part business infrastructure, enable the creation and rapid growth of new start-ups whilst established companies are motivated to innovate more aggressively, thus creating more companies and jobs (IBM Communications, 2013). A country's collective efforts toward developing technological innovations is termed the National System of Innovation (NSI) and includes several components which need synergetic relationships towards building robust innovation-driven economies (Manzini, 2012).

Mobile applications are shaping the economic, political and social lives of people in Africa (Murugesan, 2013). Kenya's emerging digital entrepreneurship ecosystem, which saw the development of several mobile enabled services, is an inspiring African case study for entrepreneurs and innovating businesses in the developing world towards changing their business landscape/s and the lives of the underserved (Drouillard, Taverner, Willianson, & Harris, 2014). Drouillard et al. (2014) indicate that despite Nairobi's potential to become a major digital entrepreneurship hub, financial, commercial and technical challenges deter most digital start-ups from realising their full potential. These deterrents are also applicable to other African digital entrepreneurship hubs, Botswana included.

Attempts in Africa to develop innovation ecosystems is evident in Kenya, where Nairobi's iHub is run by the local start-up community and offers start-up meetings and contests, interactions with venture capitalists, business incubation space, a supercomputer provided by Google and Intel and a coffee bar where people can meet informally (IBM Communications, 2013). Botswana's Innovation Hub (BIH), which became fully operational in 2016, offers technology entrepreneurship development, business support services, strategic partnership collaborations, intellectual property advisory services and innovation capacity building services within the BIH Science and Technology Park located on a 57-hectare site (http://www.bih.co.bw/bih-profile/). Nigeria has CCHub (https://cchubnigeria.com/), Hivecolab (http://hivecolab.org/) in Uganda, BongoHive (https://bongohive.co.zm/) in Zambia and mLab (https://www.mlab.co.za/), amongst several others, in South Africa.

4.4.1 Innovation Ecosystems - Success Factors and the Developing World

A healthy innovation ecosystem depends on a handful of factors which are regarded as necessary ingredients. These factors include: a community of entrepreneurs, government support, good universities, availability of capital and a culture that is conducive to innovation and entrepreneurship (Durst & Poutanen, 2013). Attempts to replicate the success of the Silicon Valley's 1970 innovation powerhouse have been met with varying degrees of success. There have been some successful implementations of such innovations in areas such as Bangalore in India, Israel's coastal plain, Daejon in Korea and Beijin's Zhong Guan Cun. A few factors have been identified as necessary in the building of a healthy innovation ecosystem (IBM Communications, 2013). Durst and Poutanen (2013) identified the following innovation ecosystem success factors:

Resources: Resources play an important role in the success of an innovation ecosystem. The availability of funding, from both private and public entities, as well as the allocation and management of resources impact directly on the success of an innovation ecosystem.

Governance: Essential to innovation success is the necessity for governance structures to continuously invest in infrastructure, maintain architectural control and implement rigorous decision making. These are all facilitated by data, systematic risk assessment, clear role assignments, democracy, own organisational structure and the use of the internet to facilitate interaction amongst partners as well as flexible systems which allow for integration and expansion.

Strategy and Leadership: Leadership must be patient, guided by a clarity of purpose and attention to detail whilst maintaining a *distant* and *distanced* view on innovation.

Organisational Culture: A successful innovation ecosystem needs to nurture an innovation culture and should be open to failure and chaos.

Human Resource Management: The ability to innovate should form an integral part of job descriptions.

People: An innovation ecosystem requires the involvement of post-doctoral researchers to obtain access to worldwide Research and Development (R & D) communities.

Technology: Science and technology play an essential role in innovation ecosystems as they enable the linking of basic and applied research while facilitating strategy development and decision-making taking into consideration the feedback from key stakeholders and thus resulting in socially accountable policies and practices (Carayannis & Campbell, 2012).

Partners and Clusters: Partnerships amongst various and diverse agents, role players and organisations are essential to the success of innovation ecosystems. Clusters, or innovation communities, are groups of partners with a collective innovation agenda.

The concept of innovation systems focuses on forging connections between the entities which make up an innovation system. It is an ex post concept which originated in the developed world - such a concept is considered an ex ante concept in developing countries. Therefore, the need exists to investigate approaches which will help inform science, technology and innovation programmes in individual developing countries (Manzini, 2012).

4.4.2 Innovation Ecosystems – Challenges

No single success recipe for innovation ecosystems has been formulated. Each region and/or country needs to create its own innovation recipe in the face of challenges. Some of these challenges faced by innovation ecosystems include:

Skills: Despite the growth in the number of colleges and universities in sub-Sahara Africa, shortages in research funding, outdated programmes, overcrowding and skilling for jobs and not entrepreneurship all negatively affect ecosystems' chances of success (IBM Communications, 2013).

Capital: Although private equity investment increased from 3% of all emerging market funding in 2007 to 6% in 2010, most of these investments were in mature companies and little was invested in seed or first-round investments (IBM Communications, 2013). IBM Communications (2013) recommended that wealthy Africans contribute small amounts in seed and start-ups.

Culture: The culture of entrepreneurship in Africa is lacking. Most families prefer to enrol their children to school to obtain secure jobs. Whilst failure in Silicon Valley is considered a learning experience, the failure of a business in Africa is considered shameful. To change this cultural stigma more entrepreneurs, need to build successful companies. Sharing these success stories will encourage more individuals to take risks (IBM Communications, 2013).

4.4.3 The Mobile Applications Ecosystem

The mobile applications ecosystem provides an overview of the components of a mobile applications innovation ecosystem, thus ensuring that mobile applications reach users by linking programmers to consumers. The World Bank (2012) defines a mobile applications ecosystem as a subsystem of a wider ICT ecosystem, which specifically includes users, developers, content and platform providers of mobile applications. The users and developers of the mobile applications are linked by the mobile application distribution channel, payment systems, operating systems/platforms and the mobile phone hardware as illustrated in Figure 4-6.

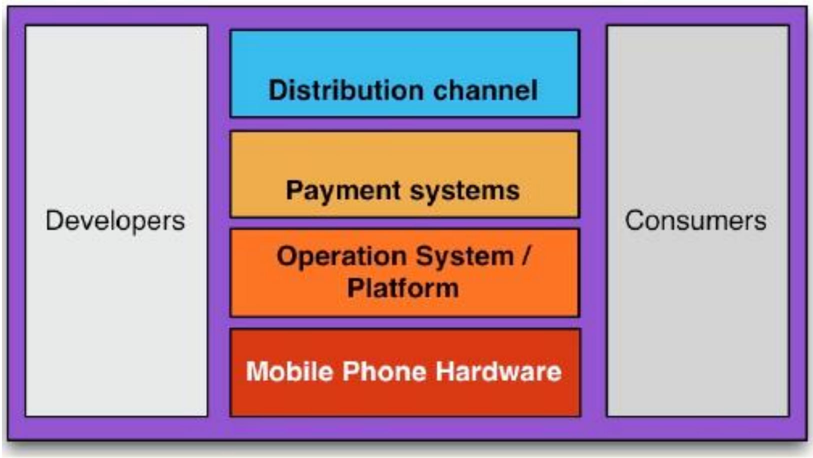

Figure 4-6: The Mobile applications ecosystem (The World Bank, 2013, p. 18)

Developing applications relevant to users requires that mobile programmers understand mobile applications ecosystem and can thus target the correct mobile hardware, operating system, payment system and application distribution channel/s within their environment.

Different configurations of the mobile applications ecosystem have been implemented by different players including Google, Blackberry and Apple as depicted in Figure 4-7.

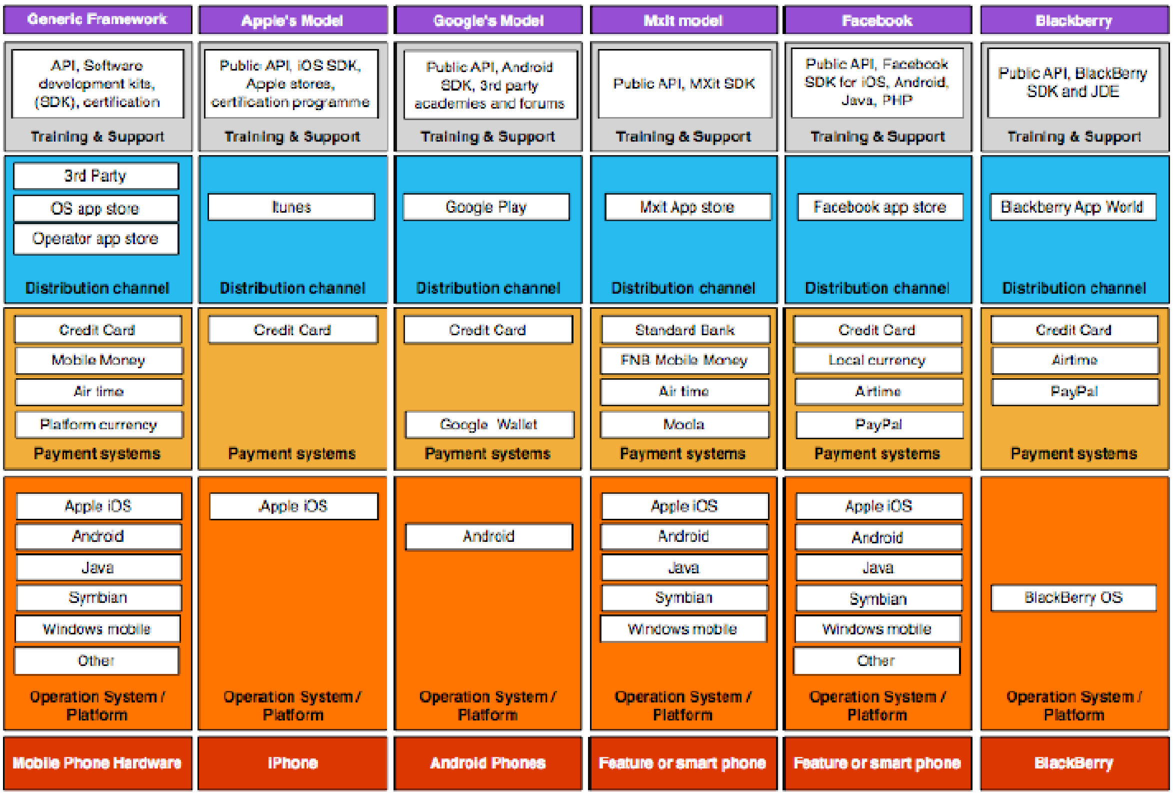

Figure 4-7: Different configurations of Mobile Applications Ecosystem (The World Bank, 2013, p. 19)

Different mobile applications ecosystem configurations determine possibilities and/or limitations when adopting a specific configuration, thus affecting the relevance of the developed mobile application. This, however, illustrates that developers need to possess certain mobile hardware, operating systems, payment systems, distribution channels and training and support structures. These can be provided through any one of the helix spheres to deliver their content to users and are considered relevant role players within the mobile applications innovation ecosystem being developed.

4.5 Theoretical Framework Summary

The theoretical framework, synthesised from literature (Figure 4-8: Adopted Research Theoretical Framework), was thus an amalgamation of ICT's 4Cs Framework (Tongia et al., 2005) to enhance computing, connectivity, content and the capacity for people to develop and use information technology together with the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) which describes the role players and roles required for innovation to take place. This theoretical framework is summarised in Figure 4-8 and shows how the role players based on the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) was investigated from the 4Cs framework of ICT4D, within the context of Botswana.

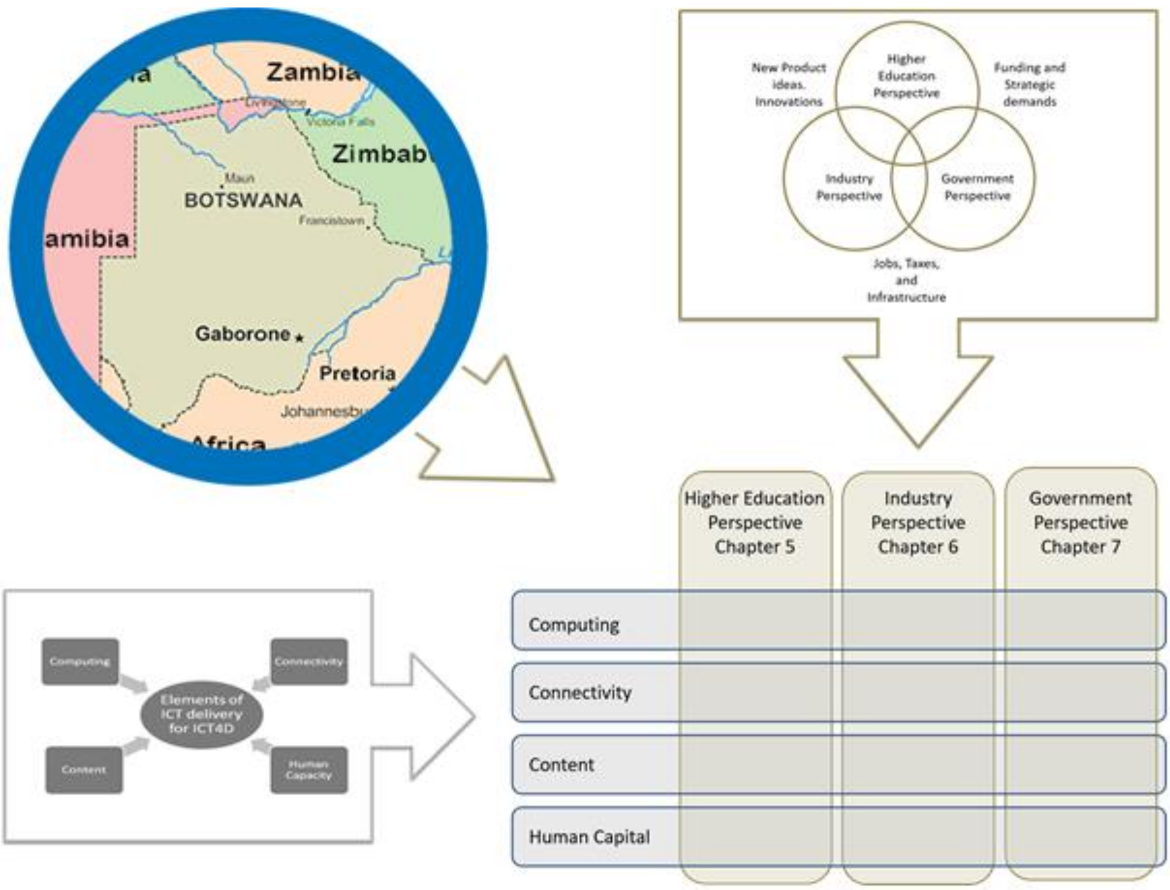

Figure 4-8: Adopted Research Theoretical Framework

Chapter 5 The Higher Education Perspective of a Mobile Applications Innovation Ecosystem

5.1 Introduction

The previous chapter discussed the research methodology, outlining the steps followed to ensure that this study achieves its research objectives. This chapter investigates literature to provide DSR rigor and the initial phase of the DSR to produce the initial framework version which addresses the Higher Education helix components of a mobile applications innovation ecosystem. This chapter addresses the research question:

RQ_1. What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Higher Education perspective?

This chapter provides the first of three iterations to rigor, design, relevance and evaluation of Phase 1 by focusing on higher education. The developed framework will, together with the designs from industry (Chapter 6) and government (Chapter 7) perspectives, inform Phase 2 of the DSR cycle as presented in Chapter 8. Figure 5-1 presents Chapter 5 relative to the adopted DSR.

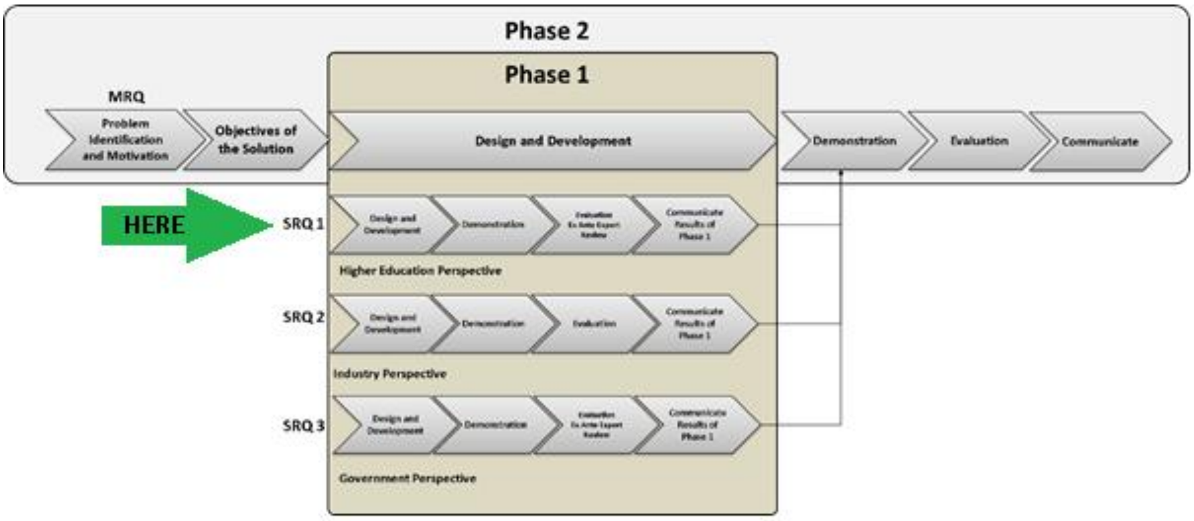

Figure 5-1: Phase 1 – Higher Education: Chapter 5 relative to DSR Strategy

This chapter, as illustrated in Figure 5-1, presents the components of mobile applications innovation ecosystem within the higher education dimension of the Triple

Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) towards designing the first version of a Mobile Applications Innovation Ecosystem Framework for Botswana. The chapter then presents findings from the *evaluate* cycle in which HE students evaluated the framework, resulting in the higher education framework.

This chapter commences with a discussion of the components which facilitate mobile application programming in higher education (the academic perspective) based on a review of the literature. The rigor requirements of DSR are thus met. These components consequently aid in the design of an initial framework which is then evaluated for relevance by HE computing students. The resultant framework, termed version 1, is presented in section 5.3.

5.2 Rigor and Design: Higher Education Components of a Mobile Applications Innovation Ecosystem

The role of academia, in a Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005), is traditionally to teach students, research and generate new knowledge and facilitate community engagement to apply knowledge to said society. This section addresses the role of academia in a mobile applications innovation ecosystem, from an academic point of view. Research notes that the role of academia has expanded to informing regulatory policies (traditionally done by government) and providing entrepreneurship and production opportunities (traditional done by industry) (Ranga & Etzkowitz, 2013). An academic institution in the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) is an entrepreneurial higher education institution as it has evolved beyond traditional roles, stepping into the shoes of government and industry by informing public policies and offering production opportunities to students and other stakeholders. These will be presented in the final framework (Etzkowitz et al., 2007).

The interaction between the academic domain and industry has resulted in higher education realising the need for mobile application programming, as evidenced by Computer Science departments realising the importance of offering mobile application development courses (Gordon, 2013). Higher education has realised that mobile application programming is important for students and are now faced with the challenge of how to best teach students to programme mobile applications (Hu & Guo, 2012). Such challenges include pedagogical gaps in programming team formats and interdisciplinary classes containing varied skill levels (Powell & Wimmer, 2016). Mobile application development is a much-discussed topic with great appeal to computing students. Such popularity can be used to attract, retain and motivate students (Jackson et al., 2012). Anderson and Gestwicki (2011) argue that the proliferation of mobile devices is undeniable and with so many tools being available, undergraduates can explore mobile development as part of their curriculum. A number of higher education institutions in the UK are already offering mobile application development courses (Alston, 2012). An educated student's community, and other mobile applications innovation ecosystem players, are better poised to drive the ICT knowledge *within* his/her community and thus address the major causes of poor internet usage in rural areas namely: lack of digital literacy, lack of understanding regarding the benefits of the internet and fear of the risks associated with using the internet (West, 2015).

Hu and Guo (2012) note that the importance of mobile applications to students provides a good foundation for motivating said students to learn mobile application programming. Mobile devices are very popular and universities, and other stakeholders, are taking steps to increase mobile application development activities. Attracting and keeping students interested in learning mobile application development can be achieved if students learn mobile application programming collaboratively using familiar technologies such as social networks.

Mobile application programming in higher education is therefore a popular research topic and this section presents the components of a Mobile Applications Innovation Ecosystem in higher education.

5.2.1 Human Capacity

Human capacity within ICT's 4Cs Framework (Tongia et al., 2005) refers to the need for users to be empowered so that they become aware, literate and innovative and so embrace and harness the power of ICT (Tongia et al., 2005). The following sub sections therefore discuss the components that can *empower* role players within the HEI, students and instructors within the MAIE.

5.2.1.1 *Mobile Application Programming Instructors*

Mobile computing has a steep learning curve (Campbell & Tafliovich, 2015). If one wishes to help students, the sourcing of suitable teaching assistants and tutors is paramount. There is a very real need to invest in the training of mobile application programming tutors since there is a scarcity of qualified tutors for MAP (Campbell & Tafliovich, 2015).

To facilitate effective teaching of mobile application programming, instructors must be empowered with relevant instructor resources (Mahmoud, 2011). Khmelevsky and Voytenko (2013) recommend that instructors be supported with readily available free and/or commercial resources.

5.2.1.2 *Students Characteristics and Learning Models*

Programming is a difficult topic for many students and is a key research area in computing education (Sheard, Simon, Hamilton, & Lönnberg, 2009). Due to the depth of research available regarding the general computer programming domain, the literature consulted in this research study mainly focused on the components of learning programming in general and, with afforded insight into the differences between computer programming and mobile programming as well as the adaption and focus on the components of learning mobile programming.

5.2.1.2.1 Ability/Aptitude/Understanding

Ability, aptitude and understanding are three characteristics demonstrated by a successful programming student, and thus a good programmer. Some research has attempted to highlight the significance of ability/aptitude/understanding in student success by administering a pre-task, or test, before students are allowed to enrol in a programming course. These pre-tests were then compared to the students' results in a post-test, later in the course (Sheard et al., 2009). The possession of certain abilities such as spatial visualisation, communication, logic, scientific orientation, proficiency at typing and sorting were investigated to discover whether they did, in fact, affect students' ability to learn programming. Below is a summary of the components that fall in this category, according to Sheard et al. (2009).

Science and Maths grades: Students with higher grades in Science and Maths as well as the student's own perception of his/her abilities are good predictors to his/her ability to succeed at programming.

***Spatial visualisation skill**:* The ability of a student to use deep learning strategies, spatial visualisation, map drawing and richness of articulation all affect his/her ability to succeed at programming.

***Meta cognitive and resource management strategies**:* These help students perform better when learning programming.

Time: It often takes two courses in programming for a student to become proficient at it, most students learn to program only at the end of the second course.

Relationship between code generation and code comprehension: Students with good code comprehension skills have better code generation abilities.

5.2.1.2.2 Teaching /learning models and theories

The teaching/learning model, or theory, looks at the theoretical frameworks which were proposed, or used and tested, to assess students' understanding of programming and their learning behaviour.

***Mental models**:* Mental models and liminal spaces are useful when investigating the learning processes.

Programming as a way of thinking: Students must understand that programming is a way of thinking which enables problem solving.

***Debugging strategies**:* Novice programmers behave unproductively when debugging. There are ways of helping these students.

***Learning experiences**:* The student's experience of learning to programme is related to the perception of programme correctness.

Student support can be offered in the form of a personal coach for code reviews, project feedback and pacing support. Mahmoud and Popowicz (2010) propose that students be introduced to programming from a mobile perspective in order to create programmers qualified to navigate the mobile landscape.

5.2.1.3 *Cognitive Apprenticeship Learning: Extreme Apprenticeship*

Traditional higher education teaching affords limited attention to reasoning and strategies, as used by experts when solving complex or real life problems (Ertmer &

Newby, 2013). Making expert thinking visible whilst working is the focus of cognitive apprenticeship.

When selecting the ideal learning theory towards creating a framework for developing innovative mobile application among higher education students, one needs to determine the most effective theory for fostering the mastery of specific tasks by specific learners (Campbell & Tafliovich, 2015). Research indicates that mobile computing is difficult and that it has a steep learning curve (Hu & Guo, 2012). Higher education has realised that mobile application programming is important for students and are now faced with the challenge of how best to teach students the programming of the mobile applications (Sheard et al., 2009). These ideas are confirmed by Vihavainen, Paksula and Luukkainen (2011) who indicated that programming is a difficult skill for many students and, as such, a key research area in computing education. Programming is considered a *craft* and thus requires much practice (Collins, Brown & Holum, 1992). Teaching students programming, which is a fairly complex task, calls for the cognitive apprenticeship model (A. Collins et al., 1991).

5.2.1.3.1 Introducing Apprenticeship

Apprenticeship involves the learning of a tangible and physical activity (Collins, Brown & Holum, 1992). Mobile application programming is a physical activity which results in the creation of an artefact which, though not tangible, can be interacted with. Teaching and learning in ancient times involved *showing* pupils how something is done and then helping them to do it. Classical examples of this being: teaching children to speak, grow crops, craft cabinets and tailor clothes. All these craft were taught through used apprenticeship as the vehicle for transmitting knowledge from the expert to the pupil (Vihavainen et al., 2011). Traditional apprenticeship is used to teach physical skills while cognitive apprenticeship focuses on the acquisition of cognitive skills (Collins, Brown & Holum, 1992). Although apprenticeship refers to the student as the apprentice and the teacher as the master, these terms may be used interchangeably.

Apprenticeship has four important aspects (Vihavainen et al., 2011):

Modelling*:* Learning happens with the student observing the teacher while he/she makes the process visible and shows the student what to do. Such observations will provide students with a conceptual model of the target task. In mobile application programming, this can be achieved by the teacher working on a task, from start to finish, thinking out loud all the time and explaining the decisions which have been made in the process (Vihavainen et al., 2011).

Scaffolding: Scaffolding occurs when the teacher supports the student in carrying out a task by affording him/her the chance to carry out none, all or some of the task. This process can be made more efficient by aligning it to Vygotsky's zone of proximal development. Students can benefit from mobile application programming exercises to which experienced teachers do not give straight answers but provide hints which help students discover the answers for themselves (Vihavainen et al., 2011).

Fading: Fading involves a gradual reduction in support offered to students to thus encourage them to accept an increasing amount of responsibility for the work.

Coaching: This is the overseeing of the student learning process by the teacher. It is achieved though activities such as: selecting tasks for students, providing hints and scaffolding, evaluating activities, helping with problems, offering feedback and structuring the way in which activities are to be done.

5.2.1.4 *Entrepreneurial Higher Education*

Although no agreed definition in literature exists as to the term *entrepreneurial university*, the concept is considered an appropriate response by higher education institutions to succeed, through self-development and innovation, in highly turbulent and unpredictable markets (Sperrer, Müller, & Soos, 2016). The term is used to describe universities, or higher education institutions, that operate in a highly competitive arena where they fight for student numbers, research opportunities and financing. This process thus requires a shift from traditional management, financing, internal structures and external relations to activities which devote more attention to the development of relationships with external stakeholders (Peterka & Salihovic, 2012). Two major role players have been identified in entrepreneurial higher education: (i) the academic entrepreneurs engaged in formal commercialisation activities which often result in patent creation, license sales and/or the creation of new ventures and spin out firms and (ii) the entrepreneurial academics who mainly focus on participating in activities that connect the higher education domain with other organisations, particularly in industry (Sperrer et al., 2016). Although developed primarily for use in the European higher education domain, the HEInnovate framework identified seven factors that entrepreneurial higher education institutions need to focus on to strengthen their entrepreneurial agenda (Nwaogu, 2012). These are as follow:

1. Leadership and governance: Entrepreneurship must form a major part of the higher education institution's strategy and commitment to implementing it must be fostered.

2. Organisational capacity, people, and incentives: A financial strategy and means of attracting and retaining the right people and incentivising entrepreneurial behaviour in individuals should exist.

3. Entrepreneurship development in teaching and learning: Teaching and learning must stimulate and support the development of entrepreneurial mindsets and skills amongst both staff and students. The entrepreneurial approach to teaching in all departments and the validation of entrepreneurship learning outcomes must be nurtured.

4. Pathways for entrepreneurs: Higher education has to support the paths taken by would-be entrepreneurs (staff and students), from ideas to market growth or into employment.

5. University–business/external relationships for knowledge exchange: Building and sustaining relationships with key partners and collaborators (including the public sector, regions, businesses, alumni and professional bodies) should be fostered.

6. The entrepreneurial university as an internationalised institution: Internationalisation must form a key part of the university's entrepreneurial strategy. There should be evidence of explicit support for the international mobility of staff and students, whilst seeking, and attracting, international and entrepreneurial staff, departments and faculties which actively participate in international networks.

7. Measuring the impact of the entrepreneurial university: Mechanisms should exist to measure the entrepreneurial impact of the higher education institution. Developing the capacity of communities to utilise mobile applications can be one such activity which can be measured.

5.2.2 Computing

5.2.2.1 *Mobile Application Programming Lab Infrastructure and Tools*

To provide a different, and better, learning experience, students should be granted access to labs and tools which will facilitate a hands-on approach to developing mobile applications.

In addition to learning the various platforms, students should be provided with physical devices as well as simulation and emulation environments (Mahmoud, 2011a). Students became very excited when provided with modern and advanced Android and iPad tablets to be used in a mobile programming course (Khmelevsky & Voytenko, 2013).

Teaching mobile programming at an introductory level requires setting up a working environment. This process can be challenging, given the diverse requirements for different development environments (Mahmoud, 2011). Mahmoud (2011a) therefore recommends setting up virtual machines with all the required software packages which students may access.

Software Tools: Software assists in the learning and teaching of programming skills among students. A number of resources have been created to assist in the teaching of mobile application development, however, successful teaching tools are the ones that require less effort to implement and which teachers feel they have control over (Sheard et al., 2009). Although obsolete, Mahmoud (2011) discusses instructor resources developed by the Centre for Mobile Education Research (CMER). The CMER academic kit is free of charge and contains 30 weeks of teaching material including slides, lab exercises, tutorials, quizzes and assignments on Java Mobile Edition, BlackBerry application development, and web based mobile apps. Such resources can be useful in getting started in teaching mobile application development.

Mobile application development *tools* have also been developed to assist in mobile application development. One such mobile development environment is TouchDevelop which allows users to create Widows mobile phone applications from their mobile phones. Nguyen, Rumee, Csallner and Tillmann (2012), in their experiment with TouchDevelop, revealed that the users could only create small applications and that student programmers with Java skills were more productive with TouchDevelop than when developing Android apps on personal computers.

Cabana is a browser based programme for developing mobile applications which offers the ability to develop cross platform web based apps. Dickson (2012) deemed Cabana successful as students found it easy to develop and work with. Some bugs were encountered as it was tested in the beta stage. Dickson (2012) further mentions that Cabana is suitable for mobile applications focusing on interface design and using prototyping as it allows for rapid prototyping and is easily mastered by beginner programmers.

App Inventor is an open source Android based development environment which enables students to create functional apps in a matter of minutes by making use of its block programming and visual interface. Wagner, Gray, Corley and Wolber (2013) used App Inventor to teach high school pupils Android app development. Wagner et al. (2013) report that App Inventor is the very satisfying teaching and that it motivates students to solve more difficult logic problems at the conclusion of the course.

The existence of several tools and resources make mobile application development learning, as well as curriculum development and delivery easier for the learner, curriculum developer and teacher. These tools can be used to shorten the curriculum developmental time and increase the level of engagement among students.

5.2.3 Connectivity within Higher Education Institutions

Connectivity allows users access to content within ICT’s 4Cs Framework through the use of computing devices (Tongia et al., 2005). The following section elucidates how connectivity components can facilitate MAP within higher education institutions.

5.2.3.1.1 Collaborative and Pair Programming

Students often have to do programming on their own which results in the process becoming boring and frustrating. This increases the learning time and degrades the learning process (Malandrino, Manno, Palmieri, & Scarano, 2012). Attracting and retaining students in a mobile application programming course can be achieved by ensuring that students remain engaged during the learning process. Studies have shown that collaborative learning is more effective than individualistic learning in stimulating motivation, raising achievement and nurturing positive social outcomes (Chen & Bryer, 2012; Faja, 2014). Collaborative programming motivates and engages students and produces better programming skills (Malandrino et al., 2012). Booch and Brown (2003) argue that collaboration is essential to every engineering domain.

Roschelle (1992) considers collaboration to be a process of convergence in which individuals ultimately share similar meanings for conversations, concepts and experiences. Thus, diverse ideas, understanding, meanings and/or representations of information exist which, upon collaboration, converge. Roschelle (1992) further argues that conversational interactions provide students with the ability to gradually refine meanings and thus construct increasingly sophisticated approximations of scientific concepts. Collaborative learning therefore involves two, or more, people with different knowledge, learning from each other. Students will normally have asymmetrical skills and collaborative learning can help transfer certain skills to student/s who lack them. The development of mobile apps requires several skill sets, including graphic designing and programming. These skills are not equally evident among students.

Collaboration presents a few challenges which have to be addressed during the learning and programming stages of mobile application development. Mccown and Gibson (2013), in their experiment, realised that after combining computer science and graphic design classes during an Android development course, collaboration resulted in computer science students being better satisfied than their graphic designer counterparts. The same experiment afforded insight into some of the challenges which emanate from such collaborative set ups: (i) communication amongst teams was not very effective; (ii) project ownership by the computing students de-motivated the graphic designers; (iii) the computing students did not show that they valued others' work and this resulted in the graphic designers feeling marginalised; (iv) mismatched deadlines resulted in sudden demands from other team members; (v) programmer limitations were evident as some students experienced more technical difficulties than others; and (vi) the Android platform was used but some students would have preferred to use iPhone's iOS. It is crucial that students collaborate when learning mobile application development as this ensures better learning results and more engagement. However, the need exists to manage the collaboration and so prevent dissatisfaction by some participants as to the collaborative programming tasks.

To address these challenges, a number of collaborative tools exist which could be adopted to facilitate collaboration among students. Bani-Salameh, Jeffery and Al-Gharaibeh (2010) argue that software development is a team effort which exacts intense knowledge and social interactions. These social interactions, during which they share ideas, artefacts, solutions and communications, are a daily occurrence for software. An ideal development environment would therefore be an Integrated Development Environment (IDE) with social processes supporting discussion, sharing of ideas, negotiating and brainstorming to improve the overall productivity of the team.

5.2.3.1.2 Online Collaboration

Key to attracting and keeping students interested in mobile application programming is online collaborative programming. This has proved to motivate and engage students, resulting in better programming skills (Malandrino et al., 2012). Software programming students have been shown to produce better results and to be more efficient if they collaborate through online tools, compared to face-to-face collaboration (Malandrino et al., 2012). Shaw (2011) reports that by adding collaborative programming activities to the ChatBot project, students were more engaged as they could relate the programming tasks to the growing cyber culture. Rosiene and Rosiene (2010), in their survey, showed that students enjoy watching other students in the spotlight (teacher’s station while typing code) and most students like the idea of a fellow student acting as a model. Collaboration is not limited to students, but applicable to the corporate world. Vannoy and Medlin (2012) state that employees establish unplanned social network configurations which facilitate collaborations and communications during product development stages. Butcher (2003) argues that collaborative learning among students, and between schools, is one of the important benefits of ICT. ICT thus provides distance learning students with better ways of collaborating. Collaboration among developers of software and products in general is a common phenomenon which makes the development process enjoyable and engaging.

5.2.3.1.3 Online Collaborative Programming Tools

Booch and Brown (2003, p. 2) define Collaborative Development Environments (CDEs) as “a virtual space wherein all stakeholders of a project – even if distributed by time or distance – may negotiate, brainstorm, discuss, share knowledge, and generally labour together to carry out some task, most often to create an executable deliverable and its supporting artefacts". Collaboration during software development can therefore be facilitated by the adoption of CDEs.

CDE adoption, though creating a frictionless developmental environment, presents some challenges. Bani-Salameh et al. (2010) identify major challenges during the implementation of a CDE: (i) distributed teams normally lose track of other members' activities; (ii) observation of other members is difficult; (iii) limited bandwidth means communication is limited to low bandwidth channels like emails; and (iv) version control and user access management within the CDE is challenging. To solve some of these challenges, CDEs with extended functionality to support community support and presence information, termed Social Collaborative Integrated Development Environments (SCIs), can be adopted. Such development environments require text chats, voice chats, an online presence facility, normally a 3D avatar, and activity awareness which enables participants to be aware of plans, statuses and code others are working on. The Economist (2012) terms a CDE implemented as a virtual environment a Collaborative Virtual Environment (CVE).

5.2.3.1.4 Social networking as a collaborative tool in mobile app programming

Online collaboration, though mainly at a social networking level, is a phenomenon familiar to students. Zanamwe, Rupere and Kufandirimbwa (2013) discovered that in neighbouring Zimbabwe, 96.8% of tertiary education students have social networking accounts. Zanamwe et al. (2013) further elaborated that students use social networking accounts for general education activities (21%) in addition to specific school work (17%). Drljevic and Boticki (2012) also note the widespread use of social networks by students. Shaw (2011) demonstrates that most students enrolled in tertiary institutions in the USA have social network accounts by the time they start software programming and that they are very comfortable using social networking sites. It can therefore be argued that social networks, which already have a large following, are a potential tool for making learning and programming more engaging, pleasant and interesting.

Chang, Liu, Chou, Chen and Shin (2007, p. 151) define social networks as "personal or professional sets of relationships between individuals". People are social beings, and thus social networks have long existed in the physical world. The advent of technology, however, has resulted in deeper and wider relationships, enabling communities to share ideas and interests. Yu, Liang, Xu, Yang and Guo (2011) differentiated between web based social networks and mobile social networks, by elaborating that mobile social networks have continuous seamless sensing enabling the device to obtain contexts from the physical world. Mobile social networks thus outperform web based social networks in supporting real world social interactions. Maleko, Hamilton and D'Souza (2012) state that mobile devices have greatly facilitated interaction amongst students and has helped improve engagement with subject material. Students use social networks for discussions, chats, brainstorming and accessing learning content. This pervasive adoption of social networking by tertiary students can be used in the facilitation of collaborative programming during mobile application programming skills development. Social networks can, therefore, be used during learning and mobile application development as a collaborative technology.

5.2.3.1.5 Social networking challenges in HEI

Social networking is a very popular amongst students and collaborative programming would be a very effective way of motivating and engaging them. However, the use of social networking for academic purposes faces various challenges. Oskouei (2010) observes a growing concern that, despite academic institutions investing heavily in computing and internet infrastructure in the hope of improving the learning experience via web resources, students use the infrastructure for non-academic purposes, especially social networking. Oskouei and Chaudhary (2010), after their analysis of 3 000 website frequented by female students, concluded that 63% of the time students use the internet for non-academic purposes, 17% constituting social networking. There is an agreement that students are prolific users of social networks (Drljevic & Boticki, 2012; Shaw, 2011; Swarts, 2009; Zanamwe et al., 2013).

The importance of collaboration during the learning and development of mobile application development and capacitating communities cannot be understated. Students need to collaborate with others, and freely available online tools can be used to facilitate collaboration over distributed space and time.

5.2.4 The Content, Learning and Teaching Approach

The content to be learnt and the way in which the content is learnt plays a role in how students utilise the learnt skills to develop useful mobile applications.

5.2.4.1 ***Curriculum***

Curriculum encompasses several facets including: the content to be learnt by students, the accompanying learning experiences, the expected learning outcomes and a plan of instruction (Lunenburg, 2011). Mahmoud (2011b) proposes that mobile application programming can be started as early as the first introductory programming lesson, but at any later stage as well. An early start is also recommended by Khmelevsky and Voytenko (2013) who suggest offering at least one general mobile programming course, no later than second year. Alston (2012), however, suggests that a mobile web application programming course be offered in the final year in order to afford students time to acquire the pre-requisite knowledge.

The nature of the curriculum, as regards the content covered, has a bearing on the learning of programming. Although teaching mobile application programming for a particular platform is no longer a viable solution, and therefore the need exists to support different mobile platforms and devices (Khmelevsky & Voytenko, 2013), this study will focus on the Android platform due to its available tools. Sung and Samuel (2014) argue for mobile application programming learning to focus on the fundamental principles and clearly present technologies and vendor hardware as vehicles for knowledge delivery. The notion also applies to the programming language used in learning, termed *programming language irrelevance* since the language used in teaching programming appears not to affect the student's ability to design programmes (Sheard et al., 2009).

To challenge students and help them prepare for the future, students must be familiarised with existing application programming interfaces and exposed to all aspects of mobile application programming, including graphical user interface, sensors and backend online services (Sung & Samuel, 2014).

Hu and Guo (2012) propose a curriculum architecture, depicted in Figure 5-2, to help students learn mobile application development. Hu and Guo (2012) further state that the curriculum proved beneficial to mobile application developing students.

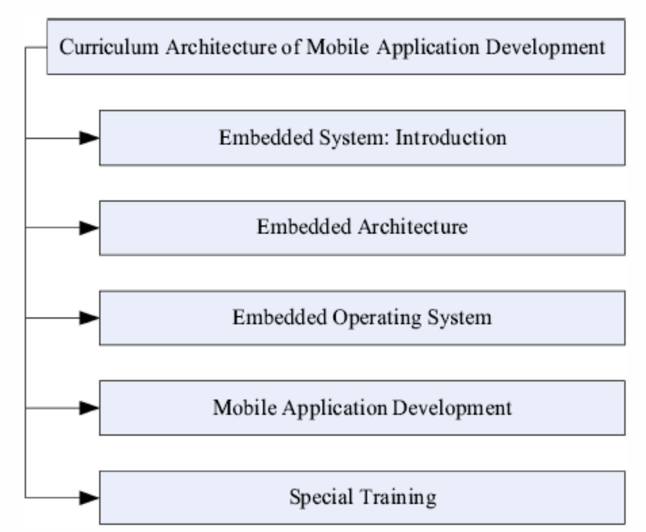

Figure 5-2: Hu and Guo Curriculum Architecture (Hu & Guo, 2012, p. 44)

Alston (2012) attests that the following curriculum, presented in Figure5-3, proved to be successful and was well received by students. The 12-week curriculum, offered as an elective to final year students, covered web app development skills as follows:

- Overview and Challenges of Mobile Computing
- HTML5 Features (Storage, Connectivity, Offline, etc.)
- CSS3 (Styling, Transitions, Transforms & Animations)
- Strategies for Web Design
  - Graceful Degradation [8]
  - Progressive Enhancement [9]
  - Hardboiled Design [10]
  - Responsive Design [11]
  - Mobile First [12]
- JavaScript Libraries and Frameworks
  - jQuery, jQuery Mobile, Sencha Touch, PhoneGap, Appcelerator Titanium, ExtJS, Mobilize.js, etc.
- Cross Platform Deployment and Marketing

Figure 5-3: Alston's Curriculum Architecture for Web Application Development (Alston, 2012, p. 240)

There is common agreement as to which topics ought to be covered as well as their sequencing in the field of computing. A first course in Android application development, in general, covers the topics detailed in Table 5-1.

Table 5-1: Essential topics of an Android Application Development course (Liu, 2014, p. 2)

Content Category	**Topics**
Android Development Tools	Android SDK (Eclipse with the Android Developer Tools plugin); or Android Studio Android SDK features Android Development Framework Android Software Stack
Android Development Framework	Android Software Stack; The Dalvik Virtual Machine
Key Android Application Concepts	GUIs; views; layouts; Activity; fragments and their life cycles; intents; events; threads
Other android Concepts	Files; SQLite database; multimedia; sensors and gestures; Google maps

The research adopts the approach of developing a curriculum based on the common topics that are covered in a mobile application programming course as given above.

5.2.4.2 ***The Learning Experiences***

5.2.4.2.1 Educational Technologies:

The technologies used by teachers has an effect on learning. The use of animations on mobile phones and presentation systems can improve students' learning. Dickson (2012) identifies some decisions that have to be made when building mobile development courses. These decisions include: Should the course be standalone or integrated? What mobile platform should be used to teach students? and What tools should be employed during teaching? Chen and Bryer (2012) note that the choice of mobile platform for teaching depends on the hardware available on campus.

5.2.4.2.2 Cognitive Apprenticeship Variation: Extreme Apprenticeship - A Success in Teaching Programming

This variation of cognitive apprenticeship and Extreme Programming, proposed by Vihavainen et al. (2011), strongly emphases guided programming exercises, especially during the scaffolding stage of apprenticeship. The value of extreme apprenticeship, as per Table 5-2, has resulted in a reported increase in the pass rate of a programming class from 58.5% to 70.1% (Vihavainen et al., 2011).

Table 5-2: Extreme Apprenticeship Values and their Practice (Adopted from Vihavainen et al., 2011)

<table>
<tr><th>Extreme Apprenticeship Value</th><th>Practice used in Class</th></tr>
<tr><td>Learning by doing. The craft will only be mastered by practicing it.</td><td rowspan="4">Avoiding the communication of too much information: Lecturing should cover only the bare minimum so that students can commence with exercises.

Relevant examples: Topics covered in the lectures have to be relevant to the exercises.

Start early: Exercises start right after the first lecture of the course.

Help Available: Exercises are completed in a lab in the presence of instructors who offer scaffolding style guidance.

Small goals: Exercises are split into small parts with clearly set intermediate goals. These small intermediate steps guarantee that students feel that they are learning and making progress all the time.

Exercises are mandatory: Since the exercises are the main instrument of learning, the majority of exercises are mandatory for all the students.

Train the routine: There should be many exercises, relatively repetitive in the nature.

Clear guidelines: Exercises have to provide a clear starting point and structure regarding the way in which to solve the task.

Encourage to look for information: While doing the exercises, students are also required to discover things which were not covered during the lectures.</td></tr>
<tr><td>Continuous Feedback. Continuous feedback must be implemented in both directions. The student receives multi-level feedback from his progress and instructors, and the instructor receives feedback by monitoring the students' progress and challenges.</td></tr>
<tr><td>No compromise. The skills to be learned are practiced for as long as it takes for each individual to master them.</td></tr>
<tr><td>An apprentice becomes a master. The ultimate goal of instruction should be that the student will eventually become the master.</td></tr>
</table>

Code Katas, ranging from 15 to 40, are small programming exercises which help programmers improve their skills through practice and repetition. These can be administered to students in extreme programming (Vihavainen et al., 2011).

5.2.4.2.3 Sequencing

A mobile application development course can be offered over 12 weeks (1 semester, with 1 hour of theory and 2 hours of practical lab sessions) (Alston, 2012). This period can be divided into sequential learning stages.

Stage 1: The *initial*, or orientation phase will introduce students to the history of mobile devices, the history of mobile application programming, the development environments and the contrasts between development environments (Yan, Becker, Hecker & Joseph, 2011). Based on their successful iPhone development teaching experience, Sung and Samuel (2014) recommend covering the unique syntax features, the software development kit, the core frameworks, development tools and design patterns in order to help students to quickly grasp essentials. Students can also present three of their favourite mobile applications in three minutes (Sung & Samuel, 2014).

Stage 2: This *hands-on* phase focuses on helping students understand GUI driven programming and how to work with small screens, sensors and web services (Sung & Samuel, 2014). The concepts included in this stage are: user interface design and usability, device corporation, hardware issues, data handling, application interaction and programming issues (Gordon, 2013). While ensuring a hands-on approach to learning, research has shown that students preferred writing gaming programmes to stories or traditional tasks. Students also preferred *specific* tasks rather than *open ended* ones (Sheard et al., 2009).

Although advocated for iPhone development, Yan et al. (2011) suggest that students need a background understanding as to the underlying programming language to enable a focus on new features. Students should explore the software development kit (SDK) and its tools. Development frameworks and their relationships should be familiar to them (Yan et al., 2011).

Collaboration in twos, or threes, can be used in this phase for assignments where students build systems that work with sensors and multiple web services (Sung & Samuel, 2014). A course which facilitates collaborative, and group work, helps in the development of useful and interesting apps (Sung & Samuel, 2014).

Stage 3: During this *research* phase students need to remain up to date with the rapid changes. The course should include self-discovery of knowledge in the mobile application domain (Sung & Samuel, 2014). In one module, students were asked to produce a four page academic paper on mobile application development (Alston, 2012). Sung and Samuel (2014) suggest that students would benefit from researching their favourite mobile related topic and then presenting their findings.

Stage 4: According to Sung and Samuel (2014), this *project and evaluation* phase, which commences around mid-way of the learning period, should afford students the opportunity to: propose their final projects, present their user interface and implement prototypes. A worthwhile, yet challenging part would be to work with local organisations and businesses on real applications (Yan et al., 2011). Projects are selected by students and the class then peer evaluates each group's final project providing written and numeric evaluations (Sung & Samuel, 2014).

5.3 A summary of the Academic Components

This section presents Components of a Mobile Applications Innovation Ecosystem from an academic point of view. It explains that academia needs to ensure the availability of instructors and labs and provide a curriculum and learning experience that will lead to improved mobile application programming skills among higher education students, through collaborative programming, whilst considering the student characteristics. The role of academia in enhancing mobile application programming therefore no longer involves academic institutions developing mobile application skills among students but going further by partnering or venturing into product development, thus influencing government policies. Table 5-3 summarises the mobile applications innovation ecosystem elements derived from literature, from a higher education perspective. The same elements are presented in Figure 5-4 as a concept map diagram.

Table 5-3: Higher Education Components for Mobile Application Programming

Higher Education Components for Mobile Application Programming	***Author***
Offering mobile application development courses	*(Gordon, 2013), (Alston, 2012)*

Higher Education Components for Mobile Application Programming	***Author***
Qualified teaching assistants and tutors	*(Campbell & Tafliovich, 2015)*
Invest in the training of tutors	*(Campbell & Tafliovich, 2015)*
Instructors must be empowered with instructor resources (commercial and free)	*(Mahmoud, 2011), (Khmelevsky & Voytenko, 2013)*
Students' Science and Maths Grades	*(Sheard et al., 2009)*
Students' Spatial Visualisation Skil,	*(Sheard et al., 2009)*
Students' Meta Cognitive and Resource Management Strategies	*(Sheard et al., 2009)*
Students' Minimum Programming Learning Time (starting early after developing prerequisite knowledge)	*(Sheard et al., 2009), (Khmelevsky & Voytenko, 2013), (Alston, 2012)*
Students' relationship between Code Generation and Code Comprehension	*(Sheard et al., 2009)*
Learning using Mental Models	*(Sheard et al., 2009)*
Learning that Programming is a way of thinking	*(Sheard et al., 2009)*
Learning Debugging Strategies	*(Sheard et al., 2009)*
Perception of programme correctness	*(Sheard et al., 2009)*
Introduce programming from a mobile perspective	*(Mahmoud & Popowicz, 2010)*
Provide students with physical mobile devices	*(Mahmoud, 2011a), (Khmelevsky & Voytenko, 2013)*
Access to simulation and emulation environments	*(Mahmoud, 2011a)*
Setting up virtual machines with all the required packages	*(Mahmoud, 2011a)*
Availability of Teaching resources	*(Sheard et al., 2009), (Mahmoud, 2011), (Nguyen, Rumee, Csallner & Tillmann (2012), (Wagner et al., 2013), (Dickson, 2012), (Chen & Bryer, 2012)*
Teaching resources implementation effort	*(Sheard et al., 2009)*

Higher Education Components for Mobile Application Programming	***Author***
Teachers' control over teaching resources	*(Sheard et al., 2009), (Dickson, 2012)*
Curriculum starting programming early	*(Mahmoud, 2011b), (Khmelevsky & Voytenko, 2013)*
Curriculum that supports different mobile platforms and devices	*(Khmelevsky & Voytenko, 2013), (Dickson, 2012)*
Curriculum that focuses on the fundamental principles	*(Sung & Samuel, 2014), (Sheard et al., 2009)*
Curriculum that challenges students	*(Sung & Samuel, 2014)*
Curriculum sequencing	*(Alston, 2012), (Liu, 2014, p. 2), (Hu & Guo, 2012), (Sung & Samuel, 2014), (Yan et al., 2011)*
Learning through extreme apprenticeship	(Vihavainen et al., 2011)
Collaborative and Pair Programming	*(Malandrino et al., 2012), (Chen & Bryer, 2012), (Mccown & Gibson, 2013), (Shaw, 2011),* (Faja, 2014)
Using Collaborative Development Environments	*(Booch & Brown, 2003), (Bani-Salameh et al., 2010)*
Using Social networking as a collaborative tool	*(Zanamwe et al., 2013), (Drljevic & Boticki, 2012), (Shaw, 2011)*
Entrepreneurial Higher Education through engaging in formal commercialisation activities and participating in activities that connect higher education with industry	(*Nwaogu, 2012)*

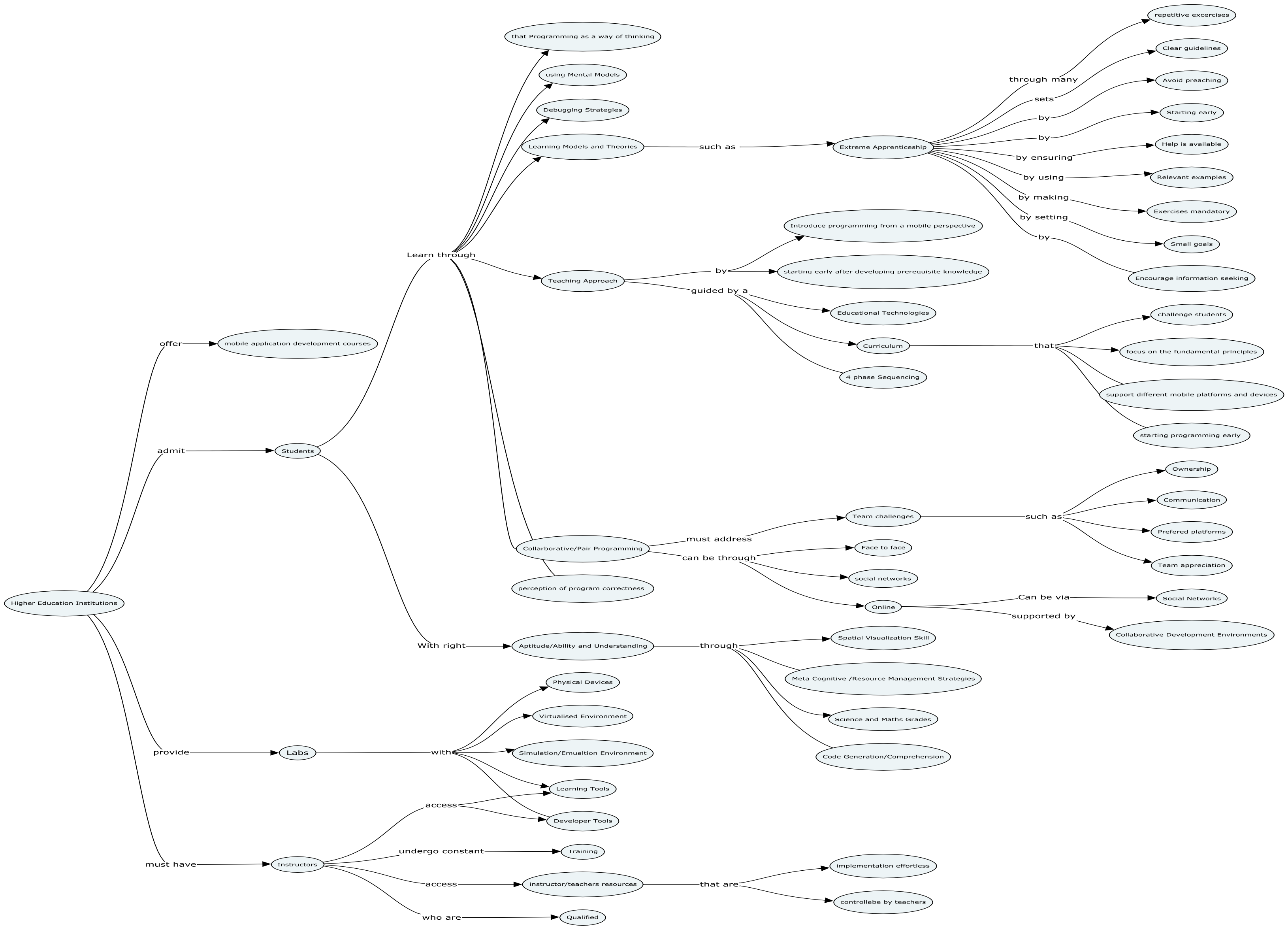

Figure 5-4: Higher Education Mobile Application Programming Components Concept Map

5.4 Relevance and Evaluation: Challenges and Learning Needs to Mobile Application Programming at Higher Education Institutions in Botswana

To address the evaluation and relevance cycles of the DSR, this section investigates specific environmental aspects which need to be incorporated into the framework to make it relevant to Botswana.

This section elucidates the challenges faced by Botswana's HEI computing students in mobile application programming as well as their learning needs. As described in Chapter 3, a case study survey was conducted amongst students from the three campuses of Botho University students in Botswana: Maun (17 students), Francistown (2 students) and the main campus in Gaborone (184 students).

An objective and standardised questionnaire, made up of structured and unstructured questions, was used as the research instrument to identify the challenges faced by higher education students in mobile application programming. Most questions were structured to obtain focused input. The questionnaire had five sections, A to E. *Section A* sought demographic details; *Section B* solicited the mobile application programming interests of the respondent and his/her learning preferences; *Section C* assessed ownership and access to computing and connectivity ICT4D components and the usage patterns of these components; *Section D* solicited the resource constraints faced by students in learning mobile application programming in terms of resources and personal challenges faced that might affect learning and, in conclusion; *Section E* sought to establish whether IT students had innovative ideas for government, corporations and/or society and their perceptions regarding ease of implementation and/or sharing of such ideas.

The following section presents findings garnered from the relevance cycle and explain how these findings were adapted to the designed framework.

5.4.1 Demographics of Botswana's Higher Education Institution Computing Students

5.4.1.1 *Biometric profile*

Most of the participants (144) were in the 21 to 25 year age group as shown in Table 5-4. Sixteen students were below 20 years of age and 8 were above 30 years of age. This indicated that the majority of respondents were quite young. The table also indicates that ratio of male to female students, studying IT at the private higher education institution, is well balanced.

Table 5-4: Respondents' demographics details

Count		Age				
		20 and Below	21-25	26-30	Above 30	**Total**
Gender	Male	8	79	17	5	**109**
	Female	8	65	18	3	**94**
Total		**16**	**144**	**35**	**8**	**203**

The study group was made up of students studying towards an Information Technology related qualification (99.5%), ranging from a diploma to a bachelor's degree. As shown in Figure 5-5, respondents included: 3 students in their first year, 83 in their second year, 53 in their third year and 64 in their fourth and final year.

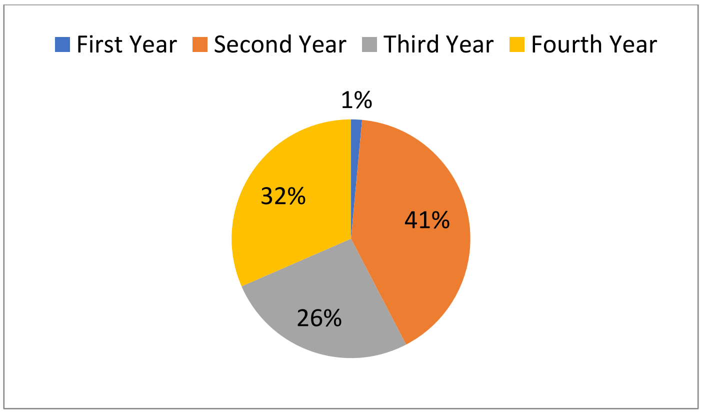

Figure 5-5: Respondents' Level of Study

The underrepresentation of first year students reflects the bias brought about by convenience sampling. Ninety-six % of respondents were studying towards an IT qualification. The majority of the students (96%) were government sponsored, indicating that the government of Botswana is the largest contributor to higher education fees, as shown Figure 5-6: Sponsor of respondents.

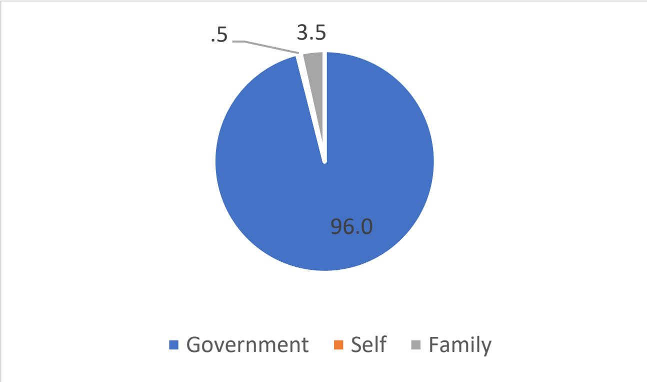

Figure 5-6: Sponsor of respondents

5.4.1.2 *Mobile Application Learning Preferences of Botswana's IT students*

Although 72.6% (146 of the 203) of students know that their institution offers mobile application programming, only 11.3% had developed a mobile application before, confirming limited MAP among students. Notably, 98.5% of students expressed interest in learning MAP, with 92.6% of students considering learning mobile application programming essential. The motivation for learning MAP was not to increase job prospects, but rather to start developing their own apps. This was confirmed when students indicated that they would apply the mobile application programming skills they learnt with only 28% wanting to merely possess the skill whilst 72% of the students indicated that they would put their skills to immediate use.

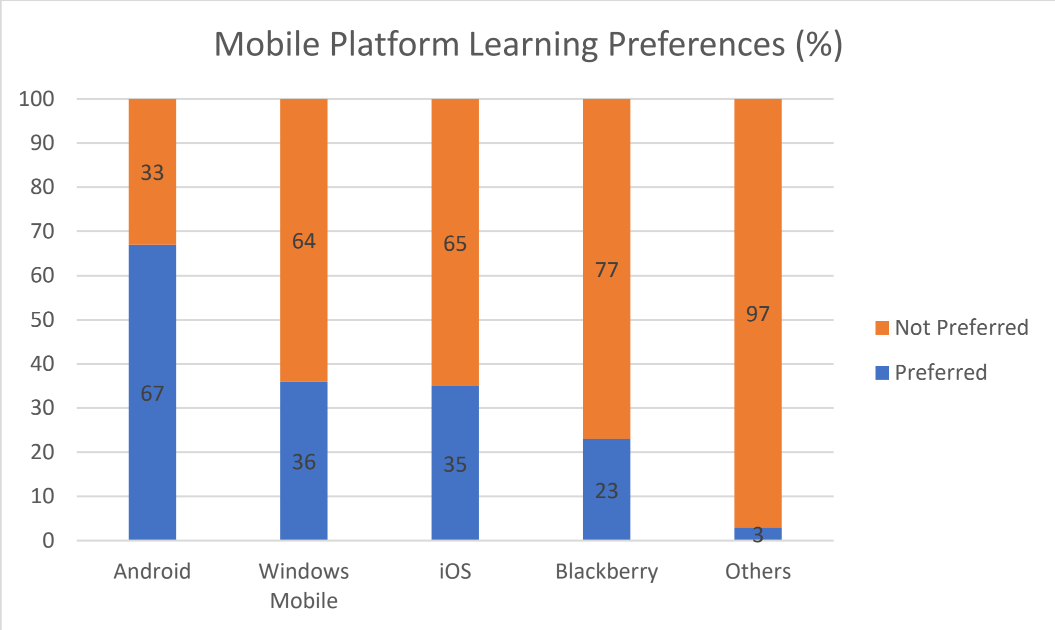

Figure 5-7: Mobile Platform Learning Preferences of students

The learning preferences expressed by students, and shown in Figure 5-7, indicated that 67% were interested in learning Android mobile programming compared to 35% who preferred iOS programming.

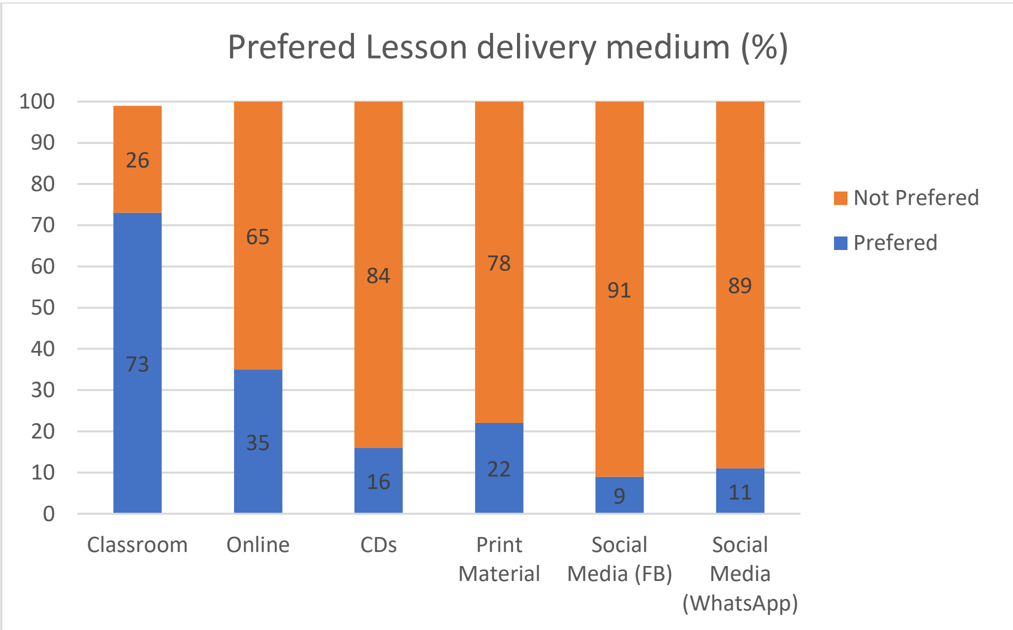

Figure 5-8: Preferred lesson delivery method for MAP

Students preferred a maximum of 4 hours of mobile application programming learning in a week, for a duration of about 4 months. The classroom learning preferences, as shown in Figure 5-8, spanned all other delivery models, with social media learning being the least preferred. The practical nature of mobile application programming requiring practice and access to support when a student became stuck were indicated as crucial factors with 98% of students wanting support when they become stuck.

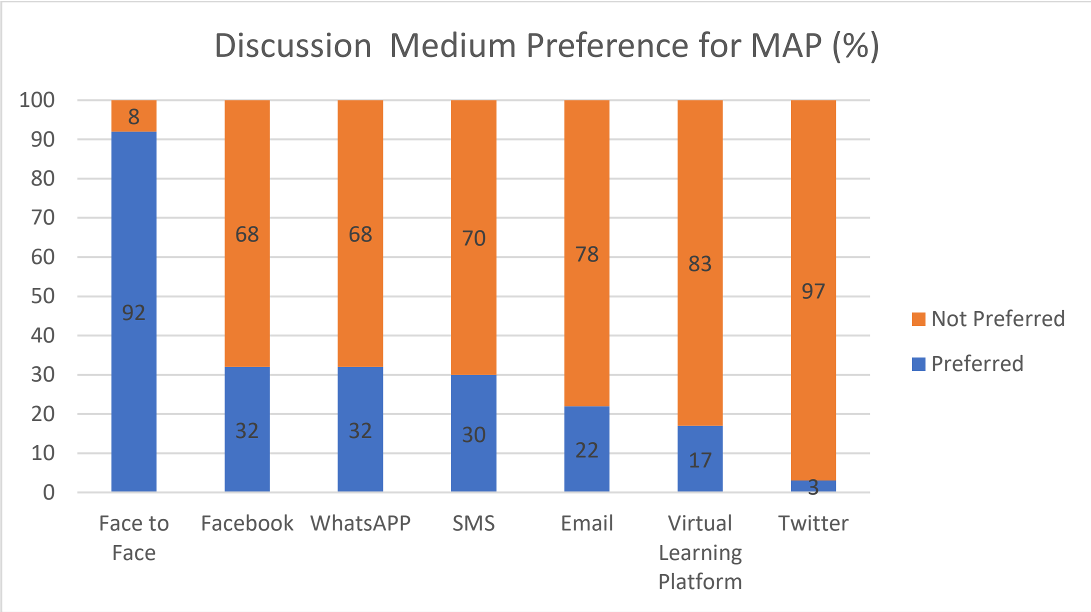

Figure 5-9: Discussion Medium Preferences for MAP

Discussions of mobile application programming study material amongst students and tutors, as part of the MAP learning, is considered critical with only 7% preferring *not* to engage while 93% of students indicated that they preferred to have these discussions with tutors and/or colleagues. The mode of discussion preferred by students was face-to-face, as indicated in Figure 5-9.

5.4.1.3 *Student Phone Features and usage*

Botswana's HEI computing students' phone type and usage of devices were assessed to gain insight into how best to make the framework relevant.

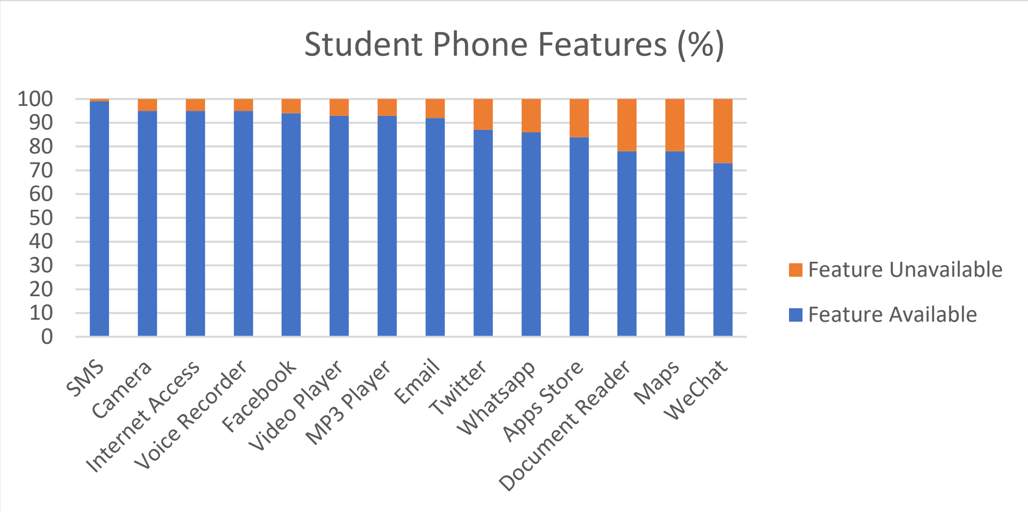

Figure 5-10: HEI Students' Phone Features

It can be observed from Figure 5-10, that computing students at higher education institutions do possess smart phones that can support most apps from their platform app store.

5.4.1.4 *Internet Usage Patterns by Computing Students*

An exploration of the internet usage patterns of computing students was conducted revealing, as shown in Figure 5-11, that chatting with friends, social networking, accessing emails and downloading study material were the major daily online activities.

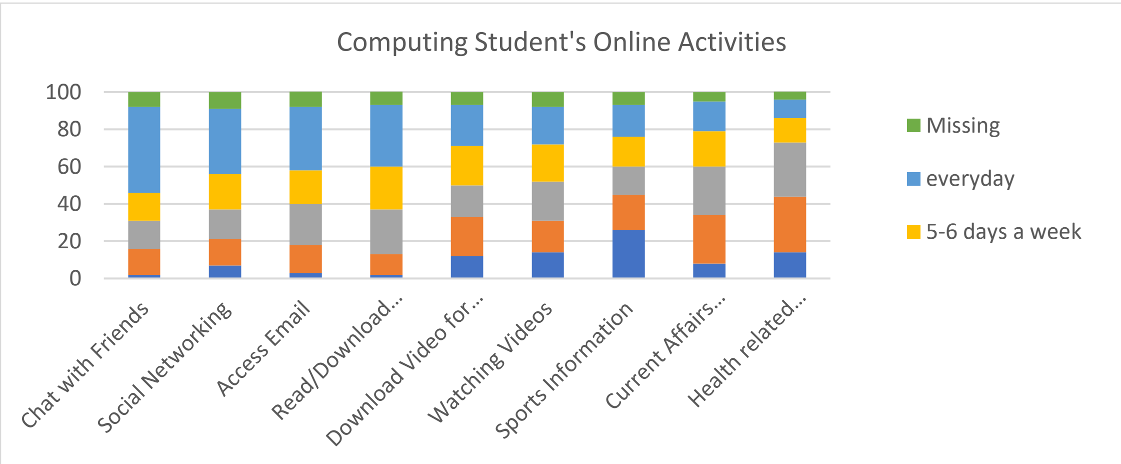

Figure 5-11: Online Activities for Botswana's Computing Students

5.4.1.5 *MAP Innovation Related Activities: Participation and Awareness among Students*

Students' willingness to take part in innovative MAP activities, such as participating in MAP competitions, was assessed. As shown in Figure 5-12, despite the majority neither having participated in mobile application competitions before nor having approached a company with a mobile app idea, most indicated that they were willing to work on a mobile app idea and share these ideas, if such sharing platforms existed.

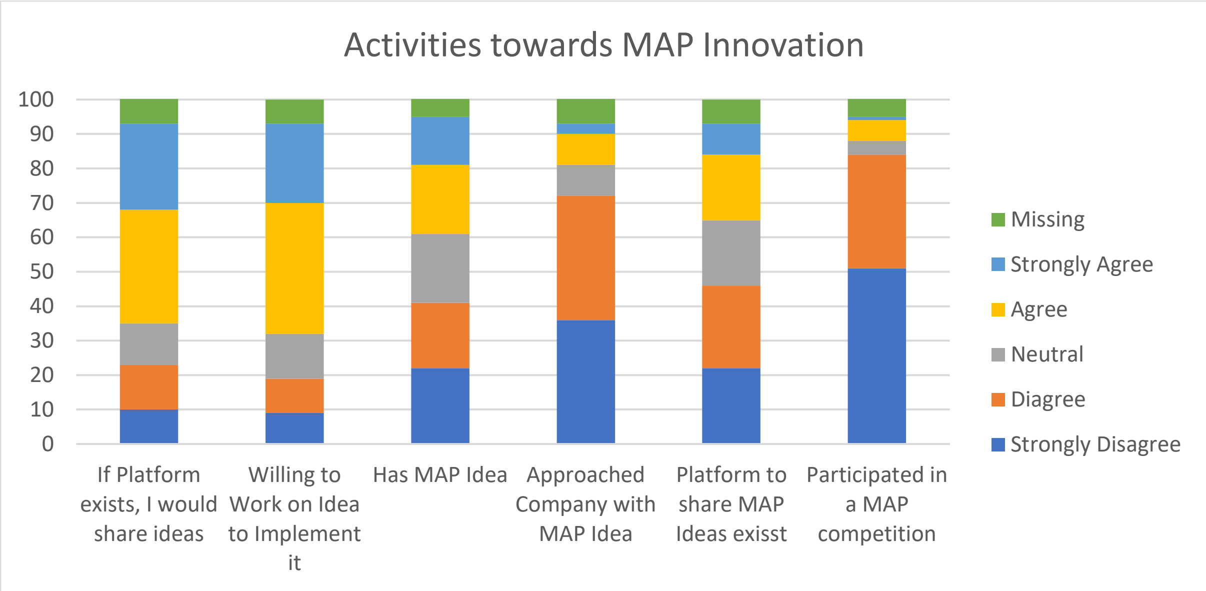

Figure 5-12: Student participation in MAP innovation activities

5.4.1.6 *Demographic Details of Respondents*

The previous findings indicate that, despite the majority of students being 21 to 25 years old, with access to government support for their studies, the preferred mediums in which to learn and discuss MAP materials were indicated as a traditional classroom setting and face-to-face interactions, respectively. Social media and the online medium were preferred by a minority of students.

5.4.2 Challenges related to Infrastructure and resources

5.4.2.1 *Ownership of ICT resources (computing) and accessibility of connectivity services*

An assessment of computing, and access to connectivity services, was done to establish the ways in which these could play a role in mobile application programming.

As shown in Figure 5-13, the majority of students (84%) own a laptop and mobile phone. A small number of students (25%), however, possess a desktop and 24% own a printer. Ownership of other ICT devices, such as televisions and DVD players, were limited to 39 and 26% of students.

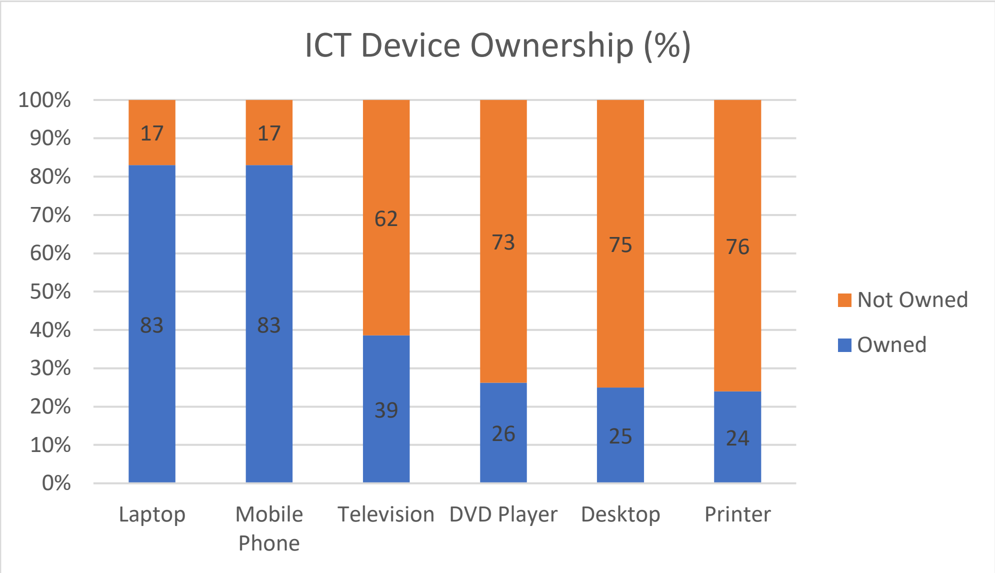

Figure 5-13: Computing device ownership of respondents

Figure 5-14: Mobile device platform of respondents presents the mobile device platform used for those respondents who possess mobile phones. As shown, 45.7% of respondents' mobile devices were running on Android, 14.9% on Blackberry, 12% on Windows Mobile, 6.2% on iOS and 20.7% did not know which platform their mobile phones used.

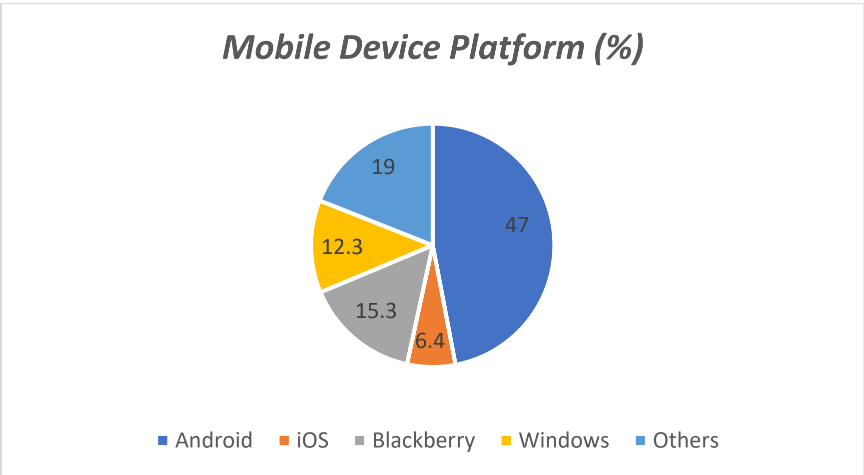

Figure 5-14: Mobile device platform of respondents

Usage of internet was assessed to establish which devices were used to access the internet and the findings in Figure 5-15 are discussed. The mobile phone was the leading device from where the internet was accessed daily. Overall, students accessed the internet from their mobile phones, desktops and laptops, at school or at home. Over 60% of the respondents had never accessed the internet from a workplace, a possible confirmation that the students are young and have not yet joined the mainstream workforce.

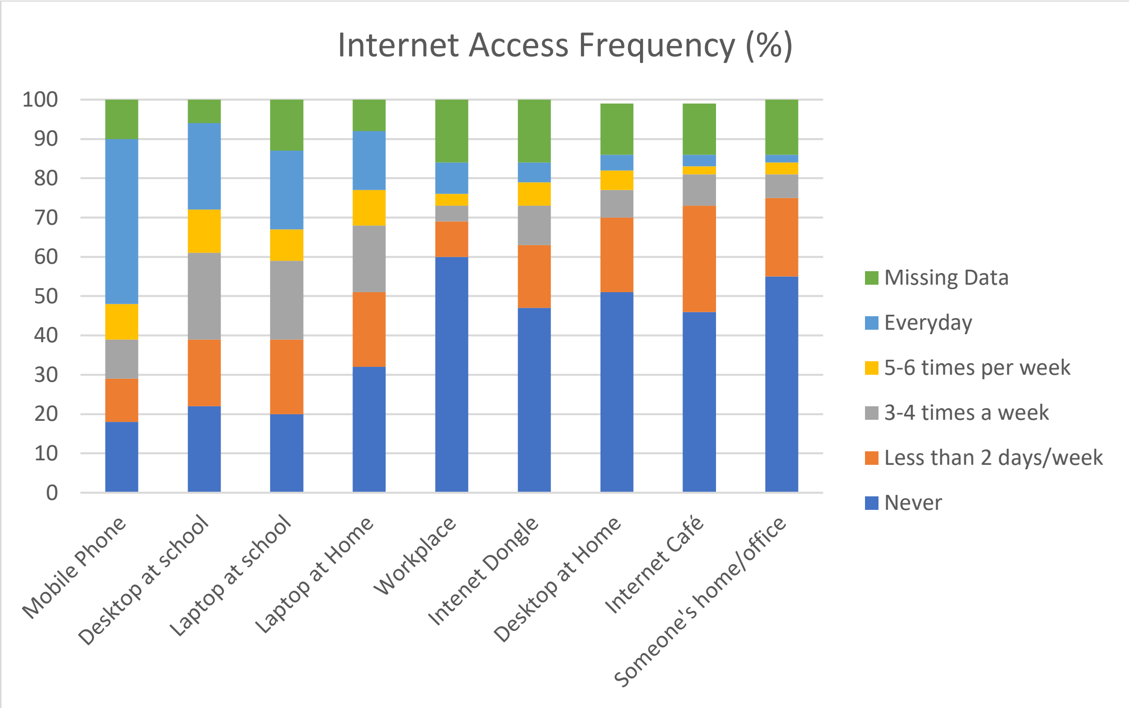

Figure 5-15: Frequency of Internet access by computing students using various access methods

A further analysis, shown in Figure 5-16, as to the speed and reliability of the internet from students' mobile phones, laptops and desktops at university and home, was done to ascertain whether connectivity was considered sufficient. A large group of participants (45%) indicated that the internet speed on their phones was good when compared to the laptops and desktops at home or university.

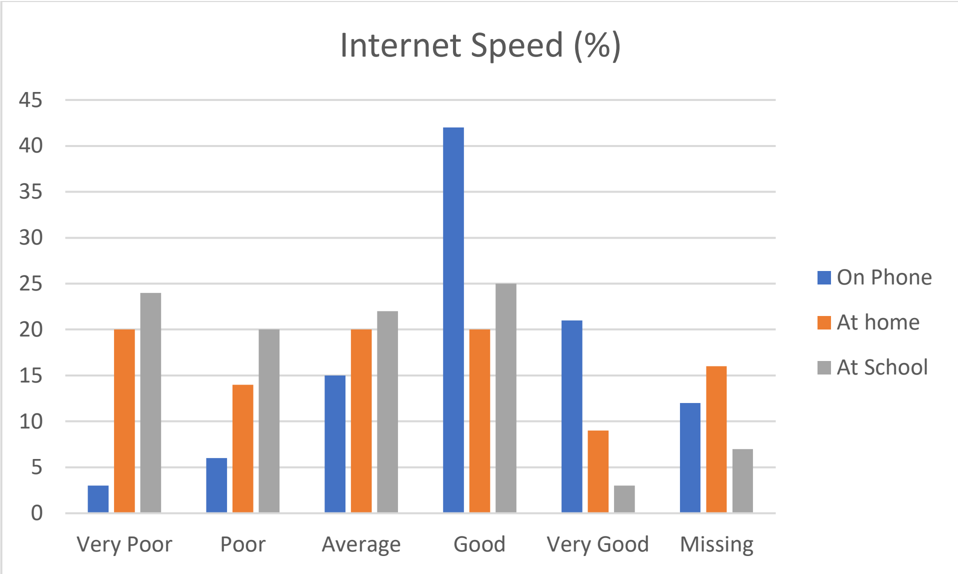

Figure 5-16: Internet Speed on commonly used devices

The reliability of the internet in the most commonly used access devices was assessed and presented in Figure 5-7. Similar to the findings regarding speed, reliability was considered good on mobile phones when compared to laptops and desktops at school and at home.

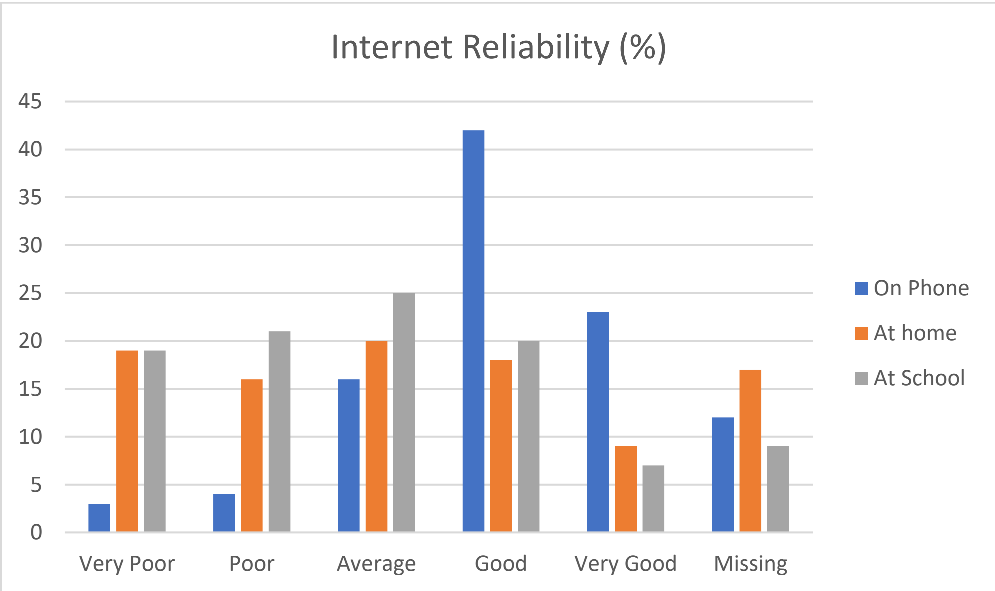

Figure 5-17: Internet reliability

5.4.2.2 *Access to MAP Learning Resources*

Most students did not have access to MAP resources with 83.7% of students indicating that they did not have access to MAP labs. Despite the 81.2% ownership of mobile phones amongst students, 68.8% said they did not have access to mobile phones to practice MAP with, indicating the need to elaborate and communicate how students' mobile phones can be used as a practice device. Access to other resources, as shown in Figure 5-18: Access to Infrastructure and resources for MAP, is discussed together with Figure 5-19: Infrastructure and resource related challenges to MAP, in the following section.

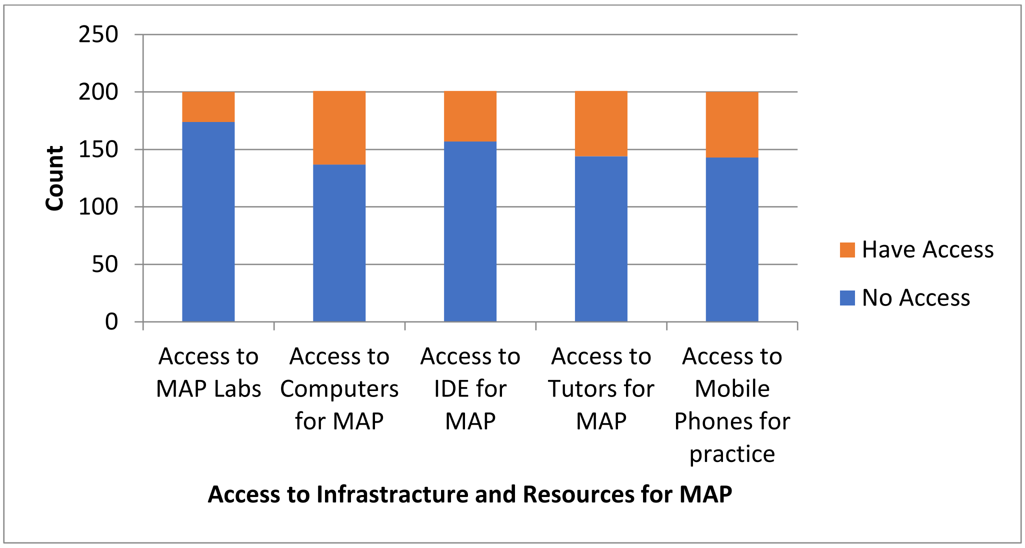

Figure 5-18: Access to Infrastructure and resources for MAP

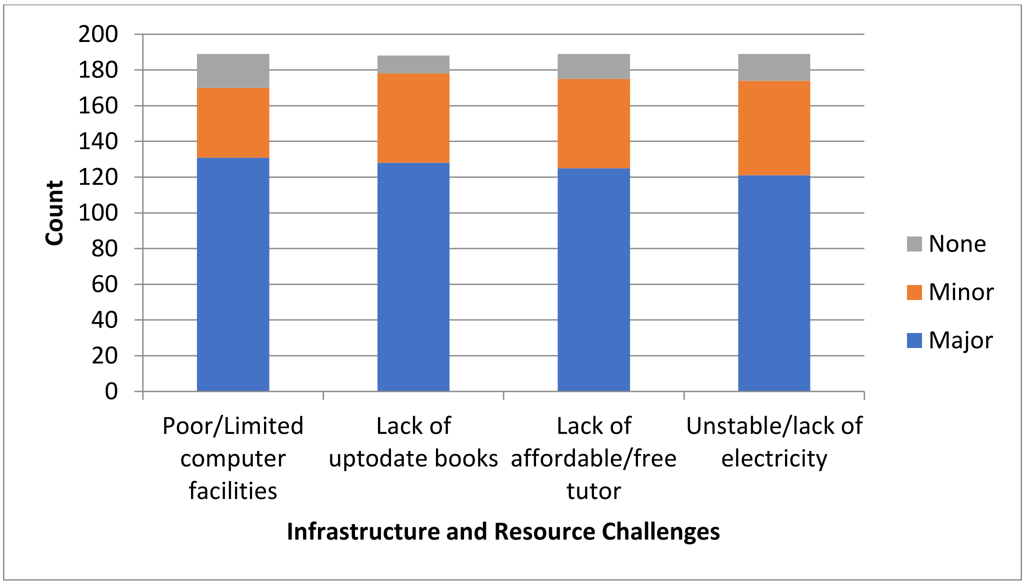

Figure 5-19: Infrastructure and resource related challenges to MAP

Figures indicate that, despite the significant laptop ownership of 81.7%, students generally perceive poor/limited computer facilities as a major challenge. Sixty-three % of the students indicated poor, or limited, computer facilities as a major challenge to

MAP learning, possibly referring to the lack of the Integrated Development Environment (IDE) with 75.5% of students saying that they did not have access to the required IDE for MAP. Up to date literature was another major challenge as 61.5% indicated a lack of up to date literature and publications on mobile application development as a major challenge to learning MAP. The lack of affordable tutors was another major challenge in MAP as indicated by 60.1% of the students. Unstable, or lack of electricity, is a major challenge in learning MAP as indicated by 58.2% of respondents. It would seem, from the above, that most students do possess the required ICT resources for MAP, but the lack of tutors inhibits the ability of students to use their resources to develop mobile applications.

5.4.3 Challenges related to Personal Factors

5.4.3.1 *Personal Challenges to Mobile Application Programming*

Although not as severe as the infrastructure and resource related challenges presented earlier, Figure 5-20: Personal challenges to MAP, presents the challenges related to personal factors.

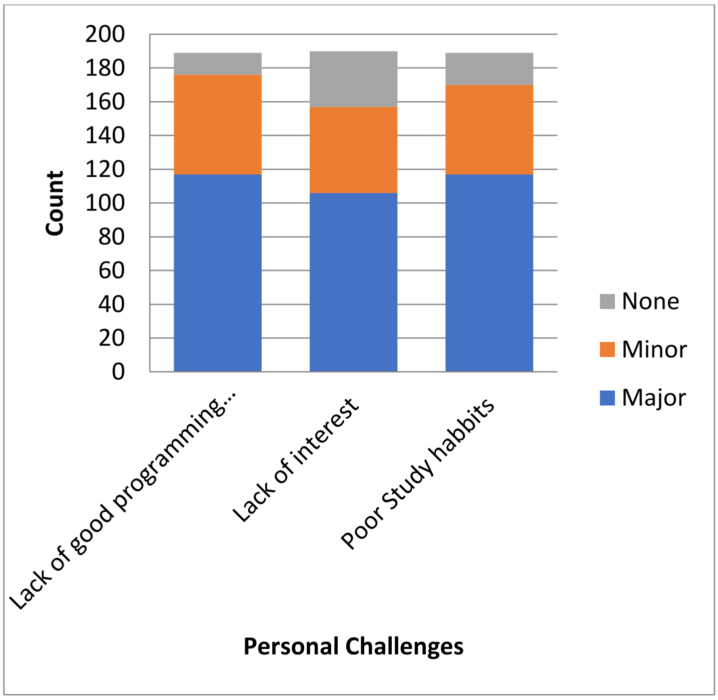

Figure 5-20: Personal challenges to MAP

Poor programming backgrounds amongst students was ascertained to be a major challenge in MAP with 56.2% of students perceiving the lack of a solid programming background to be a major challenge to MAP. Poor study habits were also indicated as a major challenge in learning MAP by 56.2% of the students. Lack of interest was a relatively major challenge with 51% of students indicating lack of interest as a major challenge in learning MAP programming.

5.4.3.2 *Student Residence relative to Higher Education Institution*

Transport expenses to and from their place of study is considered a severe personal challenge by students. Thirty % of students spend more than P800 a month on transport. The minority (8%) do not incur any transport costs as they can walk or stay on campus. The majority (58%), however, spend between P200 and P800 on their monthly transport expense.

With 98% of computing students in Botswana staying off campus, either renting on their own (54%) or staying with family (44%), it transpired that 35% of students do not pay rent while the remaining (65%) do. Fifty-seven % of students pay monthly accommodation rental within the P100 to P1 000 range.

With a stipend of around P13 00, transport and accommodation expenses are indeed a challenge faced by Botswana's higher education institutions students.

5.4.3.3 *Student Possession of Prerequisite Knowledge for MAP*

An understanding of Java is essential to MAP using Android and, as such, the need exists to assess the level of prerequisite programming knowledge amongst computing students.

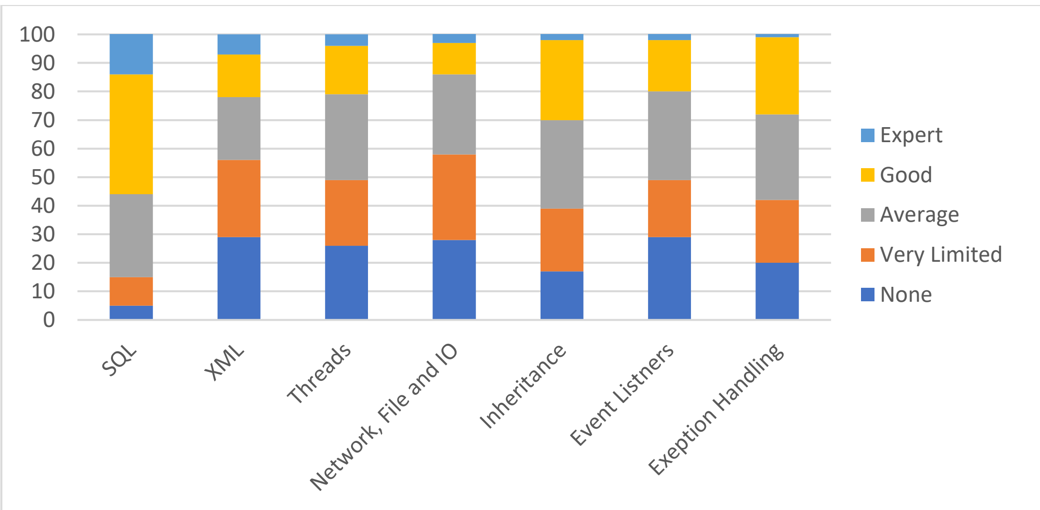

Figure 5-21: MAP prerequisite skills among computing students

The prerequisite programming knowledge among students, as shown in Figure 5-21, is considered sufficient, although some programming prerequisites had most students showing limited, to no skills. These included XML, Threads and Network IO.

5.4.4 General Discussion

The study confirmed that the government of Botswana is the largest financer of higher education institutions in the country. There is equality as to the number of male and female students studying IT at the private higher education institution. This could reflect the fact that IT appeals equally to both genders as well as an intentional position adopted by both the major financer of higher education and the higher education institution.

The research also confirmed that few students are engaged in MAP, despite a huge interest and knowledge of their institution offering MAP related courses. This could reflect some challenges students face when attempting to register for MAP courses offered by their institution, such as the course not being core, or elective, for their qualification. The infancy of the MAP industry in Botswana is also confirmed when students perceive that MAP skills cannot better job prospects of getting a job. Students' intention to build their own mobile apps will create a pool of community members who are technically capable of delivering locally relevant content to their communities.

Although there are challenges faced in MAP, respondents perceive personal challenges to be less severe than infrastructure and resource related challenges. The infrastructure, resource and personal challenges identified in the study revealed the need to address challenges faced by students in order to develop a conducive MAP environment at higher education institutions. These conditions are discussed below.

5.4.5 Framework Recommendations

The large number of students possessing mobile phones and laptops, yet citing lack of MAP labs, computers, IDEs, mobile phones for practice, relevant MAP books and lack of affordable tutorship, indicates lacking knowledge and/or interest on the part of students to understand how precisely to start developing mobile applications using available infrastructure and free online MAP books. Higher education institutions can, therefore, create a "bring your devices" environment with dedicated MAP tutors. This environment will enable students to access MAP tutorship which will, in addition to providing general and MAP programming learning support, help set-up IDEs on student laptops and freely share available electronic MAP books and videos with their students. Such a platform should admit students, irrespective of whether the MAP course is core or elective, to the student's programme of study. Students can also access study improvement techniques. If resources are available, back-up generators can be installed to ensure continued electricity supply for the MAP students.

5.4.6 Summary

This chapter explored the elements of a mobile applications innovation ecosystems framework from a higher education perspective. The rigor cycle was achieved through literature reviews on elements of mobile a mobile application innovation ecosystem from a higher education perspective while the relevance cycle was executed using a survey questionnaire in which data was collected and analysed. Findings show that access to a reliably powered MAP Lab, with good computing and mobile phone facilities, up to date books, an affordable or free tutor, improved programming backgrounds and enhanced study habits of students which, in turn, helped to address their challenges. The study also uncovered that most students consider MAP an essential skill to build their own apps, rather than increasing job prospects.

The study recommends a mobile application programming environment which takes advantage of student laptop and mobile phone ownership by setting up IDEs for students and offering free tutorials and electronic books. In addition, imparting programming skills earlier and stirring interest among students to engage in MAP would address challenges to MAP. The final framework version 1 is consequently presented as a concept map diagram in Figure 5-22 and the summarised framework is illustrated in Figure 5-23.

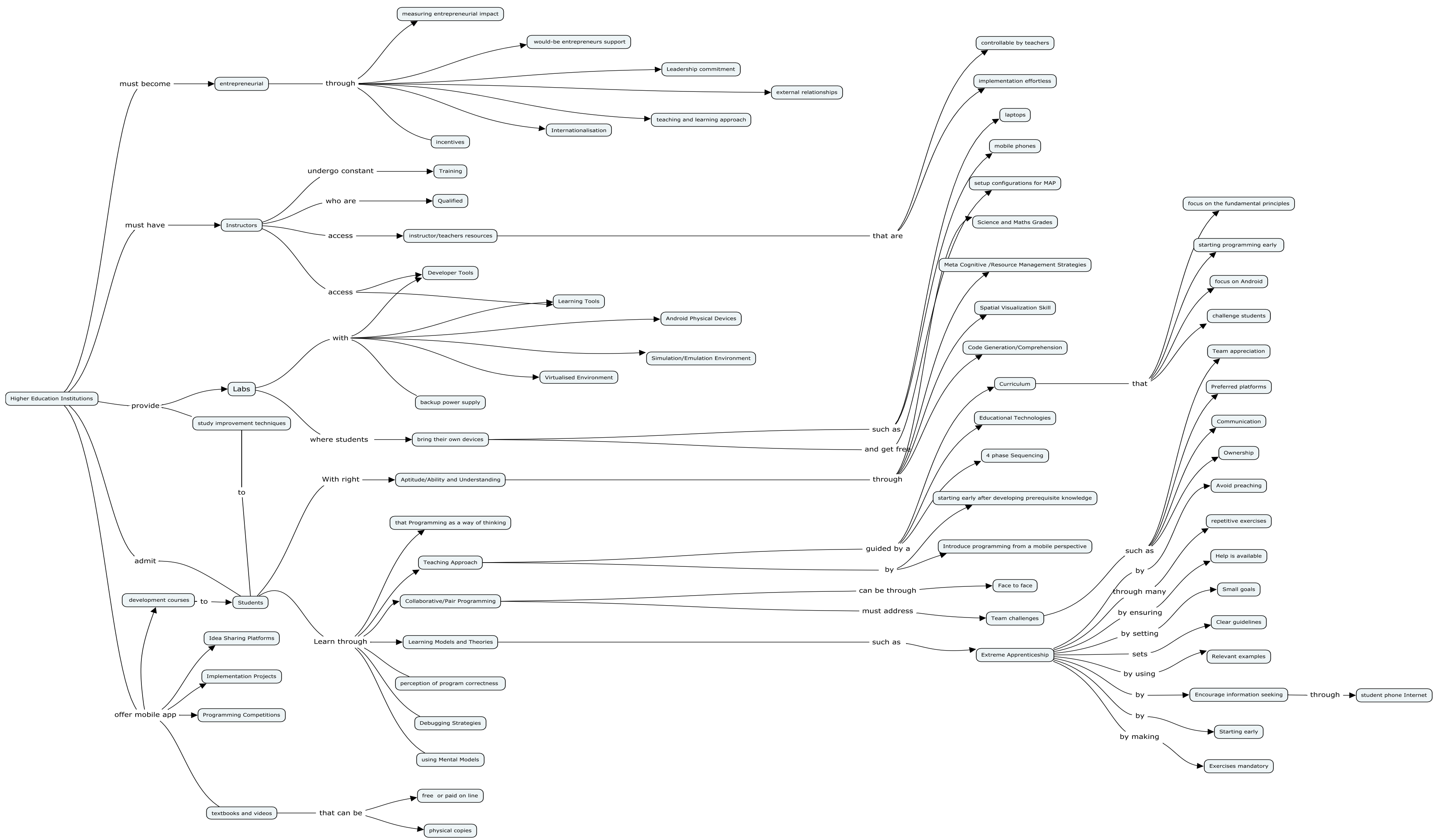

Figure 5-22: Higher Education Perspective: Mobile Applications Innovation Ecosystem Framework v1 Components Concept Diagram

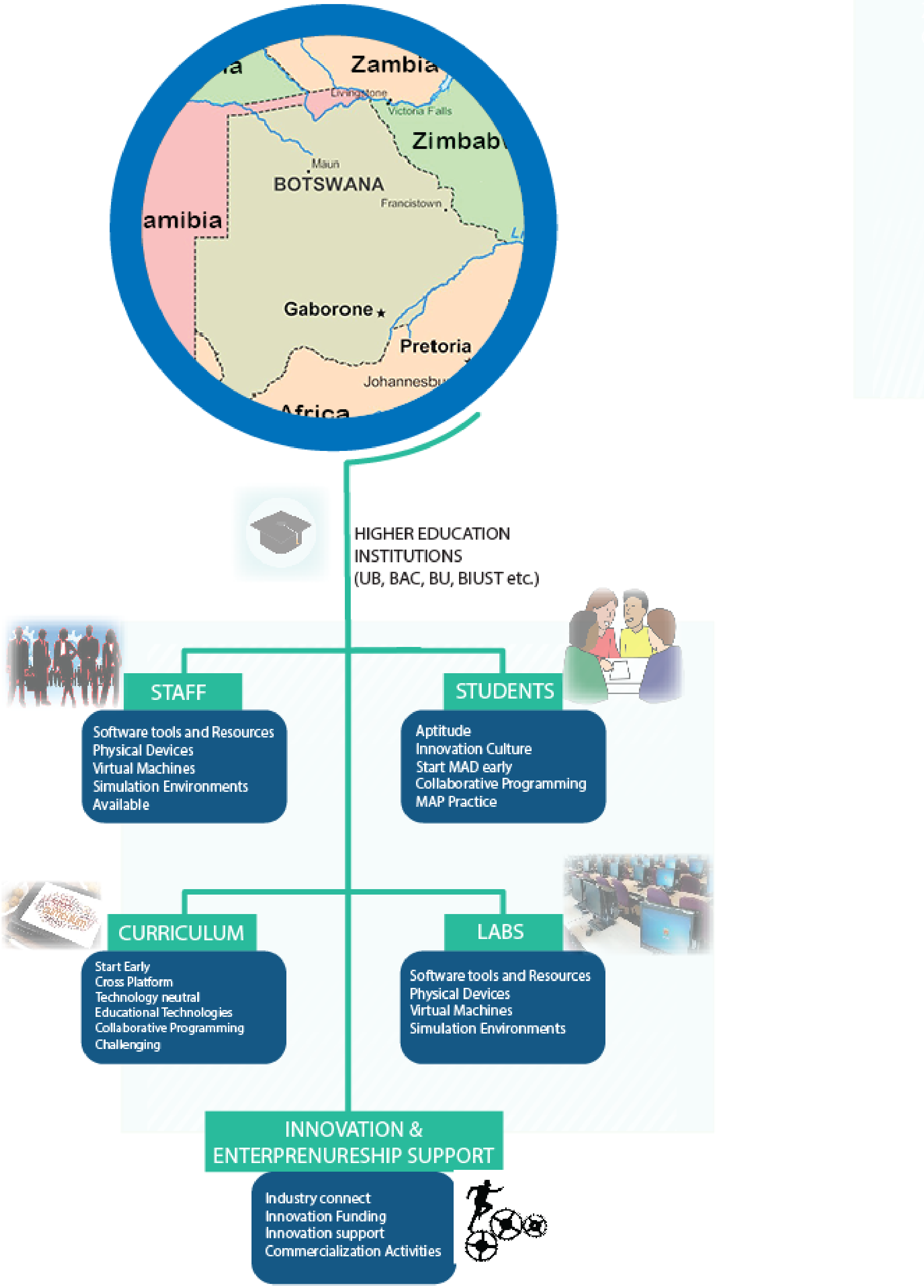

Figure 5-23: Higher Education Perspective: Mobile Applications Innovation Ecosystems Framework v1

Chapter 6 Industry Components of a Mobile Applications Innovation Ecosystem

6.1 Introduction

The previous chapter presented framework version 1 from the higher education dimension. This chapter describes the second helix of Phase 1 of the DSR which addresses the following research question:

RQ_2. What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Industry perspective?

This chapter, as illustrated in Figure 6-1, therefore provides the second rigor, design, relevance and evaluation iteration of the industry perspective framework components that will inform Phase 2 of the DSR cycle.

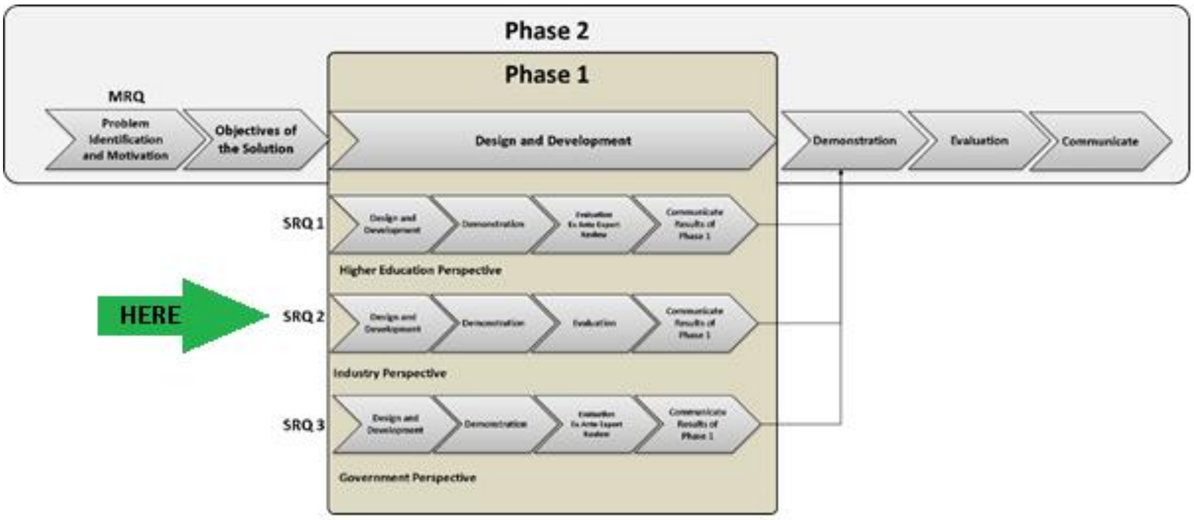

Figure 6-1: Phase 1 – Industry; Chapter 6 relative to the DSR Strategy

Industry has traditionally focused on economic production of goods and services whilst innovation was driven from this helix to ensure business opportunities for private companies (Manzini, 2012). The increased importance of knowledge, research and development (R&D) in production has seen industry conducting training (a role traditionally assigned to the academia) and partnering with academia to innovate and obtain ideas. This section presents the components of a mobile applications innovation ecosystem which are largely influenced by industry and explores how these components can enhance the development of useful mobile applications for societal development. Focus is afforded to those industry components which have bearing on enhancing the development and use of mobile applications.

In addition, this chapter, as part of the relevance cycle, presents the challenges and opportunities within Botswana's mobile applications industry, leading to the creation of framework version 2. The chapter therefore presents an overview of mobile entrepreneurship in developing countries before discussing the components facilitating mobile application development within the mobile industry (thus the Industry perspective). The identified components are then used to design framework version 2 which is, in turn, evaluated for relevance by 41 mobile application developers.

6.2 Rigor and Design: Industry Components of a Mobile Applications Innovation Ecosystem

6.2.1 Overview of Mobile Ecosystem Entrepreneurship in Developing Countries

Mobile applications are shaping the economic, political and social lives of people in Africa (Murugesan, 2013). Kenya's emerging digital entrepreneurship ecosystem, which saw the development of several mobile enabled services, is an inspiring African case study for entrepreneurs and innovating businesses in the developing world inspiring them to change the business landscape and the lives of the underserved (Drouillard et al., 2014). Setting up successful digital economies require collaboration between academia and industry, easy access to venture capital, high levels of government research spending and meet-up among likeminded individuals (The World Bank, 2016). A study into Vietnamese ICT business's source of international competitiveness revealed that a positive macroeconomic environment and investment from both government and multi-lateral organisations are essential to setting up a successful software ecosystem (Chidamber, 2003). The role of government, primary, secondary and tertiary education, incubators as well as international players, like the World Bank, were also identified to be essential in creating a successful digital ecosystem (Gray & Sanzogni, 2004). Drouillard et al. (2014) indicate that, despite Nairobi's potential to become a major digital entrepreneurship hub, financial, commercial and technical challenges are deterrents to most digital start-ups in the realisation of their full potential. Challenges faced by mobile entrepreneurships were also identified in several other developing countries as reported by Dehlinger and Dixon (2011), The United Nations Conference on Trade and Development (2011), The World Bank (2016) and West (2012). These deterrents can also apply to other African digital entrepreneurship hubs, Botswana included.

6.2.1.1 *Stages in mobile application entrepreneurship*

The stages to creating a successful mobile application entrepreneurship within the Mobile applications ecosystem can be described through the five staged digital start-up model proposed for Kenya by Drouillard et al. (2014). The digital start-up stages include: Idea, Prototype, Seed, Growth Series and Expansionary Growth, as described in Drouillard, Taverner, Willianson and Harris (2014, p. 46).

Table 6-1: Digital Start-Up Stages and The Mobile Applications Ecosystem Adopted from Drouillard et al. (2014)

Stage	Description	Link to Mobile Application Ecosystem
Idea	Founders have more than one idea but no tangible prototype.	Developers exist, but no consumers exist yet. The ideal hardware, operating system and the distribution channel are all still ideas.
Prototype	Founders have crystallised their ideas.	Developers exist, but no consumers exist yet. The ideal hardware, operating system have been developed slightly but the distribution channel are still ideas.
Seed	Founders have formed a company based on their ideas and have a clear business model and a core team.	Developers exist, and some initial consumers exist. The hardware, operating system and the distribution channels have been established, but are still being improved.
Growth (Series A):	Company has a polished product or service, a well proven market, a clear commercialisation strategy and a considerable customer base. Revenues are strong and growing. Company has several employees and focused teams. Focus is on scaling up operations.	Developers exist, and consumers exist. The hardware, operating system and the distribution channel have been established, and revenues from the payment system are strong and growing.

Expansionary (Series B):	Profitable company looking to expand operations regionally or internationally.	A fully-fledged mobile applications ecosystem exists.

In their study, situated in Kenya, Drouillard et al. (2014) observed that Nairobi's potential to become a major digital entrepreneurship hub faced financial, commercial and technical challenges which deterred the majority of digital start-ups from realising their full potential of developing profitable organisations from ideas which reflect regional and international presence. In addition, it has been noted that upon reaching a certain threshold, new and existing entrepreneurial activities can be stimulated through "enhanced access to finance, services to entrepreneurs, and the demonstration effects of successful 'first mover' start-ups" (The World Bank, 2016, p. 229).

6.2.2 Human Capacity: Mobile Start-Up Support

Several organisations have established labs that help to nurture start-up and innovative mobile solutions. Such start-up support adopts many forms such as hands-on mentorship, seed stage funds, start-up loans as well as favourable mobile applications procurement policy by government and other institutions. Orange established the Emerginov platform, an open source incubator to stimulate innovative local mobile solutions. Nailab, 88Mph, Innovation 4 Africa, Savannah Fund and GrowthHub are seed funders and incubators in Kenya which mainly focus on mobile technology (Drouillard et al., 2014). Despite recent advances in infrastructure, hosting options that replicate live conditions remain expensive and/or impractical (Drouillard et al., 2014). Service providers can provide support for mobile application programmers in the form of office space where the service provider provides rack, power, air conditioning, Internet connectivity as well as server leases which provide operating system level administration support (Drouillard et al., 2014). Such support is essential to enhance mobile application programming and is it is therefore cardinal that financial, cultural and policy obstacles to mobile entrepreneurship be addressed and overcome (West, 2012).

6.2.2.1 *Financial Support*

Most mobile applications struggle to achieve long term sustainability and thus require donor, or government, funding to incentivise innovation and entrepreneurship in this sector (West, 2012). Accessing capital is also a major concern for mobile entrepreneurs as they often lack the collateral needed to guarantee bank loans (Drouillard et al., 2014). Similar concerns, including improved access to loans and the need to secure such loans, were identified among South Africa entrepreneurs (The United Nations Conference on Trade and Development, 2011). Governments can therefore support early mobile application entrepreneurship through early stage funds and accelerators, implementation of procurement frameworks which support local mobile application entrepreneurs, "entrepreneurship visas" and by setting up mobile entrepreneurship hubs (The Economist, 2012). Other funding options can be availed upon to boost the mobile applications ecosystem through seed funders and incubators, examples being Kenya's Nailab, 88Mph, Innovation 4 Africa, Savannah Fund and GrowthHub which mainly focus on mobile technology (Drouillard et al., 2014). Funding for Kenya's current mobile entrepreneurship hub, although considered insufficient by start-ups, has stemmed from: competition prize money, donors, angel investors, venture capital investment, private equity, family and friends, bank loans, own investments and other sources. Funding for Kenya's digital start-ups varies across the different start-up stages and gaps between the *demand* for funding and its *supply* (number of funders and amounts at each start-up stage) were observed (Drouillard et al., 2014). Botswana's mobile entrepreneurship also face other financial challenges as it is rated, on availability of venture capital, at 2.7 out of 7, a position of 71 from 138 countries (World Economic Forumn, 2017).

6.2.2.2 *Commercial Support*

The need for commercial support among mobile application entrepreneurs was demonstrated in Kenya when less than 50% of founding mobile entrepreneur teams felt that they possessed the skills necessary to run an organisation (Drouillard et al., 2014). This sentiment was echoed by most investors who indicated that mobile entrepreneurship start-up teams, seeking growth capital, generally presented poor quality business models and demonstrated weak business acumen. This might be ascribed to their highly technical backgrounds and lack of skills regarding business, marketing, intellectual property rights, management and financial matters (Drouillard et al., 2014). In South Africa, general entrepreneurs reported, amongst others, on the need for assistance regarding marketing, accessing raw materials and partnering with others in similar businesses (The United Nations Conference on Trade and

Development, 2011). Such challenges can be addressed through coaching and mentorship programmes.

6.2.2.3 *Technical Support*

Despite recent advances in infrastructure, hosting options that replicate live conditions remain expensive and/or impractical for most mobile entrepreneurs, as evidenced by 50% of start-ups indicating that their biggest technical challenge is the high costs of operator resources (Drouillard et al., 2014). As a result, service providers were recommended to provide support to mobile application programmers in the form of office space/housing, rack, power, air conditioning, internet connectivity, server leases and operating system level administration support (Drouillard et al., 2014). Additionally, if start-ups wish to successfully monetise their services, it is essential that they integrate with prevailing and available payment platforms, via mobile operators (Dehlinger & Dixon, 2011; Joorabchi, Mesbah, & Kruchten, 2013; König-Ries, 2009). One such collaborative effort saw Orange establish the Emerginov platform which is an open source incubator to stimulate the creation of innovative local mobile solutions. Such support is essential in a mobile applications innovation ecosystem.

6.2.2.4 *Other Challenges affecting Human Capacity*

Mobile application developers also face technical challenges such as the fact that mobile platforms move towards fragmentation, rather than unification. The need exists to better analyse and test support tools for mobile applications which enhance and address: mobility, location services, sensors, various gestures and inputs, open and closed development platforms, limited ability of intensive apps due to storage, screen and connection speed as well as connection change limitations and the rapid changes in software development kits (Drouillard et al., 2014).

6.2.3 Computing

6.2.3.1 ***Advanced mobile hardware***

Identified as another characteristic of mobile application development, advanced mobile hardware drives mobile applications development (Gasimov et al., 2010). Hardware manufactures aim to produce mobile phones with bigger screens, faster processing power, longer battery life and which are lighter devices, with some phones already providing processing power comparable to notebooks, all of which present developers with more mobile application options (Gasimov et al., 2010). BOCRA (2016) reported a 14.4% increase (to 1 360 236 individuals) in mobile internet penetration from smart phone and other wireless technologies, such as USB modems, especially amongst the youth. The advancement of mobile hardware in Botswana is therefore implied.

There are many different types of mobile phones, but the future of mobile computing will be dominated by tablets and smart phones. Minges (2012) identified four categories of mobile phones, based on their capabilities:

Table 6-2: Mobile Devices and their capabilities (Minges, 2012, p. 15)

Device	**Capabilities**
Basic mobile phone	Network services, including: Voice telephony and voice mail SMS (short message service) USSD (unstructured supplementary service data) SMS-based services, such as mobile money USSD services, such as instant messaging
Feature phone	As basic mobile phone plus: Multimedia Messaging Service (MMS) Still picture camera MP3 music player 2.5G data access
Smartphone	As Feature phone plus: Video camera Web browser GPS (global positioning system) 3G+ internet access Mobile operating “platform” (such as iOS, Android, Blackberry) Ability to download and manage applications VoIP (Voice over Internet Protocol) Mobile TV (if available) Removable memory card
Tablet	As Smartphone plus: Front and rear-facing video cameras (for video calls) Larger screen and memory capability Faster processor, enabling video playback Touch screen with virtual keyboard USB (universal serial bus) port

Smartphone adoption in Africa is poised for rapid growth. In 2012, smart phones represented only 4.6% of sub-Saharan Africa's active mobile phones, largely due to their hefty price tags. Their adoption, however, was expected to grow at 6% per year to reach 16% by 2017 (Roseboro, 2013). By 2020 it is forecasted that over half of the connection base in sub-Saharan Africa will use smart phones (GSMA, 2014). Botswana appears to have surpassed these estimates. In 2018, there were already more than 1.5 million mobile broadband internet subscriptions for the 3.1 million mobile network subscriptions in Botswana (BOCRA, 2018). Smart phones are expected to become the main computing device in the future. Dunn, Galletta, Hypolite, Puri and Raghuwanshi (2013) state that the shipment of smart mobile phones surpassed that of personal computers in 2011 and that the number of mobile internet users is said to grow at an annual compound rate of 16.6%. Adkins (2013) reports that at the end of 2012, over 50% of internet access in Africa was via mobile phones, thus indicating a future where smart phones will be commonly used, and mobile devices will constitute the primary means of accessing information from the internet. Botswana's internet is accessed mainly via mobile devices as over 1.5 million internet users are mobile (97%) whilst only 50 494 employ fixed wireless or ADSL (BOCRA, 2018). Gordon (2013) confirms that the future of computing seems to be increasingly dominated by mobile devices. Safaricom Kenya announced that they would be phasing out feature phones in favour of low cost smart phones, whilst Samsung announced that in certain African countries, smart phones were outselling personal computers at a ratio of 1:4 (Adkins, 2013). Figure 6-2 illustrates the expected growth of basic, feature and smart phones in sub-Saharan Africa. The growth in the number of smart phones will surely require mobile applications which can aid users to find, what the ITU (2010) refers to as "content that is relevant to the cultures and languages of individuals in the information society" (p. 176).

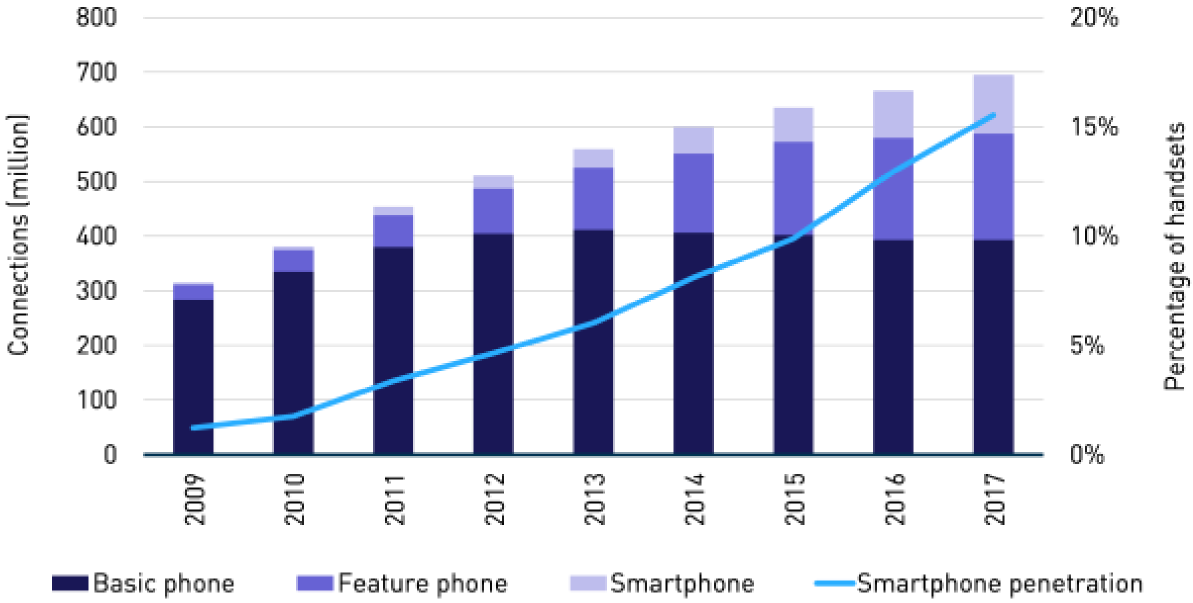

Figure 6-2: Active Mobile Handsets by device type, sub-Saharan Africa, 2009–2017 (Roseboro, 2013).

The handset device component of the mobile applications ecosystem indicates that devices are getting smarter and more powerful, thus increasingly creating an enabling environment for the mobile app economy. The World Bank (2016) shows that the global cost of smartphones has been declining, as per Figure 6-3.

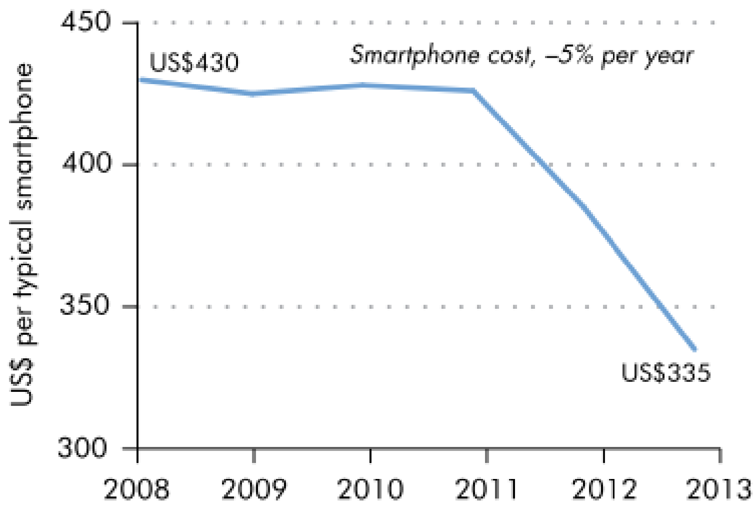

Figure 6-3: The Global Cost of Smartphones (Adopted from The World Bank, 2016, p. 217)

6.2.4 Connectivity Components

6.2.4.1 *Mobile network infrastructure maturity*

Gasimov, Tan, Phang and Sutanto (2010) report that the maturity of the mobile network infrastructure is one of the three characteristics of mobile application development. While recent technological advances have seen 160 countries use 4G, 2G networks cover 95% of the world's population (ITU, 2017a). The development of new mobile communication protocols, like 4G, results in more bandwidth for mobile users which, in turn, make the internet more accessible to mobile users (Gasimov et al., 2010). Botswana, with a population of over 2 million had 1 523 545 mobile broadband subscriptions in March 2018 (BOCRA, 2018). Developers are therefore afforded the chance to tap into the possibilities presented by faster internet. These factors derive from the Infrastructure and Support Services and Mobile Network Operators value chain components of the mobile ecosystem.

Botswana's mobile network infrastructure was discussed in Chapter 2, section 2.3. Botswana's access to undersea fibre optic cables and the national land-based fibre infrastructure, covering more than 6 000km, allows for Botswana's four major telecommunications market players to provide connectivity technologies ranging from 3G and LTE, in urban areas, to GPRS and EDGE in parts of the country (BOFINET, 2016).

6.2.5 Content Enabling

6.2.5.1 *Increased demand for mobile services and applications*

An increased demand for mobile services and applications is considered another of the three characteristics essential for mobile applications development (Gasimov et al., 2010). Mobile phones are gaining popularity and the future might, very well, be mobile. In Botswana, for example, 97% of internet users use mobile devices to access the net (BOCRA, 2018). Zanamwe et al. (2013) observe that, in neighbouring Zimbabwe: 70.4% of the respondent students accessed the internet through their smart phones, 79.2% use laptops, whilst desktops were used by 56.8% of the respondents. An increasing number of people are using their mobile devices for work which was traditionally done by computers. Therefore, developers will need to offer these computer applications and services on mobile phones to increase the level of mobile application programming. Botswana reported a 14.4% increase in mobile internet penetration on smart phones and other wireless technologies such as USB modems, especially amongst the youth (BOCRA, 2016). These figures point towards an increased demand for mobile-based services in Botswana.

6.2.5.2 *Collaboration among Mobile Application Programmers and Mobile Operators*

Mobile operators play a pivotal role in the digital services ecosystem of developing countries due to the huge adoption of mobile phones. Despite this central role, few start-ups have managed to secure meaningful partnerships (Drouillard et al., 2014). Mobile operators provide services such as: voice messaging, payments and billing, identity/user authentication, location awareness, nurturing customer trust and loyalty in addition to physical assets like face-to-face distribution networks and network infrastructure (Drouillard et al., 2014). Mobile application programming can benefit from collaborations as these will enable: channel access; distribution; the enhancement of hardware, software, physical network and operation capabilities as well as build a good reputation (“Hackathons,” 2013).

6.2.5.3 *Zero Rating:*

Data connectivity, in the form of internet access, remains a *digital divide*. This divide needs to be addressed if everyone is to benefit from ICT4D (The World Bank, 2016). Access to connectivity is more critical in rural areas if said connectivity is to be leveraged to use ICT in development (ITU, 2010; West, 2015). Several factors affect the ability of people in developing countries to connect to the internet and industry can play a significant role in closing this digital divide. Zero rating is when mobile service providers enable mobile service customers to download and upload online content without incurring data usage charges or having their usage counted against data usage limits (Eisenach, 2015). It is therefore argued that *zero rating* could be an effective way in which the world’s poorer communities could join the digital era while promoting innovation and competition in the internet sector (West, 2015). Due to higher costs of mobile data per capita, zero rating plays an important role in enabling content in developing countries (Eisenach, 2015). Two types of zero rating are identified by Eisenach (2015). Zero rating is a risk laden move as some regulators consider it a violation of the principles of net neutrality (Eisenach, 2015). It should therefore be executed with caution and due regulator consultation.

6.2.5.3.1 Type of Content Zero Rating

In this arrangement the type of content determines whether zero rating applies. For example, access to online government and community service sites and other popular services such as Facebook, Google, Twitter and Wikipedia can be zero rated while the rest is not.

6.2.5.3.2 Business Arrangement Zero Rating

The underlying relationship between business and mobile service providers also leads to business arranged zero rating programmes. Mobile service providers can initiate zero rating programmes as a way of attracting customers while sponsored data plans occur when content providers pay mobile service providers to have their data zero rated.

6.2.5.4 *Hackathons*

Mobile innovative road show *hackathons* have been held in Botswana, Namibia, Mozambique and Zambia. These were organised as a way of stimulating the development of mobile applications. These hackathons brought together skilled developers and resulted in the development of mobile applications that solved some national concerns ("Hackathons," 2013). A hackathon, also known as a *hacking marathon*, is "an event where people in small groups participate in an intensive prototyping activity for a limited amount of time" (Burnham, 2012, p. 790). Hackathons have varying objectives, the development of new and innovative software, or services, being the leading aim. They have been presented in Africa to obtain nurture the development of mobile applications. Hackathons are becoming increasingly popular and have been adopted as part of the organisational culture at firms like Google and Facebook (Burnham, 2012). Although limited literature exists on the effectiveness of hackathons, they are generally considered a successful way of facilitating innovative creations. For example, after a hackathon event at Facebook, 60% of the original ideas are developed further and consequently shipped in three months (Burnham, 2012). An effective hackathon needs proper planning. Raatikainen et al. (2013) present lessons on how to organise successful hackathons with a focus on the following concepts: pay attention to group dynamics, motivate, length of hackathon needs to be considered, location, support as well as flow and inter-team interaction. Hackathons have been likened to a new way of prototyping and, as such, require a team which already has a solid skill set. Hackathons aim at quickly producing something, thus calling for highly intense and fast developmental activities (Botswana Innovative Hub, 2013). Even though hackathons are carried out in highly collaborative environments, the level of intensity and speed involved is not necessarily suitable to nurturing mobile application development skills, but rather to rapidly develop idea prototypes. Hackathons are, however, a good way to get students to interact and come up with ideas, requirements, designs and implementations, once they have acquired the necessary skills.

6.2.5.5 *Innovation Competitions*

On 29 January 2013, the Botswana Innovative Hub launched the first mHealth IT Innovative Competition. This competition was aimed at encouraging the youth of Botswana to come up with ideas which could improve public health and health care delivery in Botswana in the face of a shortage of health workers and poor IT infrastructure in non-urban areas (Churu, 2014). The competition was aimed at Botswana residents as they would be aware of the local challenges facing Botswana's health sector and, thus most likely to provide locally relevant content. Contestants could use any of the following mobile technologies in their solutions: voice, SMS, image/video capture, barcode or QR code scanning, GPS, internet access, computing and access to social networks (Orange, 2013). The competition originated from a partnering of government, industry and academic institutions. These institutions included Orange, UNICEF, the Botswana Innovation Hub, PEPFAR (US), the Ministry of Health, the Ministry of Transport and Communication and the Botswana-UPENN. The mHealth competition afforded special consideration to unemployed youth and was not only open to ICT developers but encouraged diverse teams made of a computer science major, nurse and a philosophy major (Churu, 2015). Similar crowd-sourced start-up competitions, like Safaricom’s App Wiz Challenge and the Orange African Social Venture Prize in Kenya, incentivise local developers and start-ups to develop innovative mobile services (Drouillard et al., 2014). The diverse nature of the participants in these competitions infuses the team with variety and new ideas. However, these groups do not get training on how to manage diverse groups and group dynamics. This research acknowledges the benefits of a diverse mobile application programming team when team management skills are incorporated. The use of competitions, like hackathons, requires programmers that have been exposed to mobile programming skills. Although, not enough, the prize money from such competitions can be used to support early stage mobile entrepreneurs. Sustainability of the application must be considered when disbursing funds on a milestone basis (West, 2012)

6.3 A summary of the Industry Components

This section presented the components of a mobile applications innovation ecosystem from industry, primarily by mobile service providers and developers. Table 6-3 summarises the mobile applications innovation ecosystem elements derived from literature, from an industry perspective. The same elements are elucidated in Figure 6-4 as a concept map diagram.

Table 6-3: Industry Components for Mobile Application Programming

Industry Components for Mobile Application Programming	***Author***
Enhancing mobile network infrastructures - internet more accessible to mobile users	*(Gasimov et al., 2010)*
Enhancing mobile network infrastructures - more bandwidth for mobile users	*(Gasimov et al., 2010)*
Advancing mobile hardware - mobile phones with bigger screens	*(Gasimov et al., 2010)*
Advancing mobile hardware - faster processing power	*(Gasimov et al., 2010)*
Advancing mobile hardware - longer battery life	*(Gasimov et al., 2010)*
Advancing mobile hardware - lighter devices	*(Gasimov et al., 2010)*
Reducing costs of smart phones	*(The World Bank, 2016)*
Increase demand for mobile services and applications	*(Gasimov et al., 2010)*
Start-up support: hands-on mentorship	*(Drouillard et al., 2014)*
Start-up support - seed stage funds, start-up loans, competition prize, donors, angel investors, venture capital investment, private equity, family and friends, bank loans, own investments and other sources of funds	*(Drouillard et al., 2014), (The Economist, 2012)*
Start-up support - favourable mobile applications procurement policies	*(Drouillard et al., 2014), (The Economist, 2012)*
Stimulate innovative local mobile solutions	*(Drouillard et al., 2014)*

Industry Components for Mobile Application Programming	***Author***
Mobile technology focused seed funders and incubators	*(Drouillard et al., 2014), (The Economist, 2012)*
Service providers provide housing (rack, power, air conditioning and Internet connectivity and server leases and provides operating system level administration support)	*(Drouillard et al., 2014)*
Integration with the prevailing payment platforms	*(Dehlinger & Dixon, 2011), (Joorabchi et al., 2013), (König-Ries, 2009)*
Donor funding	*(West, 2012)*
Mobile entrepreneurship hubs	*(The Economist, 2012)*
Improving business acumen (business models, marketing, intellectual property rights, management and financial skills)	*(Drouillard et al., 2014)*
Mobile operators provide services such as voice, messaging, payments and billing, identity/user authentication, location awareness, customer trust and loyalty, as well as physical assets like face-to-face distribution networks and network infrastructure.	*(Drouillard et al., 2014), ("Hackathons," 2013)*
Zero rating	*(West, 2015), (Eisenach, 2015)*
Conduct hackathons	*("Hackathons," 2013)*
Conduct innovative competition	*(Churu, 2014), (Orange, 2013)*
Meet-up among like-minded individuals	*(The World Bank, 2016)*

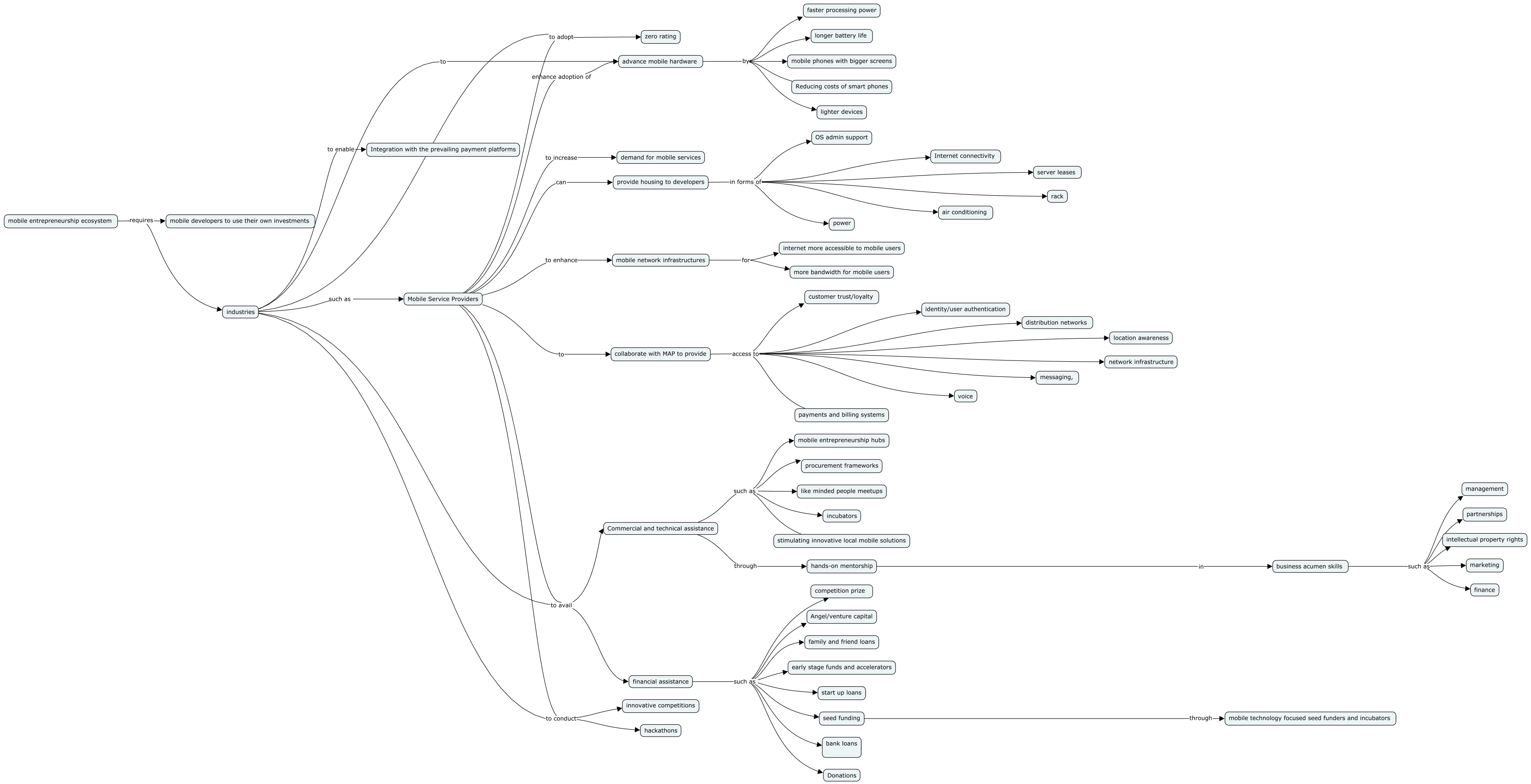

Figure 6-4: Industry Perspective- Mobile Application Programming Components Concept Map

6.4 Industry Relevance and Evaluation Cycle: Mobile Application Programming Support Needs in Botswana

This section provides the relevance and evaluation cycle to the DSR by exploring Botswana's mobile applications ecosystem challenges and opportunities in line with industry research question 2. The section presents the components necessary for the success of Botswana's mobile applications ecosystem and their evaluation in order to enhance the conceptual framework for a mobile applications innovation ecosystem.

Structured face-to-face and telephonic interviews were used to collect data from forty-one mobile application developers in Gaborone, Botswana. This was done to establish the status quo within the mobile ecosystem including the state of funding as well as commercial and technical support available to Botswana's mobile application developers. A purposeful sampling technique was used to extract information from information-rich sources based on their match being a developer of mobile applications in Botswana.

Objective and structured interview questions were used as research instruments to identify the extent of financial and technical support afforded mobile application developing organisations and individuals in Botswana. Refer to Appendix 11-6 for the interview instruments. To ensure adherence to the four principles of informed consent, absence of deception, privacy and confidentiality and accuracy (Christians, 2005), consent was obtained before the interview and data was collectively analysed, thus anonymising the participants.

6.4.1 Botswana's Mobile Application Industry Biometric Profile

Most mobile application developers and organisations in Botswana (97.5% [39 of 40]) are privately owned, with only 2.5% (1 of 40) being government owned. Most mobile application positions were found to be male dominated, both in terms of organisational leadership as well as operational roles, as per Figure 6-5.

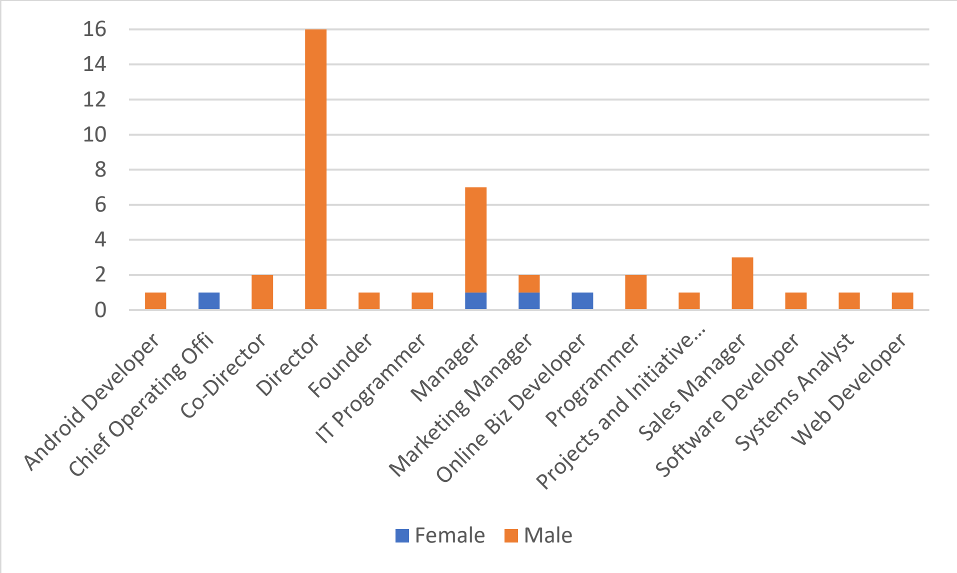

Figure 6-5: Mobile Developers: Gender - position cross tabulation

The age of most role players in Botswana's mobile application development industry ranges from 26 to 38 years old. A total of 69% of the players are 30 years, or younger, as depicted in Figure 6-6: Age analysis of Mobile Application developers. The mobile application development industry is attracting young males and thus efforts to grow the industry can focus on this group of individuals.

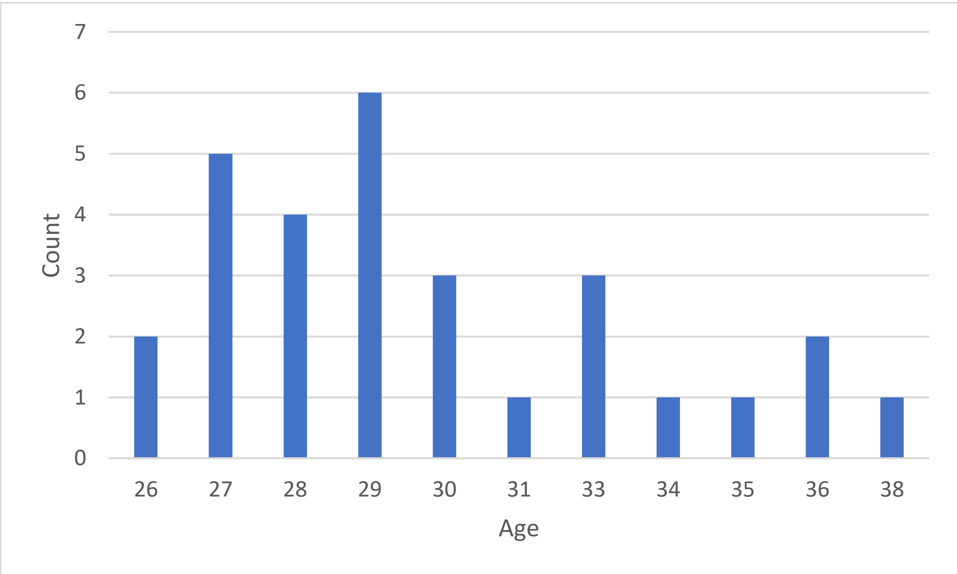

Figure 6-6: Age analysis of Mobile Application developers

The majority (66.7%) of mobile application developing organisations indicated that they are attempting to grow within Botswana with 25.6% reported moving into the regional market and only 7.7% of organisations reported growing into the international market. Despite these growth reports, 60% (21 out of 35) of mobile application developers reported weak revenues. The size of the mobile application industry in Botswana, as measured by the number of developers in organisations (refer to Figure 6-7: No. of developers in Mobile Application Development Organisations) and the number of mobile applications developed, shows that the industry is still small with 28.2% of Botswana' mobile application developers reported to be solo application developers.

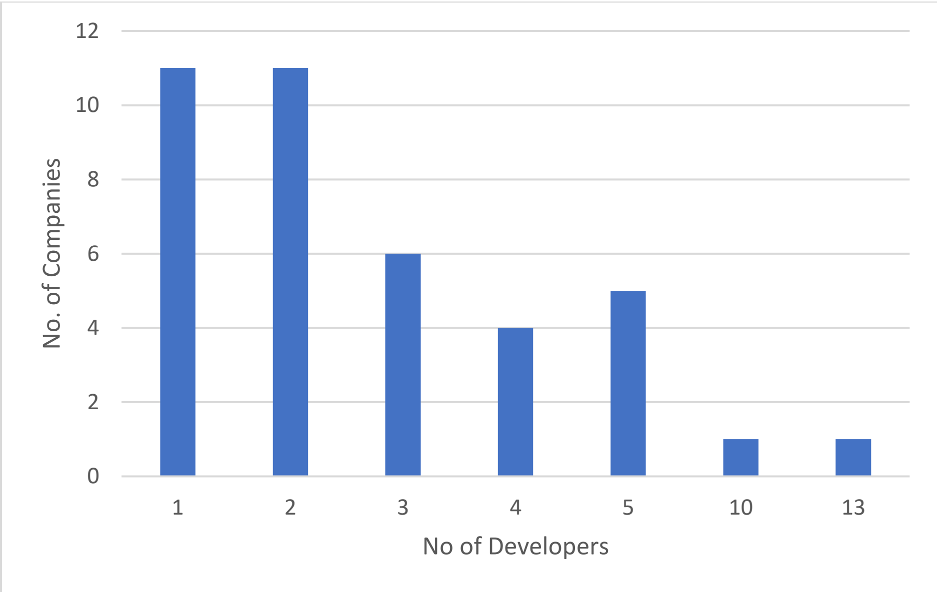

Figure 6-7: No. of developers in Mobile Application Development Organisations

As shown in Figure 6-8: Number of mobile application development organisations established mobile application development organisations were established from 1999 with 68% of mobile application development organisations established from 2011 onwards. This shows that, over time, the number of mobile application organisations has steadily been increasing.

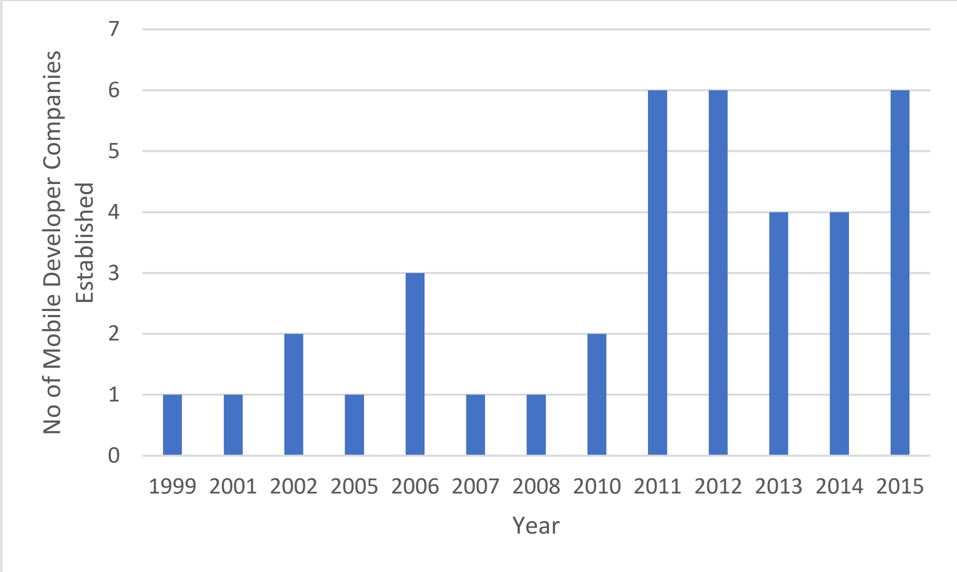

Figure 6-8: Number of mobile application development organisations established

One can thus deduce that Botswana's Mobile Application Development industry is small and young, yet it is a growing industry which is privately owned and dominated by young males.

6.4.2 Funding within Botswana's Mobile Application Industry

Unlike Kenya, where 20.3% of mobile entrepreneurs obtained funding from friends and families (Drouillard et al., 2014), only 4.9% of mobile application individuals and organisations in Botswana obtained funding from family and/ friends and 4.9% did seek funding from family and friends, indicating a possible ease of funding access from family and friends.

The mobile application developers and organisations in Botswana which were set up using owner funding was 87.8%. This percentage indicates that a lot of mobile application developers, similar to the situation in Kenya, bootstrap their start-ups. The majority (94.3%) of the bootstrapped organisations used owner's funds when the mobile application was still only an idea. The owner's funding was considered enough by 88.9% of the mobile application developers, while 11.1% considered their own funding to have been insufficient.

Mobile application development organisations and individuals in Botswana rarely apply for funding. Only 17.5% applied for funding at any stage in the organisation life cycle. Despite the low funding seeking behaviour of mobile application developers in Botswana, 17.9% of organisations did receive funding from funding bodies. This points to the possibility of sufficient funding being available. The received funding was used to: develop ideas into prototypes, develop local mobile phones, increase the number of mobile app offerings, grow organisations and set up workspace for these organisations.

Major funding challenges, as reported by mobile application developers in Botswana, include: strong competition for funding from traditional organisations such as physical product and agricultural producers, high interest rates on funds and stringent funding requirements. Mobile application developers indicated that business pitching, sustainability of the business model, funder understanding of the business and the level of business establishment were minor challenges in obtaining funding, as per Figure 6-9: Funding challenges faced by Mobile Application developers. Other challenges faced by mobile application developers include investor unwillingness to fund mobile apps and limited funding for ICT as most funders prefer traditional investments. This was confirmed in section 7.4.3 by certain support organisations' statements that "Loans are mostly for livestock and physical products" and "No mobile app developer has been funded by the organisation".

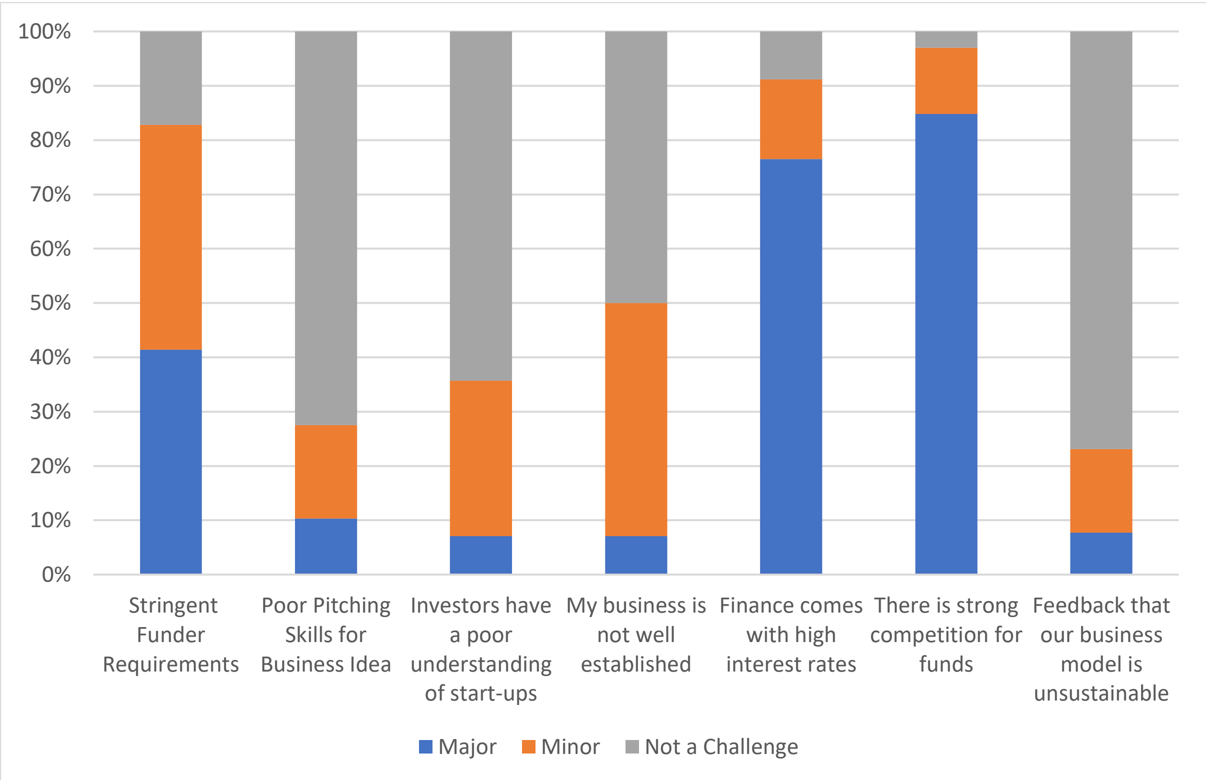

Figure 6-9: Funding challenges faced by Mobile Application developers

An analysis into funding sought, and obtained, at various points in the organisation’s start-up stage revealed, as illustrated in Table 6-4: Fund Seeking and sufficiency at various start-up stages that very few organisations seek any kind of funding. Yet, those that receive the funding find the funds sufficient to address their needs. For example, only 12% of the mobile application organisations sought competition prize money funding. Those mobile application development organisations that received competition prize money received 60% of the funding when the organisation had developed an app prototype and the other 40% of the funding was obtained when the organisation had grown beyond the app prototype stage hinting to an ideal timing for mobile application developers to seek funding. The competition prize money funding was found to be 80% sufficient for the mobile app organization’s needs. A notable observation is that no mobile app organisation in Botswana has approached the interviewed banks for a loan. This can be linked to high loan interest rates and strong competition for funding as challenges already identified.

Although 77% of mobile application developers indicated that “Feedback that our business model is unsustainable” was not a funding challenge, 83% of the funding and support organisations cited it as a major reason for rejecting mobile application developers’ funding requests. There was similar inconsistency when only 7 and 43% of mobile application developers cited “business is not well established” as a major and minor funding challenge, respectively, and yet 64% of support and funding organisations cited it as a major reason for rejecting funding to mobile application developers. Also, 40% of mobile application developers cited “Stringent Funder Requirements “as a major challenge”. Support and funding organisation indicated that 67% of funding applicants did not meet their requirements. Such gaps indicate a miscommunication between funders and mobile application developers which can be addressed by funding bodies workshopping mobile application developers on their requirements to fund mobile apps.

Table 6-4: Fund Seeking and sufficiency at various start-up stages

Funding Type	Sought Funding (%)	Received Funding Stage-wise	Sufficiency of Received Funding
Competition prize money	12.2	60% of funding was received when App prototyped was developed while 40% was received when organisation was growing locally	80% sufficient
Donors	4.9	50% funding received when App was an idea, 50% was received when app prototype was developed	100% sufficient
Angel investors	4.9	50% funding received when App was an idea, 50% was received when app prototype was developed	100% sufficient
Venture capital investment	9.8	100% funding received when App prototype was developed	100% sufficient
Private equity	14.6	66.7% funding received when App prototype was developed, 33.3% when organisation had an app and customers	100% sufficient
Family and friends	4.9	50% of funding was received when App prototyped was developed while 50% was received when organisation was growing locally	100% sufficient
Bank loans	0	None	N/A

The above findings lead to the conclusion that Botswana's Mobile Application Organisations are bootstrapped using owner funds and rarely seek external funding due to several perceived challenges.

6.4.3 Botswana's Mobile Application Developers Skills

Close to 98% of Botswana's mobile application organisations were founded by people with a technical background and business skills were acquired along the way. Only 15% of the mobile app founders had mentorship with 85% never being mentored. An analysis of mentorship of mobile application organisation founders reveals that only 5% of mobile application founders had mentorship in business acumen, marketing, financial skills and/or mobile technical skills whereas only 2% were mentored as to management and/or intellectual property rights. The reported weak revenue sources, unwillingness to seek funding and failure to meet funder requirements could be addressed if mobile application developers were mentored in various areas of business skills as all recipients of mentorship indicated that mentorship was a key success factor to mobile application development.

Table 6-5: Mentorship Uptake and Mobile App Organisation Success shows that all founders who received mentorship indicated that the mentorship was a key success factor to the success of their mobile app organisations.

Table 6-5: Mentorship Uptake and Mobile App Organisation Success

Mentorship Type	Had Mentorship (%)	Considered Key in Mobile Application Success
Business acumen	5	100% of mentorship recipients considered it a major success factor in mobile app development
Management	2	100% of mentorship recipients considered it a major success factor in mobile app development
Marketing	5	100% of mentorship recipients considered it a major success factor in mobile app development
Intellectual property rights	2	100% of mentorship recipients considered it a major success factor in mobile app development
Financial Skills	5	100% of mentorship recipients considered it a major success factor in mobile app development
Mobile Technical Skills	5	100% of mentorship recipients considered it a major success factor in mobile app development

It can be concluded that Botswana's mobile application organisations are founded by technical minded individuals with some business skills who receive very limited mentorship and technical partnerships during any stage of the start-up. Such limited mentorship affects the business' ability to obtain funding and grow.

6.4.4 Partnerships between Botswana's Mobile Application Developers and Critical Organisations

Despite mobile applications' dependence on mobile devices and mobile service providers, only 18% of mobile app developers in Botswana have partnerships with any one of the mobile service providers. Slightly fewer mobile app organisations (10%), however, have integrated their apps with mobile service providers' payment systems, authentication systems, network and location services as these might be, what mobile application developers consider, a key success factor to mobile application development.

Only 2.4% of mobile app organisations in Botswana have partnerships which allow them to access internet connectivity, or access office space, server leases or operating system leases. This despite the fact that 25 to 30% of the funding and support providers provide these services to individuals and companies as part of their core mandate. It is also clear, from Table 6-6: Technical Support Partnership Uptake and Mobile App Organisation Success, that the uptake of various forms of technical support is low among mobile application developers, despite them being considered key success factors in mobile application development.

Table 6-6: Technical Support Partnership Uptake and Mobile App Organisation Success

Partner Arrangement	Has Partnership (%)	Considered Key in Mobile Application Success
Office Space	2.4	100% of office space partnerships considered it a major success factor in mobile app development
Internet Connectivity	2.4	100% of internet partnership recipients considered it a major success factor in mobile app development
Server and Operating System Leases	5	50% of Server and Operating System partnership recipients considered it a major success factor in mobile app development
Integration with MSP payment, network, location, authentication etc. systems	10	100% of integration service partnership recipients considered it a major success factor in mobile app development

Partnerships between Mobile Application developers and Technical support organisations, such as Mobile Service Providers, despite being identified as a key success factor, are still limited.

6.4.5 Botswana's Mobile Applications Market: Perspectives from mobile Application Developers

Botswana appears, to mobile application developers, to have a small market for mobile applications due to low consumption of apps and mobile applications being a new field. Internet accessibility, due to pricing as well as connectivity reliability and coverage, is a concern raised by mobile application developers. A low consumption of mobile applications was noted as a challenge for mobile application developers. This challenge was attributed to low Information Technology knowledge amongst the broader Botswana population and low online presence for business in the country. Mobile application developers in Botswana thus believe that the Botswana market for mobile applications is still new, should overcome internet connectivity challenges and has low consumption of mobile applications due to limited Information Technology knowledge among consumers.

6.4.6 Framework Recommendations

6.4.6.1 *Mentorship, training on funding requirements as well as innovation driven funding for mobile application developers*

Funding and supporting organisations indicated that mobile app developers in Botswana are not innovative enough and rarely have viable business models. The gap between funders and mobile application developers' understanding of funding requirements asks of funding bodies to engage mobile application developers in understanding funding requirements, in addition to mentorship. Mentorship of mobile application developers can help in marketing and market analysis, business acumen, management, marketing, intellectual property rights and financial skills to solve low revenue sources and in developing proposals that can meet funder requirements. Training can also be offered by funding and support organisations as well as higher education institutions to increase the chances of success among mobile application developers. Innovation driven funding and procurement models can be implemented by government, and non-governmental organisations, by offering funding for and procuring mobile apps that will drive the achievement of Botswana's Vision 2036, or their goals, respectively.

6.4.6.2 *Mobile application developers to be encouraged to actively seek funding and do so after developing a prototype*

Mobile Application Developers must actively seek funding and do so when their application is at the prototype stage, or later, and actively strive to develop innovative solutions. The low funding seeking behaviour among mobile application developers in Botswana was noted. Despite confirmations of challenges faced, from the 18% of mobile application developers which sought funding, a similar percentage of mobile application developers managed to receive funding from various sources. Higher education institutions and funding bodies can encourage fund seeking among mobile application developers through the creation of awareness of the availability of funding and by training current and potential mobile application developers on how to meet funding requirements.

6.4.6.3 *Mobile application developers to partner with support organisations*

Partnerships with various support organisations for office space, internet connectivity, server and operating system leases, integration with mobile service providers payment, network, location and authentication systems are considered a key success factor in mobile application development. Mobile application developers thus need to seek such partnerships. MSPs, because they would benefit from higher data consumption and a growing customer base from mobile app users, can offer support in the form of reduced data, or no data costs, for local mobile apps as part of the benefits of partnering with mobile application developers.

6.4.6.4 *Government to support mobile application developers through funding and internet connectivity challenge resolutions*

Funding for mobile application developers can be increased, or dedicated funding set aside, to fund mobile applications as traditional financial institutions focus on more traditional funding. Such funding can be awarded through innovation competitions and/or other funding models that have *innovation* as part of the awarding criteria. Once such support is available, the need to inform mobile application developers becomes essential and a body representing mobile application developers can be created to facilitate such communication. Resolving internet connectivity challenges can be addressed by expanding fibre connections in the country, motivating mobile service providers to reduce charges and encouraging smart phone adoption and training Botswana's population on how to use them.

6.4.6.5 *Information and Communications Technology Training (ICT) for the population and enhancing internet connectivity access*

Developing the mobile applications market and enhancing app consumption requires users to be knowledgeable regarding ICT, hence the need to create ICT skills among the general population of Botswana. Such training can target users of mobile phones to increase awareness of information access via mobile phones. Increased access to information via mobile devices can be improved if the cost of mobile data is reduced, as well as availing internet services to basic phones. Such an initiative is specified as digital literacy programmes in the draft national broadband strategy for Botswana (Ministry of Transport and Communications, 2016).

6.4.6.6 *Driving gender equality in the mobile application development industry in Botswana*

As noted in the findings, mobile application developer leadership and operation roles are male dominated, thus creating opportunities for females to participate in the mobile application industry. This can be achieved by dedicating funding and reserving training and mentorship seats for female mobile application developers.

6.5 Summary

This chapter sought to explore, determine and evaluate the elements of a mobile applications innovation ecosystem framework from a mobile applications industry perspective. The framework components were presented in section 6.3. An evaluation of these elements was done through structured face to face and telephonic interviews with 41 mobile application developers leading to enhanced and more relevant mobile applications innovation ecosystem framework components from a mobile industry perspective. Framework version 2 is presented in this section. The findings from this study will enable higher education stakeholders, mobile application entrepreneurs, funding bodies, government policy developers, mobile network providers, non-governmental organisations, curriculum developers of mobile application programming in higher education and other commercial support bodies to obtain a better understanding as to the challenges faced by mobile entrepreneurship and the possible ways in which these challenges can be addressed to thus create an enabling environment for mobile entrepreneurship for Botswana’s knowledge based economy.

The final updated framework version 2 is consequently presented as a concept map diagram in Figure 6-10 and the summarised framework is illustrated in Figure 6-11.

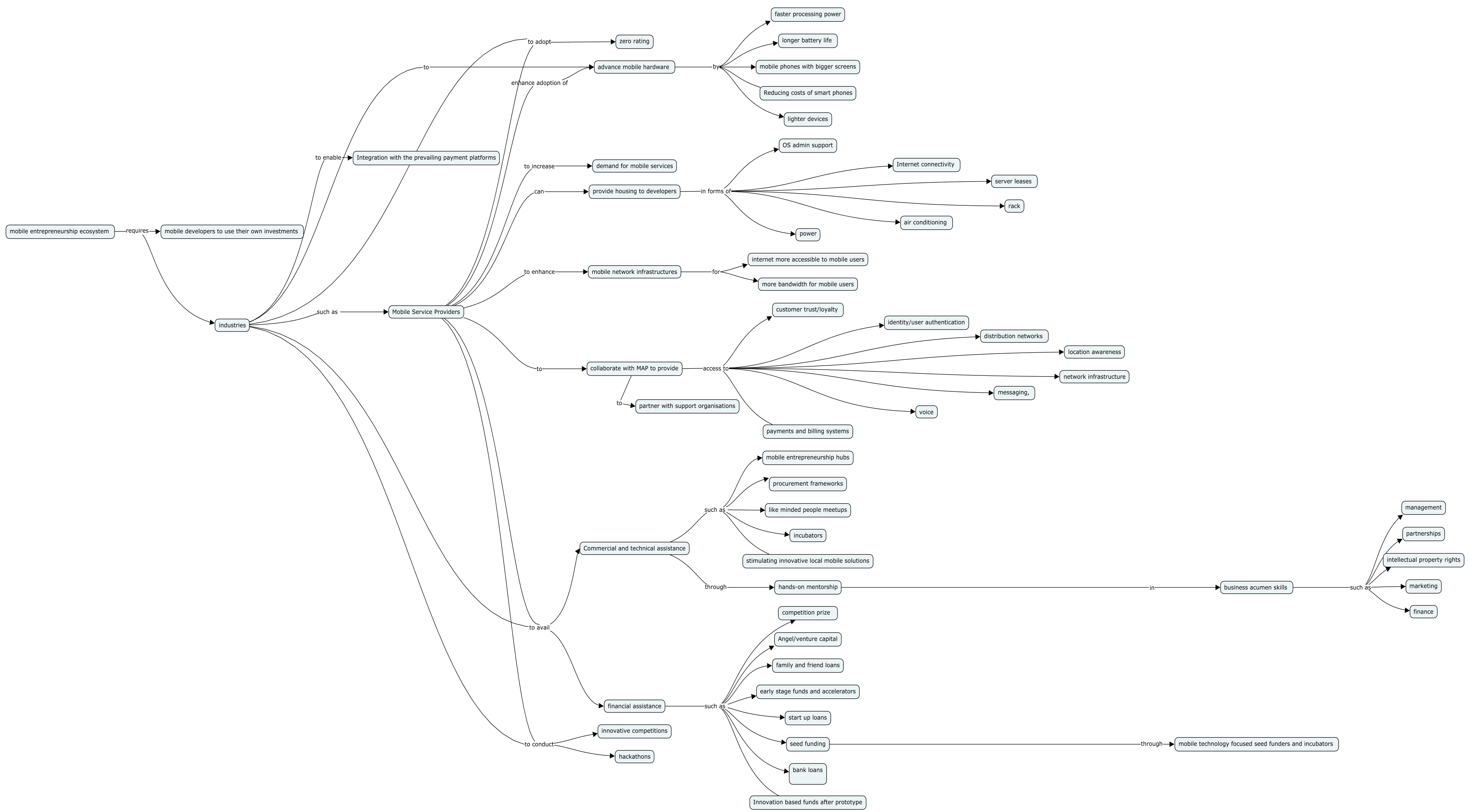

Figure 6-10: Industry Perspective: Mobile Applications Innovation Ecosystem Framework v2 Components Concept Diagram

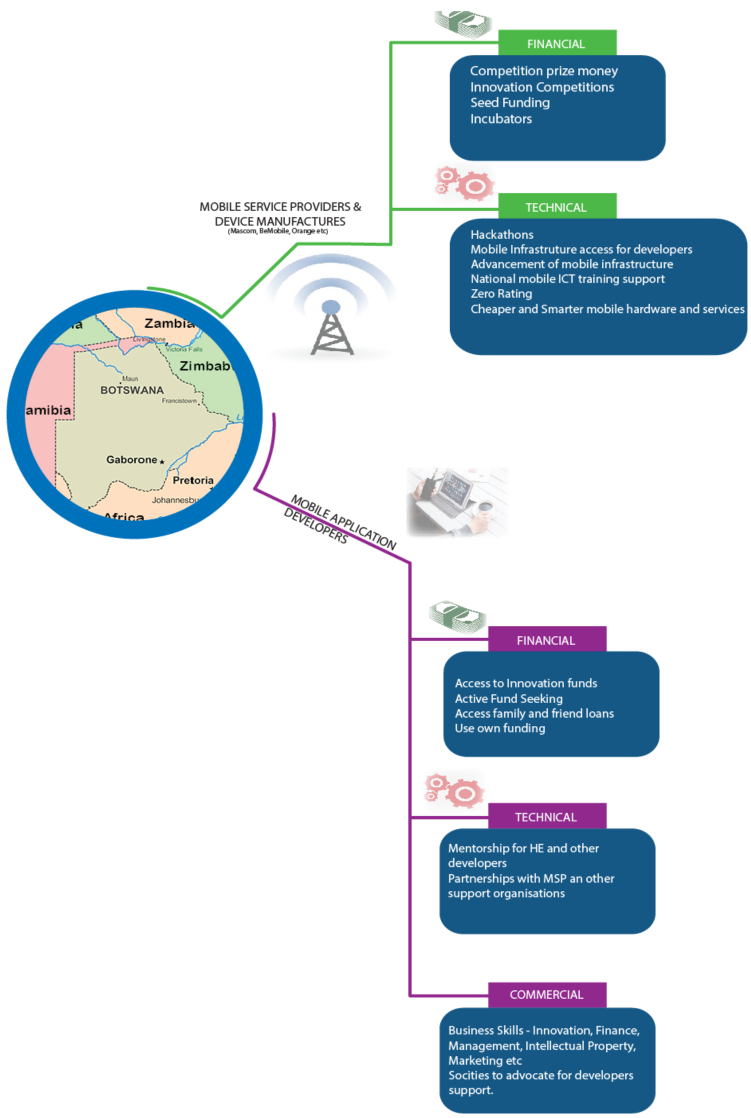

Figure 6-11: Industry Perspective: Mobile Applications Innovation Ecosystems Framework v2

Chapter 7 Government Perspective of a Mobile Applications Innovation Ecosystem

7.1 Introduction

Chapters 5 and 6 presented framework versions 1 and 2 which were created from the components of a mobile applications innovation framework, from HE and Industry perspectives respectively, based on the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005). The challenges and opportunities faced by HE students as well as mobile application developers within a mobile applications innovation ecosystem were also discussed. This chapter uses literature to provide the DSR rigor and design. In addition, it evaluates framework version 3 by addressing Research Question 3 from the Government perspective of the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005).

RQ_3. What are the components, support opportunities available to the mobile applications innovation ecosystem from the Government perspective, and what is the uptake of this support?

This chapter, as illustrated by Figure 7-1, provides the third of three iterations to rigor, design, relevance and evaluation of Phase 1 by focusing on the Government perspective. The developed framework will, together with the designs from Higher Education (Chapter 5) and Industry (Chapter 6) perspectives, inform Phase 2 of the DSR cycle presented in Chapter 8.

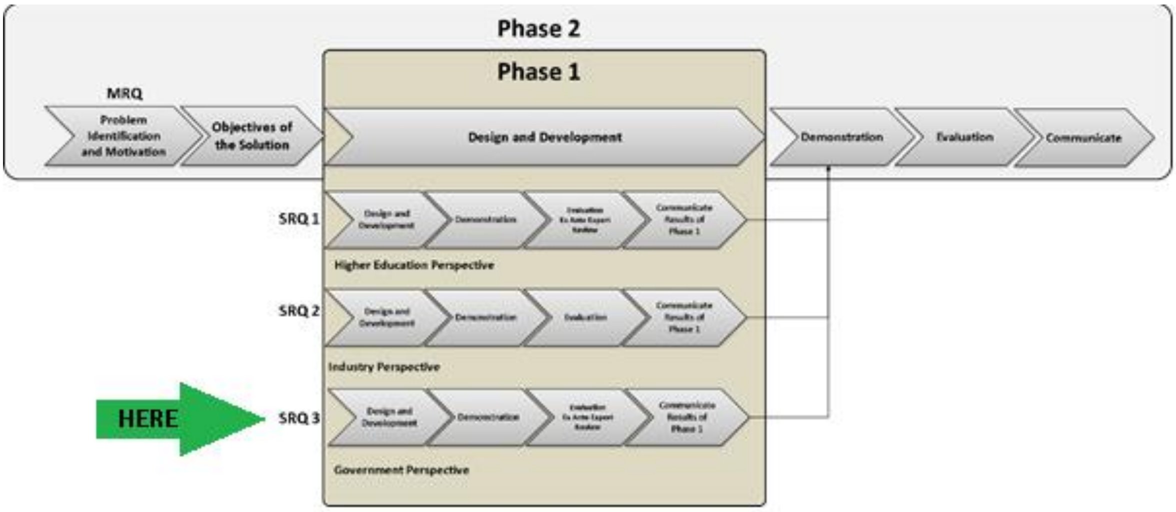

Figure 7-1: Phase 1 - Government: Chapter 7 relative to the DSR Strategy

This chapter presents the components of a mobile applications innovation ecosystem from the government perspective. It evaluates the components by exploring the support availed to the mobile applications innovation ecosystem from 20 government and other support organisations, through interviews, resulting in the design of framework 3 of a Mobile Applications Innovation Ecosystem Framework for Botswana. The next chapter will develop and present a complete synthesised framework from HE, Industry and Government components which will then be evaluated by Knowledgeable Professional/s from all three helixes. A final MAIE framework will subsequently be presented in Chapter 8.

This chapter commences with a discussion of the components of a mobile applications innovation ecosystem, from policy and regulatory points of views (thus the Government perspective), through literature reviews thereby addressing the rigor requirements of DSR. The components are then used to design a framework that will be evaluated for relevance by government stakeholders as well as other support organisations.

7.2 Rigor and Design: Government Components of a Mobile Applications Innovation Ecosystem

Research has shown that government policies and regulations promote, or hinder, innovation (Patanakul & Pinto, 2014). The shape of the digital economy is shaped by government policies and regulation and, as such, most countries have developed national ICT sector strategies for broadband, e-government and local content (The

World Bank, 2016). Government policies on mobile entrepreneurship, taxation and investment policies such as company registration and licensing costs, and purchasing policies should encourage entrepreneurship (Djiofack-Zebaze & Keck, 2009). Governments can ensure competition, regulation and a commitment to pro-competitive policies leading to lower prices and improved availability of mobile telephony services. Concerns regarding the easing of government regulations and access to modern technology were identified as a technical challenge in South Africa (The United Nations Conference on Trade and Development, 2011). The following sections explain how governments can create innovation environments for a mobile applications ecosystem.

7.2.1 Human Capacity

7.2.1.1 *Supporting Entrepreneurship*

Governments can support early mobile application development through: initiating early stage funds and accelerators, implementing procurement frameworks that support local mobile application entrepreneurs, issuing *entrepreneurship visas* and creating mobile entrepreneurship hubs (Drouillard et al., 2014). In Kenya, less than 50% of mobile entrepreneur founding teams felt they possessed all the skills necessary to run the company (Swarts, 2009). In line with the Millennium Development Goal (MDG) and the Sustainable Development Goal (SDG) of achieving quality and lifelong learning, there has been considerable commitment and investments by national governments, and their partners, to improve access, retention and quality of education. Patanakul and Pinto (2014) noted that this is also true of digital entrepreneurship mentoring programmes. Government support can also be in the form of *awareness training* on topics such as: intellectual property rights and through free legal advice. Government can thus, with the help of industry and higher education, support learning of mobile applications development and identify mentorship opportunities to develop the skills required to successfully run mobile applications companies.

7.2.2 Computing and Connectivity: Mobile Network Infrastructure Support

7.2.2.1 *Policies driving mobile application programming*

Phillips et al. (2011) and Sutherland (2014) agree that the mobile network infrastructure is an important factor to guide the development of mobile applications. Gasimov et al.’s (2010) three mobile application development factors can be enhanced if government adopts policies which encourages: (i) the maturity of the mobile network infrastructure, (ii) advancement of mobile hardware, and (iii) the increased demand for mobile services and applications. Regulations and taxation on mobile phones and all associated equipment must therefore be favourable. Botswana has a draft national broadband strategy which aims to create an enabling environment for the deployment, accessibility, availability and utilisation of broadband infrastructure (Ministry of Transport and Communications, 2016).

7.2.2.2 *Policies to regulate network congestion*

African countries obtain their equipment from European and now increasingly from Chinese manufacturers. These mobile operators normally have more customers than their infrastructure can handle and this results in complaints regarding the absence of signals, dropped calls, limited internet speeds and non-delivery of text messages (Sutherland, 2014). Avoiding such congestion requires clear policies by government to regulate network congestion.

7.2.2.3 *National ICT strategies to close the digital divide*

The World Bank (2016) posits that a drive towards the digital economy requires connectivity at four levels:

(i) the *first* mile – the point at which the internet enters a country;

(ii) the *second/middle* mile – the national, intercity internet backbone of the country;

(iii) the *last* mile – the connection between users and their nearest internet point of presence; and

(iv) the *invisible* mile – the less visible network components and potential bottlenecks which include SIM cards, the wireless network and cybersecurity concerns.

The government can thus support the connectivity requirements of a digital economy by enabling internet access across these four miles through international access to the internet. This is done by ensuring that first mile components (such as submarine cable landing stations, satellite dishes, domain name registration), second mile components (such as national backbone and intercity networks), last mile local access network and invisible mile access through policies on SIM card registrations, spectrum management and cyber security, amongst others, are provided (The World Bank, 2016). Botswana's draft national broadband strategy aims to ensure cyber security by ensuring the integrity and security of the broadband networks whilst, simultaneously, protecting and respecting privacy and personal dignity by amending existing consumer laws to cover electronic transactions (Ministry of Transport and Communications, 2016).

Proper mobile network infrastructure management is therefore crucial to developing the mobile ecosystem and so enhance mobile application development. Governments can: adopt pro-competitive policies, offer financial and political support for rural infrastructure by issuing more licenses, reclaiming and re-licensing unused spectrum, encouraging more mobile virtual network operators, require operators to share sites and masts, mandate national roaming agreements and force cost-based interconnection fees (Drouillard et al., 2014).

Botswana's ICT technology and services are licensed according to three categories: Public Telecommunication Operator (PTO), Value Added Network Service (VANS) and Private Telecommunications Network Licence (PTNL) (BOCRA, 2015). The VANS are issued to small-to-medium business enterprises. The number of ICT operators has been slowly increasing as per Table 7-1.

Table 7-1: Number of Licenses per Licensing Category (BOCRA, 2015)

	2011	2012	2013	2014	2015
VANS	53	58	61	64	71
PTNL	29	31	32	33	33
PTO	3	3	3	3	3

Botswana's telecommunications market has four major players: Botswana Telecommunications Corporation, Mascom, Orange and the Botswana Fibre Networks. Ninety five % of Botswana's population is covered by mobile telephony and 98% of these are prepaid services (BOCRA, 2015).

The type of mobile devises approved by BOCRA has been mainly mobile phones constituting 48% of all devices as illustrated in Figure 7-2.

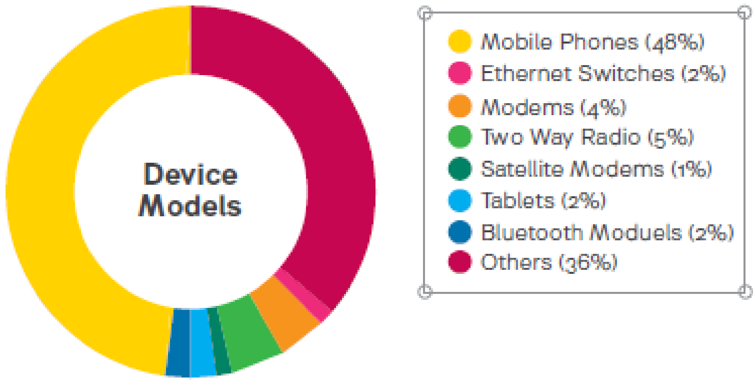

Figure 7-2: Types of approved mobile devises (BOCRA, 2015)

7.2.2.4 *Establishing national broadband targets*

Government, as part of national ICT strategy, can set national broadband targets in terms of speed of service offered and percentage of coverage, penetration and specific groups targeted (OECD, 2018). Rolling out broadband is becoming a priority as 151 countries have already introduced a National Broadband Plan (NBP) (ITU, 2017a). To drive availability targets coverage obligations must be established for service providers as part of the spectrum awarding process (OECD, 2018). Botswana is already moving towards the creation of a national broadband strategy and already has a draft national broadband strategy with minimum broadband speed targets for the country (Ministry of Transport and Communications, 2016). Figure 7-3 illustrates such minimum broadband speeds.

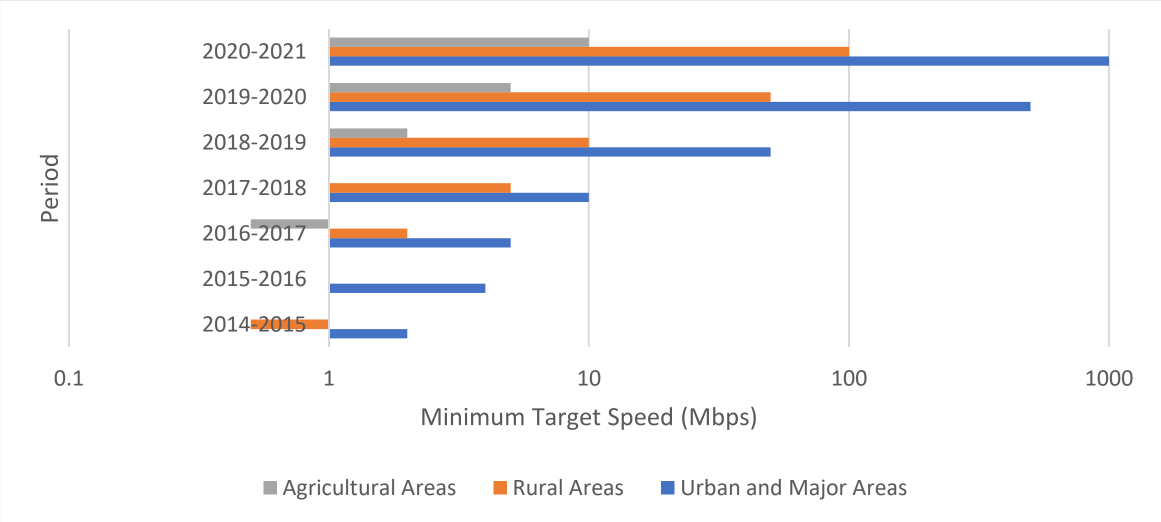

Figure 7-3: Botswana's proposed National Broadband Target Speed (Ministry of Transport and Communications, 2016)

7.2.3 Content Facilitation:

7.2.3.1 *Bridging the internet digital divide*

Digital divide is a term used to describe inequalities of access to technology (Thatcher & Ndabeni, 2011). OECD (2018) states that the term is used to describe “different levels of access and use of information and communication technologies (ICTs) and, more specifically, to the gaps in access and use of Internet-based digital services” (p. 11). Due to profitability challenges posed by poor, rural and sparsely populated areas, the government plays a crucial role in ensuring connectivity, an essential component of ICT4D and mobile application programming as identified by Tongia et al. (2005).

Facilitating access to local content in Botswana is stated as an objective of the draft national broadband strategy. This objective is to be achieved through digital literacy programmes as well as the creation of appropriate and relevant local content (Ministry of Transport and Communications, 2016).

7.2.3.2 *Adopting Electronic Governance*

E-government refers to the usage of ICT by government to exchange information and services with citizens, businesses and other arms of government (Kumar & Sinha, 2007). Adopting e-Gov brings improved efficiency, convenience and results in better accessibility to public services (Kumar & Sinha, 2007). M-Government is thus a subset of e-Gov which limits the ICT to mobile devices such as mobile phones. Africa, having the second highest mobile penetration rate in the world, can benefit from m-governments. Unlike developed countries, the adoption of e-Gov in developing countries focuses mainly on core government administration systems including financial management, customs and tax management rather than transactional government-to-citizen and government-to-business services like e-filing of taxes and portals which enable citizens to access a variety of services from one website (The World Bank, 2016).

Botswana recognises the role of ICT in the delivery of government services and intends to drive efficiencies in both private, and public, sectors using ICT. As stated in Vision 2036, ICT “is also a crucial enabler of efficient product and service delivery across all economic sectors, including in the delivery of government services” and “We will leverage leading information technology ICT as a key contributor to economic growth and employment whilst also enabling an efficient private and public sector" (Vision 2036 Presidential Task Team, 2016, p. 16). Enabling an open government by empowering citizens, collaboration and information sharing can be achieved if private companies and citizens become involved in the creation of government mobile apps (Sandoval-Almazan, Gil-Garcia, Luna-Reyes, Luna, & Rojas-Romero, 2012). The draft national broadband strategy of Botswana has the objective, amongst others, of implementing *Maitlamo* (e-Government, e-Health, e-Education and e-Commerce) initiatives (Ministry of Transport and Communications, 2016).

7.2.3.3 *Reducing taxes on mobile service providers and equipment*

A move by the government to reduce taxes on mobile service providers and the associated mobile equipment would boost internet usage and thereby improve access to the digital economy (West, 2015).

7.2.3.4 *Zero Rating and Net Neutrality Policies*

Zero rating programmes allow consumers access to certain internet traffic without it counting against their data plans (Brake, 2016). Zero rating programmes, as advocated for from the industry perspective, has been differently approached by regulators. Eisenach (2015) highlights the fact that, despite cases in which countries have found zero rating to be in violation of net neutrality laws and thus fined mobile service providers or banned zero rating, broad-based bans, or restrictions, on zero rating plans "are likely to be counterproductive and harm consumer welfare", (p.3). Government can therefore develop policies which encourage zero rating for local content among mobile service providers.

7.2.3.5 *Digital Divide Funds*

Setting up specific universal access funds to increase internet access through mandatory contributions, or spectrum licensing requirements, can be adopted to close inequalities of access to technology (OECD, 2018). The funds, sourced from both private and public sectors, can be used to: fund broadband programmes, reduce deployment costs and fund municipal network (OECD, 2018). Botswana's draft national broadband strategy aims to ensure universal access to broadband services through the development of appropriate funding mechanisms though subsidies and public private partnerships (Ministry of Transport and Communications, 2016). BOCRA runs a Universal Access and Service Fund, established in Aril 2014, which has been tendered to award Wi-Fi hotspots in key strategic areas including hospitals, malls and bus stations (BOCRA, 2015).

7.3 A summary of the Government Components

This section presented the role that government can play in the mobile ecosystem. The components are presented in Table 7-2 and Figure 7-4. Table 7-2 summarises the mobile applications innovation ecosystem elements derived from literature, from a government perspective. The same elements are presented in Figure 7-4 as a concept map diagram.

Table 7-2: Industry components for Mobile Application Programming

Government Support Components for Mobile Application Programming	***Author***
Policies and regulations to enable entrepreneurship visas	*(Drouillard et al., 2014), (The Economist, 2012)*
Procurement frameworks that encourages mobile entrepreneurship	*(Drouillard et al., 2014)*
Network congestion regulation to avoid dropped calls, non-delivery of text messages, absence of signals, limited internet speeds	*(Sutherland, 2014)*
Broadband national ICT strategies for first mile connectivity through satellite, domain name registration, submarine cable landing stations	*(The World Bank, (2016)*
Broadband national ICT strategies for second mile connectivity through intercity networks, national backbones	*(The World Bank, 2016)*
Broadband national ICT strategies for last mile connectivity through many points of presence	*(The World Bank, 2016)*
Broadband national ICT strategies for invisible mile connectivity through SIM card registrations, cyber security, forcing cost-based interconnection fees, sharing of sites and masts	*(The World Bank, 2016)*
Broadband national ICT strategies for invisible mile spectrum management through reclaiming and relicensing unused spectrum, encouraging mobile virtual network operators, issuing more licenses	*(The World Bank, 2016)*
Adopt pro-competitive policies	*(Drouillard et al., 2014)*
Offer financial and political support for rural infrastructure	*(Drouillard et al., 2014)*
Mandating national roaming agreements	*(Drouillard et al., 2014)*
Establishment of Universal Access and Service Fund/digital divide funds	(BOCRA, 2015), *(OECD, 2018)*
Becoming a public entrepreneur/venture capitalist by setting up mobile entrepreneurship hubs	*(Drouillard et al., 2014)*
Becoming a public entrepreneur/venture capitalist by offering early stage funds and accelerators	*(Drouillard et al., 2014)*
Extending Education For All (EFA) in the form of awareness trainings regarding intellectual property rights, through free legal advice	*(Patanakul & Pinto, 2014)*

Government Support Components for Mobile Application Programming	***Author***
Adopting mobile governance and enabling companies to develop government apps	(Sandoval-Almazan et al., 2012)
Taxes that favour mobile service providers to boost internet usage and thereby improve access to the digital economy	*(West, 2015)*
Importing of mobile phones and network infrastructure to boost internet usage and thereby improve access to the digital economy	*(West, 2015)*
Policies that allow zero rating	*(Eisenach, 2015)*
Policies that encourage net neutrality	*(Eisenach, 2015)*
ICT strategies that establishes national broadband targets in terms of speed of service offered and percentage of coverage, penetration and specific groups	*(OECD, 2018)*
Policies that encourage the maturity of the mobile network infrastructure	*(Gasimov et al., 2010)*
Policies that encourage advancement of mobile hardware	*(Gasimov et al., 2010)*
Policies that encourage increased demand for mobile services and applications	*(Gasimov et al., 2010)*
National ICT sector strategies for local content	*(The World Bank, 2016)*
Taxation policies that encourage mobile entrepreneurship	*(Djiofack-Zebaze & Keck, 2009)*
Favourable investment policies such as company registration and licensing costs	*(Djiofack-Zebaze & Keck, 2009)*
Purchasing policies that encourage entrepreneurship	*(Djiofack-Zebaze & Keck, 2009)*
Governments can adopt pro-competitive policies leading to reduced prices and improved availability of mobile telephony services	*(The United Nations Conference on Trade and Development, 2011)*

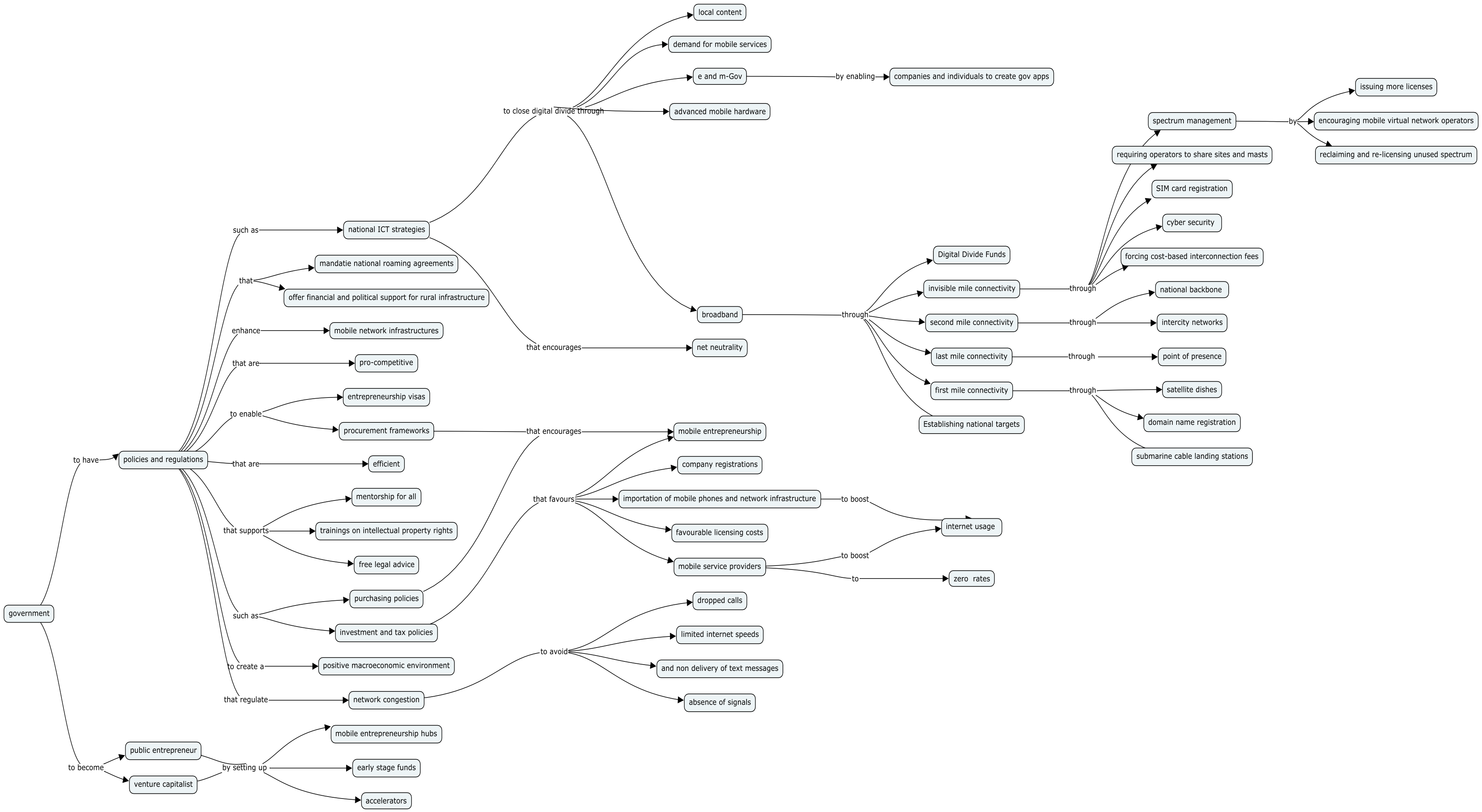

Figure 7-4: Government Perspective: Mobile Application Innovation Ecosystem Framework Components Concept Map

7.4 Government Relevance and Evaluation Cycle: Mobile Application Programming Support and Uptake

This section provides the relevance and evaluation cycle to the DSR by exploring the components which support the Botswana mobile applications ecosystem, as provided by the government and other support organisations, as well as the uptake of said support towards addressing the research question.

RQ$_3$. What are the components, support opportunities available to the mobile applications innovation ecosystem from the Government perspective, and what is the uptake of this support?

To establish the support availed to mobile application developers by the government, and other support organisations, the study used structured face-to-face and telephonic interviews to collect data from twenty funding and business support institutions, 14 of which are government-controlled institutions and 6 which are privately owned in Gaborone, Botswana. A purposeful sampling technique was used to extract information from information-rich sources based on their match of being a government or support provider of technical or funding support in Botswana.

Structured interviews were used as the research instrument to identify the extent to which financial and technical support is offered to mobile application developing organisations and individuals by government, financial and other support organisations in Botswana. Refer to Appendix 0-10: Phase 1 Research Structured Interview Tool - MSP, Support and Funding Agencies Instrument, for the interview instruments. To ensure adherence to the four principles of informed consent, absence of deception, privacy and confidentiality and accuracy (Christians, 2005), consent was obtained before the interviews and data were collectively analysed, thus anonymising the participants.

7.4.1 Biometric Profile of the Mobile Entrepreneurship Support Sector in Botswana

As shown in Figure 7-5: Support organisations interviewed and Figure 7-6: Support organisations ownership, the funding and business support institutions interviewed included four banking institutions, which are 50% government owned, and 50% parastatals, jointly owned by the government and private sector. The single communications regulator interviewed was government owned. The three entrepreneurship support institutions sampled were all government owned. The three mobile service providers which were interviewed included one which was government owned, and two privately owned MSPs. Botswana's sole national wholesale internet service provider, which is government owned, was included in the sample interview as well as three venture capitalists sampled which included two privately owned organisations and one parastatal. Of the 5 youth support organisations in the sample, 4 are government owned and one, a parastatal. Thus, 14 government-controlled institutions (70%) and 6 private support providers (30%) were sampled and interviewed.

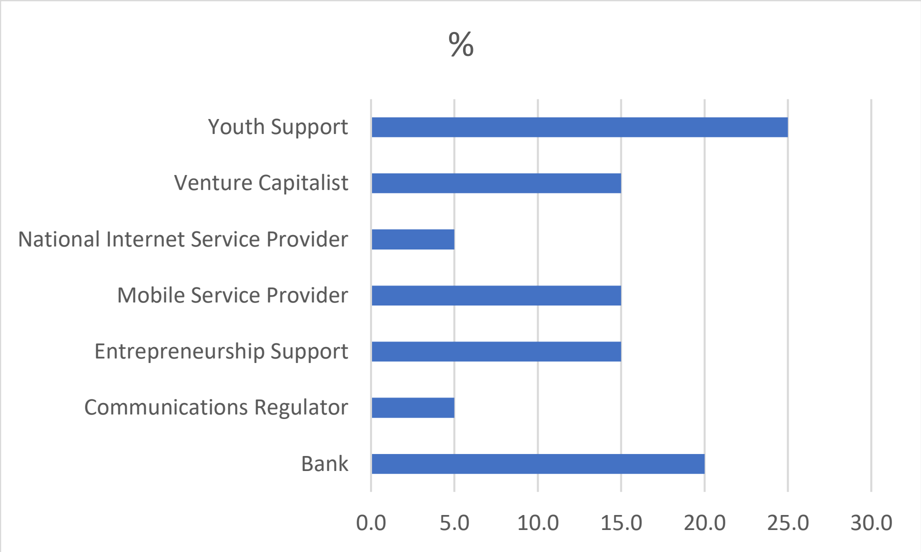

Figure 7-5: Support organisations interviewed

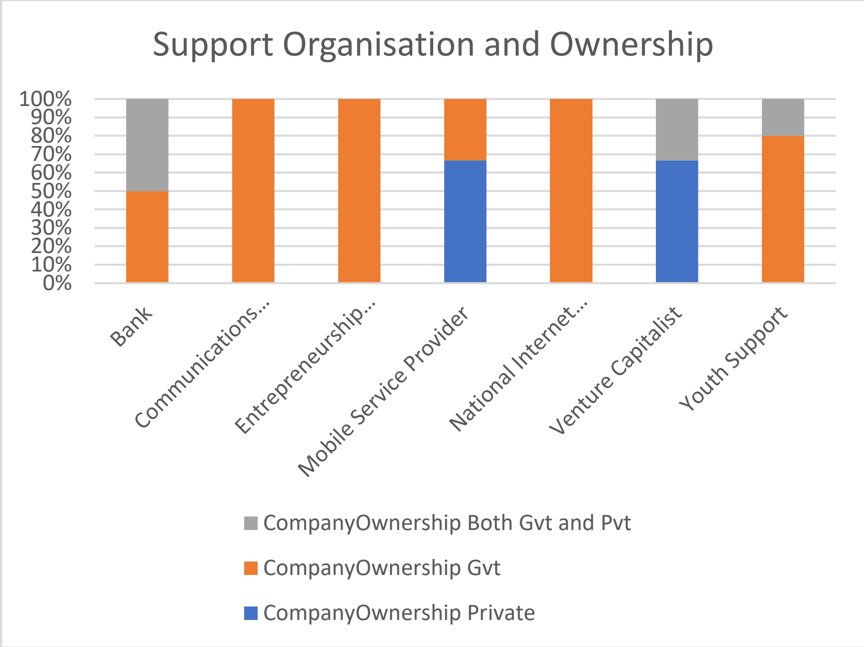

Figure 7-6: Support organisations ownership

An analysis of the size of the support organisations, in terms of number of employees, shows that Botswana's support organisations are large and government owned, as shown in Figure 7-7: Support organisations size by employee numbers. Only one organisation (a private venture capitalist) had between 5 and 9 employees while the rest of the sampled support organisations had more than 15 employees.

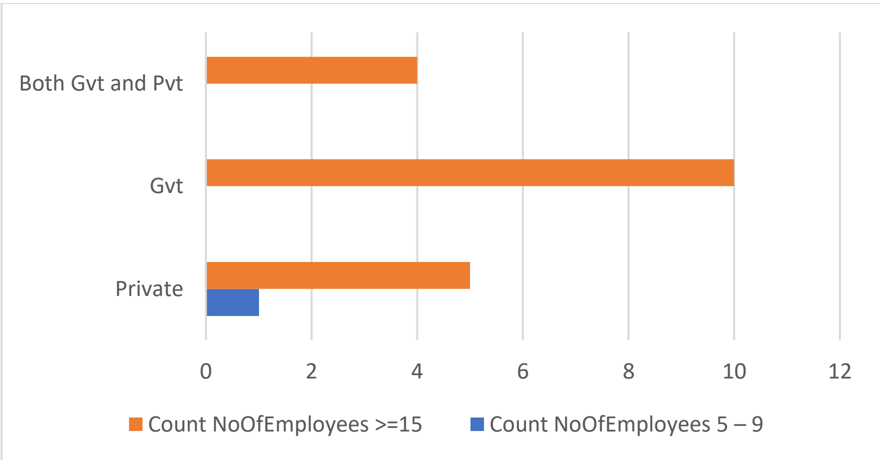

Figure 7-7: Support organisations size by employee numbers

The previous discussion shows that government, compared to the private sector, plays a major role in supporting the establishment and growth of mobile application entrepreneurship in the country. The one exception being the provision of mobile service provision and venture capital provision services.

7.4.2 Technical Support Available to Mobile Application Developers

The technical support availed to mobile application developer organisations, or individuals, in Botswana by the sampled support organisations included: the provision of office space, internet connectivity, server and operating system leases, integration with various MSP services, payment authentication, support services and training. The support organisations interviewed provided several support services, as indicated in Figure 7-8: Core Mandates (Technical) of Sampled Support Organisations, with 30 and 25% of the respondents offering training to individuals and/or companies as their core mandate. Integration with various MSP services such as network, location and authentication systems are provided by 20% of the respondents to both individuals and companies alike. Thirty % of respondents provide payment authentication and facilitation services to individuals and companies alike as their core mandate. The leasing of server and operating systems to companies and individuals, respectively, is offered by 30 and 25% of the respondents. Internet connectivity support is offered by 25% of the respondents as a core mandate, regardless of being a company or an individual. The provision of office space support was a core mandate of 25% of the respondents, regardless of the entity occupying the space being a company or an individual.

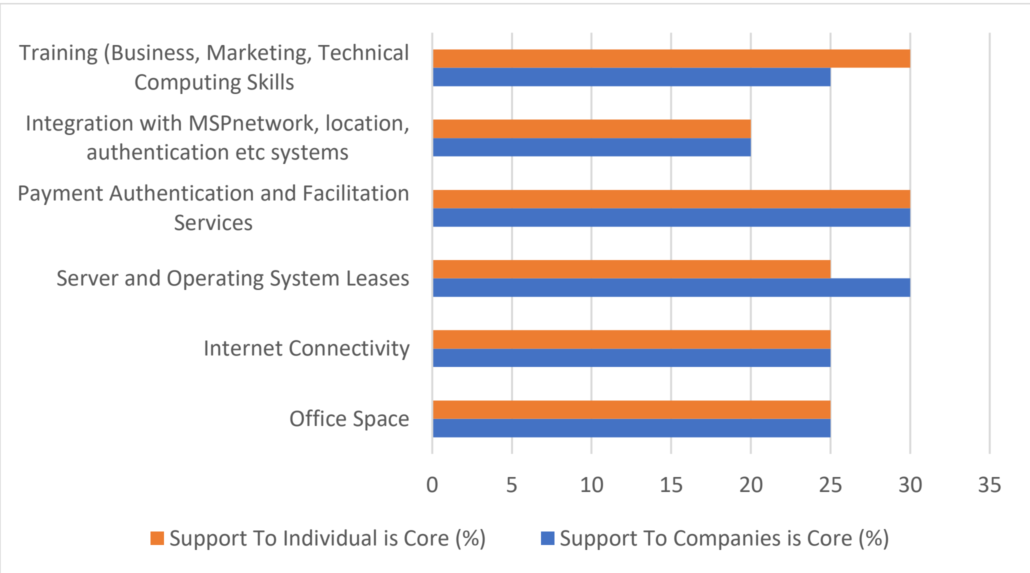

Figure 7-8: Core Mandates (Technical) of Sampled Support Organisations

As per Figure 7-9: Technical Support Offered to Mobile Entrepreneurship established companies are afforded access to more support, when compared to individuals. Of the

20 sampled support organisation, 30% offered training to individuals while 35% offered the same service to companies, 20% offered MSP integrated services to individuals while 25% offered the same service to companies, 30% offered payment authentication and facilitation services to individuals while 35% offered the same to companies, 25% offered internet connectivity services to individuals while 30% offered the same service to companies, 25% offered office space services to individuals while 30% offered the same service to companies. Server and operating system lease support services were equally availed to both companies and individuals by 30% of the sampled mobile support service providers. A bias towards the provision of support to companies compared to individuals is evident in the areas of training, integration support, payment authentication, internet connectivity and office space support services.

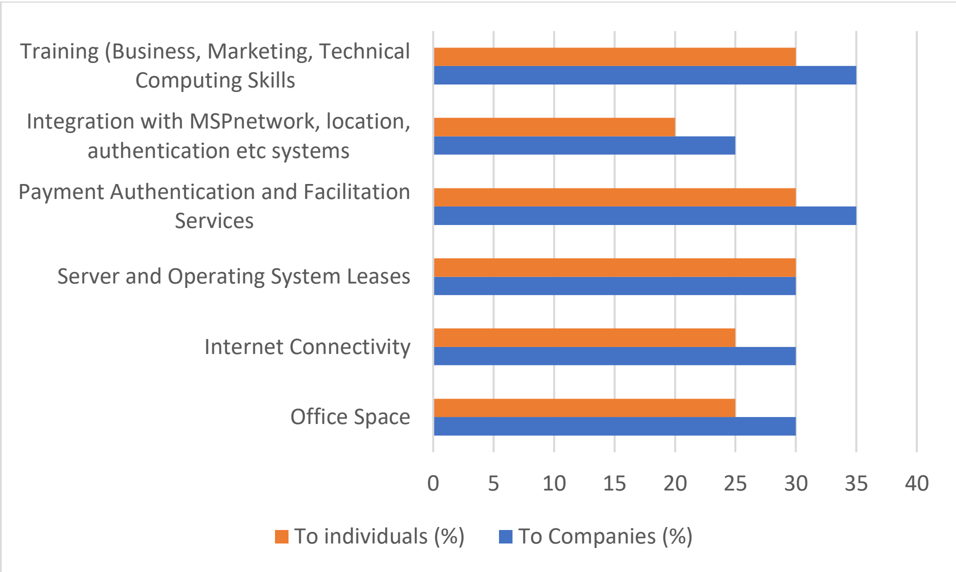

Figure 7-9: Technical Support Offered to Mobile Entrepreneurship

The provision of technical support services, both from government and the private sector, was analysed from the sampled support organisations and the findings are presented in the following section. As shown, government support is relatively larger in training support while other forms of support are largely dominated by private support organisations.

7.4.2.1 *Training Support Services Status by Support Organisation Ownership*

The training services availed to mobile application entrepreneurs in Botswana included training regarding business, marketing, technical computing skills including intellectual property rights. As shown in Figure 7-10: Technical support by provider type20% of the sampled government organisations provided training support to individuals and 20% to companies while 10% of the private sector respondents provided training support to individual MAP developers and 10% to MAP companies.

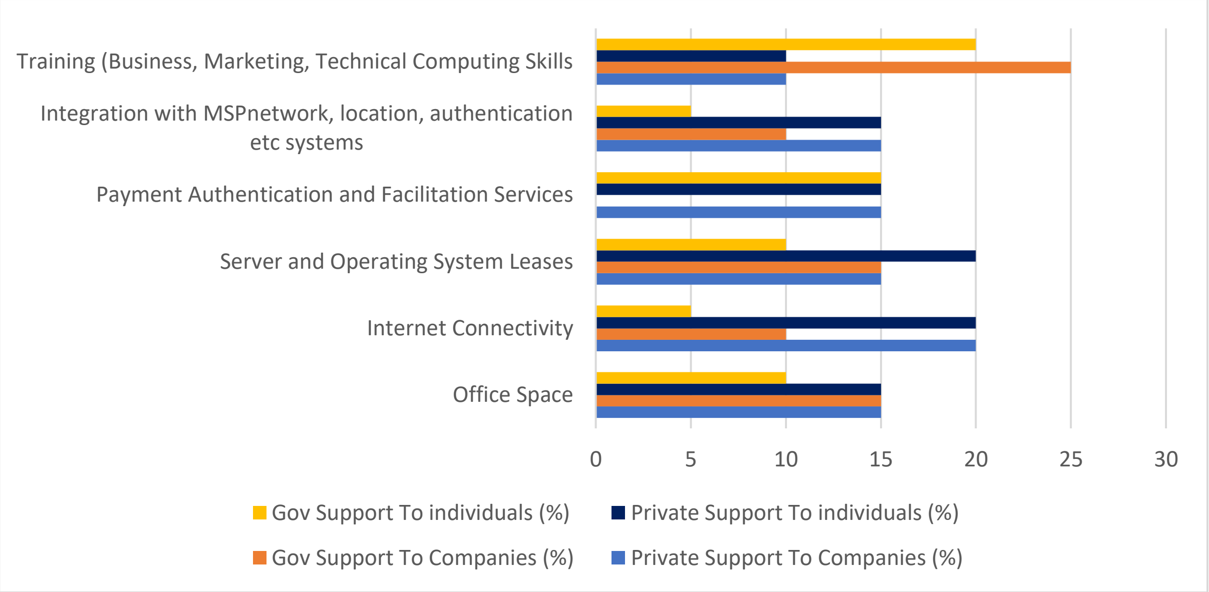

Figure 7-10: Technical support by provider type

A single support organisation (parastatal) provided training services exclusively to companies, thus accounting for the 5% difference observed in Figure 7-9: Technical Support Offered to Mobile Entrepreneurship. It is evident that training support is provided largely by the government to both individuals and companies, with a bias towards companies. The private sector does offer training services, but to a lesser extent than government organisations. Both, however, offer training services equally to individuals and companies.

7.4.2.2 *MSP Integration Support Services Status by Support Organisation Ownership*

The MSP integration services availed to mobile application entrepreneurs in Botswana included access to MSP application programming interfaces, network, location and authentication systems. As shown in Figure 7-10: Technical support by provider type, 5% of the sampled government organisations provided MSP integration support to individuals and 10% to companies while 15% of private sector respondents provided MSP integration support to both individual MAP developers and MAP companies. The private sector provides more MSP integration support services as most MSPs in Botswana are privately owned.

7.4.2.3 *Payment Authentication and Facilitation Support Services Status by Support Organisation Ownership*

The payment authentication and facilitation services available to mobile application entrepreneurs in Botswana included payment channels which facilitate the exchange of money, such as mobile money transactions, as well as bank transfers. As shown in Figure 7-10: Technical support by provider type15% of the sampled government organisations (10% government and 5% parastatal) provided payment authentication and facilitation support to individuals and a single parastatal (5%) provides the same to companies. The private sector is not selective as 15% of the respondents provides payment authentication and facilitation support to individual MAP developers and MAP companies alike. It is evident that payment authentication and facilitation support, to both individuals and companies, is largely provided by the private sector.

7.4.2.4 *Server and Operating System Lease Support Service Status by Support Organisation Ownership*

The server and operating system lease services availed to mobile application entrepreneurs in Botswana included cloud-based services which enable access to hardware and software from cloud services without the need to purchase, set up and administer MAP developers' own servers. As shown in Figure 7-10: Technical support by provider type10% of the sampled government organisations provided server and operating system lease support to individuals and 15% to companies while 20% of the private sector respondents provided server and operating system lease support to individual MAP developers and 15% to MAP companies. It is evident that server and operating system lease support is equally availed to companies by both government and private support organisations while the private support providers are twice more likely to offer the same to individual mobile app developers than the government. This was observed to be the case because most server and operating system lease services were provided largely by privately owned mobile service providers.

7.4.2.5 *Internet Connectivity Services Status by Support Organisation Ownership*

The internet connectivity services were the largest technical support availed to mobile application entrepreneurs in Botswana. As shown in Figure 7-10: Technical support by provider type only 5% of the sampled government organisations provided internet connectivity support to individuals and 10% to companies while 20% of the private sector respondents provided internet connectivity support in equal measure to both individual and company MAP developers. This was also attributed to the influence of MSPs which are largely privately owned.

7.4.2.6 *Office Space Support Services Status by Support Organisation Ownership*

Office space services availed to mobile application entrepreneurs in Botswana included free, subsidised and paid for offices. As shown in Figure 7-10: Technical support by provider type10% of the sampled government organisations provided office space support to individuals and 15% to companies while 15% of the private sector respondents provided office space support to both individual MAP developers and MAP companies. It was observed that most office space support was availed through innovation hubs operated by some MSPs and the government's Botswana Innovation Hub.

7.4.3 Financial Support Available to Mobile Application Developers

The financial support available to company, or individual mobile application developers, in Botswana by the sampled support organisations ranged from competition prize money, donations, angel investing, venture capital investment, private equity, loans and other financial support. From the 20 sampled support organisations, Figure 7-11: Core Mandates (Financial) of Sampled Support Organisations shows that most (40 and 35%) of the respondents offer financial support in the form of loans to companies and individuals, respectively. The second largest financial support is afforded by venture capital investment which is offered by 35% of the respondents to companies and individuals alike. Private equity and competition prize money was the third largest financial support available to mobile application developers as 30% of the respondents offered this support to companies and individuals alike. Angel investment and financial donations were core mandates of

20% of the respondents and this was available to both individuals and companies alike. The provision of other financial support services, not mentioned above, was a core mandate of 1 (5%) of the respondent and this was available to companies and individuals alike.

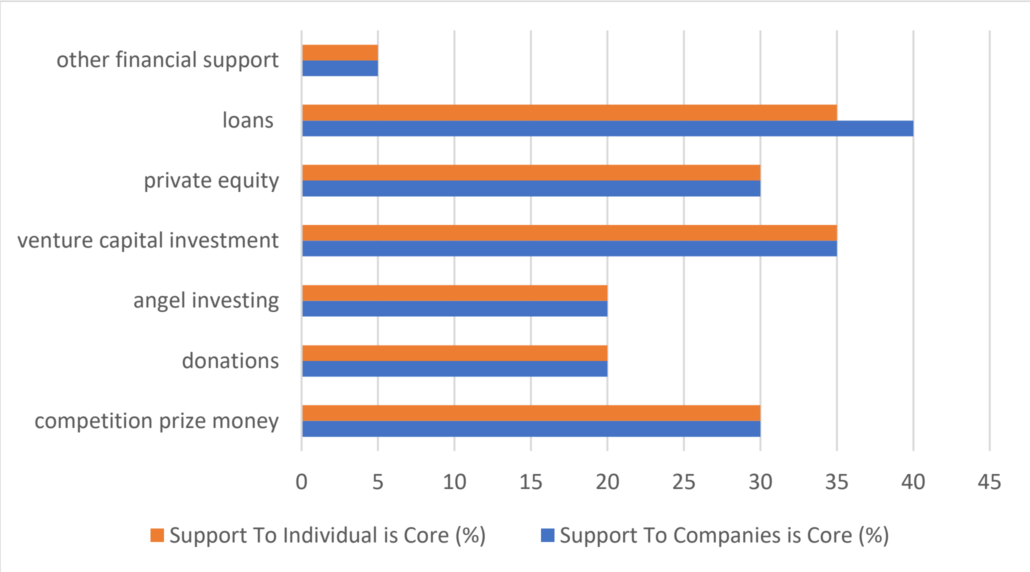

Figure 7-11: Core Mandates (Financial) of Sampled Support Organisations

As seen in Figure 7-12: Financial support offered to mobile entrepreneurship, established companies obtain access to more support when compared to individuals in most support categories. Of the 20 sampled support organisations, 35% offered competition prize money to companies compared to 25% being offered to individuals. Financial donations were also biased towards companies as 30% of the respondents offered donations to companies whilst only 25% offered the same to individuals. Venture capital investment support was offered in equal measure to both individuals and companies from 35% of the respondents while private equity was offered by 30% of the respondents to both companies and individuals alike. Loans, as a financial support service, was offered by 40% of the respondents to companies while 35% of the respondents offered loans to individuals. The provision of other financial support services was offered to companies by 5% of the respondents while 10% offered the same to individuals. A bias towards the provision of support to companies compared to individuals is evident from loans, donations and competition prize money.

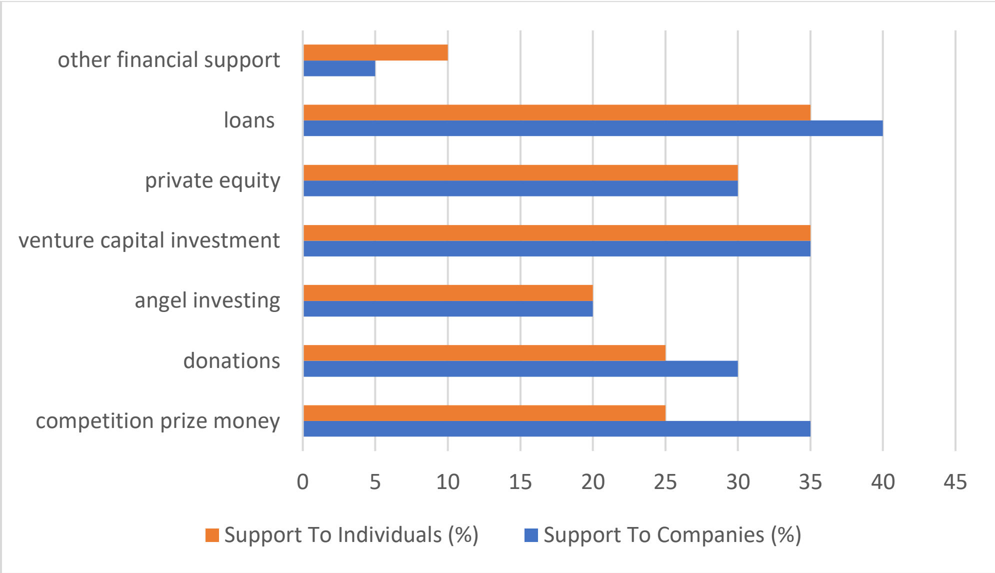

Figure 7-12: Financial support offered to mobile entrepreneurship

The provision of financial support services from the government and private sector was analysed from the sampled support organisations and the findings are presented in Figure 7-13.

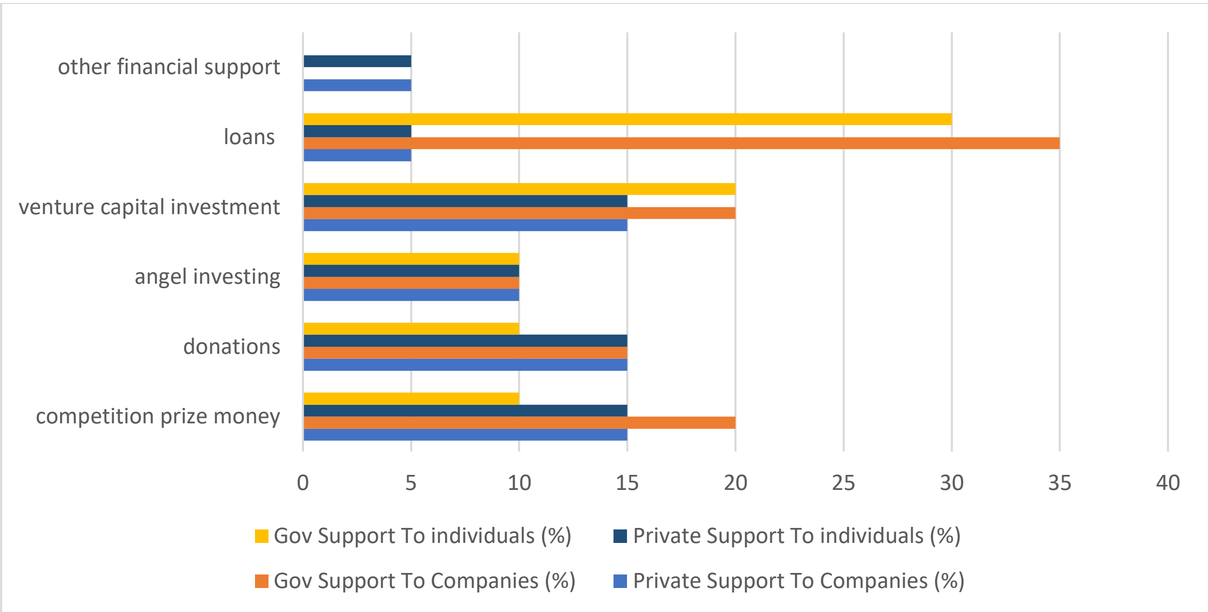

Figure 7-13: Financial Support by provider type

The support provided to mobile entrepreneurs in Botswana originate largely from government support organisations compared to private support organisations. This support is afforded in the form of loans, venture capital investment and competition prize money. The analysis of support availed is detailed in the following section.

7.4.3.1 *Competition Prize Money Support Status by Support Organisation Ownership*

Competition prize money is availed to mobile application entrepreneurs in Botswana, as shown in Figure 7-13: Financial Support by provider type. Ten % of the sampled government organisations provided competition prize money support to individuals and 20% to companies while 15% of the private sector respondents provided competition prize money to individual MAP developers and to MAP companies alike. Although the government is the largest competition prize money provider, a bias towards awarding prize money to mobile application developing companies than to individual developers was observed while the private sector had less competition prize money offerings, it was available equally to individuals and companies.

7.4.3.2 *Donation Support Status by Support Organisation Ownership*

Donations are another form of financial support availed to mobile application entrepreneurs in Botswana, as per Figure 7-13: Financial Support by provider type. Ten % of the sampled government organisations provided donation support to individuals and 15% to companies while 15% of the private sector respondents provided financial donation support to individual MAP developers and to MAP companies alike. More private sector support organisations therefore provide donation support when compared to the government.

7.4.3.3 *Angel Investment Support Status by Support Organisation Ownership*

Angel investment financial support is afforded when organisations, or individuals, provide their own financial resources to a start-up or growing company in exchange for ownership options or a loan. In Botswana, as shown in Figure 7-13: Financial Support by provider type10% of the sampled government as well as private organisations provide angel investor support to individuals and companies alike.

7.4.3.4 *Venture Capital Investment Support Status by Support Organisation Ownership*

Venture capital investor support is afforded when organisations, or individuals, provide financial resources which they manage on behalf of their clients, to a start-up or growing company in exchange for some ownership option or as a loan. Venture capital is availed to mobile application entrepreneurs in Botswana, as shown in Figure 7-13:

Financial Support by provider type, by 20% of the sampled government organisations to both individuals and companies alike while 15% of the private sector respondents provided venture capital investment to individual MAP developers and to MAP companies alike. Thus, venture capital investment financial support is offered by more government support organisations and no bias was noted in this category of financial support.

7.4.3.5 *Loan Support Status by Support Organisation Ownership*

The provision of financial support in the form of loans, as shown in Figure 7-13: Financial Support by provider type shows that 35% of government institutions sampled provided loans to companies and 30% offered loans to individuals. Private financial support, in the form of loans, was limited as only 5% of the respondents offer loans to individuals or companies that develop mobile applications.

7.4.4 Technical and Financial Support Uptake by Mobile App Developers in Botswana

To gain an understanding of the uptake of the technical, as well as financial support availed, support organisations were asked to provide information regarding the number and type of support applications they received from mobile application developers as well as the support granted through the different mobile application development life cycles, as described in the 5-staged digital start-up stage model presented in Table 6-1: Digital Start-Up Stages and The Mobile Applications Ecosystem Adopted from Drouillard et al. (2014).

7.4.4.1 *Number of Mobile App Developer Support Requests Received by Supporting Organisations*

The number of support requests from mobile application developers will be presented in the following section.

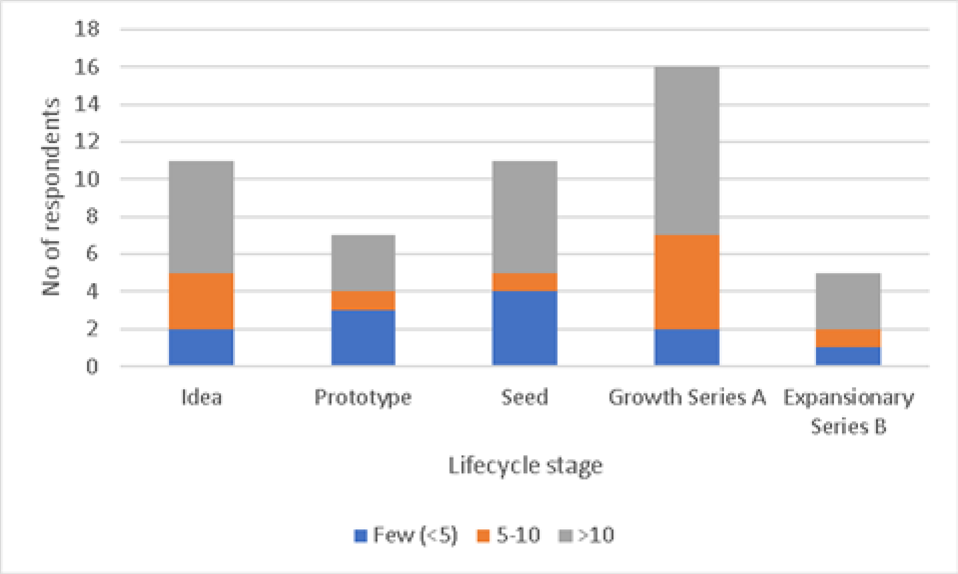

Figure 7-14: No. of Support Applications from Mobile App Developers

As shown in Figure 7-14: No. of Support Applications from Mobile App Developers most support organisations (16) received support requests when the developers were expanding locally, with 9 of the support organisation receiving more than 10 support requests, 5 respondents indicating that they received between 5 and 10 requests and only 2 support organisations receiving less than 5 support requests.

Eleven support organisations indicated that they received support requests during the idea and seed stages. The requests received during the idea stages included 2 support organisations that received fewer than 5 support requests, 3 support organisations that received between 5 and 10 requests while 6 of the support organisations indicated that they received more than 10 support requests. The support requests received during the seed stage reveals that 4 support organisations received fewer than 5 support requests, a single support organisation received between 5 and 10 requests whilst 6 support organisations received more than 10 applications for support.

Support requests from mobile application developers at the prototype stage were received by 3 support organisation who received fewer than 5 applications, while 1 support organisation reported to have received between 5 and 10 applications. Three support organisations indicated that they had received more than 10 applications for support from mobile application developers that were at the prototype stage.

Support organisations reported few applications for support from mobile application developers that are expanding regionally and international (the expansionary stage) as only 1 support organisation indicated that they had received fewer than 5 applications, another support organisation indicated that they had received between 5 and 10 applications whilst which3 support organisations indicated that they had received more than 10 support applications.

7.4.4.2 *Number of Mobile App Developer Support Requests Awarded by Supporting Organisations*

The number of mobile app developer support requests which were granted by support organisations was analysed and the findings are presented in Figure 7-15.

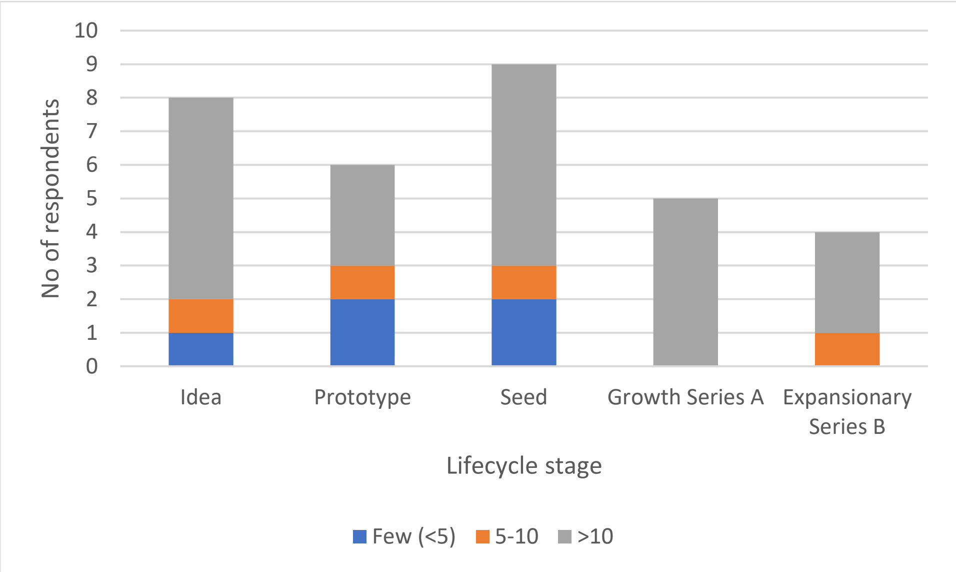

Figure 7-15: Number of Mobile Application Support Requests Granted by Support Organisations

As shown in Figure 7-15: Number of Mobile Application Support Requests Granted by Support Organisations, the majority of respondents granted support during the seed and idea stages and the numbers granted were in excess of 10s. Of the 8 respondents that had granted support during the idea stage, 6 indicated that they had offered more than 10 mobile application developers support while a single support provider indicated that they had offered less than 5 developers support. The prototype stage revealed that 3 support organisations had each offered more than 10 developers support, while 1 indicated they had offered between 5 and 10. Two support organisations reported that they had offered less than 5 developers support.

7.4.4.3 *Type of Mobile App Developer Support Granted by Supporting Organisations*

The type of support granted to mobile application developers by the sampled support organisations ranged from competition prize money, donations, venture capital investment, loans, office space, internet connectivity, server leases, OS leases, integration with MSP payment, network, location, authentication etc systems, training, credit guarantee schemes and others, as per Figure 7-16.

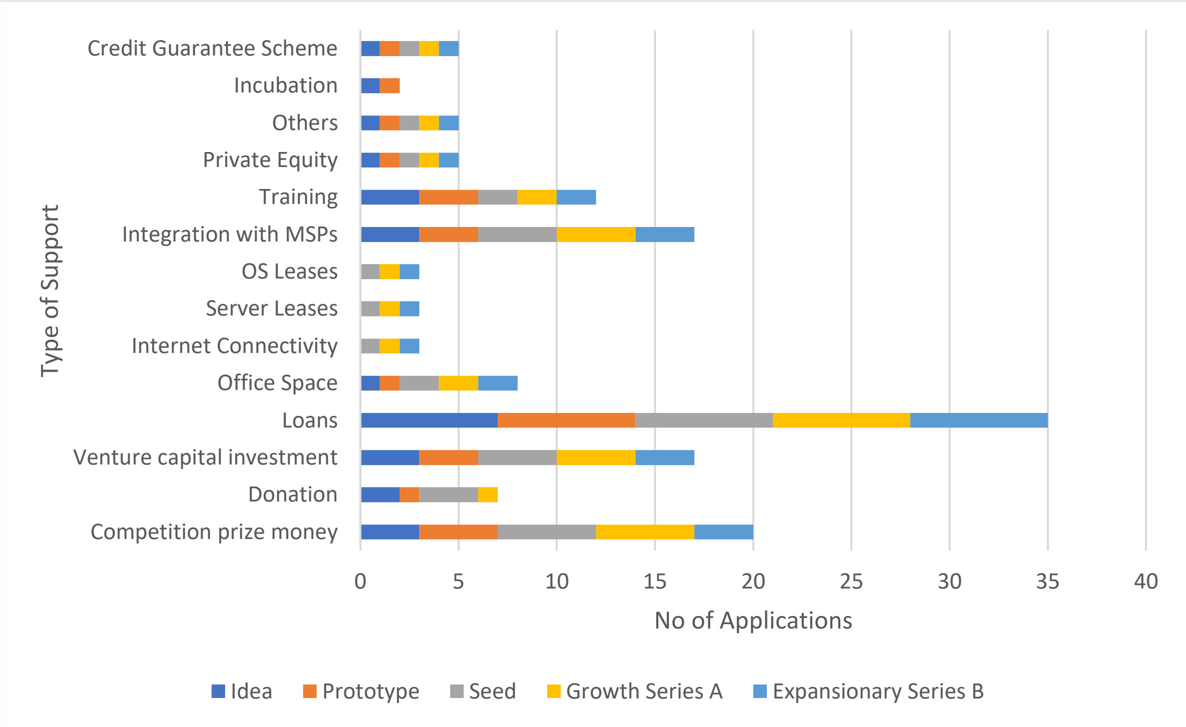

Figure 7-16: Mobile App Developer Support Type Granted by Support Organisations

As shown in Figure 7-16: Mobile App Developer Support Type Granted by Support Organisations the leading financial support was in the form of loans, competition prize money and venture capital investment while leading technical support was in the form of training and integration with MSP.

Loans were availed to mobile application developers in all stages, with 7 respondents indicating that they granted loans at each of the 5 stages. Competition prize money was also availed to developers in all stages with 3 respondents granting it at the idea stage, 4 at prototype stage, 5 at the seed stage, 5 at growth series A and 3 at expansionary stages. Venture capital investment was also reported to have been granted by 3 respondents during the idea stage, 3 at prototype stage, 4 during the seed stage, 4 at growth series A and 3 at expansionary stages. Support with integration with essential MSP services was indicated to have been offered by 3 respondents at the idea stage, 3 at prototype stage, 4 during the seed stage, 4 at growth series A and 3 at expansionary stages. Support in the form of training was indicated to have been offered by 3 respondents at the idea stage, 3 at prototype stage, 2 during the seed stage, 2 at growth series A and 2 at expansionary stages. The provision of office space support was indicated to have been offered by 1 respondent at the idea stage, 1 at prototype stage, 2 during the seed stage, 2 at growth series A and 2 at expansionary stages. Donations were reported to have been offered by 2 respondents at the idea stage, 1 at prototype stage, 3 during the seed stage, 1 at growth series A and none at expansionary stages. Private equity support was reported to have been provided, for each stage of the life cycle, by a single support organisation. Loan guarantee schemes were reported by a single support organisation as having been availed to mobile application developers at each of the life cycle. Internet connectivity, server leases and operating system lease support were reported to have been offered by 1 support organisation during the seed, growth and expansionary stages. Incubation support services was reported to have been availed to mobile application developers by a single support organisation and only during the idea and prototype stages.

7.4.5 Mobile Application Developers Support Uptake Challenges

The support organisations sampled provided reasons that resulted in some of the support requests from mobile application developers being turned down. The findings are presented in Figure 7-17.

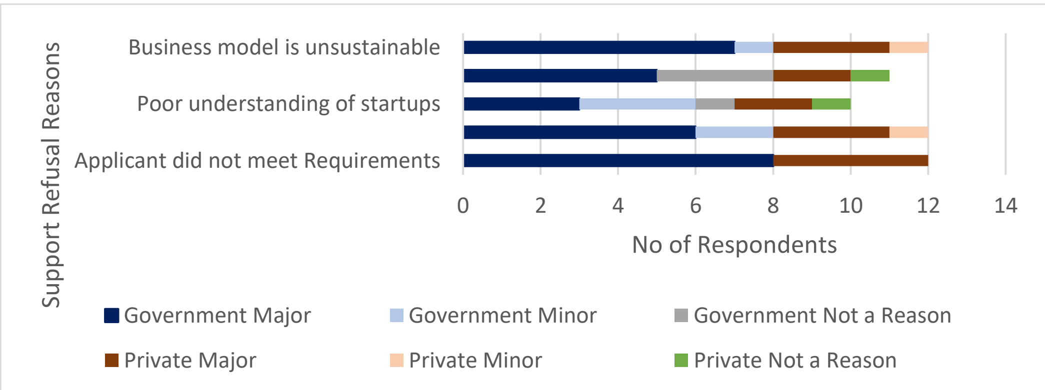

Figure 7-17: Funding Support Refusal Reasons by Support Organisation Type

As shown in Figure 7-17: Funding Support Refusal Reasons by Support Organisation Type all 12 respondents who rejected support requests indicated that their decision was mainly because the applicants did not meet the support requirements, with 8 of the respondents being government support organisations and 4 of the respondents being private support providers. Poor business pitching skills were also cited by 12 respondents to be a reason for support being turned down. Six government and 3 private support organisations indicated that poor pitching skills was a major reason for rejecting support requests while 2 government and 1 private support organisation indicated this challenge as minor. A poor understanding of the proposed business start-up was cited as a major reason for support rejections by 3 government and 2 private support providers while the same was cited to be a minor rejection reason by 3 government organisations. A single private and single government support organisation indicated that a poor understanding of start-ups was a not a reason for support rejections. Support rejections due to mobile app developer business not being well established was cited to be a major cause of support rejections by 5 government and 2 private support organisations while 3 government and 1 private support provider indicated that this was not a reason for rejecting support.

Other reasons for mobile application developers failing to secure support from funding organisations included: failure to target a market, copying existing solutions, non-application for support and unsustainable business models. Some support organisation indicated that they do not offer support to mobile application programming organisations but focus mostly on livestock and physical products.

7.4.6 Framework Recommendations

7.4.6.1 *Mentorship and training for mobile application developers*

Funding and supporting organisations indicated that mobile app developers in Botswana are not innovative enough, rarely offer viable business models and often do not meet the requirements for support. Mobile application developers can therefore be granted access to training, offered by any of the three helixes, on meeting support requirements, business modelling, pitching business ideas and targeting a market.

7.4.6.2 *Encouraging more Private and Higher Education Sector Support Organisations:*

There are more government support organisations in Botswana, as per Figure 7-5: Support organisations interviewed, and private sector as well as higher education sector players can be encouraged to offer various forms of support to Botswana's mobile application developers. This can be achieved by setting up joint innovation hubs that can provide a wide range of support at a single location. Due to the bias towards supporting companies, such innovation hub centres can therefore provide support in registering companies for individual mobile application developers.

7.5 Summary

This chapter sought to explore, determine and evaluate the elements of a mobile applications innovation ecosystem framework, from a government perspective, as well as establish the support available to a mobile application innovation ecosystem in Botswana and the uptake of this support. The framework components were presented in Section 7.3. An evaluation of these elements was done through structured face-to-face and telephonic interviews with 20 government and other support organisations in Botswana leading to enhanced and more relevant mobile applications innovation ecosystem framework components from a mobile industry's perspective, framework version 3, presented in this section.

The findings elucidate the role that government and non-government support organisations play in the establishment of a mobile applications innovation ecosystem and provides insight as to how mobile application developers can utilise such support. The final updated framework version 3 is consequently presented as a concept map diagram in Figure 7-18 and the summarised framework is illustrated in Figure 7-19.

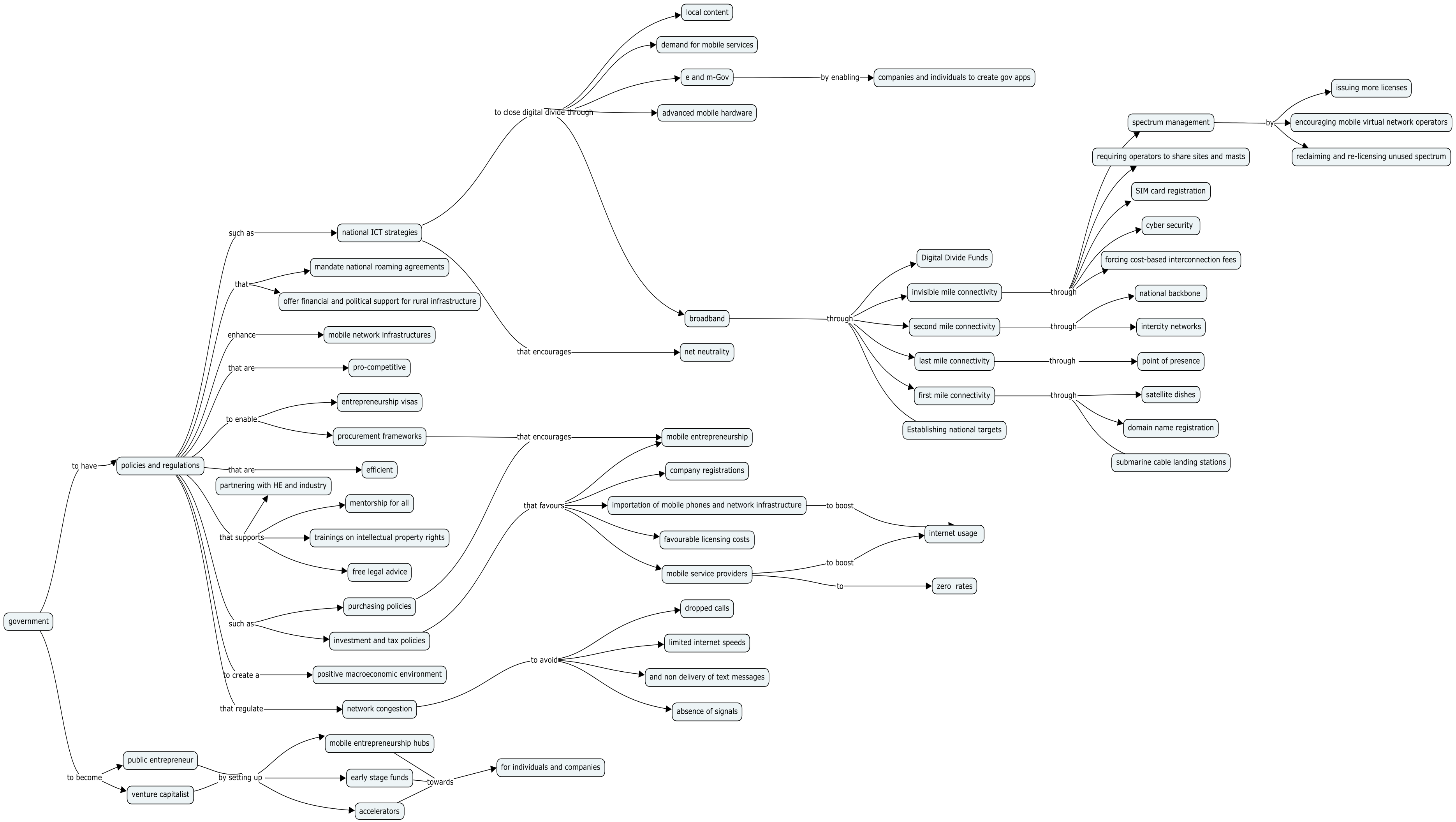

Figure 7-18: Government Perspective: Mobile Applications Innovations Ecosystem Framework version 3 Concept Map

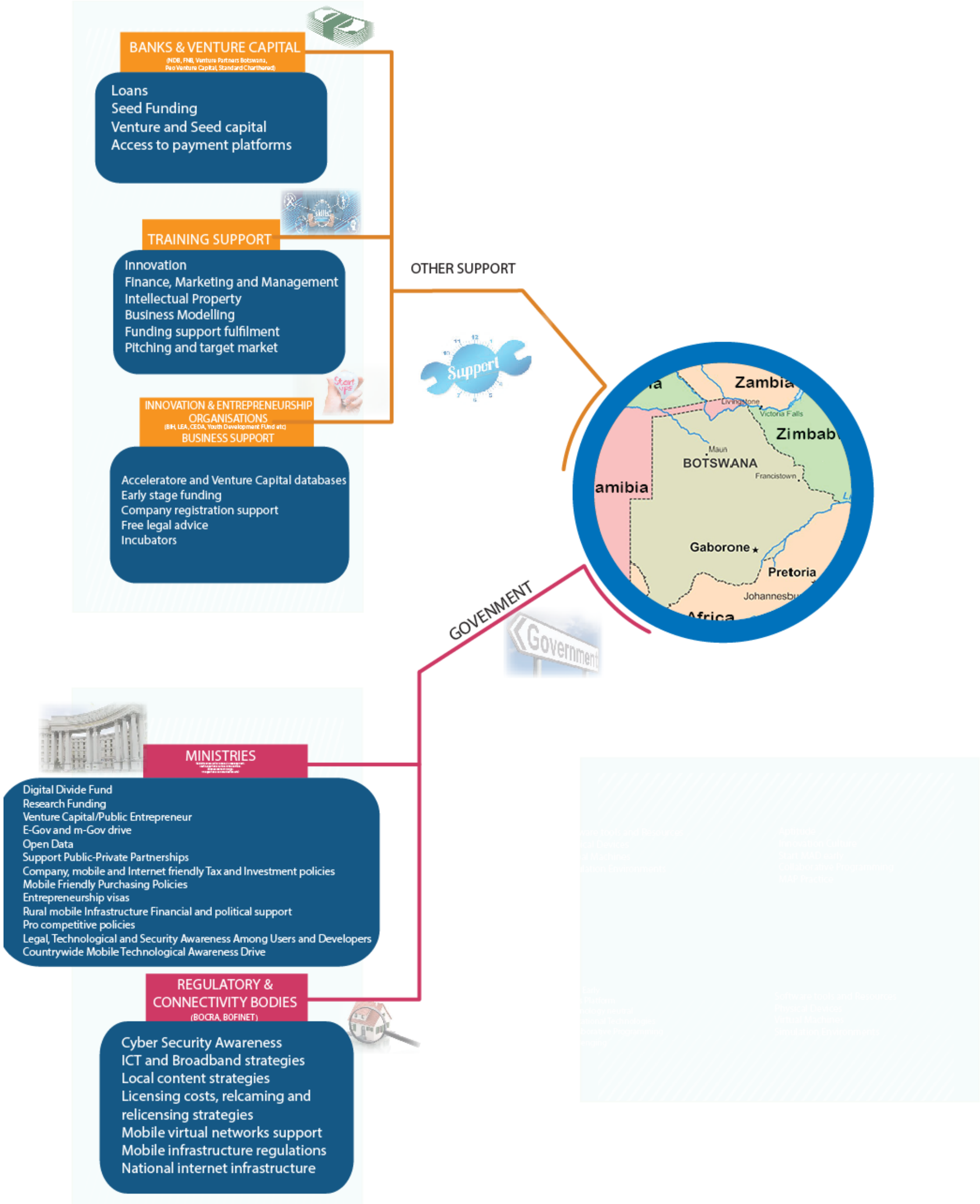

Figure 7-19: Government Perspective: Mobile Applications Innovations Ecosystems Framework v3

Chapter 8 Evaluation of the Mobile Applications Innovation Ecosystem Framework

8.1 Introduction

This chapter presents the second phase of the DSR which is operationalised through the synthesis of the mobile applications innovation ecosystem framework versions 1, 2 and 3 from Chapters 5, 6 and 7 into a final mobile applications innovation ecosystem framework for Botswana (sections 8.1.1 and 8.3), which is then evaluated by knowledgeable professionals within each of the Triple Helix perspectives (section 8.4). The final framework is presented in section 8.6.

This chapter addresses the main research question:

RQ_M. What are the components of a mobile applications innovation ecosystem framework for Botswana?

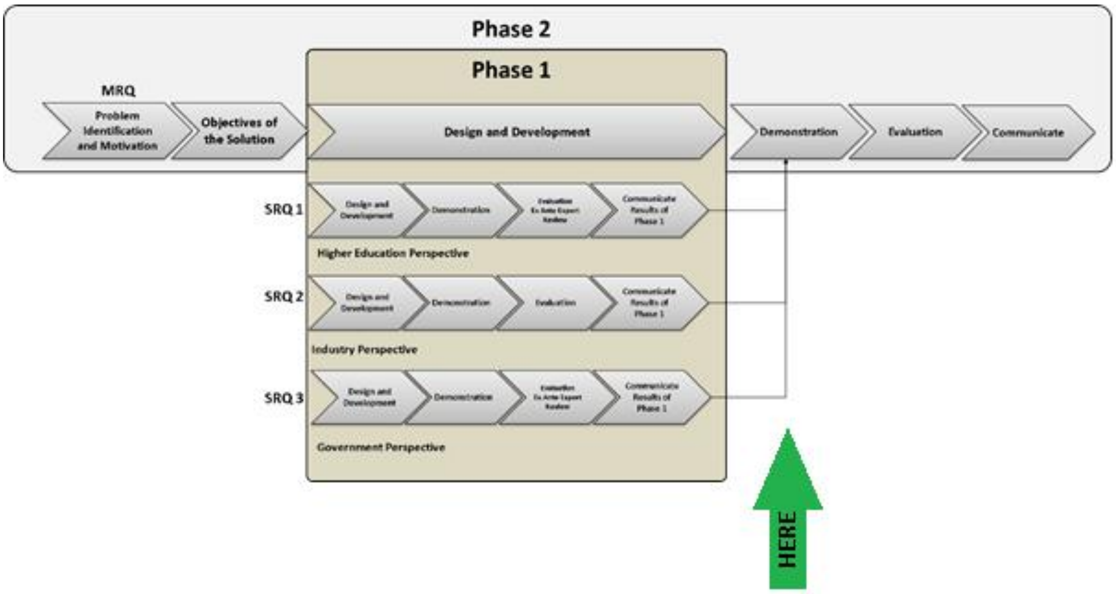

Figure 8-1: Phase 2 - Chapter 8 relative to DSR Strategy

8.1.1 Consolidated Components of a Mobile Applications Innovation Ecosystem Framework

The components of the mobile applications innovation ecosystem framework established and used to design the sub frameworks from HE, industry and government perspectives, as presented in Chapters 5, 6 and 7, were combined to develop the consolidated mobile applications innovation framework.

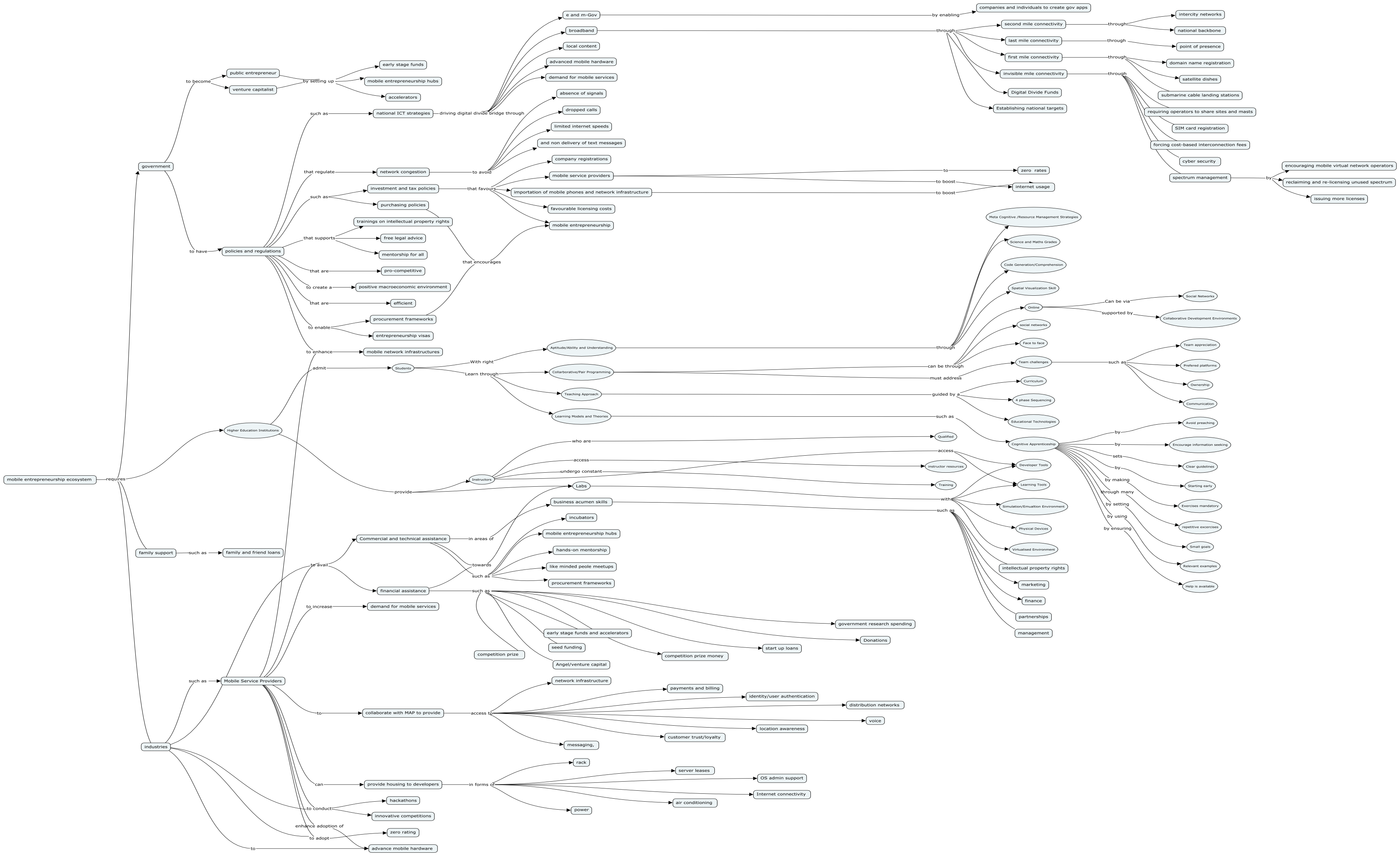

Figure 8-2: Consolidated Framework Components Concept Map for a MAIE Framework

8.1.2 Evaluation Methodology

The evaluation of the mobile applications innovation ecosystem framework was carried out using Prat, Comyn-Wattiau and Akoka's (2014) hierarchy of criteria for IS artefact evaluation through knowledgeable professionals (KPs) from each of the perspectives of the Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005). The KPs provided their evaluation regarding the importance of the identified framework components within the Botswana context using a Likert scale thus providing an evaluation of the framework based on the goal dimension (relevance of components), environment dimension (people and organisational consistency), structure dimension (completeness, clarity, level of detail and simplicity) as well as the evolution dimension (ability to continue producing mobile app developers in changing environments).

In determining the number of knowledgeable professionals necessary to evaluate the framework and to contextualise it to Botswana, the research used the argument that after the fifth user, the same findings of previous users are observed and nothing new is really being learnt, thus it becomes a waste of time (Nielson, 2000). Though carried out to determine usability problems, the number of problems detected has been determined to be a function of the number of users employed (Nielsen & Landauer, 1993). Nielson (2000) clarifies that this is due to overlaps in users' insights during testing thus, the more users you add, the less you learn, as shown in Figure 8-3.

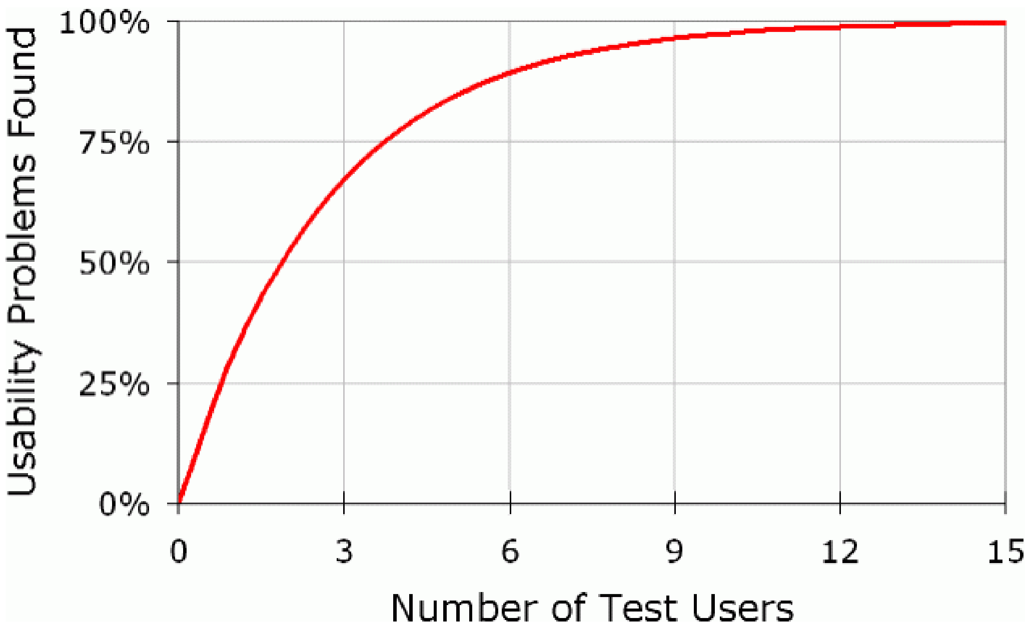

Figure 8-3: Numbers of Test Users and Usability Problems Found (Nielson, 2000)

Figure 8-3: Numbers of Test Users and Usability Problems Found (Nielson, 2000) shows that to identify 100% of the problems, 15 users are required. The researcher sent out evaluation questionnaires to 47 knowledgeable professionals, 15 of which have had direct interaction with the mobile applications ecosystem of Botswana, in each of the three helices, and 2 additional questionnaires were sent to the sole society organisation for ICT in Botswana for evaluation of the framework. However, only 25 responses were received, showing a response rate of 53%. The responses were: 7 from 15 higher education knowledgeable professionals, 8 from 15 government and parastatal knowledgeable professionals, 9 from 15 industry knowledgeable professionals and 1 from 2 knowledgeable professionals from an NGO/society organisation, as per Table 8-1.

Table 8-1: Knowledgeable professional areas and response rates

Area	**Sent Out (No)**	**Received Responses (No)**	**Response Rate (%)**
Higher Education	15	7	47
Government	15	8	53
Private Industry	15	9	60
NGO/Society	2	1	50
Overall	47	25	53

8.2 Biographic details of Knowledgeable Professionals (KPs)

8.2.1 Expertise Levels of KPs

The KPs level of expertise was evaluated for each of the helixes. As shown, within the higher education helix, 3 knowledgeable professionals ranked their expertise level as ‘expert’ and ‘intermediate’ respectively, while 1 KP indicated that their expertise level was that of ‘beginner’. The government had 4 KPs that ranked themselves ‘experts’ with 2 ranking themselves as ‘intermediate’ and ‘beginner’, respectively. The industry helix had 4 ‘experts’, 3 ‘intermediate’ and 2 ‘beginner’ KPs.

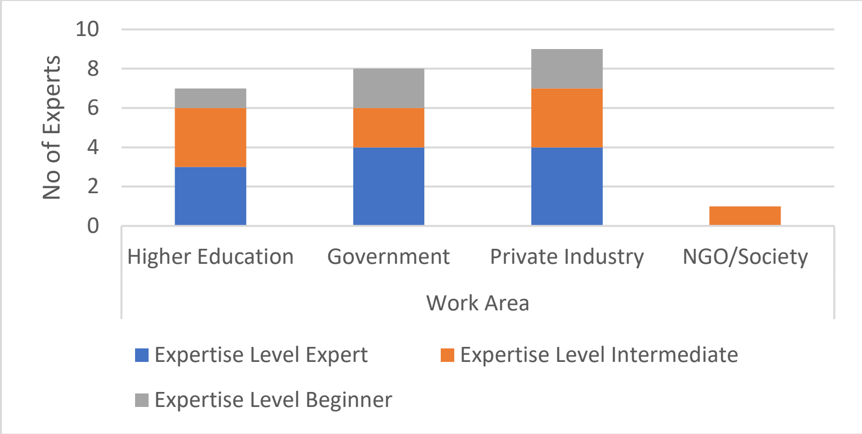

Figure 8-4: Knowledgeable Professionals' Expertise Levels

8.2.2 KPs' Mobile Ecosystem Active Period

The periods of active participation in Botswana's mobile applications ecosystem were assessed and the results show that most KPs have been active within the mobile ecosystem for some period. As indicated, higher education and industry KPs had the youngest participants in the mobile ecosystem of Botswana with 2 in each helix having been active for less than 3 years. The number of KPs who have been active in Botswana's mobile ecosystem for 3 to 6 years were 4, 4 and 5 for higher education, government and industry respectively. Higher education and industry each had 1 KP who had been active in Botswana's mobile ecosystem for 7 to 10 years. Government had 4 KPs who had been active in Botswana's mobile applications ecosystem compared to industry and civic society who had 1 KP each.

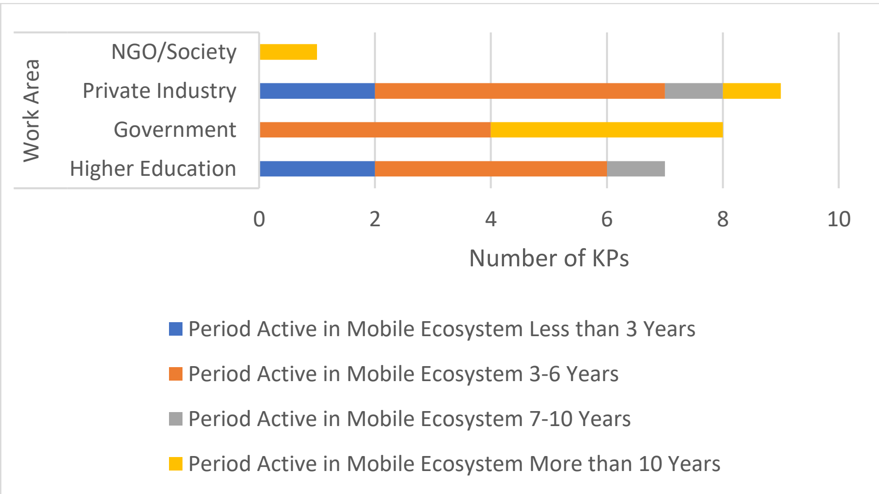

Figure 8-5: Knowledge Professionals' Mobile Ecosystem Active Period

8.2.3 Knowledge Professionals' Age

As shown in Figure 8-6, the age of KPs who evaluated the framework ranged from 18 to above 40, with both age extremes found within the government based KPs, the majority (52%) of KPs being 26 to 35 years old. The mobile application industry KPs, aged 25 to 35 years old, made up 89% of the helix KPs, while the government helix KPs of the same age made up 38% of the KPs and 43% of the higher education KPs. The government helix has more diversity age wise, whereas the mobile application industry KPs are mainly young adults and higher education being made up of KPs aged between 26 and 45 years old. The young KPs within the industry were also established during Phase 2 and has been confirmed in the industry perspective study of Phase 1 of the study.

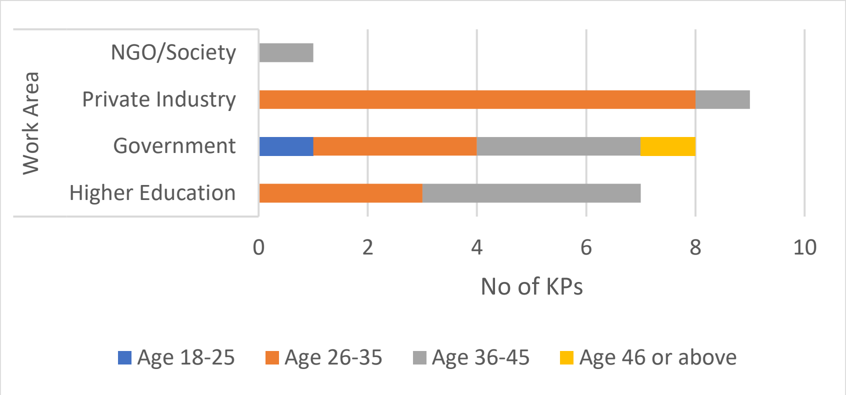

Figure 8-6: Age of KPs

8.2.4 Knowledge Professionals' Gender

As per Figure 8-7: Gender of KPs female KPs in industry made up only 22% of the KPs while 78% were male, a percentage confirmed in Phase 2. Similar male domination was observed in higher education where 29% of the KPs were female while 71% were male. In the case of the government based KPs, however, 63% were female while 37% were male. The industry and higher education section in Botswana are largely male dominated while government KPs were largely female.

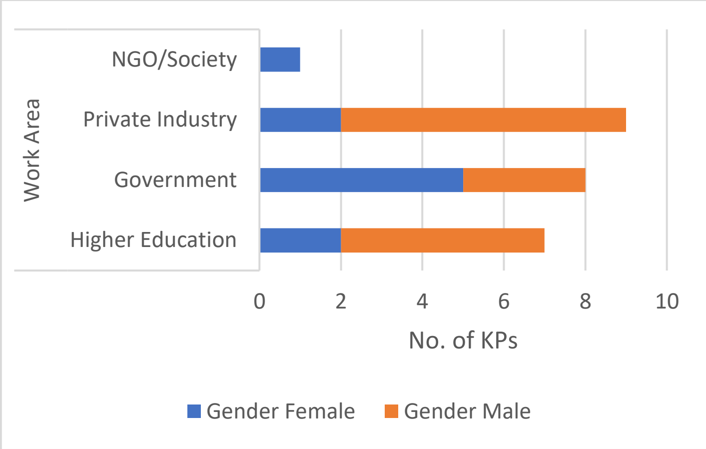

Figure 8-7: Gender of KPs

8.2.5 Detailed Biographic Details of Knowledge Professions

The following tables provide details of the individual KPs used to evaluate the framework from each of the helices.

8.2.5.1 *Higher Education KPs' Biographic Details*

As shown in Table 8-2: Higher Education Knowledge Professionals Biographic Details7 of the 15 KPs responded to the evaluation survey and all of them were employed within a university or college domain. All but 1 of the respondents were involved in teaching while 1 responded had an innovation development role. All teaching staff held master's degrees. Males made up the majority of respondents, 5 out of 7. Three respondents ranked themselves as 'experts', 3 as 'intermediate' and 1 as a 'beginner' within the mobile applications ecosystem of Botswana.

Table 8-2: Higher Education Knowledge Professionals Biographic Details

No.	Organization	Job Title	Period Active in Mobile Ecosystem	Expertise Level	Highest Qualification	Age	Gender
1	University	Senior Lecturer	3-6 years	Intermediate	Masters	36-45	Female
2	University	Lecturer	3-6 years	Expert	Masters	36-45	Male
3	University	Senior Lecturer	Less than 3 years	Intermediate	Masters	26-35	Male
4	College	Lecturer	3-6 years	Expert	Masters	26-35	Male
5	University	Fellow	3-6 years	Intermediate	Masters	36-45	Male
6	College	Lecturer	7-10 years	Expert	Masters	36-45	Male
7	University	Innovation Development	Less than 3 years	Beginner	Degree	26-35	Female
Total	7	7	7	7	7	7	7

8.2.5.2 *Industry KPs' Biographic Details*

Table 8-3: Industry Knowledge Professionals' Biographic Details shows that 9 out of 15 KPs responded to the evaluation survey, with all being employed by companies which provide mobile application related to products and/or services. Respondent roles ranged from directors of companies to developers of systems. Most of the industry respondents (7 of the 9) held degrees while the other 2 did not provide their qualifications. Males made up most of the respondents (7 out of 9). Four respondents ranked themselves as 'experts', 3 as 'intermediate' and 2 ranked themselves as 'beginners' within the mobile applications ecosystem of Botswana. Most respondents were aged 26 to 35 years. In Botswana, younger males dominate as KPs in the mobile application ecosystem, as identified in Phase 2 of the study. This phenomenon is also confirmed in Phase 1. It is worth noting that none of the KPs hailing from the three private mobile service providers responded to the evaluation survey.

Table 8-3: Industry Knowledge Professionals' Biographic Details

No.	**Organisation Mandate**	**Job Title**	**Period Active in Mobile Ecosystem**	**Expertise Level**	**Highest Qualification**	**Age**	**Gender**
1	Web and Software Development	Lead Developer	7-10 years	Expert	Degree	26-35	Male
2	Media and Software Development	Admin Manager	3-6 years	Beginner	Degree	26-35	Female
3	Software Development and Consulting	Director	Less than 3 years	Intermediate	Degree	26-35	Female
4	Mobile App Development	Mobile App Developer	3-6 years	Intermediate	Not Provided	26-35	Male
5	Research Consulting	Business Development Manager	3-6 years	Expert	Degree	26-35	Male
6	Provide IT Solutions	Developer	Less than 3 years	Beginner	Degree	26-35	Male
7	Research Consulting	Business Development Manager	3-6 years	Expert	Degree	26-35	Male
8	IT Solution Providers	Systems Analyst	3-6 years	Intermediate	Degree	36-45	Male
9	Mobile App Development	Managing Director	More than 10 years	Expert	Not Provided	26-35	Male
Total	9	9	9	9	7	9	9

8.2.5.3 *Government KPs' Biographic Details*

As shown in

Table 8-4: Government Knowledge Professionals' Biographic Details, 8 out of 15 KPs responded to the evaluation survey. Respondents' roles varied, working in organisations that ranged from the ministry in charge of telecommunications, regulators of telecommunications, internet backbone providers and mobile application support organisations. In the case of government respondents, 50% were holders of degrees whilst the other 50% were holders of master's degrees. Gender, expertise and age were more diverse within the government respondent group with 5 of the 8 being females and ages ranging from 18 to 25 years to over 46 years old. Regarding their expertise level, 4 respondents were 'experts', 2 'intermediate' and 2 viewed themselves as 'beginners' within Botswana's mobile application ecosystem.

Table 8-4: Government Knowledge Professionals' Biographic Details

No.	Organisation Mandate	Period Active in Mobile Ecosystem	Expertise Level	Highest Qualification	Age	Gender
1	Financial assistance	3-6 years	Beginner	Masters	18-25	Female
2	ICT sector policy formulation and infrastructure development	More than 10 years	Expert	Masters	46 or above	Female
3	ICT and transport services	More than 10 years	Expert	Degree	36-45	Male
4	Information access to all	More than 10 years	Expert	Degree	18-25	Male
5	Financial assistance	3-6 years	Beginner	Masters	26-35	Female
6	Regulate telecommunications industry	3-6 years	Intermediate	Masters	26-35	Female
7	Provide world class telecoms backbone infrastructure	3-6 years	Intermediate	Degree	26-35	Male
8	Efficient, effective, reliable, sustainable and safe road transport and communication	More than 10 years	Expert	Degree	36-45	Female
Total	8	8	8	8	8	8

8.2.5.4 *NGO/Society Organisations KPs' Biographic Details*

Table 8-5: NGO/Society Organisation Knowledge Professional Biographic Details shows that the respondents from the NGO/Society organisation, whose mandate was to lobby for ICT professionals, were female with over 10 years of active participation in Botswana's mobile ecosystem. She also held a master's degree and indicated an 'intermediate' expertise level regarding Botswana's mobile applications ecosystem.

Table 8-5: NGO/Society Organisation Knowledge Professional Biographic Details

No.	**Organisation Mandate**	**Period Active in Mobile Ecosystem**	**Expertise Level**	**Highest Qualification**	**Age**	**Gender**
1	Lobby for IT professionals	More than 10 Years	Intermediate	Masters	36-45	Female
Total	1	1	1	1	1	1

8.3 Evaluation Tool - Merging of Components

Due to the size of the tool used to evaluate Botswana's mobile applications innovation ecosystem framework, the components identified from literature had to be combined and merged, thus resulting in less components to manage. Care was taken to avoid eliminating the initial identified components. The components in the *Initial Group of Components* of Table 8-6 show several components, separated by commas and the *Merged Component* column of Table 8-6, 8-7 and 8-8 shows the single merged component used during the evaluation stage.

Table 8-6: Merging of Botswana's Higher Education Mobile Application Innovation Components before Evaluation

Initial Group of Components	**Merged Component**
Student spatial visualisation skill, student meta cognitive/resource management strategies and student code generation/comprehension	Student cognitive and coding ability
Curriculum that focuses on fundamental concepts, curriculum that starts programming early, sequencing of learning	Curriculum that starts the programming early, focuses on fundamental concepts with suitable sequencing of learning
Availability of simulation/emulation environment, availability of virtualised environment	Availability of simulation/emulation/virtualised environment

Initial Group of Components	Merged Component
Availability of learning tools, availability of developer tools	Availability of developer and learning tools (books, IDEs, videos, lab equipment etc.)
Qualified, undergoing constant training, access to instructor resources, access to developer tools, access to learning tools	Qualified, undergoing constant training with access to instructor resources
Able to access teaching resources that are easy to implement, able to access teaching resources that can be controlled by teachers	Able to access teaching resources that are easy to implement and control
Avoid 'preaching', using repetitive exercises, making programming exercises mandatory	Hands on
Setting small goals, clear guidelines for students	Clear expectations
Student collaborative/pair programming, teaching students how to address student team challenges (ownership, communication, team appreciation, preferred platforms), student collaborative/pair programming through face-to-face teaching	Face-to-face student collaborative/pair programming and addressing team challenges
Teaching students a perception of programme correctness, teaching students through mental models, teaching programming as a way of thinking, teaching students debugging strategies	Teaching students to think from a programming perceptive
Offer free and paid for online textbooks and videos, offer free and paid for physical textbooks and videos	Offer free and paid for online and physical textbooks and videos
Offer programming competitions, offer real app implementation projects	Offer programming competitions with real app implementations

Table 8-7: Merging Botswana's Industry Mobile Application Innovation Components before Evaluation

Initial Group of Components	Merged Component
Bank loans, start-up loans	Start-up and bank loans
Marketing skills, management skills	Management and marketing skills
Like-minded people meet-ups, incubators, mobile entrepreneurship hubs	Mobile entrepreneurship hubs/incubators
Stimulating innovative local mobile solutions through competitions, stimulating innovative local mobile solutions through hackathons	Stimulating innovative local mobile solutions through competitions and hackathons

Initial Group of Components	Merged Component
Voice related services, messaging services, location awareness services	Voice, location and messaging services
Identity/user authentication services, payment and billing services	Payment, billing, identity/user authentication services
Server leases, rack housing, OS admin support, air conditioning, power	Server leases
Faster processing power, Longer battery life, Bigger screens, Lighter	Faster processing power, longer battery life, bigger screens, lighter devices

Table 8-8: Merging Botswana's Government Mobile Application Innovation Components before Evaluation

Initial Group of Components	Merged Component
Setting up accelerators, setting up mobile entrepreneurship hubs	Setting up accelerators and mobile entrepreneurship hubs
Avoid absence of signals, avoid dropped calls	Avoid dropped calls and the absence of signals
Issuing more licenses, reclaiming ad relicensing unused spectrum	Reclaiming, issuing more and re-licensing unused spectrum
Support mentorship for all, offer free legal advice, support mentorship, support training on intellectual property rights	Offer free legal advice, intellectual property education and mentorship
Ensure efficiency, create positive macro-economic conditions, encourage competition	Create positive, competitive and efficient macro-economic conditions
Submarine cable landing stations, national satellite dishes	National satellite dishes and submarine cable landing stations
National backbones, intercity networks	National backbones and Intercity networks

8.4 Framework Components Evaluation Findings

The following present the findings from Botswana’s KPs regarding the importance of the components for Botswana’s mobile applications ecosystem as well as an artefact evaluation of the framework components. Each component was presented to the KP who ranked the component’s ability to effectively enhance Botswana’s mobile applications innovation ecosystem, based on a 5-point Likert scale of Not Important - 0, A bit Important - 1, Moderately Important - 2, Important - 3 and Very Important - 4. Using descriptive statistics, frequency components ranked Important to Very important (that is with a mean of 2.5 up to 4) remained in the framework while the rest were removed as KPs considered them unimportant to Botswana's mobile applications innovation ecosystem.

8.4.1 Higher Education Components Evaluation Findings

8.4.1.1 *Admission - Cognitive Ability*

As illustrated in Table 8-9: KPs' evaluation of component *Admission - Cognitive Ability's* importance to Botswana's , 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked the Higher Education's Admission - Cognitive Ability component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24), from across the 3 helices, agreed and indicated that this component is either Important or Very Important with a mean of 3.25. The mode was *Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-9: KPs' evaluation of component *Admission - Cognitive Ability*'s importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Admission - Cognitive Ability				Total	Mean	Std. Dev
		Not Important	Moderately Important	Important	Very Important			
Work Area	Higher Education	0	1	4	2	7	3.25	.897
	Government	0	0	4	3	7		
	Private Industry	0	0	4	5	9		
	NGO/Society	1	0	0	0	1		
Total		1	1	12	10	24		

8.4.1.2 *Admission - Science and Maths*

As evident from Table 8-10: KPs' evaluation of component *Admission - Science and Maths's* importance to Botswana's 24 KPs made up of 7 from higher education, 7 from government, 9 from industry and 1 from NGO, ranked Higher Education's Admission - Cognitive Ability component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.13. The mode was *Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-10: KPs' evaluation of component *Admission - Science and Maths*'s importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Admission - Science and Maths				Total	Mean	Std. Dev
		A bit Important	Moderately Important	Important	Very Important			
Work Area	Higher Education	0	2	2	3	7	3.13	.741
	Government	0	0	6	1	7		
	Private Industry	0	0	6	3	9		
	NGO/Society	1	0	0	0	1		
Total		1	2	14	7	24		

8.4.1.3 *Teaching - Educational Technologies*

As shown in Table 8-11, 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Teaching - Educational Technologies component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (19 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.33. The mode was *Very Important*, as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-11: KPs' evaluation of component *Teaching - Educational Technologies* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Teaching - Educational Technologies				Total	Mean	Std. Dev
		A bit Important	Moderately Important	Important	Very Important			
Work Area	Higher Education	0	0	1	6	7	3.33	.917
	Government	0	2	2	3	7		
	Private Industry	1	2	2	4	9		
	NGO/Society	0	0	0	1	1		
Total		1	4	5	14	24		

8.4.1.4 *Teaching - Start Early*

As shown in Table 8-12, 24 KPs made up of 7 from higher education, 7 from government, 9 from industry and 1 from NGO ranked Higher Education's Teaching - Start Early component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.54. The mode was *Very Important*, as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-12: KPs' evaluation of component *Teaching - Start Early*'s Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Teaching Start Early			Total	Mean	Std. Dev
		Moderately Important	Important	Very Important			
Work Area	Higher Education	0	3	4	7	3.54	.588
	Government	1	2	4	7		
	Private Industry	0	3	6	9		
	NGO/Society	0	1	0	1		
Total		1	9	14	24		

8.4.1.5 *Teaching – Challenge Students*

As illustrated in Table 8-13, 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Teaching - Start Early component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.42. The mode was *Very Important* as ranked from 24 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and it is therefore retained.

Table 8-13: KPs' evaluation of component *Teaching – Challenge Students* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Teaching - Challenge Students			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	3	4	7	3.42	.654
	Government	1	5	1	7		
	Private Industry	1	1	7	9		
	NGO/Society	0	1	0	1		
Total		2	10	12	24		

8.4.1.6 *Android Focused Curriculum*

As shown in Table 8-14: KPs' evaluation of component *Android Focused Curriculum* as important to Botswana's 24 KPs made up of 7 hailing from higher education, 7 from government, 9 from industry and 1 from NGO ranked Higher Education's Android Focused Curriculum component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (17 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 2.88. The mode was *Important*, as ranked from 11 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and it is therefore retained.

Table 8-14: KPs' evaluation of component *Android Focused Curriculum* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Android Focused Curriculum				Total		
		Not Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	3	3	7	2.88	.947
	Government	1	1	4	1	7		
	Private Industry	0	3	4	2	9		
	NGO/Society	0	1	0	0	1		
Total		1	6	11	6	24		

8.4.1.7 *Availability of Developer and Learning Tools (Books, IDEs, Videos, Lab equipment etc)*

As shown in Table 8-15: KPs' evaluation of component *Availability of Developer and Learning Tools (Books, IDEs, Videos, Lab equipment, etc)* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Availability of Developer and Learning Tools (Books, IDEs, Videos, Lab equipment, amongst others) component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All KPs (24 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.63. The mode was *Very Important* as ranked by 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-15: KPs' evaluation of component *Availability of Developer and Learning Tools (Books, IDEs, Videos, Lab equipment, etc)* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Availability of Developer and Learning Tools (Books, IDEs, Videos, Lab equipment, etc)		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	4	3	7	3.63	.495
	Government	1	6	7		
	Private Industry	3	6	9		
	NGO/Society	1	0	1		
Total		9	15	24		

8.4.1.8 *Availability of Physical Mobile Devices*

As shown in Table 8-16: KPs' evaluation of component *Availability of Physical Mobile Devices* as important to Botswana's 24 KPs made up of 7 from higher education, 7 from government, 9 from industry and 1 from NGO ranked Higher Education's Availability of Physical Mobile Devices component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.33. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-16: KPs' evaluation of component *Availability of Physical Mobile Devices* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Availability of Physical Mobile Devices (Android): Moderately Important	Important	Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	0	3	4	7	3.33	.761
	Government	1	4	2	7		
	Private Industry	2	1	6	9		
	NGO/Society	1	0	0	1		
Total		4	8	12	24		

8.4.1.9 *Availability of Simulation/Emulation/Virtualised Environment*

As illustrated in Table 8-17: KPs' evaluation of component *Availability of Simulation/Emulation/Virtualised Environment's* importance to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Availability of Simulation/Emulation/Virtualised Environment component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All KPs (24 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.63. The mode was *Very Important* as ranked from 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-17: KPs' evaluation of component *Availability of Simulation/Emulation/Virtualised Environment*'s importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Availability of Simulation/Emulation/Virtualised Environment: Important	Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	3	4	7	3.63	.495
	Government	3	4	7		
	Private Industry	3	6	9		
	NGO/Society	0	1	1		
Total		9	15	24		

8.4.1.10 *Availability of backup power supply*

As shown in Table 8-18: KPs' evaluation of Component *Availability of backup power supply's* importance to Botswana's 24 KPs made up of 7 from higher education, 7 from government, 9 from industry and 1 from NGO ranked Higher Education's Availability of backup power supply component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.25. The mode was *Important* as ranked from 16 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-18: KPs' evaluation of Component *Availability of backup power supply*'s importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Availability of backup power supply			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	5	2	7	3.25	.532
	Government	1	4	2	7		
	Private Industry	0	6	3	9		
	NGO/Society	0	1	0	1		
Total		1	16	7	24		

8.4.1.11 *Allow students to Bring Your Own Device (laptops and mobile phones)*

As illustrated in

Table 8-19: KPs' evaluation of component *Allow students to Bring Your Own Device (laptops and mobile phones*) as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Allow students to Bring Your Own Device (laptops and mobile phones) component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (15 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 2.83. The mode was *Important* as ranked from 10 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-19: KPs' evaluation of component *Allow students to Bring Your Own Device (laptops and mobile phones)* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Allow students to Bring Your Own Device (laptops and mobile phones): Moderately Important	Important	Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	2	3	2	7	2.83	.761
	Government	3	2	2	7		
	Private Industry	3	5	1	9		
	NGO/Society	1	0	0	1		
Total		9	10	5	24		

8.4.1.12 *Offer free configuration of student devices for mobile app development*

As illustrated in Table 8-20: KPs' evaluation of component *Offer free configuration of student devices for mobile app development* as important to Botswana's , 24 KPs made up of 7 from higher education, 7 from government, 9 from industry and 1 from NGO ranked Higher Education's Offer free configuration of student devices for mobile app development component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (19 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.21. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-20: KPs' evaluation of component *Offer free configuration of student devices for mobile app development* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		That offer free configuration of student devices for mobile app development: Not Important	Moderately Important	Important	Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	0	1	3	3	7	3.21	1.021
	Government	0	0	2	5	7		
	Private Industry	0	3	2	4	9		
	NGO/Society	1	0	0	0	1		
Total		1	4	7	12	24		

8.4.1.13 *Qualified tutors, undergoing constant training with access to instructor resources*

As shown in Table 8-21: KPs' evaluation of component *Qualified Tutors, undergoing constant training with access to instructor resources* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Qualified Tutors, undergoing constant training with access to instructor resources component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All KPs (24 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.75. The mode was *Very Important* as ranked from 18 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-21: KPs' evaluation of component *Qualified Tutors, undergoing constant training with access to instructor resources* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Qualified, undergoing constant training with access to instructor resources		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	3	4	7	3.75	.442
	Government	0	7	7		
	Private Industry	2	7	9		
	NGO/Society	1	0	1		
Total		6	18	24		

8.4.1.14 *Access teaching resources that are easy to implement and control*

As shown in Table 8-22: KPs' evaluation of component *Access teaching resources that are easy to implement and control's* importance to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Access teaching resources that are easy to implement and control component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All KPs (24 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.58.

The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana’s mobile applications innovation ecosystem and is therefore retained.

Table 8-22: KPs’ evaluation of component *Access teaching resources that are easy to implement and control*'s importance to Botswana’s Mobile Applications Innovation Ecosystem

Count		Able to access teaching resources that are easy to implement and control.		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	3	4	7	3.58	.504
	Government	2	5	7		
	Private Industry	4	5	9		
	NGO/Society	1	0	1		
Total		10	14	24		

8.4.1.15 *Hands On (avoid ‘preaching’, using relevant teaching examples, using repetitive exercises, making programming exercises mandatory)*

As shown in Table 8-23, 24 KPs made up of 7 from higher education, 7 from government, 9 from industry and 1 from NGO ranked Higher Education’s Hands On (avoid ‘preaching’, using relevant teaching examples, using repetitive exercises, making programming exercises mandatory) component in terms of its ability to effectively enhance Botswana’s mobile applications innovation ecosystem. All KPs (24 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.67. The mode was *Very Important* as ranked from 16 KPs. This component is therefore considered important to Botswana’s mobile applications innovation ecosystem and is therefore retained.

Table 8-23: KPs' evaluation of component *Hands On (avoid 'preaching', using relevant teaching examples, using repetitive exercises, making programming exercises mandatory)* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Hands On (avoid 'preaching', using relevant teaching examples, using repetitive exercises, making programming exercises mandatory)		Total	Mean	Std. Dev
		Important	Very Important			
Work Area	Higher Education	3	4	7	3.67	.482
	Government	1	6	7		
	Private Industry	4	5	9		
	NGO/Society	0	1	1		
Total		8	16	24		

8.4.1.16 *Clear Expectations (setting Small Goals, Clear Guidelines for students)*

As shown in Table 8-24: KPs' evaluation of component *Clear Expectations (setting Small Goals, Clear Guidelines for students)* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Clear Expectations (setting small goals, clear guidelines for students) component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All KPs (24 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.42. The mode was *Important* as ranked from 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-24: KPs' evaluation of component *Clear Expectations (setting Small Goals, Clear Guidelines for students)* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Clear Expectations (Setting Small Goals, Clear Guidelines for students)		Total	Mean	Std. Dev
		Important	Very Important			
Work Area	Higher Education	4	3	7	3.42	.504
	Government	5	2	7		
	Private Industry	5	4	9		
	NGO/Society	0	1	1		
Total		14	10	24		

8.4.1.17 *Encouraging information seeking through student phone internet*

As shown in Table 8-25: KPs' evaluation of component *Encouraging information seeking through student phone internet* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Encouraging information seeking through student phone internet component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.13. The mode was *Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-25: KPs' evaluation of component *Encouraging information seeking through student phone internet* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Encouraging information seeking through student phone internet			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	5	2	7	3.13	.680
	Government	3	2	2	7		
	Private Industry	1	6	2	9		
	NGO/Society	0	0	1	1		
Total		4	13	7	24		

8.4.1.18 *Making help available to students*

As shown in Table 8-26: KPs' evaluation of component *Making help available to students* as important to Botswana's 24 KPs made up of 7 from higher education, 7 from government, 9 from industry and 1 from NGO ranked Higher Education's Making help available to students component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.33. The mode was *Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-26: KPs' evaluation of component *Making help available to students* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Making help available to students			Total	Mean	Std. Dev
		Moderately Important	Important	Very Important			
Work Area	Higher Education	0	5	2	7	3.33	.637
	Government	0	3	4	7		
	Private Industry	1	4	4	9		
	NGO/Society	1	0	0	1		
Total		2	12	10	24		

8.4.1.19 *Face-to-Face Student Collaborative/Pair Programming and addressing team challenges*

As shown in Table 8-27: KPs' evaluation of component *Face-to-Face Student Collaborative/Pair Programming and addressing team challenges* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Availability of Developer and Learning Tools (Books, IDEs, Videos, Lab equipment etc) component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.33. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-27: KPs' evaluation of component *Face-to-Face Student Collaborative/Pair Programming and addressing team challenges* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Face-to-Face Student Collaborative/Pair Programming and addressing team challenges			Total	Mean	Std. Dev
		Moderately Important	Important	Very Important			
Work Area	Higher Education	0	4	3	7	3.33	.761
	Government	1	1	5	7		
	Private Industry	3	2	4	9		
	NGO/Society	0	1	0	1		
Total		4	8	12	24		

8.4.1.20 *Online teaching (including through social networks and collaborative development environments)*

As illustrated in Table 8-28: KPs' evaluation of component *Online teaching (including via social networks and collaborative development environments)* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Online teaching (including that taking place via social networks and collaborative development environments) component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.29. The mode was *Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-28: KPs' evaluation of component *Online teaching (including via social networks and collaborative development environments)* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Online teaching (including via social networks and collaborative development environments)			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	5	1	7	3.29	.624
	Government	1	2	4	7		
	Private Industry	0	6	3	9		
	NGO/Society	0	0	1	1		
Total		2	13	9	24		

8.4.1.21 *Teaching students to think from a programming perceptive*

As shown in Table 8-29: KPs' evaluation of component *Teaching students to think from a programming perspective* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Teaching students to think from a programming perceptive component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.33. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana’s mobile applications innovation ecosystem and is therefore retained.

Table 8-29: KPs’ evaluation of component *Teaching students to think from a programming perspective* as important to Botswana’s Mobile Applications Innovation Ecosystem

Count		A bit Important	Moderately Important	Important	Very Important	Total	Mean	Std. Dev
		Teaching students to think from a programming perceptive						
Work Area	Higher Education	0	1	3	3	7	3.33	.816
	Government	0	0	3	4	7		
	Private Industry	1	1	3	4	9		
	NGO/Society	0	0	0	1	1		
Total		1	2	9	12	24		

8.4.1.22 *Offer free and paid for online and physical textbooks and videos*

As shown in Table 8-30: KPs’ evaluation of component *Offer free and paid for online and physical textbooks and videos* as important to Botswana’s 23 KPs made up of 6 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education’s Offer free and paid for online and physical textbooks and videos component in terms of its ability to effectively enhance Botswana’s mobile applications innovation ecosystem. Most KPs (20 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.04. The mode was *Important* as ranked from 16 KPs. This component is therefore considered important to Botswana’s mobile applications innovation ecosystem and is therefore retained.

Table 8-30: KPs’ evaluation of component *Offer free and paid for online and physical textbooks and videos* as important to Botswana’s Mobile Applications Innovation Ecosystem

Count		Moderately Important	Important	Very Important	Total	Mean	Std. Dev
		Offer free and paid for online and physical textbooks and videos					
Work Area	Higher Education	1	5	0	6	3.04	.562
	Government	1	4	2	7		
	Private Industry	1	7	1	9		
	NGO/Society	0	0	1	1		
Total		3	16	4	23		

8.4.1.23 *Offers mobile app idea sharing platforms*

As shown in Table 8-31: KPs' evaluation of component *Offers mobile app idea sharing platforms* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's offers mobile app idea sharing platforms component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.54. The mode was *Very Important* as ranked from 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-31: KPs' evaluation of component *Offers mobile app idea sharing platforms* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Offers mobile app idea sharing platforms			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	0	6	7	3.54	.658
	Government	0	4	3	7		
	Private Industry	1	3	5	9		
	NGO/Society	0	0	1	1		
Total		2	7	15	24		

8.4.1.24 *Offer mobile app course to all students*

As illustrated in Table 8-32, 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Offer mobile app course to all students component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 2.63. The mode was *Important* as ranked from 7 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and therefore retained

Table 8-32: KPs' evaluation of component *Offer mobile app course to all students* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Offer mobile app course to all students					Total		
		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	2	2	3	7	2.63	1.313
	Government	2	0	1	2	2	7		
	Private Industry	1	1	2	4	1	9		
	NGO/Society	0	0	0	0	1	1		
Total		3	1	5	8	7	24		

8.4.1.25 *Provide study improvement techniques*

As shown in Table 8-33: KPs' evaluation of component *Provide study improvement techniques* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Provide study improvement techniques component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.29. The mode was *Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and therefore retained.

Table 8-33: KPs' evaluation of component *Provide study improvement techniques* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Provide study improvement techniques						
		A bit Important	Moderately Important	Important	Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	0	1	2	4	7	3.29	.859
	Government	0	0	3	4	7		
	Private Industry	1	2	3	3	9		
	NGO/Society	0	0	0	1	1		
Total		1	3	8	12	24		

8.4.1.26 *Entrepreneurship support must be a major part of the Higher Education Institutions' strategy*

As shown in Table 8-34: KPs' evaluation of component *Entrepreneurship support must be major part of the Higher Education Institutions' Strategy* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Entrepreneurship support must be a major part of the Higher Education Institutions' strategy component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.63. The mode was *Very Important* as ranked from 17 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-34: KPs' evaluation of component *Entrepreneurship support must be major part of the Higher Education Institutions' Strategy* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Entrepreneurship support must be major part of the Higher Education Institutions' strategy			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	2	5	7	3.63	.647
	Government	0	1	6	7		
	Private Industry	2	2	5	9		
	NGO/Society	0	0	1	1		
Total		2	5	17	24		

8.4.1.27 *Have an entrepreneurship financial strategy*

As illustrated in Table 8-35: KPs' evaluation of component *Have an entrepreneurship financial strategy* as important to Botswana's 24 KPs made up of 7 from higher education, 7 from government, 9 from industry and 1 from NGO ranked Higher Education's having an entrepreneurship financial strategy component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.29. The mode was *Important* as ranked from 1 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-35: KPs' evaluation of component *Have an entrepreneurship financial strategy* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Have an entrepreneurship financial strategy			Total	Mean	Std. Dev
		Moderately Important	Important	Very Important			
Work Area	Higher Education	0	1	6	7	3.29	.690
	Government	0	4	3	7		
	Private Industry	2	6	1	9		
	NGO/Society	1	0	0	1		

8.4.1.28 *Stimulate and support the development of entrepreneurial mindsets and skills (staff and students)*

As shown in Table 8-36, 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Stimulate and support the development of entrepreneurial mindsets and skills (staff and students) component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (18 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.13. The mode was *Very Important* as ranked from 10 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-36: KPs' evaluation of component *Stimulate and support the development of entrepreneurial mindsets and skills (staff and students)* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Stimulate and support the development of entrepreneurial mindsets and skills (staff and students)				Total	Mean	Std. Dev
		A bit Important	Moderately Important	Important	Very Important			
Work Area	Higher Education	0	0	3	4	7	3.13	.900
	Government	0	2	0	5	7		
	Private Industry	1	3	4	1	9		
	NGO/Society	0	0	1	0	1		
Total		1	5	8	10	24		

8.4.1.29 *Support the pathways taken by would-be entrepreneurs*

As shown in Table 8-37, 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Support the pathways taken by would-be entrepreneurs component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (19 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.17. The mode was *Important* as ranked from 11 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-37: KPs' evaluation of component *Support the pathways taken by would-be entrepreneurs* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Support the pathways taken by would-be entrepreneurs (staff and students) from ideas to market growth			Total	Mean	Std. Dev
		Moderately Important	Important	Very Important			
Work Area	Higher Education	0	1	6	7	3.17	.761
	Government	2	4	1	7		
	Private Industry	3	4	2	9		
	NGO/Society	0	1	0	1		
Total		5	10	9	24		

8.4.1.30 *Build and sustain relationships with key partners and collaborator*

As shown in Table 8-38, 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Build and sustain relationships with key partners and collaborator component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.50. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-38: KPs' evaluation of component *Build and sustain relationships with key partners and collaborator* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Build and sustain relationships with key partners and collaborators such as public sector, regions, businesses, alumni and professional bodies			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	3	4	7	3.50	.659
	Government	2	3	2	7		
	Private Industry	0	2	7	9		
	NGO/Society	0	0	1	1		
Total		2	8	14	24		

8.4.1.31 *Support the international mobility of staff and students*

As shown in Table 8-39: KPs' evaluation of component *Support the international mobility of staff and students* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Support the international mobility of staff and students' mobile applications innovation ecosystem. Most KPs (23 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.46. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-39: KPs' evaluation of component *Support the international mobility of staff and students* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Support the international mobility of staff and students			Total	Mean	Std. Dev
		Moderately Important	Important	Very Important			
Work Area	Higher Education	0	4	3	7	3.46	.588
	Government	0	4	3	7		
	Private Industry	1	3	5	9		
	NGO/Society	0	0	1	1		
Total		1	11	12	24		

8.4.1.32 *Measure entrepreneurial impact*

As shown in Table 8-40: KPs' evaluation of component *Measure entrepreneurial impact* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Higher Education's Measure entrepreneurial impact component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.33. The mode was *Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-40: KPs' evaluation of component *Measure entrepreneurial impact* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Measure its entrepreneurial impact			Total	Mean	Std. Dev
		Moderately Important	Important	Very Important			
Work Area	Higher Education	0	5	2	7	3.33	.637
	Government	0	2	5	7		
	Private Industry	2	5	2	9		
	NGO/Society	0	0	1	1		
Total		2	12	10	24		

8.4.1.33 *Industry and HE Project Partnerships: Additional HE Component*

The KPs recommended that industry support higher education through partnerships. One identified benefit would be to enable students to develop real life apps sponsored by companies during assignments and projects and the establishment of mobile technology centres throughout the country to increase awareness of the developmental potential of mobile applications.

8.4.2 Higher Education Framework Artefact Evaluation

8.4.2.1 *People Consistency Evaluation*

As shown in Table 8-41: KPI evaluation of the HE framework's *People Consistency* in Botswana's 23 KPs made up of 7 higher education, 7 government, 8 Industry and 1 NGO KP assessed Higher Education's framework for People Consistency in Botswana's mobile applications innovation ecosystem. Most KPs (15 out of 23) from across the 3 helices indicated that they Agree or Strongly Agree that the HE framework has people consistency. The mode was *Agree* as ranked from 14 KPs. KPs from the HE helix also supported this when all 7 Agreed on the HE framework's people consistency. The HE framework was therefore considered people consistent within the HE helix.

Table 8-41: KPI evaluation of the HE framework's *People Consistency* in Botswana's Mobile Applications Innovation Ecosystem

Count		People Consistency in Higher Education (ease of use, usefulness, ease to understand)			Total
		Undecided	Agree	Strongly Agree	
Work Area	Higher Education	0	7	0	7
	Government	3	3	1	7
	Private Industry	4	4	0	8
	NGO/Society	1	0	0	1
Total		8	14	1	23

8.4.2.2 *Organisation Consistency Evaluation*

As shown in Table 8-42, 23 KPs made up of 7 higher education, 7 government, 8 industry and 1 NGO KP assessed the Higher Education's framework for Organisation Consistency in Botswana's mobile applications innovation ecosystem. Most KPs (19 out of 23) from across the 3 helices indicated that they Agree or Strongly Agree that the HE framework has organisation consistency. The mode was *Agree* as ranked from 16 KPs. KPs from the HE helix also supported this when all 7 Agreed on the HE framework's organisational consistency. The HE framework was therefore considered to have organisation consistency within the HE helix.

Table 8-42: KPI evaluation of the HE framework's *Organisation Consistency* in Botswana's Mobile Applications Innovation Ecosystem

Count		Organisation Consistency (fits with Higher Education objectives, useful for HE Institutions)				Total
		Disagree	Undecided	Agree	Strongly Agree	
Work Area	Higher Education	0	0	7	0	7
	Government	1	1	2	3	7
	Private Industry	1	1	6	0	8
	NGO/Society	0	0	1	0	1
Total		2	2	16	3	23

8.4.2.3 *Structure Evaluation*

As shown in Table 8-43, 23 KPs made up of 7 higher education, 7 government, 8 industry and 1 NGO KP assessed the Higher Education's framework structure for Botswana's mobile applications innovation ecosystem. Most KPs (16 out of 23) from across the 3 helices indicated that they Agree or Strongly Agree that the structure of the HE framework is complete, clear, simple and detail appropriate. The mode was *Agree* as ranked from 15 KPs. KPs from the HE helix also supported this when 6 of the 7 Agreed on the HE framework's structure. The HE framework was therefore considered to meet the structure requirements of IS artefacts.

Table 8-43: KPI evaluation of the HE framework's *Structure* for Botswana's Mobile Applications Innovation Ecosystem

Count		Structure (completeness, clarity, level of detail, simplicity)				Total
		Disagree	Undecided	Agree	Strongly Agree	
Work Area	Higher Education	0	1	5	1	7
	Government	0	2	5	0	7
	Private Industry	1	3	4	0	8
	NGO/Society	0	0	1	0	1
Total		1	6	15	1	23

8.4.2.4 *Evolution Evaluation*

As shown in Table 8-44: KPI evaluation of the HE framework's *Evolution* within Botswana's 22 KPs made up of 7 higher education, 7 government, 7 industry and 1 NGO KP assessed the Higher Education's framework for its ability to continue producing mobile applications in changing environments e.g. political, social, economic, legal changes within Botswana's mobile applications innovation ecosystem. Most KPs (18 out of 22) from across the 3 helices indicated that they Agree or Strongly Agree that the HE framework can evolve. The mode was *Agree* as ranked from 12 KPs. KPs from the HE helix also supported this when 6 of the 7 Agreed on the HE framework's evolution. The HE framework was therefore considered capable of evolution within the HE helix.

Table 8-44: KPI evaluation of the HE framework's *Evolution* within Botswana's Mobile Applications Innovation Ecosystem

Count		Evolution (ability to continue producing mobile apps in a changing environments e.g. political, social, economic, legal changes)				Total
		Disagree	Undecided	Agree	Strongly Agree	
Work Area	Higher Education	0	1	4	2	7
	Government	0	2	4	1	7
	Private Industry	1	0	4	2	7
	NGO/Society	0	0	0	1	1
Total		1	3	12	6	22

8.4.3 Industry Components Evaluation Findings

8.4.3.1 *Donations*

As shown in Table 8-45: KPs' evaluation of component *Donations* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's Donations component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. A few KPs (9 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 2.13, while the majority (15 of the 24) indicated that donations towards the mobile application industry were moderately important, a little important or not an important component of the MAIE in Botswana. The mode was *Moderately Important* as ranked from 7 KPs. This component is therefore not considered important to Botswana's mobile applications innovation ecosystem and was therefore removed.

Table 8-45: KPs' evaluation of component *Donations* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Donations					Total		
		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	0	2	3	1	7	2.13	1.329
	Government	1	3	1	0	2	7		
	Private Industry	1	2	3	1	2	9		
	NGO/Society	0	0	1	0	0	1		
Total		3	5	7	4	5	24		

8.4.3.2 *Angel/Venture Capital*

As shown in Table 8-46, 23 KPs made up of 7 higher education, 6 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's access to Angel/Venture capital in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (19 out of 23) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.09. The mode was *Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-46: KPs' evaluation of component *Angel/Venture capital* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Angel/Venture Capital			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	2	5	0	7	3.09	.668
	Government	1	4	1	6		
	Private Industry	1	3	5	9		
	NGO/Society	0	1	0	1		
Total		4	13	6	23		

8.4.3.3 *Competition Prizes*

As shown in Table 8-47: KPs' evaluation of component *Competition Prizes* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's access to Competition Prizes in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (18 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.00. The mode was bimodal with *Important* and *Very Important* as ranked from 9 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-47: KPs' evaluation of component *Competition Prizes* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Competition Prizes				Total		
		A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	4	2	7	3.00	1.022
	Government	2	1	1	3	7		
	Private Industry	1	1	3	4	9		
	NGO/Society	0	0	1	0	1		
Total		3	3	9	9	24		

8.4.3.4 *Seed Funding*

As shown in Table 8-48: KPs' evaluation of component *Seed Funding* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's access to Seed Funding in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All KPs (24 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.75 on a scale of 4. The mode was *Very Important* as ranked from 18 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-48: KPs' evaluation of component *Seed Funding* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Seed Funding		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	3	4	7	3.75	.442
	Government	2	5	7		
	Private Industry	1	8	9		
	NGO/Society	0	1	1		
Total		6	18	24		

8.4.3.5 *Start-up and bank loans*

As shown in Table 8-49, 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's access to start-up and bank loans in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (16 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 2.79. The mode was bimodal, *Important* and *Very Important* as ranked from 8 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-49: KPs' evaluation of component *Start-up and Bank loans* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Start-up and Bank loans					Total		
		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	1	3	2	7	2.79	1.179
	Government	1	0	0	4	2	7		
	Private Industry	0	2	3	0	4	9		
	NGO/Society	0	0	0	1	0	1		
Total		1	3	4	8	8	24		

8.4.3.6 *Early stage funds and accelerators*

As shown in Table 8-50: KPs' evaluation of component *Early stage funds and accelerators* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's access to early stage funds and accelerators in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (19 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.00. The mode was *Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-50: KPs' evaluation of component *Early stage funds and accelerators* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Early stage funds and accelerators				Total		
		A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	5	1	7	3.00	.780
	Government	1	1	2	3	7		
	Private Industry	0	2	5	2	9		
	NGO/Society	0	0	1	0	1		
Total		1	4	13	6	24		

8.4.3.7 *Family and Friends loans*

As shown in Table 8-51: KPs' evaluation of component *Family and Friends loans* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's Family and Friends loans in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. A few KPs (6 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 1.83. The mode was *Moderately Important* as ranked from 11 KPs. This component is therefore not considered important to Botswana's mobile applications innovation ecosystem and is therefore removed.

Table 8-51: KPs' evaluation of component *Family and Friends loans* as important to Botswana's Mobile Applications Innovation Ecosystem

		Family and Friends loans					Total		
Count		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	4	2	1	7	1.83	1.308
	Government	3	0	2	1	1	7		
	Private Industry	2	1	5	0	1	9		
	NGO/Society	1	0	0	0	0	1		
Total		6	1	11	3	3	24		

8.4.3.8 *Partnership Skills*

As shown in Table 8-52: KPs' evaluation of component *Partnership Skills* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's Partnership Skills in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.42. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-52: KPs' evaluation of component *Partnership Skills* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Partnership Skills A bit Important	Important	Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	0	6	1	7	3.42	.717
	Government	0	2	5	7		
	Private Industry	1	3	5	9		
	NGO/Society	0	0	1	1		
Total		1	11	12	24		

8.4.3.9 *Management and Marketing Skills*

As shown in Table 8-53: KPs' evaluation of component *Management and Marketing Skills* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's Management and Marketing Skills in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.33. The mode was bimodal, *Important* and *Very Important* as ranked from 11 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-53: KPs' evaluation of component *Management and Marketing Skills* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Management and Marketing Skills A bit Important	Moderately Important	Important	Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	0	0	5	2	7	3.33	.761
	Government	0	0	4	3	7		
	Private Industry	1	1	2	5	9		
	NGO/Society	0	0	0	1	1		
Total		1	1	11	11	24		

8.4.3.10 *Financial Skills*

As shown in Table 8-54: KPs' evaluation of component *Financial Skills* as important to Botswana's , 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's Financial Skills in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.46. The mode was *Very Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-54: KPs' evaluation of component *Financial Skills* as important to Botswana's Mobile Applications Innovation Ecosystem

		Financial Skills			Total		
Count		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	6	1	7	3.46	.658
	Government	0	1	6	7		
	Private Industry	2	2	5	9		
	NGO/Society	0	0	1	1		
Total		2	9	13	24		

8.4.3.11 *Intellectual property Skills*

As shown in Table 8-55: KPs' evaluation of component *Intellectual property Skills* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developers' Intellectual Property Skills in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.54. The mode was *Very Important* as ranked from 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-55: KPs' evaluation of component *Intellectual property Skills* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Intellectual property Skills			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	4	3	7	3.54	.658
	Government	0	1	6	7		
	Private Industry	2	2	5	9		
	NGO/Society	0	0	1	1		
Total		2	7	15	24		

8.4.3.12 *Hands-on Mentorship*

As shown in Table 8-56: KPs' evaluation of component *Hands-on Mentorship* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developers' access to Hands-on Mentorship in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.17. The mode was *Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-56: KPs' evaluation of component *Hands-on Mentorship* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Hands-on Mentorship			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	5	2	7	3.17	.702
	Government	2	2	3	7		
	Private Industry	1	5	3	9		
	NGO/Society	1	0	0	1		
Total		4	12	8	24		

8.4.3.13 *Mobile Entrepreneurship Hubs/Incubators*

As shown in Table 8-57: KPs' evaluation of component *Mobile Entrepreneurship Hubs/Incubators* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer access to Mobile Entrepreneurship Hubs/Incubators in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.42. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-57: KPs' evaluation of component *Mobile Entrepreneurship Hubs/Incubators* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Mobile Entrepreneurship Hubs/Incubators			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	2	4	7	3.42	.654
	Government	0	5	2	7		
	Private Industry	1	2	6	9		
	NGO/Society	0	1	0	1		
Total		2	10	12	24		

8.4.3.14 *Procurement Policies that support Mobile App Developers*

As shown in Table 8-58: KPs' evaluation of component *Procurement Policies that support Mobile App Developers* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KPs ranked Mobile Application Developer Industry's access to Procurement Policies that support Mobile App Developers in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.54. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-58: KPs' evaluation of component *Procurement Policies that support Mobile App Developers* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Procurement Policies that support Mobile App Developers			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	3	4	7	3.54	.588
	Government	0	2	5	7		
	Private Industry	1	4	4	9		
	NGO/Society	0	0	1	1		
Total		1	9	14	24		

8.4.3.15 *Competitions and hackathons*

As shown in Table 8-59: KPs' evaluation of component *Competitions and hackathons* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's Competitions and hackathons in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.42. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-59: KPs' evaluation of component *Competitions and hackathons* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Competitions and hackathons				Total		
		A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	2	5	7	3.42	.830
	Government	0	2	1	4	7		
	Private Industry	1	0	3	5	9		
	NGO/Society	0	0	1	0	1		
Total		1	2	7	14	24		

8.4.3.16 *Access to Voice, Location and Messaging services*

As shown in Table 8-60: KPs' evaluation of component *Access to Voice, Location and Messaging services* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's access to Voice, Location and Messaging services in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.33. The mode was *Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-60: KPs' evaluation of component *Access to Voice, Location and Messaging services* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Voice, Location and Messaging services			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	3	3	7	3.33	.637
	Government	0	3	4	7		
	Private Industry	1	5	3	9		
	NGO/Society	0	1	0	1		
Total		2	12	10	24		

8.4.3.17 *Payment, Billing, Identity/User Authentication services*

As shown in Table 8-61: KPs' evaluation of component *Access to Payment, Billing, Identity/User Authentication services* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's access to Payment, Billing, Identity/User Authentication services in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.54. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-61: KPs' evaluation of component *Access to Payment, Billing, Identity/User Authentication services* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Payment, Billing, Identity/User Authentication services			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	4	2	7	3.54	.588
	Government	0	2	5	7		
	Private Industry	0	3	6	9		
	NGO/Society	0	0	1	1		
Total		1	9	14	24		

8.4.3.18 *Content Distribution networks*

As shown in Table 8-62: KPs' evaluation of component *Access to Content Distribution network* as important to Botswana's 23 KPs made up of 6 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's access to Content Distribution networks in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.52. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-62: KPs' evaluation of component *Access to Content Distribution network* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Content Distribution networks			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	2	3	1	6	3.52	.665
	Government	0	1	6	7		
	Private Industry	0	3	6	9		
	NGO/Society	0	0	1	1		
Total		2	7	14	23		

8.4.3.19 *Network Infrastructure*

As shown in Table 8-63: KPs' evaluation of component *Access to Network Infrastructure* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's Network Infrastructure in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.33. The mode was *Very Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-63: KPs' evaluation of component *Access to Network Infrastructure* as important to Botswana's Mobile Applications Innovation Ecosystem

		Network Infrastructure				Total		
Count		Not Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	1	2	3	7	3.33	.963
	Government	0	0	2	5	7		
	Private Industry	0	1	4	4	9		
	NGO/Society	0	0	0	1	1		
Total		1	2	8	13	24		

8.4.3.20 *Customer trust and loyalty*

As shown in Table 8-64: KPs' evaluation of component *Customer trust and loyalty* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's Customer trust and loyalty in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.38. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-64: KPs' evaluation of component *Customer trust and loyalty* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Customer trust and loyalty				Total		
		A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	2	4	7	3.38	.770
	Government	0	0	2	5	7		
	Private Industry	1	0	6	2	9		
	NGO/Society	0	0	0	1	1		
Total		1	1	10	12	24		

8.4.3.21 *Server leases*

As shown in Table 8-65: KPs' evaluation of component *Access to Server lease* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's access to Server leases in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (17 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 2.96. The mode was *Very Important* as ranked from 9 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-65: KPs' evaluation of component *Access to Server lease* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Server leases					Total		
		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	0	5	2	7	2.96	1.083
	Government	0	0	1	2	4	7		
	Private Industry	1	1	3	1	3	9		
	NGO/Society	0	0	1	0	0	1		
Total		1	1	5	8	9	24		

8.4.3.22 *Internet Connectivity*

As shown in Table 8-66: KPs' evaluation of component *Internet Connectivity* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's access to Internet Connectivity in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.38. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-66: KPs' evaluation of component *Internet Connectivity* as important to Botswana's Mobile Applications Innovation Ecosystem

		Internet Connectivity				Total		
Count		Not Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	2	4	7	3.38	.970
	Government	0	0	3	4	7		
	Private Industry	1	1	1	6	9		
	NGO/Society	0	0	1	0	1		
Total		1	2	7	14	24		

8.4.3.23 *Zero Rating Services*

As shown in Table 8-67: KPs' evaluation of component *Zero Rating Services* as important to Botswana's 21 KPs made up of 6 higher education, 6 government, 8 industry and 1 NGO ranked Mobile Application Developer Industry's access to Zero Rating Services in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (14 out of 21) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 2.67. The mode was *Important* as ranked from 10 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-67: KPs' evaluation of component *Zero Rating Services* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Zero Rating Services					Total		
		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	3	3	0	6	2.67	1.065
	Government	0	1	0	3	2	6		
	Private Industry	1	0	1	4	2	8		
	NGO/Society	0	1	0	0	0	1		
Total		1	2	4	10	4	21		

8.4.3.24 *Internet access to more users*

As shown in Table 8-68: KPs' evaluation of component *Internet access to more users* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's Internet access to more users in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All KPs (24 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.71. The mode was *Very Important* as ranked from 17 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-68: KPs' evaluation of component *Internet access to more users* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Make internet accessible to more users		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	4	3	7	3.71	.464
	Government	1	6	7		
	Private Industry	1	8	9		
	NGO/Society	1	0	1		
Total		7	17	24		

8.4.3.25 *More bandwidth for mobile internet users*

As shown in Table 8-69: KPs' evaluation of component *More bandwidth for mobile internet users* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's More bandwidth for mobile internet users in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All KPs (24 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.71. The mode was *Very Important* as ranked from 17 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-69: KPs' evaluation of component *More bandwidth for mobile internet users* as important to Botswana's Mobile Applications Innovation Ecosystem

		Provide more bandwidth for mobile internet users		Total		
Count		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	4	3	7	3.71	.464
	Government	2	5	7		
	Private Industry	1	8	9		
	NGO/Society	0	1	1		
Total		7	17	24		

8.4.3.26 *Mobile business and payment systems*

As shown in Table 8-70: KPs' evaluation of component *Adopt mobile business and payment systems* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's adoption of mobile business and payment systems in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.67. The mode was *Very Important* as ranked from 17 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-70: KPs' evaluation of component *Adopt mobile business and payment systems* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Adopt mobile business and payment systems			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	2	5	7	3.67	.565
	Government	1	2	4	7		
	Private Industry	0	2	7	9		
	NGO/Society	0	0	1	1		
Total		1	6	17	24		

8.4.3.27 *Family and Friends Support*

As shown in Table 8-71: KPs' evaluation of component *Family and Friends Support* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked Mobile Application Developer Industry's Family and Friends Support in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (14 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 2.71. The mode was bimodal with *Important* and *Moderately Important* as ranked from 8 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-71: KPs' evaluation of component *Family and Friends Support* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Family and Friends Support					Total		
		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	2	3	1	7	2.71	1.042
	Government	0	0	2	3	2	7		
	Private Industry	1	0	3	2	3	9		
	NGO/Society	0	0	1	0	0	1		
Total		1	1	8	8	6	24		

8.4.3.28 *Smarter Phones*

As shown in Table 8-72: KPs' evaluation of component *Smarter Phones* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's Smarter Phones in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.21. The mode was *Very Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-72: KPs' evaluation of component *Smarter Phones* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Faster processing power, Longer battery life, Bigger screens, Lighter					Total		
		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	0	2	5	7	3.21	1.141
	Government	0	0	1	1	5	7		
	Private Industry	1	2	0	3	3	9		
	NGO/Society	0	0	0	1	0	1		
Total		1	2	1	7	13	24		

8.4.3.29 *Lower phone prices*

As shown in Table 8-73, 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked Mobile Application Developer Industry's Lower phone prices in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (19 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.08. The mode was *Very Important* as ranked from 10 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-73: KPs' evaluation of component *Lower phone prices* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Lower Phone prices					Total		
		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	1	3	3	7	3.08	1.060
	Government	0	0	0	3	4	7		
	Private Industry	1	1	2	2	3	9		
	NGO/Society	0	0	0	1	0	1		
Total		1	1	3	9	10	24		

8.4.3.30 *Legal, Technological and Security Awareness Among Users and Developers: Additional Industry Component*

The KPs recommended that mobile application developers, as well as users, be made more aware of the legal, technological and security aspects surrounding the usage of mobile applications. Developers and users were recommended to identify mobile application needs as well as obtain exposure to the existing and new technological potentials.

8.4.4 Industry Framework Artefact Evaluation

8.4.4.1 *People Consistency Evaluation*

As shown in Table 8-74, 23 KPs made up of 7 higher education, 7 government, 8 industry and 1 NGO KP assessed the Mobile Applications Industry's framework for People Consistency in Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 23) from across the 3 helices indicated that they Agree that the framework supports people consistency. The mode was Agree as ranked from 20 KPs. KPs from the mobile Applications Industry helix also supported this when 6 of the 8 Agreed that the industry framework is people consistent. The industry framework was therefore considered people consistent within the mobile applications industry helix.

Table 8-74: KPs' evaluation of Mobile Applications Industry framework's *People Consistency* in Botswana's Mobile Applications Innovation Ecosystem

Count		People Consistency in Industry (Ease of use, usefulness, ease to understand)			Total
		Disagree	Undecided	Agree	
Work Area	Higher Education	0	1	6	7
	Government	0	0	7	7
	Private Industry	1	1	6	8
	NGO/Society	0	0	1	1
Total		1	2	20	23

8.4.4.2 *Organisation Consistency Evaluation*

As shown in Table 8-75: KPs' evaluation of Mobile Applications Industry framework's *Organisation Consistency* in Botswana's 23 KPs made up of 7 higher education, 7 government, 8 industry and 1 NGO KP assessed the Mobile Applications Industry's framework for Organisation Consistency in Botswana's mobile applications innovation ecosystem. Most KPs (16 out of 23) from across the 3 helices indicated that they Agree or Strongly Agree that the framework has organisational consistency. The mode was *Agree* as ranked from 13 KPs. KPs from the Mobile Applications Industry helix also supported this when most (6 of the 8) Agreed on the framework's organisational consistency. The Mobile Applications Industry's framework was therefore considered to have organisation consistency within the Mobile Applications Industry's helix.

Table 8-75: KPs' evaluation of Mobile Applications Industry framework's *Organisation Consistency* in Botswana's Mobile Applications Innovation Ecosystem

Count		Organisation Consistency (fits with industry objectives, useful for industry)			Total
		Undecided	Agree	Strongly Agree	
Work Area	Higher Education	1	5	1	7
	Government	2	3	2	7
	Private Industry	3	5	0	8
	NGO/Society	1	0	0	1
Total		7	13	3	23

8.4.4.3 *Structure Evaluation*

As shown in Table 8-76: KPs' evaluation of Mobile Applications Industry framework's *Structure* for Botswana's 23 KPs made up of 7 higher education, 7 government, 8 industry and 1 NGO KP assessed the Mobile Applications Industry's framework structure for Botswana's mobile applications innovation ecosystem. Most KPs (15 out of 23) from across the 3 helices indicated that they Agree that the framework's structure is complete, simple, clear and the appropriate level of detail. The mode was *Agree* as ranked by 15 KPs. KPs from the Mobile Applications Industry's helix also supported this when 5 of the 8 Agreed on the framework's structure evaluation. The Mobile Applications Industry's framework was therefore considered to meet the structure requirements of IS artefacts.

Table 8-76: KPs' evaluation of Mobile Applications Industry framework's *Structure* for Botswana's Mobile Applications Innovation Ecosystem

Count		Structure (completeness, clarity, level of detail, simplicity)			Total
		Disagree	Undecided	Agree	
Work Area	Higher Education	0	2	5	7
	Government	0	2	5	7
	Private Industry	1	2	5	8
	NGO/Society	1	0	0	1
Total		2	6	15	23

8.4.4.4 *Evolution Evaluation*

As shown in Table 8-77: KPs' evaluation of Mobile Applications Industry framework's *Evolution* within Botswana's 23 KPs made up of 7 higher education, 7 government, 8 Industry and 1 NGO KP assessed the Mobile Applications Industry's framework for its ability to continue producing mobile app developers in changing environments e.g. political, social, economic and legal changes within Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 23) from across the 3 helices indicated that they Agree or Strongly Agree that the framework can evolve. The mode was *Agree* as ranked by 14 KPs. KPs from the Mobile Applications Industry helix also supported this when all 8 of the 8 Agreed or Strongly Agreed on the framework's evolution evaluation.

The Mobile Applications Industry's framework was therefore considered capable of evolving within the Mobile Applications Industry's helix.

Table 8-77: KPs' evaluation of Mobile Applications Industry framework's *Evolution* within Botswana's Mobile Applications Innovation Ecosystem

Count		Evolution (ability to continue producing mobile app developers in changing environments e.g. political, social, economic, legal changes)				Total
		Disagree	Undecided	Agree	Strongly Agree	
Work Area	Higher Education	0	1	4	2	7
	Government	1	0	3	3	7
	Private Industry	0	0	6	2	8
	NGO/Society	0	0	1	0	1
Total		1	1	14	7	23

8.4.5 Government Components Evaluation Findings

8.4.5.1 *Accelerators and mobile entrepreneurship hubs*

As shown in Table 8-78, 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked Government's Accelerators and mobile entrepreneurship hubs component in terms of their ability to effectively enhance Botswana's mobile applications innovation ecosystem. All KPs from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.56. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-78: KPs' evaluation of component *Accelerators and mobile entrepreneurship hubs* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Setting up accelerators and mobile entrepreneurship hubs		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	4	3	7	3.56	.507
	Government	3	5	8		
	Private Industry	4	5	9		
	NGO/Society	0	1	1		
Total		11	14	25		

8.4.5.2 *Early Stage funding*

As shown in Table 8-79: KPs' evaluation of component *Early Stage Funding* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 Industry and 1 NGO KP ranked Government's Early Stage funding component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (24 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.52. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-79: KPs' evaluation of component *Early Stage Funding* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Early Stage funding			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	2	5	7	3.52	.586
	Government	1	4	3	8		
	Private Industry	0	4	5	9		
	NGO/Society	0	0	1	1		
Total		1	10	14	25		

8.4.5.3 *Elimination of dropped calls and the absence of signals*

As shown in Table 8-80: KPs' evaluation of component *Elimination of dropped calls and the absence of signal* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's elimination of dropped calls and the absence of signals component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.24. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-80: KPs' evaluation of component *Elimination of dropped calls and the absence of signal* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Avoid dropped calls and the absence of signals					Total		
		Not Important	A bit Important	Moderately Important	Importa nt	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	0	6	1	7	3.24	1.012
	Government	0	0	0	3	5	8		
	Private Industry	1	1	1	1	5	9		
	NGO/Society	0	0	0	0	1	1		
Total		1	1	1	10	12	25		

8.4.5.4 *Avoid non-delivery of text messages*

As shown in Table 8-81: KPs' evaluation of component *Avoid non-delivery of text messages* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Avoid non-delivery of text messages component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.12. The mode was *Important* as ranked from 11 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-81: KPs' evaluation of component *Avoid non-delivery of text messages* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Avoid non-delivery of text messages					Total		
		Not Important	A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	1	5	1	7	3.12	1.013
	Government	0	0	0	4	4	8		
	Private Industry	1	1	1	1	5	9		
	NGO/Society	0	0	0	1	0	1		
Total		1	1	2	11	10	25		

8.4.5.5 *Minimum internet speeds*

As shown in Table 8-82: KPs' evaluation of component *Minimum internet speed* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Minimum internet speeds component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.44. The mode was *Very Important* as ranked from 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-82: KPs' evaluation of component *Minimum internet speed* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Avoid limited internet speeds				Total		
		Not Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	6	1	7	3.44	.917
	Government	0	0	1	7	8		
	Private Industry	1	1	1	6	9		
	NGO/Society	0	0	0	1	1		
Total		1	1	8	15	25		

8.4.5.6 *Reclaiming, Issuing more and relicensing unused spectrum*

As shown in Table 8-83: KPs' evaluation of component *Reclaiming, Issuing more and relicensing unused spectrum* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Reclaiming, Issuing more and relicensing unused spectrum component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.12. The mode was *Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-83: KPs' evaluation of component *Reclaiming, Issuing more and relicensing unused spectrum* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Reclaiming, Issuing more and re licensing unused spectrum			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	5	1	7	3.12	.666
	Government	1	3	4	8		
	Private Industry	2	5	2	9		
	NGO/Society	0	1	0	1		
Total		4	14	7	25		

8.4.5.7 *Encouraging mobile virtual network operators*

As shown in Table 8-84: KPs' evaluation of component *Encouraging mobile virtual network operators* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 Industry and 1 NGO KP ranked government's Encouraging mobile virtual network operators component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.36. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-84: KPs' evaluation of component *Encouraging mobile virtual network operators* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Encouraging mobile virtual network operators			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	3	3	7	3.36	.810
	Government	2	0	6	8		
	Private Industry	2	2	5	9		
	NGO/Society	0	1	0	1		
Total		5	6	14	25		

8.4.5.8 *Enabling entrepreneurship visas*

As shown in Table 8-85: KPs' evaluation of component *Enabling entrepreneurship visa's* Importance to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked government's Enabling entrepreneurship visas component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.21. The mode was *Very Important* as ranked by 11 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and therefore retained.

Table 8-85: KPs' evaluation of component *Enabling entrepreneurship visa*'s Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Enable entrepreneurship visas				Total		
		Not Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	2	2	3	7	3.21	.977
	Government	1	0	3	3	7		
	Private Industry	0	1	3	5	9		
	NGO/Society	0	0	1	0	1		
Total		1	3	9	11	24		

8.4.5.9 *Enhancing mobile network infrastructure*

As shown in Table 8-86: KPs' evaluation of component *Enhancing mobile network infrastructure* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Enhancing mobile network infrastructure component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All 25 KPs from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.56. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-86: KPs' evaluation of component *Enhancing mobile network infrastructure* as important to Botswana's Mobile Applications Innovation Ecosystem

		Enhance mobile network infrastructure				
Count		Important	Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	3	4	7	3.56	.507
	Government	3	5	8		
	Private Industry	4	5	9		
	NGO/Society	1	0	1		
Total		11	14	25		

8.4.5.10 *Offer free legal advice, intellectual property education and mentorship*

As shown in Table 8-87: KPs' evaluation of component *Offer free legal advice, intellectual property education and mentorship* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 Industry and 1 NGO KP ranked government's Offer free legal advice, intellectual property education and mentorship component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.29. The mode was *Very Important* as ranked from 11 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-87: KPs' evaluation of component *Offer free legal advice, intellectual property education and mentorship* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Offer free legal advice, intellectual property education and mentorship			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	4	2	7	3.29	.751
	Government	3	0	4	7		
	Private Industry	0	5	4	9		
	NGO/Society	0	0	1	1		
Total		4	9	11	24		

8.4.5.11 *Mandating national roaming agreements*

As shown in Table 8-88: KPs' evaluation of component *Mandating national roaming agreements* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked Government's Mandating national roaming agreements component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.28. The mode was *Very Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-88: KPs' evaluation of component *Mandating national roaming agreements* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Mandate national roaming agreements				Total		
		Not Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	3	3	7	3.28	.980
	Government	0	1	2	5	8		
	Private Industry	1	1	2	5	9		
	NGO/Society	0	0	1	0	1		
Total		1	3	8	13	25		

8.4.5.12 *Financial and political support for rural mobile infrastructure*

As shown in Table 8-89: KPs' evaluation of component *Financial and political support for rural mobile infrastructure's* Importance to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's financial and political support for rural mobile infrastructure component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All 25 KPs from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.60. The mode was *Very Important* as ranked from 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-89: KPs' evaluation of component *Financial and political support for rural mobile infrastructure*'s Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Offer financial and political support for rural mobile infrastructure		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	4	3	7	3.60	.500
	Government	1	7	8		
	Private Industry	4	5	9		
	NGO/Society	1	0	1		
Total		10	15	25		

8.4.5.13 *Positive, competitive and efficient macro-economic conditions*

As shown in Table 8-90: KPs' evaluation of component *Positive, competitive and efficient macro-economic conditions* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's positive, competitive and efficient macro-economic conditions component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All 25 KPs from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.64. The mode was *Very Important* as ranked from 16 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-90: KPs' evaluation of component *Positive, competitive and efficient macro-economic conditions* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Create positive, competitive and efficient macro-economic conditions		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	2	5	7	3.64	.490
	Government	2	6	8		
	Private Industry	4	5	9		
	NGO/Society	1	0	1		
Total		9	16	25		

8.4.5.14 *National broadband targets*

As shown in Table 8-91: KPs' evaluation of component *National broadband target* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's national broadband targets component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All 25 KPs across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.60. The mode was *Very Important* as ranked from 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-91: KPs' evaluation of component *National broadband target* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Establishing national broadband targets		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	4	3	7	3.60	.500
	Government	2	6	8		
	Private Industry	3	6	9		
	NGO/Society	1	0	1		
Total		10	15	25		

8.4.5.15 *Net neutrality*

As shown in Table 8-92: KPs' evaluation of component *Net neutrality's* Importance to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Net neutrality component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All 25 KPs from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.44. The mode was *Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-92: KPs' evaluation of component *Net neutrality*'s Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Encourages net neutrality		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	5	2	7	3.44	.507
	Government	3	5	8		
	Private Industry	5	4	9		
	NGO/Society	1	0	1		
Total		14	11	25		

8.4.5.16 *National satellite dishes and submarine cable landing stations*

As shown in Table 8-93: KPs' evaluation of component *National satellite dishes and submarine cable landing station's* Importance to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's National satellite dishes and submarine cable landing stations component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.36. The mode was *Very Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-93: KPs' evaluation of component *National satellite dishes and submarine cable landing station*'s Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		National satellite dishes and submarine cable landing stations			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	5	2	7	3.36	.757
	Government	1	1	6	8		
	Private Industry	3	1	5	9		
	NGO/Society	0	1	0	1		
Total		4	8	13	25		

8.4.5.17 *Domain name registration*

As shown in Table 8-94: KPs' evaluation of component *Domain name registration* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Domain name registration component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.32. The mode was *Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and therefore retained.

Table 8-94: KPs' evaluation of component *Domain name registration* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Domain name registration				Total		
		A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	4	3	7	3.32	.748
	Government	0	0	4	4	8		
	Private Industry	1	1	3	4	9		
	NGO/Society	0	0	1	0	1		
Total		1	1	12	11	25		

8.4.5.18 *National backbone and Intercity networks*

As shown in Table 8-95: KPs' evaluation of component *National backbones and Intercity network* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's National backbone and Intercity networks component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.36. The mode was *Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-95: KPs' evaluation of component *National backbones and Intercity network* as important to Botswana's Mobile Applications Innovation Ecosystem

		National backbones and Intercity networks			Total		
Count		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	4	3	7	3.36	.638
	Government	0	5	3	8		
	Private Industry	2	2	5	9		
	NGO/Society	0	1	0	1		
Total		2	12	11	25		

8.4.5.19 *Internet points of presence*

As shown in Table 8-96: KPs' evaluation of component *Internet points of presence* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Internet points of presence component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (24 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.36. The mode was *Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-96: KPs' evaluation of component *Internet points of presence* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Internet points of presence			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	4	3	7	3.36	.569
	Government	0	4	4	8		
	Private Industry	1	5	3	9		
	NGO/Society	0	1	0	1		
Total		1	14	10	25		

8.4.5.20 *SIM card registrations*

As shown in Table 8-97: KPs' evaluation of component *SIM card registrations'* Importance to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's SIM card registrations component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (21 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.20. The mode was *Very Important* as ranked from 11 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-97: KPs' evaluation of component *SIM card registrations*' Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		SIM card registrations				Total		
		Not Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	3	4	7	3.20	.957
	Government	0	0	3	5	8		
	Private Industry	1	2	4	2	9		
	NGO/Society	0	1	0	0	1		
Total		1	3	10	11	25		

8.4.5.21 *Mobile operators sharing sites and masts*

As shown in Table 8-98: KPs' evaluation of component *Mobile operators sharing sites and mast* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 Industry and 1 NGO KP ranked government's mobile operators sharing sites and masts component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (18 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.00. The mode was bimodal with *Very Important* and *Important* as ranked from 9 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-98: KPs' evaluation of component *Mobile operators sharing sites and mast* as important to Botswana's Mobile Applications Innovation Ecosystem

		Requesting operators to share sites and masts				Total		
Count		Not Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	4	3	7	3.00	1.000
	Government	0	2	0	6	8		
	Private Industry	1	3	5	0	9		
	NGO/Society	0	1	0	0	1		
Total		1	6	9	9	25		

8.4.5.22 *Cost-based interconnection fees*

As shown in Table 8-99: KPs' evaluation of component *Cost-based interconnection fees* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 Industry and 1 NGO KP ranked government's Cost-based interconnection fees component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (20 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.20. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-99: KPs' evaluation of component *Cost-based interconnection fees* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Enforcing cost-based interconnection fees				Total		
		Not Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	0	5	2	7	3.20	1.000
	Government	0	2	0	6	8		
	Private Industry	1	2	2	4	9		
	NGO/Society	0	0	1	0	1		
Total		1	4	8	12	25		

8.4.5.23 *Cyber-security*

As shown in Table 8-100: KPs' evaluation of component *Cyber-security's* Importance to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Cyber-security component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (24 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.76. The mode was *Very Important* as ranked from 20 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-100: KPs' evaluation of component *Cyber-security*'s Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Cyber-security			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	6	7	3.76	.523
	Government	0	1	7	8		
	Private Industry	1	1	7	9		
	NGO/Society	0	1	0	1		
Total		1	4	20	25		

8.4.5.24 *Adopting m-Gov and e-Gov*

As shown in Table 8-101: KPs' evaluation of component *Adopting m-Gov and e-Gov's* Importance to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked government's Adopting m-Gov and e-Gov component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.54. The mode was *Very Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-101: KPs' evaluation of component *Adopting m-Gov and e-Gov*'s Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Adopting m and e-Gov by enabling companies to develop gov apps			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	3	3	7	3.54	.588
	Government	0	2	5	7		
	Private Industry	0	3	6	9		
	NGO/Society	0	1	0	1		
Total		1	9	14	24		

8.4.5.25 *Driving local content*

As shown in Table 8-102: KPs' evaluation of component *Driving local content* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Driving local content component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All 25 KPs from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.68. The mode was *Very Important* as ranked from 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-102: KPs' evaluation of component *Driving local content* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Drive local content: Important	Drive local content: Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	3	4	7	3.60	.500
	Government	4	4	8		
	Private Industry	3	6	9		
	NGO/Society	0	1	1		
Total		10	15	25		

8.4.5.26 *Driving demand for mobile services*

As shown in Table 8-103: KPs' evaluation of component *Driving demand for mobile services* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Driving demand for mobile services component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (24 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.68. The mode was *Very Important* as ranked from 18 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-103: KPs' evaluation of component *Driving demand for mobile services* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Driving demand for mobile services: Moderately Important	Driving demand for mobile services: Important	Driving demand for mobile services: Very Important	Total	Mean	Std. Dev
Work Area	Higher Education	0	2	5	7	3.68	.557
	Government	0	1	7	8		
	Private Industry	1	3	5	9		
	NGO/Society	0	0	1	1		
Total		1	6	18	25		

8.4.5.27 *Advance mobile hardware*

As shown in Table 8-104: KPs' evaluation of component *Advance mobile hardware's* Importance to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Advance mobile hardware component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. All 25 KPs from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.68. The mode was *Very Important* as ranked from 17 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-104: KPs' evaluation of component *Advance mobile hardware*'s Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Advance mobile hardware		Total		
		Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	4	3	7	3.68	.476
	Government	1	7	8		
	Private Industry	3	6	9		
	NGO/Society	0	1	1		
Total		8	17	25		

8.4.5.28 *Digital divide funds*

As shown in Table 8-105: KPs' evaluation of component *Digital divide funds* as important to Botswana's 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Digital divide funds component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (24 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.56. The mode was *Very Important* as ranked from 15 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-105: KPs' evaluation of component *Digital divide funds* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Digital divide funds			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	3	4	7	3.56	.583
	Government	0	2	6	8		
	Private Industry	1	4	4	9		
	NGO/Society	0	0	1	1		
Total		1	9	15	25		

8.4.5.29 *Driving internet usage through importation of mobile phones and network infrastructure*

As shown in Table 8-106, 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Driving internet usage through importation of mobile phones and network infrastructure component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.20. The mode was *Important* as ranked from 13 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-106: KPs' evaluation of component *Driving internet usage through importation of mobile phones and network infrastructure* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Driving internet usage through importation of mobile phones and network infrastructure				Total		
		A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	5	1	7	3.20	.764
	Government	0	0	4	4	8		
	Private Industry	1	1	3	4	9		
	NGO/Society	0	0	1	0	1		
Total		1	2	13	9	25		

8.4.5.30 *Zero Rating*

As shown in Table 8-107: KPs' evaluation of component *Zero Rating's* Importance to Botswana's 23 KPs made up of 7 higher education, 7 government, 8 industry and 1 NGO KP ranked government's Zero-Rating component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (18 out of 23) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.09. The mode was bimodal with *Very Important* and *Important* as ranked from 9 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-107: KPs' evaluation of component *Zero Rating*'s Importance to Botswana's Mobile Applications Innovation Ecosystem

Count		Zero Rating				Total		
		A bit Important	Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	1	4	2	7	3.09	.949
	Government	1	0	3	3	7		
	Private Industry	0	2	2	4	8		
	NGO/Society	1	0	0	0	1		
Total		2	3	9	9	23		

8.4.5.31 *Business establishment processes*

As shown in Table 8-45: KPs' evaluation of component *Donations* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked government's Business establishment processes component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (17 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.04. The mode was *Important* as ranked from 9 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-108: KPs' evaluation of component *Business establishment processes* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Business establishment processes			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	1	4	2	7	3.04	.806
	Government	3	2	2	7		
	Private Industry	2	3	4	9		
	NGO/Society	1	0	0	1		
Total		7	9	8	24		

8.4.5.32 *Favourable mobile licensing costs*

As shown in Table 8-109, 25 KPs made up of 7 higher education, 8 government, 9 industry and 1 NGO KP ranked government's Favourable mobile licensing costs component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (23 out of 25) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.40. The mode was *Very Important* as ranked from 12 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-109: KPs' evaluation of component *Favourable mobile licensing costs* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Favourable licensing costs			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	6	1	7	3.40	.645
	Government	0	2	6	8		
	Private Industry	1	3	5	9		
	NGO/Society	1	0	0	1		
Total		2	11	12	25		

8.4.5.33 *Mobile entrepreneurship supportive procurement frameworks*

As shown in Table 8-110: KPs' evaluation of component *Mobile entrepreneurship supportive procurement framework* as important to Botswana's 24 KPs made up of 7 higher education, 7 government, 9 industry and 1 NGO KP ranked government's Mobile entrepreneurship supportive procurement frameworks component in terms of its ability to effectively enhance Botswana's mobile applications innovation ecosystem. Most KPs (22 out of 24) from across the 3 helices agreed and indicated that this component is either Important or Very Important with a mean of 3.50. The mode was *Important* as ranked from 14 KPs. This component is therefore considered important to Botswana's mobile applications innovation ecosystem and is therefore retained.

Table 8-110: KPs' evaluation of component *Mobile entrepreneurship supportive procurement framework* as important to Botswana's Mobile Applications Innovation Ecosystem

Count		Procurement frameworks that encourages mobile entrepreneurship			Total		
		Moderately Important	Important	Very Important		Mean	Std. Dev
Work Area	Higher Education	0	4	3	7	3.50	.659
	Government	1	1	5	7		
	Private Industry	1	3	5	9		
	NGO/Society	0	0	1	1		
Total		2	8	14	24		

8.4.5.34 *Countrywide Technological Awareness, Open Data, and Open Market: Additional Government Components*

The KPs recommended that government reduce regulations to create an increasing number of open mobile ecosystem while availing open data to enable developers to develop relevant mobile applications. The education of school learners across the country in the development of local content was also a component of the mobile applications innovation ecosystem. KPs also recommended that the private sector should invest more in the mobile application industry.

8.4.6 Government Framework Artefact Evaluation

8.4.6.1 *People Consistency Evaluations*

As shown in Table 8-111: KPs' evaluation of Government Framework's People Consistency in Botswana's 24 KPs made up of 7 higher education, 8 government, 8 industry and 1 NGO KP assessed the government framework components for People Consistency in Botswana's mobile applications innovation ecosystem. Most KPs (17 out of 24) from across the 3 helices indicated that they Agree or Strongly Agree that the government framework exhibits people consistency. The mode was *Agree* as ranked by 14 KPs. KPs from the government helix also supported this when 6 of the 8 Agreed on the government framework's people consistency. The government framework therefore exhibited people consistency within the government helix.

Table 8-111: KPs' evaluation of Government Framework's People Consistency in Botswana's Mobile Applications Innovation Ecosystem

Count		People Consistency in Industry (Ease of use, usefulness, ease to understand)				Total
		Disagree	Undecided	Agree	Strongly Agree	
Work Area	Higher Education	0	1	5	1	7
	Government	2	0	5	1	8
	Private Industry	2	2	3	1	8
	NGO/Society	0	0	1	0	1
Total		4	3	14	3	24

8.4.6.2 *Organisation Consistency Evaluation*

As shown in Table 8-112: KPs' evaluation of government Framework's Organisation Consistency in relation to Botswana's 23 KPs made up of 7 higher education, 8 government, 7 industry and 1 NGO KP assessed the government framework components for Organisation Consistency in Botswana's mobile applications innovation ecosystem. Most KPs (17 out of 23) from across the 3 helices indicated that they Agree or Strongly Agree that the government framework has organisational consistency. The mode was *Agree* as ranked from 14 KPs. KPs from the government helix also supported this when 6 of the 8 Agreed on the framework's organisational consistency. The government framework was therefore considered to have organisation consistency within the government helix.

Table 8-112: KPs' evaluation of government Framework's Organisation Consistency in relation to Botswana's Mobile Applications Innovation Ecosystem

Count		Organisation Consistency (fits with Gov) objectives, useful for Gov				Total
		Disagree	Undecided	Agree	Strongly Agree	
Work Area	Higher Education	0	1	5	1	7
	Government	0	2	5	1	8
	Private Industry	1	1	4	1	7
	NGO/Society	0	1	0	0	1
Total		1	5	14	3	23

8.4.6.3 *Structure Evaluation*

As shown in Table 8-113: KPs' evaluation of government Framework's Structure for Botswana's 23 KPs made up of 7 higher education, 8 government, 7 industry and 1 NGO KP assessed the government's framework structure for Botswana's mobile applications innovation ecosystem. Most KPs (17 out of 23) from across the 3 helices indicated that they Agree or Strongly Agree that the structure of the government framework's structure is complete, clear, simple and displays an appropriate level of detail. The mode was Agree as ranked by 13 KPs. KPs from the government helix also supported this when 6 of the 8 Agreed on the evaluation. The government framework was therefore considered to meet the structure requirements of IS artefacts.

Table 8-113: KPs' evaluation of government Framework's Structure for Botswana's Mobile Applications Innovation Ecosystem

Count		Structure (completeness, clarity, simplicity and level of detail)				Total
		Disagree	Undecided	Agree	Strongly Agree	
Work Area	Higher Education	0	1	5	1	7
	Government	2	0	4	2	8
	Private Industry	1	2	3	1	7
	NGO/Society	0	0	1	0	1
Total		3	3	13	4	23

8.4.6.4 *Evolution Evaluation*

As shown in Table 8-114: KPs' evaluation of government Framework's Evolution within Botswana's 23 KPs made up of 7 higher education, 8 government, 7 industry and 1 NGO KP assessed the government framework for its ability to continue producing mobile app developers in changing environments e.g. political, social, economic and legal changes within Botswana's mobile applications innovation ecosystem. Most KPs (18 out of 23) from across the 3 helices indicated that they Agree or Strongly Agree that the government framework can withstand evolution. The mode was *Agree* as ranked from 13 KPs. KPs from the government helix also supported this when 6 of the 8 Agreed on the government framework's evolution. The government framework was therefore considered capable of evolution within the government helix.

Table 8-114: KPs' evaluation of government Framework's Evolution within Botswana's Mobile Applications Innovation Ecosystem

Count		Evolution (ability to continue producing mobile app developers in changing environments e.g. political, social, economic and legal changes)				Total
		Disagree	Undecided	Agree	Strongly Agree	
Work Area	Higher Education	0	1	4	2	7
	Government	0	2	5	1	8
	Private Industry	1	1	3	2	7
	NGO/Society	0	0	1	0	1
Total		1	4	13	5	23

8.5 Revision of the Mobile Applications Innovation Ecosystem Framework for Botswana

From the DSR methodology followed the final framework developed for Botswana's mobile applications innovation ecosystem. After the final evaluation by KPs, the ecosystem components presented in Table 8-115 were removed, or added, as a result of the evaluation by the KPs.

Table 8-115: MAIE Revision from KP Evaluation

Component	Action	Reason
Donations	Removed	KPs indicated that donations are not relevant in the MAIE
Family and friend loans	Removed	KPs indicated that donations are not relevant in the MAIE
Industry and HE partnerships	Added	KPs indicated that partnerships between HE and industry is relevant for Botswana's MAIE
Legal, technological and security awareness among users and developers	Added	KPs indicated that partnerships between HE and industry are relevant for Botswana's MAIE
Countrywide technological awareness, open data, and open market	Added	KPs indicated that partnerships between HE and industry are relevant for Botswana's MAIE

The final MAIE framework for Botswana is presented in Figure 8-8 as a concept map which is summarised in Figure 8-9.

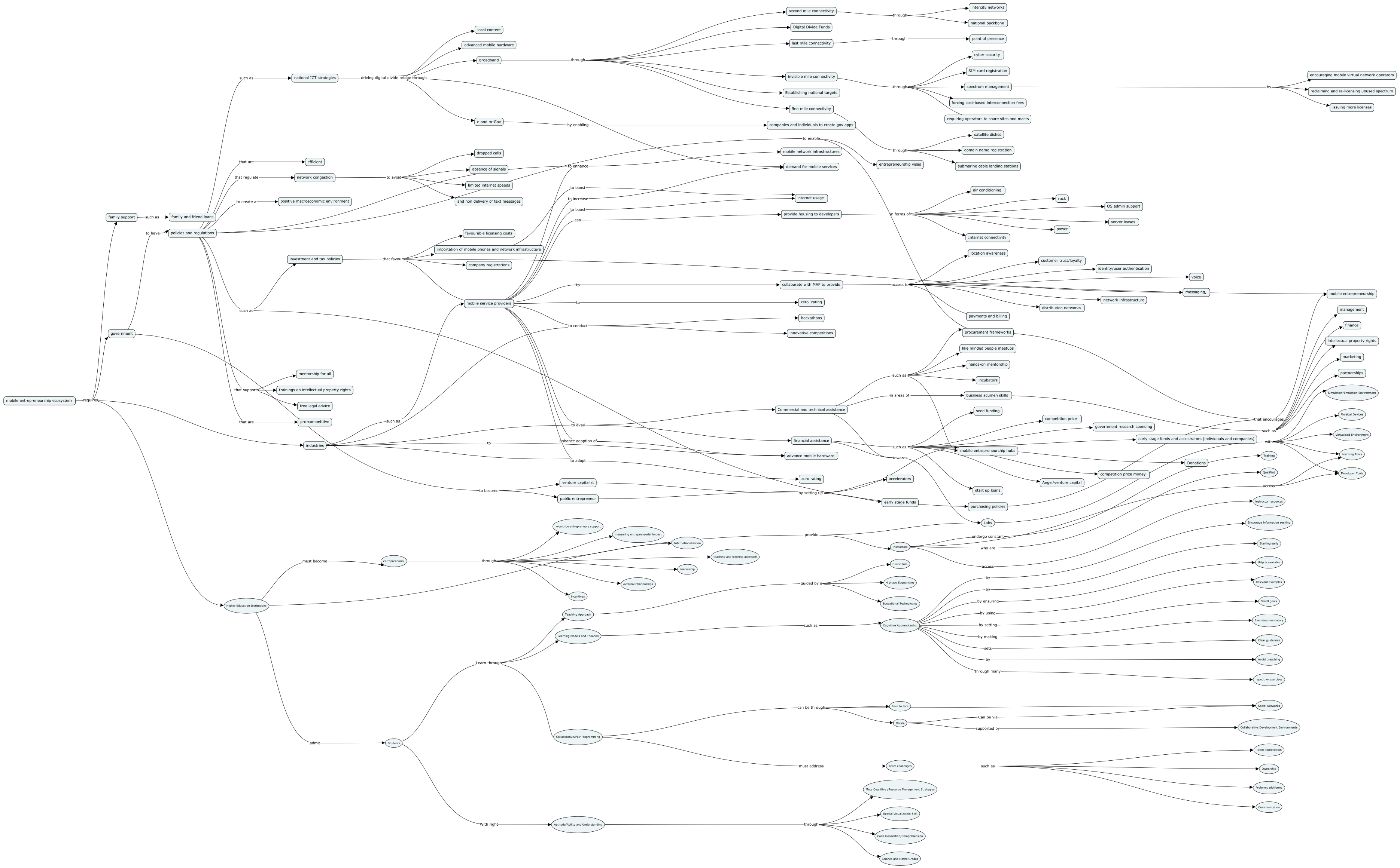

Figure 8-8: Final MAIE Framework for Botswana Concept Map

8.6 Conclusion

The evaluation of the MAIE framework by the KPs from the three helixes confirmed the relevance of the developed framework within the Botswana context. KPs generally agreed on the evaluation ratings, irrespective of their helix origin. A summarised framework is subsequently presented.

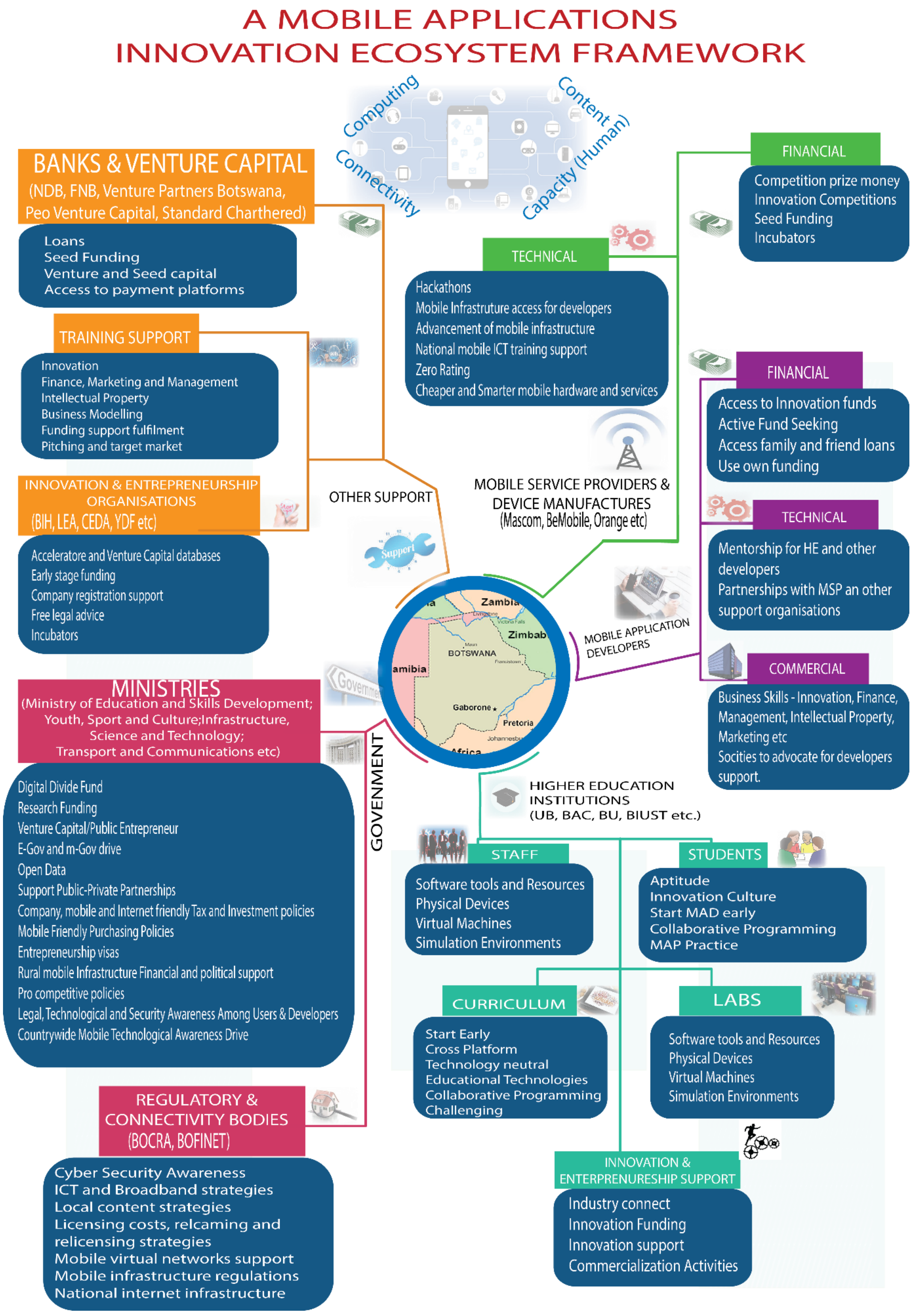

Figure 8-9: Final Mobile Applications Innovation Ecosystem Framework

Chapter 9 Conclusion, Reflection and Recommendations

9.1 Introduction

Achieving the developmental potential presented by ICT in developing countries with a high mobile penetration rate can be enhanced if the mobile applications ecosystem becomes innovative enough to establish new ways of conducting business and providing relevant content to users via mobile devices. Such a thriving mobile applications ecosystem can commence with the establishment of a mobile applications innovation ecosystem that is aimed at addressing the 4Cs of ICT through the collaboration of HEI, Industry and Government. This thesis, within the domain of ICT4D, considers how the collaboration among HEI, Industry and Government can lead to a mobile applications innovation ecosystem which drives societal development through the creation of locally relevant mobile applications. Through the identification of the actors and their roles, an artefact that guides the establishment of an innovation ecosystem for mobile applications was designed and evaluated using a DSR research strategy.

Following the two DSR phases presented in Chapters 5, 6, 7 (Phase 1) and 8 (Phase 2), this chapter presents the research overview in section 9.2 and the reflections on the research questions as well as the research objectives in section 9.3. The contribution of the research is discussed in section 9.4, a critical reflection is presented in section 9.5, the challenges experienced in 9.6 and the recommendations based on the findings in 9.7.

9.2 Research Overview

This thesis consists of 9 chapters detailing the research investigation undertaken into the development of a mobile applications innovation ecosystem framework for the Southern African country of Botswana.

Chapter 1 introduced the research by motivating the role of locally relevant mobile applications in societal development and presenting the research questions, which the study set out to answer.

Chapter 2 presented the research's application context through an introduction of Botswana.

Chapter 3 elaborated on the adopted Design Science Research (DSR) strategy through the two phases used to develop the mobile applications innovation ecosystem framework for Botswana.

Chapter 4 presented the unique amalgamation of ICT's 4Cs Framework (Tongia et al., 2005) and the systems theory's Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) which was adopted as the theoretical framework for the study.

Chapter 5 presented the initial DSR cycles where the components of a mobile applications innovation ecosystem from a higher education perspective were explored through a literature review resulting in an initial framework being designed and described. The initial framework's relevance was evaluated through a survey involving HE students. An updated HE framework was then presented.

Chapter 6 presented the components of a mobile applications innovation ecosystem from an industry perspective. An initial set of components were explored from literature reviews and a framework was designed and described before being evaluated for relevance through interviews with mobile application developers.

Chapter 7 presented the components of a mobile applications innovation ecosystem from a government perspective. Initial framework components were identified from the literature reviews and the relevance of the components from the government's framework was established through surveys from government and other support organisations.

Chapter 8 presented Phase 2 of the DSR as the consolidated framework design from the three Phase 1 perspectives of Higher Education (Chapter 5), Industry (Chapter 6) and Government (Chapter 7). The consolidated framework was developed and evaluated through a survey involving knowledgeable professionals from all three perspectives in Botswana. This process resulted in the presentation of a final framework for Botswana's mobile applications innovation ecosystem.

Chapter 9 concludes the study through a reflection and presents recommendations emanating from the study.

9.3 Research Reflections: Research questions and Objectives

The study sought to explore, describe and refine a mobile applications innovation ecosystem framework for Botswana in a bid to create an enabling environment for the development of locally relevant mobile applications that can act as agents for societal development. To achieve this objective, the research question: ***What Innovation Ecosystem can support the development of Mobile Applications in Botswana?*** was formulated. Due to several actors and the roles they play within innovation ecosystems, a Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) from the systems theory was adopted, thus requiring the sub questions to be answered by addressing the questions for each of the triple helix perspectives of higher education, industry and government. This main research question was answered through three sub questions:

RQ_1. What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Higher Education perspective?

RQ_2. What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Industry perspective?

RQ_3. What are the components, support opportunities available to the mobile applications innovation ecosystem from the Government perspective, and what is the uptake of this support?

The following section summarises the answers to the research questions.

For the Higher Education helix, the following sub questions were addressed:

RQ_1. What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Higher Education perspective?

Chapter 5 explored, described and refined the HE perspective framework components through literature reviews and questionnaires administered to 202 students.

Summary Answer: The Higher Education components within a mobile applications innovation ecosystem include role players such as HE administrators, teaching staff, students, guest mobile application developers' lecturers and the associated laboratories, curriculum and its delivery. Entrepreneurship supports structures that enable the development of human capacity to innovate, develop and use mobile content. The challenges faced by higher education students in mobile application programming were infrastructural: poor lab facilities, lack of up to date books, outdated computers, limited access to tutors and practice phones as well as personal challenges such as: poor programming skills, lack of interest in MAP and poor study habits. Opportunities therefore exist for higher education institutions to develop environments that support “bring your own devices” with dedicated and accessible MAP tutors, while providing general and MAP programming learning support, setting up IDEs on student laptops and freely sharing available electronic MAP books and videos with students, thus ensuring communities have the capacity to develop, innovate and use mobile applications for development.

For the Industry perspective, the following sub questions were addressed:

RQ_2. What are the components, challenges and opportunities within the mobile applications innovation ecosystem from the Industry perspective?

Chapter 6 explored, described and refined the industry perspective framework components through literature reviews and introduced relevance through interviews with 41 mobile application developers and developer organisations.

Summary Answer: The Industry components within a mobile applications innovation ecosystem include role players such as mobile application developers, mobile service providers, mobile device manufacturers and other industry support organisations which offer training, financial, technical and commercial support to the mobile application industry to enable the innovation, development, distribution and consumption of mobile content. Challenges within the mobile ecosystem include limited finances, poor business acumen by the developer communities and few technical partnerships among critical players of the ecosystem. Innovative funding, mentorship and partnership programmes are opportunities for innovative funding. Mentorships and training as regards business and management skills are opportunities that exist to help mobile application developers within the mobile applications ecosystem in Botswana.

The Government perspective was incorporated when the following sub question was addressed:

RQ_3. What are the components, support opportunities available to the mobile applications innovation ecosystem from the Government perspective, and what is the uptake of this support?

This sub question sought to explore, describe and refine the components of a mobile applications innovation ecosystem within the government perspective and to establish the level of support which the government of Botswana and other support organisation offer the Mobile Application Development industry and the uptake of this support. Chapter 7 addressed the government components through literature reviews and interviews with 20 government and private support organisations.

Summary Answer: The government components within a mobile applications innovation ecosystem contain role players such as various ministries including the Ministry of Education and Skills Development; Youth, Sport and Culture; Infrastructure, Science and Technology as well as Transport and Communications and the regulatory and connectivity bodies such as BOCRA and BOFINET which play varying roles within the mobile ecosystem. Ensuring access to devices, connectivity, content and human capacity to use mobile technologies by the users and abilities by developers throughout the mobile ecosystem value chain can be achieved through funding, regulations, policies and strategies which create conducive environments for mobile application innovations.

RQ_M. **What are the components of a mobile applications innovation ecosystem framework for Botswana?**

The main research question was therefore answered after the components from the three sub questions had been consolidated and evaluated by 24 knowledgeable professionals from the triple helix related to the mobile applications ecosystem. The final framework is presented in Section 8.6.

Summary Answer:

The study therefore managed to answer all research questions and achieve the stated research objectives.

9.4 Contribution

The impact of a research study ranges from raising awareness of findings to changing behaviour (Walter, Nutley, & Davies, 2003). A DSR research study's contribution to practice or theory, which can be in the form of constructs, models, methods and instantiations aids to understand, explain and frequently improve the behaviour of social systems, as shown in Figure 3-1: DSR contribution types (Gregor & Hevner, 2010). As a Level 2 contribution, the research's primary contribution presents the human, relational and structural capital that can be adopted in a Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) to develop an innovation ecosystem for mobile applications. Additional contributions are:

- The components of a mobile applications innovation ecosystem which facilitate mobile application development, as presented in sections 5.2, 6.2 and 7.2 and summarised in sections 5.3, 6.3 and 7.3.
- Challenges faced by Botswana's higher education students in Mobile Application Programming presented in section 5.4.
- The challenges faced by Botswana's mobile application developers presented in section 6.4.
- The availability of support for Botswana's mobile application industry and the uptake of this support presented in section 7.4.
- A presentation of the actors and roles that are needed for a mobile applications innovation ecosystem for Botswana shown in Figure 8-9 (Section 8.6).
- Practical contributions of the study resulted in a mobile applications development club at Botho University with an Extreme Apprenticeship mobile application development curriculum.

9.5 Critical Reflection

A reflection on the study process, the research product as well as the learning that took place is presented in this section. This process is based on the seven guidelines of DSR and the seven principles of interpretive research (Myers & Klein, 1999) seeing that the study was pragmatic in nature and included both interpretivist and positivist approaches.

The research contributions, therefore, present the foundational components of a mobile applications innovation ecosystem, thus presenting a foundation upon which future theories on mobile applications innovation ecosystems can be developed.

The research followed a DSR methodology and ascribed to the 7 DSR guidelines of Hevner et al. (2004) to thus adhere to the completeness requirements of a DSR study.

Table 9-1: Critical reflection of the 7 DSR guidelines of Hevner et al. (2004) to the study

Guideline	Description	Implications for this research
Guideline 1: Design as an Artefact	Design-science research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.	The research produced a framework whose viability is assessed through KPs from the mobile ecosystem in Botswana
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.	The developed framework incorporates literature and relevant student and mobile app developers' challenges and opportunities available to the mobile ecosystem in Botswana.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.	The refinement, efficacy and evaluation of the framework was done by KPs from Botswana/s mobile ecosystem.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies.	The primary research contribution, A mobile applications innovation ecosystem framework is presented in addition to the communication from each DSR cycle including the challenges and opportunities faced by HE students and mobile application developers in mobile application programming, the support and opportunities available to Botswana's mobile application industry are presented.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.	Rigor for the framework is provided by literature reviews to identify the components and the evaluation of the designs through the 202 Higher Education Students, 41 Mobile Application Developers, 20 Government and NGO support organisations, 24 Knowledgeable Professionals

Guideline	Description	Implications for this research
Guideline 6: Design as a Search Process	The search for an effective artefact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.	Literature reviews were used to search for the initial components of the ecosystem and additional searches done from the stakeholders for relevance and contextualisation.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.	The thesis tries to present information as detailed in Guideline 4 above, to management and technology-oriented audiences.

The conduct and evaluation of field research in Information Systems was guided and reflected the 7 principles presented by Myers and Klein (1999). A critical reflection of how these principles were addressed in the study is presented as a means of evaluating the quality of the study.

Table 9-2: Critical reflection of the 7 principles of evaluating interpretive IS studies (Myers & Klein, 1999)

Principle	Description	Implications for this research
Hermeneutic Circle	Reflects on how understanding is achieved by iterating between the parts and the whole which they create	The research conducted 2 DSR phases with the first phase (Chapters 5, 6 and7) addressing the parts and the second phase (Chapter 8) addressing the whole.
Contextualisation	Reflects on the social and historical background of the research setting	Chapter 2 presented the context of the research by introducing Botswana and its mobile ecosystem.
Interaction between the Researchers and the Subjects	Reflects on how data was socially constructed through the interaction of the researcher and the participants	The participants of the study included students, lecturers, mobile application developers, mobile service providers, government and other supporting participants, and through the interviews or surveys revealing the components, challenges and opportunities faced.
Abstraction and Generalisation	Requires relating the details of the study to theoretical and/or general concepts	The study presented the research details in Chapters 5, 6, 7 and section 8.4. Generalisations, as well as the final framework artefact, were presented in section 8.5

Principle	Description	Implications for this research
Dialogical Reasoning	Sensitivity to possible contradictions between the theoretical and actual findings	Due to the iterative nature of DSR, the theoretical findings from literature were evaluated by stakeholders several times to address possible contradictions.
Multiple Interpretations	Sensitivity to possible differences in interpretations among the participants	Due to the diverse nature of participants in the study, various views from various phases and helixes were used to revise the framework. Chapter 8 presented the consensus resultant framework, thus addressing the principle.
Suspicion	Sensitivity to biases and distortions in the narratives collected from the participants	This principle was addressed through: i) literature reviews which identified the initial framework components and ii) involvement of Knowledgeable Professionals in evaluating the framework which ensured that biases and distortions were eliminated.

9.6 Challenges

9.6.1 Methodological: An initial focus on human capacity and content

The study developed a mobile applications innovation ecosystem framework to ensure the development of locally relevant mobile applications which can drive society's development through mobile technologies. The study therefore initially focused on developing the human capacity to develop innovative mobile content, and thus focused largely on two (namely human capacity and content) of the 4Cs, as the high mobile penetration rate was assumed to address the computing and connectivity needs of the developmental requirements of ICT4D. Chapter 5 is reflective of this bias as it focused on human capacity to develop locally relevant mobile content. As the study progressed, it became apparent that connectivity through mobile devices is an area which needed to be addressed as the cost and reliability of mobile connections were raised as concerns by students and mobile application developers alike. Therefore, a need exists to explore ways of addressing the connectivity and reliability gaps within Botswana to ensure inclusion for all.

9.6.2 Application: Applicability to varying contexts

The study acknowledges that young community members attending higher education institutions and mobile application developers are ideal drivers for "*ICT for society through society*", provided they are armed with appropriate mobile application development skills within a conducive ecosystem (Coetzee, 2010). The study did not involve the users of mobile applications, despite them being central to any ICT4D project, as the ecosystem will ensure the inclusion of users through various components as described in section 8.6.

Only 53% of the KPs responded with an evaluation of the framework, and thus, as per Nielson (2000), about 90% of the problems in the MAIE framework were considered , thus reducing the applicability of the framework within Botswana. Although the study was limited to Botswana, applicability can be extended to countries with a similar mobile ecosystem profile with few relevance DSR cycles. Applicability to other countries can be achieved through the engagement of local stakeholders and guided by some of the DSR relevance cycles.

9.7 Recommendations

The desired growth of Botswana's knowledge-based economy, through human capital and the use of ICT, requires ICT innovations and advancement in human knowledge. Adopting mobile phones as a means of availing ICT to Botswana is justified by the huge mobile penetration rate in the country and the consequent need to develop a mobile applications innovation ecosystem. The Triple Helix Model of Innovation (Etzkowitz et al., 2007; Leydesdorff, 2005) from the systems theory proved to be useful in the identification of the components within the innovation ecosystem, while the 4Cs Framework (Tongia et al., 2005) provided valuable insight into the essential components from each helix employed to drive developmental goals that every innovation ecosystem tries to achieve. The adopted theoretical framework, presented in Chapter 4, was therefore appropriate for the study and is recommended for other innovation framework studies. Some more recommendations are now highlighted.

9.7.1 The Importance of Collaboration

Collaboration is key in any innovation ecosystem as it allows the flow of both human and structural resources. The study therefore recommends that the 4Cs Framework

(Tongia et al., 2005) adds a *Collaboration C* to include collaboration among all role players in any ICT4D driven innovation ecosystem. Collaboration amongst all stakeholders, in addition to the 4Cs, should result in more effective ICT4D.

9.7.2 Establishing Mobile App Innovation Centres

The MAIE framework shows that innovation can take place if public (government) and private organisations, within the mobile applications ecosystem, collaborate and provide the required human capacity, computing, connectivity, content and support to users while providing technical, financial and commercial support required to motivate *users to use* and *developers to develop* the required mobile applications. To meet these requirements, the establishment of Mobile App Innovation Centres across the country can be adopted. These centres will provide the required human capacity as well as facilitate computing and connectivity among the population. Mobile apps will thus be used to meet informational needs. These same communities can identify needs that can be taken on board by the Innovation Centres, which will then develop content to address the community's developmental requirements. Such innovation centres can be funded by public-private partnerships, which provide the infrastructure and facilitate the computing and connectivity, whilst mobile application developers provide the content and HE provides the human capacity needed to use and manage the mobile applications.

9.7.3 Enhancing the Mobile Technology Infrastructure

The 4Cs framework (Tongia et al., 2005) highlighted the importance of computing and connectivity components in the mobile applications innovation ecosystem. As shown from the Higher Education, Industry and Government perspectives, access to mobile connectivity and the availability, cost, speed and reliability thereof needs to be improved to support the development of a mobile innovation ecosystem.

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Appendices

Appendix 0-1: Ethical Clearance from UNISA

UNISA college of science, engineering and technology

Dear Mr Tutsirayi Admore Nyamaka (44801858)

Date: 2015-02-10

Application number: 001/TAN/2015

REQUEST FOR ETHICAL CLEARANCE: (A Framework for Enhancing Mobile Application Programming in a Resource-Constrained Environment)

The College of Science, Engineering and Technology's (CSET) Research and Ethics Committee has considered the relevant parts of the studies relating to the abovementioned research project and research methodology and is pleased to inform you that ethical clearance is granted for your research study as set out in your proposal and application for ethical clearance.

Therefore, involved parties may also consider ethics approval as granted. However, the permission granted must not be misconstrued as constituting an instruction from the CSET Executive or the CSET CRIC that sampled interviewees (if applicable) are compelled to take part in the research project. All interviewees retain their individual right to decide whether to participate or not.

We trust that the research will be undertaken in a manner that is respectful of the rights and integrity of those who volunteer to participate, as stipulated in the UNISA Research Ethics policy. The policy can be found at the following URL:
http://cm.unisa.ac.za/contents/departments/res_policies/docs/ResearchEthicsPolicy_apprvCounc_21Sept07.pdf

Please note that the ethical clearance is granted for the duration of this project and if you subsequently do a follow-up study that requires the use of a different research instrument, you will have to submit an addendum to this application, explaining the purpose of the follow-up study and attach the new instrument along with a comprehensive information document and consent form.

Yours sincerely

Prof Ernest Mnkandla
Chair: College of Science, Engineering and Technology Ethics Sub-Committee

Prof IOG Moche
Executive Dean: College of Science, Engineering and Technology

RECEIVED
2015 -02- 12
OFFICE OF THE EXECUTIVE DEAN
College of Science, Engineering and Technology

University of South Africa
College of Science, Engineering and Technology
The Science Campus
C/o Christiaan de Wet Road and Pioneer Avenue, Florida Park, Roodepoort
Private Bag X6, Florida, 1710
www.unisa.ac.za/cset

UNISA college of science, engineering and technology

Appendix 0-2: Permission to conduct research at Botho University – a higher education institution in Botswana

GABORONE CAMPUS:
Botho Education Park, Kgale, Gaborone
P.O. Box 501564, Gaborone
Tel: +267 391 9999 / 391 9666
Fax: +267 318 7858

FRANCISTOWN CAMPUS:
Barclays Plaza, Blue Jacket Street, Francistown
P/Bag F451, Francistown
Tel: +267 244 0686
Fax: +267 244 0685

MAUN CAMPUS:
Opp. Maun Technical College, Boseja, Maun
P.O. Box 20157,Boseja, Maun
Tel: +267 686 5404
Fax: +267 686 5035

www.bothouniversity.ac.bw
BOS ISO 9001:2008 CERTIFIED ORGANIZATION

BOTHO UNIVERSITY 1997

BOTHO UNIVERSITY
EXCELLENCE | LEADERSHIP | INNOVATION

Ref: - 119/GBE/ORQM/2014
11 December 11, 2014

College Research and Ethics Committee
University of South Africa
Preller Street
Muckleneuk Ridge
Pretoria
0003

To whom it may concern

RE: Permission to conduct research using Botho University students

This letter serves to confirm that Botho University has been made aware of, and grants Admore Tutsirayi Nyamaka the permission to conduct research on the University premises. The University understands that the study seeks to understand the challenges and needs of mobile application programming among tertiary students so as to enable the development of a framework for enhancing mobile application programming in Botswana.

Botho University understands that the research will be conducted during the January 2015 and August 2015 periods.

The University acknowledges that student participation is voluntary and participants will be granted the choice of stopping to participate at any time during the research.

Regards

Dr. M. Chawawa
Research Manager
Date: 11. 12. 14
Signature:

EXCELLENCE | LEADERSHIP | INNOVATION

Appendix 0-3: Permission to conduct research in Botswana

Republic of Botswana
Ministry of Transport and Communications
Private Bag 00414, Gaborone, Botswana, Tel: (+267) 361200 Fax: (+267) 3907236

REF: MT&C 1/13/9 IV (28) **10th July 2017**

Mr Admore Nyamaka

Dear Sir,

APPLICATION FOR A RESEARCH PERMIT: "A Framework for Developing Innovative Mobile applications among Higher Education Students in Botswana".

We refer to the introductory letter from Dr Norman Rudmumbu at Botho University, dated 20th June 2017 and your research proposal, on the above subject.

1. Ministry of Transport and Communications, hereby grants you permission to conduct research on the above mentioned topic, as requested.
2. The Ministry looks forward to receive the findings of your research, for future references.

Yours Faithfully

Moses M. Moreri

/FOR PERMANENT SECRETARY

BOTSWANA Our pride, your destination

we connect communities

Appendix 0-4: Questionnaire Consent Form for establishing challenges faced by HEI students

Edit this form

Resource Constraints Faced by Botswana High… Education Institution Students in Mobile Application Programming

Dear Participant,

This form is to get your consent to participate in a research conducted by Admore Nyamaka (admoren@gmail.com, Tel. +267 72301819) as part of a PhD Information Systems at UNISA, under the supervision of Prof. Judy V. Biljon (vbiljja@unisa.ac.za) and Prof Adele Botha (abotha@csir.co.za). This questionnaire seeks to identify the needs of, and challenges faced by students in Botswana's tertiary education institutions in mobile application programming.

The questionnaire will take approximately 30 minutes of your time. The questionnaire has 5 sections, A - E. Kindly answer the questions as honestly as possible. The information you provide will be valuable in assisting mobile application programming enhancement efforts in Botswana.

Your responses will be kept confidential and the information will not, in any way, be used to identify you. The information you provide will be used only for the purposes of this research.

Your participation in this research is voluntary, and you have the right to, at any time, withdraw or refuse to participate without giving any reason. All responses from you and other participants will be kept confidential. All responses will be collectively analyzed and therefore will not be linked to any participant name.

Yours,

Admore Tutsirayi Nyamaka
University of South Africa (UNISA)
+267 72301819.

* Required

Consent Form

I confirm that I have read and understood the information sheet for the above study. *

- ○ Yes
- ○ No

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason. *

- ○ Yes
- ○ No

I agree to take part in the above study. *

- ○ Yes
- ○ No

Your name (Optional)

Appendix 0-5: Interview Consent Form for Mobile Application Developers in Botswana

Mobile App Developer | Instrument: Structured Interview

Date of interview		Start time :	
Interviewer ID		Finish Time :	

Good day! My name is Admore Nyamaka, a PhD Information Systems Student under the supervision of Prof. Judy V. Bilion (vbiljja@unisa.ac.za) and Prof Adele Botha (abotha@csir.co.za) at UNISA South Africa. I am conducting a research to establish the needs of, and challenges faced by, start-up mobile entrepreneurships in Botswana. I would like to conduct a 25 minute interview with you now if we can? Are you willing to participate?

IF yes, Your participation in this research is voluntary, and you have the right to, at any time, withdraw or refuse to participate without giving any reason. All responses from you and other participants will be kept confidential. All responses will be collectively analyzed and therefore will not be linked to any participant name.

If **No**, thank respondent and leave.

Respondents Demographics

Appendix 0-6: Interview Consent Form for Support and Funding Agencies in Botswana's Mobile Application Ecosystem

MSP, Support and Funding Agencies Instrument: Structured Interview

Date of interview		Start time :	
Interviewer ID		Finish Time :	

Good day! My name is Admore Nyamaka, a PhD Information Systems Student under the supervision of Prof. Judy V. Biljon (vbiljja@unisa.ac.za) and Prof Adele Botha (abotha@csir.co.za) at UNISA South Africa. I am conducting a research to establish the financial, commercial and technical needs of, and challenges faced by, start-up mobile entrepreneurships in Botswana. I would like to conduct a 15 minute interview with you now if we can? Are you willing to participate?

IF yes, Your participation in this research is voluntary, and you have the right to, at any time, withdraw or refuse to participate without giving any reason. All responses from you and other participants will be kept confidential. All responses will be collectively analyzed and therefore will not be linked to any participant name.

If **No**, thank respondents and leave.

Respondents Demographics

Appendix 0-7: Questionnaire Consent Form for KP's evaluating the MAIE framework

Components of a Framework for Enhancing Botswana's Mobile Application Ecosystem

Dear Participant,

Batswana have 1.5 times more mobile phone subscriptions to the population, and yet the mobile application industry in the country is still in its infancy.

My name is Admore Nyamaka, a PhD Information Systems Student under the supervision of Prof. Judy V. Biljon (vbiljja@unisa.ac.za) and Prof Adele Botha (abotha@csir.co.za) at UNISA South Africa. I am conducting a research to develop a framework for positioning Higher Education Students to Participate in Botswana's Mobile Application Development Ecosystem.

A literature review on mobile application ecosystems enhancement components was carried out and and an initial framework was developed. To evaluate and contexualise the framework to Botswana, knowledgeable professionals within Industry, Government and Higher Education, such as yourself, are required to assist.

Kindly note that your participation in this research is voluntary, and you have the right to, at any time, withdraw or refuse to participate without giving any reason. All responses from you and other participants will be kept confidential. All responses will be collectively analyzed and therefore will not be linked to any participant name

Appendix 0-8: Survey Questionnaire - Resource Constraints Faced by Botswana Higher Education Institution Students in Mobile Application Programming

Resource Constraints Faced by Botswana Higher Education Institution Students in Mobile Application Programming

Dear Participant,

This form is to get your consent to participate in a research conducted by Admore Nyamaka (admoren@gmail.com, Tel. +267 72301819) as part of a PhD Information Systems at UNISA, under the supervision of Prof. Judy V. Biljon (vbiljja@unisa.ac.za) and Prof Adele Botha (abotha@csir.co.za). This questionnaire seeks to identify the needs of, and challenges faced by students in Botswana's tertiary education institutions in mobile application programming.

The questionnaire will take approximately 30 minutes of your time. The questionnaire has 5 sections, A - E. Kindly answer the questions as honestly as possible. The information you provide will be valuable in assisting mobile application programming enhancement efforts in Botswana.

Your responses will be kept confidential and the information will not, in any way, be used to identify you. The information you provide will be used only for the purposes of this research.

Your participation in this research is voluntary, and you have the right to, at any time, withdraw or refuse to participate without giving any reason. All responses from you and other participants will be kept confidential. All responses will be collectively analyzed and therefore will not be linked to any participant name.

Yours,

Admore Tutsirayi Nyamaka
University of South Africa (UNISA)
+267 72301819.

* Required

Consent Form

1. **I confirm that I have read and understood the information sheet for the above study.** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

2. **I understand that my participation is voluntary and that I am free to withdraw at any time, without giving reason.** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

3. **I agree to take part in the above study.** *
   Mark only one oval.
   - ◯ Yes
   - ◯ No

4. **Your name (Optional)**

____

SECTION A: DEMOGRAPHIC DETAILS

Kindly provide demographic details

5. **Your Gender.** *
Choose Applicable
Mark only one oval.
   - ◯ Male
   - ◯ Female

6. **Your Age** *
Select your age range
Mark only one oval.
   - ◯ 20 and Below
   - ◯ 21 - 25
   - ◯ 26 - 30
   - ◯ Above 30

7. **Programme of Study**
Indicate the programme you are studying towards e.g Bsc Computing, Diploma in Information Technology etc.

____

8. **Name of School/College/University/Institution**

____

9. **Level of study** *
Select what best describes the level of study you are currently in.
Mark only one oval.
   - ◯ First Year
   - ◯ Second Year
   - ◯ Third Year
   - ◯ Fourth Year
   - ◯ Postgraduate (Msc or PhD)

10. **Who pays for your tuition or school fees?**
Select who pays your fees, or the majority (more than 50%) of your tuition fees
Mark only one oval.

- Government
- Family
- Non Governement Scholarship
- Self
- Other: ____________________

11. **Town/City where you are studying:**
Select the town from which you are currently studying in
Mark only one oval.

- Gaborone
- Francis Town
- Maun
- Palapye
- Other: ____________________

12. **Describe your place of residence**
Select what best describes the place you stay in during the semester.
Mark only one oval.

- On Campus
- Off campus - with family
- Off Campus - Renting

SECTION B: MOBILE APPLICATION PROGRAMMING INTERESTS

13. **Does your institution offer mobile application programming as a course/programme/module?**
Select only 1 applicable choice
Mark only one oval.

- Yes
- No
- Not sure

14. **Have you developed one (1) or more mobile applications before?**
Select only 1 applicable choice
Mark only one oval.

- Yes
- No

15. **How many of your friends know or are learning mobile application programming?**
Select only 1 applicable choice
Mark only one oval.

- None
- 1
- 2
- 3
- 4
- More than 4
- Not sure

16. **Do you think learning mobile application programming is an essential skill?**
Select only 1 applicable choice
Mark only one oval.

- Very essential
- Essential
- Not very essential
- Not essential at all
- Not sure

17. **If you prefer to learn Mobile Application Programming, indicate why would you want to learn Mobile Application Programming?**
Select all choice that are applicable
Check all that apply.

- [ ] Increase prospects of getting a job
- [ ] Start developing my own Mobile Apps
- [ ] Just to gain the skill
- [ ] I do not want to learn mobile application programming
- [ ] Other: ______________________

18. **Which mobile platform would you prefer to learn**
If you want to learn Mobile Application Programming, select all the platforms you are interested in learning
Check all that apply.

- [ ] Android
- [ ] Apple iOS
- [ ] Blackberry RIM
- [ ] Windows Mobile
- [ ] Other: ______________________

19. **How much time (per week) would you be willing to spend learning mobile application programming?**
Provide an estimate of the time you are willing to spend learning MAP every week
Mark only one oval.

- Less than 2 hours/week
- 2 - 4 hours/week
- 5 - 7 hours/week
- More than 7 hours/week

20. **How many months of learning do you think will give you a good understanding of mobile application programming**
Please indicate maximum period you will be willing to spend learning Mobile Application Programming, choose only 1 applicable
Mark only one oval.

- 1 month
- 2 months
- 3 months
- 4 months
- No Idea
- Other: ____________________

21. **How would you prefer your mobile application programming lessons delivered to you?**
Please indicate all approaches you will prefare when it comes to receiving lessons on Mobile Application Programming lessons
Check all that apply.

- [ ] Via a classroom session
- [ ] Via the internet
- [ ] Via CDs
- [ ] Via printed material
- [ ] Facebook
- [ ] Whatsapp
- [ ] WeChat
- [ ] Other: ____________________

22. **Indicate your proficiency in the following**

Please indicate your knowledge of the following by selecting the relevant option for each skill

Mark only one oval per row.

	None	Very limited understanding	Average understanding	Good understanding	Expert
Knowledge of Java - Inheritance	◯	◯	◯	◯	◯
Knowledge of Java - Exception Handling	◯	◯	◯	◯	◯
Knowledge of Java - Event Listeners	◯	◯	◯	◯	◯
Knowledge of Java - Threads	◯	◯	◯	◯	◯
Knowledge of Java - File/Network I/O	◯	◯	◯	◯	◯
XML	◯	◯	◯	◯	◯
SQL	◯	◯	◯	◯	◯

23. **How often (per week) do you discuss study material with fellow students/lecturers?**

An estimated average time per week you spend on groups discussions, chats, calls etc with other students or lecturers using either technology or face-to-face

Mark only one oval.

- ◯ Never
- ◯ Less than 2 hours/week
- ◯ 2 - 4 hours/week
- ◯ 4 - 7 hours/week
- ◯ more than 7 hours/week

24. **When stuck in learning mobile application programming, who would you prefer to contact for assistance?**

Check all that apply.

- ☐ I do not want to contact anyone
- ☐ A colleague (fellow student)
- ☐ My Instructor
- ☐ Search online
- ☐ Other: ____________________

25. **What tools do you use to discuss your study material with fellow students/lecturers?**

Select all that are applicable

Check all that apply.

- [ ] Face to Face
- [ ] Virtual Learning Platform (Blackboard/Moodle etc)
- [ ] Email
- [ ] SMS
- [ ] Facebook
- [ ] WhatsApp
- [ ] Twitter
- [ ] Other: ____________________

SECTION C: ICT INFRUSTRUCTURE OWNERSHIP

26. **Which of the following ICT resources do you own?**

Check all that apply.

- [ ] Desktop computer
- [ ] Printer
- [ ] Laptop
- [ ] Mobile phone
- [ ] Television
- [ ] DVD Player
- [ ] Other: ____________________

27. **How safe are your ICT resources identified above from the following?**

Mark only one oval per row.

	Very Safe	Safe	Neutral	Not Safe	Very Unsafe
Theft	◯	◯	◯	◯	◯
Misplacement	◯	◯	◯	◯	◯
Fire	◯	◯	◯	◯	◯
Water	◯	◯	◯	◯	◯
Other	◯	◯	◯	◯	◯

28. **Which platform does your phone use?**

Check all that apply.

- [ ] Android
- [ ] Apple iOS
- [ ] Blackberry RIM
- [ ] Windows Mobile
- [ ] I do not know
- [ ] Other: ____________________

29. **Describe the features that are available on your mobile phone?**

Mark only one oval per row.

	Yes	No	Dont Know
SMS			
Camera			
Internet access			
Video player			
Emails			
MP3 player			
Voice recorder			
Document reader			
Twitter			
Facebook			
WhatsApp			
WeChat			
Maps			
Apps download			

30. **Please indicate the amount spent on airtime per week**

If you have a monthly contract or recharge once a month, please divide monthly contract amount by four to convert to weeks)

Mark only one oval.

- I do not spend money on airtime
- Less than P20/week
- P21 - P50/week
- P51 - P100/week
- P101 - P150/week
- More than P150 /week

31. **In a week, how often do you access internet from the following?**

Mark only one oval per row.

	Never	Rarely - Less than 2 days/week	Occasionally - around 3 - 4 days/week	Frequently - around 5 - 6 days/week	Always - Every day of the week
Desktop computer at home					
Laptop computer at home					
Desktop computer at school					
Laptop computer at school					
Internet Cafe					
Someone else's house/office					
Work place					
Mobile cellular phone					
Internet Dongle					

32. **Describe your internet experience**

Mark only one oval per row.

	Very Poor	Poor	Neither poor not good	Good	Very Good
Speed - Internet at Home					
Reliability - Internet at Home					
Speed - Internet at School					
Reliability - Internet at School					
Speed - Internet on mobile phone					
Reliability - Internet on mobile phone					

33. **As part of your normal routine, to what extent do you engage in the following activities while online**

Mark only one oval per row.

	Never	Rarely - Less than 2 days/week	Occasionally - 3- 4 times/week	Frequently - Around 5- 6 days/week	Always - Everyday of the week
Search internet for news or information on current events					
Search internet for health or medical information					
Use internet to access sports results					
Watch a video online					
Download videos to watch later					
Visit social networking sites to check for updates and to update your status					
Check and respond to emails					
Read/Download Study related material					
Chat with your friends					

SECTION D: Resource Constraints

34. **What best describes the time you first had contact with a personal computer**
Mark only one oval.

- ◯ During Primary School
- ◯ During Secondary School
- ◯ During Senior School
- ◯ During Tertiary School
- ◯ Other: ______________

35. **Indicate how the following can affect your learning of mobile application programming.**
Mark only one oval per row.

	Not a challenge	Very minor challenge	Minor challenge	Major challenge	Very major challenge
Poor/Limited computer facilities	◯	◯	◯	◯	◯
Lack of up to date books	◯	◯	◯	◯	◯
Lack of an affordable/free Tutor	◯	◯	◯	◯	◯
Lack of good programming background	◯	◯	◯	◯	◯
Unstable/Lack of electricity	◯	◯	◯	◯	◯
Lack of Interest	◯	◯	◯	◯	◯
Poor study habbits	◯	◯	◯	◯	◯

36. **Which of the following resources do you have access to, at home or school?**
Check all that apply.

- ☐ Mobile Application Programming Labs
- ☐ Computers for Mobile Application Programming
- ☐ Integrated Development Environments (IDE) for mobile application programming
- ☐ Teaching Assistants/Lecturers/Tutors for mobile application programming
- ☐ Mobile Phones for practice
- ☐ Other: ______________

37. **On a monthly basis, how much do you spend on accommodation?**
If sharing, show your contribution per month.
Mark only one oval.

- ◯ Not Paying Rent
- ◯ P100 - P500
- ◯ P1501 - P2000
- ◯ Above P2000

38. **How much do you spend (per week) on transport to and from school?**
Mark only one oval.

- No transport cost - Staying on Campus/Walk
- Less than P50
- P50 - 100
- P101 - P200
- Above P200

39. **On a monthly basis, how much will you be willing to spend to acquire a Laptop?**
Mark only one oval.

- Already have a laptop
- I cannot afford any monthly installement
- P50 - P150
- P151 - P250
- P251 - P350
- More than P350

SECTION E: Mobile Applications Innovative Ideas

This section seeks to establish if you have innovative ideas for government, corporations, society etc and the easiness for you to share or implement these ideas.

40. **Innovative ideas** *
Kindly select the appropriate answer
Mark only one oval per row.

	Strongly Disagre	Disagree	Not Sure	Agree	Strongly Agree
Have you participated in an innovative competition for mobile application programming?					
Do you have mobile application ideas that can solve society, government or company problems?					
Have you approached a company, government with an innovative idea that can solve their problems					
Is there a platform for you to express or develop the above ideas into reality					
If such a platform (to express your ideas) were present, would you be willing to use it to share your ideas?					
Would you be willing to work on your idea, alone or with others, to see your idea implemented or prototyped?					

Appendix 0-9: Phase 1: Research Structured Interview Tool - Mobile App Developer Companies Instrument

Mobile App Developer Companies Instrument: Structured Interview

(R1) Interviewer's name		(R3) Date of interview	
(R2) Interviewer ID		Start time : Finish Time :	

Good day....! My name is Admore Nyamaka, a PhD Information Systems Student under the supervision of Prof. Judy V. Biljon (vbiljja@unisa.ac.za) and Prof Adele Botha (abotha@csir.co.za) at UNISA South Africa. I am conducting a research to establish the financial and technical needs of, and challenges faced by, start-up mobile entrepreneurships in Botswana. I would like to conduct a 15 minute interview with you now if we can? Are you willing to participate?

IF yes, Your participation in this research is voluntary, and you have the right to, at any time, withdraw or refuse to participate without giving any reason. All responses from you and other participants will be kept confidential. All responses will be collectively analyzed and therefore will not be linked to any participant name.

If **No**, thank respondent and leave.

Respondents Demographics

Respondents Name: ___________________________ Gender: ____________________ Age: ________________

Company Name : _______________________ Position:_________________ Company Ownership : Private: __ Gvt:__ Both:__

Q1. Does your company offer mobile based services/applications? [Yes] [No]

IF NO – Thank and leave.

Q2. No of Employees:

0 – 4	5 – 9	10 – 14	>=15

Q3. No. of Developers/Programmers: _______

Q4. Year Company Was Established:_________________________________

Q5. Is the Company Scaling Up [Locally] [Regionally] [Internationally]

Q6. Status of Revenues from the payment system [Weak] [Strong]

Q7. Type of Mobile Services/Apps Provided and their target markets: (Top 5)

Mobile Service App	Target market

Financial Aspects

Q8. Did you seek any funding when establishing or expanding the company? [Yes] [No]

Q9. Did you receive any funding when establishing or expanding the company? [Yes] [No]

IF Yes

Q10. Funding Details

Source of Funds	(Tick if applicable)	Stage of Funding (Tick)	Was Funding Sufficient at point of funding			
			Strongly Agree	Agree	Disagree	Strongly Disagree
Competition prize money		Idea: Prototype: Seed: Growth A: Growth B:				
Donors		Idea: Prototype: Seed: Growth A: Growth B:				
Angel investors		Idea: Prototype: Seed: Growth A: Growth B:				
Venture capital investment		Idea: Prototype: Seed: Growth A: Growth B:				
Private equity		Idea: Prototype: Seed: Growth A: Growth B:				
Family and friend		Idea: Prototype: Seed: Growth A: Growth B:				
Bank loans		Idea: Prototype: Seed: Growth A: Growth B:				
Own investments		Idea: Prototype: Seed: Growth A: Growth B:				
Other Specify:______________ ______		Idea: Prototype: Seed: Growth A: Growth B:				

Q 11. Did funding make a difference between success and failure of the company?

Strongly Agree	Agree	Disagree	Strongly Disagree

IF FUNDED Yes:

Q12. Usage of Funding Received:

____

____

____

____

____

Q13: Challenges faced in obtaining funding in Botswana and Recommendations (Gvt and Funding Bodies etc).

Challenge	Major	Minor	Not a challenge
Stringent Investor/Funder Requirements			
Poor Pitching Skills for Business Idea			
Investors have a poor understanding of start-ups			
My business is not well established			
Finance comes with high interest rates			
There is strong competition for funds			
Feedback that our business model is unsustainable			
No challenges			

Others:____

Technical Aspects

Q14: Founders Background (Skills/Knowledge/Qualifications):

Technical, ☐ Business ☐ Others specify________________

Q15: Did you have a mentor or coach during start up? Yes No

IF YES

Q16. Mentoring Details

Mentoring Areas offered (Tick Offered)		Considered Key in Mobile App Company Success? (Rate)		
		Major	Minor	Not at All
Business acumen (Risk and Opportunities)				
Management				
Marketing				
Intellectual property rights				
Financial Skills				
Mobile Technical Skills				

Q17: Do you have a partnership arrangement with Orange, Mascom, Bemobile (MSPs) Yes No

IF Yes

Q18. MSP Partnering Details

Partner Arrangement (Tick Offered)		Considered Key in Mobile App Company Success? (Yes/No)		
		Major	Minor	Not at All
Office Space				
Internet Connectivity				
Server Leases				
Operating Systems Leases				
Integration with MSP payment, network, location, authentication etc systems				
Other (Specify)____________ ____________				

Qn 10: Technical challenges faced in mobile app start up and success in Botswana and Recommendations (Gvt and Funding Bodies etc).

Thank you very much for your time and participation

Appendix 0-10: Phase 1 Research Structured Interview Tool - MSP, Support and Funding Agencies Instrument

MSP, Support and Funding Agencies Instrument: Structured Interview

(R1) Interviewer's name		(R3) Date of interview	
(R2) Interviewer ID		Start time : Finish Time :	

Good day....! My name is Admore Nyamaka, a PhD Information Systems Student under the supervision of Prof. Judy V. Biljon (vbiljja@unisa.ac.za) and Prof Adele Botha (abotha@csir.co.za) at UNISA South Africa. I am conducting a research to establish the financial and technical needs of, and challenges faced by, start-up mobile entrepreneurships in Botswana. I would like to conduct a 15 minute interview with you now if we can? Are you willing to participate?

IF yes, Your participation in this research is voluntary, and you have the right to, at any time, withdraw or refuse to participate without giving any reason. All responses from you and other participants will be kept confidential. All responses will be collectively analyzed and therefore will not be linked to any participant name.

If **No**, thank respondents and leave.

Respondents Demographics

Respondents Name: ____

Company Name : ________________________ Company Ownership : Private: __ Gvt:__ Both:__

No of Employees:

0 – 4	5 – 9	10 – 14	>=15

Q1. Does your company offer financial and other technical support to mobile services companies/individuals?

Type of Support	Offered to Group	Support Offered?	Is Core Business?
Technical Support	Offered for Company	Yes No	Yes No
	Offered to Individuals	Yes No	Yes No
Financial Support	Offered for Company	Yes No	Yes No
	Offered to Individuals	Yes No	Yes No

Q3. Year Company Was Established:________________________________

Qn4. Companies/Individuals Applied for Support (Funding/Technical) vs Support Offered at Different Stages (In past 2 years);

Stage	Applications Vs Funded	None (Tick)	A few (< 5)	5-10	More than 10	Type of Funding
No Company Product Just and Idea	Nos. Applied					Competition prize money:__________ Donation:______________ Venture capital investment: Loan:__________ Others (Specify):______________________________
	Nos. Granted					
No Company Product still Prototype	Nos. Applied					Competition prize money:__________ Donation:______________ Venture capital investment: Loan:__________ Others (Specify):______________________________
	Nos. Granted					
Company Exists Business Model Exists Team Exists Product exists	Nos. Applied					Competition prize money:__________ Donation:______________ Venture capital investment: Loan:__________ Others (Specify):______________________________
	Nos. Granted					
Company Exists	Nos. Applied					Competition prize money:__________ Donation:______________

Growing Locally	Nos. Granted					Venture capital investment: Loan:________ Others (Specify):________
Growing Regionally and Internationally	Nos. Applied					Competition prize money:________ Donation:________
	Nos. Granted					Venture capital investment: Loan:________ Others (Specify):________

Qn.9

Reason for Rejection/Areas needing improvement	Major Reason	Minor Reason	Not a Reason
Applicant did not meet Requirements			
Poor Pitching Skills for Business Idea			
Poor understanding of startups			
Business is not well established			
business model is unsustainable			
No Rejections			

Others:____

Thank you very much for your time and participation

Appendix 0-11: Phase 2 Survey Questionnaire – Evaluation of the Mobile applications innovation ecosystem Framework for Botswana

Components of a Framework for Enhancing Botswana's Mobile Application Ecosystem

Dear Participant,

Batswana have 1.5 times more mobile phone subscriptions to the population, and yet the mobile application industry in the country is still in its infancy.

My name is Admore Nyamaka, a PhD Information Systems Student under the supervision of Prof. Judy V. Biljon (vbiljja@unisa.ac.za) and Prof Adele Botha (abotha@csir.co.za) at UNISA South Africa. I am conducting a research to develop a framework for positioning Higher Education Students to Participate in Botswana's Mobile Application Development Ecosystem.

A literature review on mobile application ecosystems enhancement components was carried out and and an initial framework was developed. To evaluate and contexualise the framework to Botswana, knowledgeable professionals within Industry, Government and Higher Education, such as yourself, are required to assist.

Kindly note that your participation in this research is voluntary, and you have the right to, at any time, withdraw or refuse to participate without giving any reason. All responses from you and other participants will be kept confidential. All responses will be collectively analyzed and therefore will not be linked to any participant name.

You are therefore kindly requested to identify and rank relevant components that will enhance the mobile application ecosystem in Botswana.

1. **Your work area has been in**
   Check all that apply.
   - [ ] Higher Education
   - [ ] Government/Parastatal
   - [ ] Private Industry

2. **Name of your current organisation**

   ____

3. **Your current organisation's mandate**

   ____
   ____
   ____
   ____
   ____

4. **Your job title/role in your current and previous organisations**

   ____
   ____
   ____
   ____
   ____

5. **How long have you been active in Botswana's Mobile Ecosystem**

Mark only one oval.

- ◯ Less than 3 years
- ◯ 3 - 6 Years
- ◯ 7 - 10 years
- ◯ more than 10 years

6. **Rate your expertise level within the Botswana Mobile Ecosystem**

Mark only one oval.

- ◯ Expert
- ◯ Intermediate
- ◯ Beginner

7. **Your highest qualification**

Check all that apply.

- ☐ Diploma
- ☐ Degree
- ☐ Masters
- ☐ Doctoral
- ☐ Other: ____________________

8. **Your age**

Mark only one oval.

- ◯ 18 - 25
- ◯ 26 - 35
- ◯ 36-45
- ◯ 46 or more

9. **Your gender**

Mark only one oval.

- ◯ Female
- ◯ Male

Higher Education: Mobile Application Ecosystem Enhancement Factors

Please rank the following as components that can enhance Botswana's mobile application ecosystem

10. **Higher Education Institution's Mobile App Course students admission criteria**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Student Spatial Visualization Skill					
Student Meta Cognitive /Resource Management Strategies					
Student Code Generation/Comprehension					
Student Science and Maths Grades					

11. **Higher Education Institution's Mobile App Course Teaching Approach**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Use of Educational Technologies					
Curriculum that focuses on fundamental concepts					
Curriculum that starts the programming early					
Curriculum that challenges students					
Curriculum that focuses on Android					
Sequencing of Learning					

12. **Higher Education Institution's Mobile App Course Teaching Labs**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Availability of Developer Tools					
Availability of Learning Tools					
Availability of Physical Mobile Devices (Android)					
Availability of Simulation/Emualtion Environment					
Availability of Virtualised Environment					
Availability of backup power supply					
Allow students to Bring Your Own Device (laptops and mobile phones)					
That offer free configuration of student devices for mobile app development					

13. **Higher Education Institution's Mobile App Course Teaching Tutors must be**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Qualified	⬭	⬭	⬭	⬭	⬭
Under go constant training	⬭	⬭	⬭	⬭	⬭
Access to instructor resources	⬭	⬭	⬭	⬭	⬭
Access to Developer Tools	⬭	⬭	⬭	⬭	⬭
Access to Learning Tools	⬭	⬭	⬭	⬭	⬭
Able to access teaching resources that are easy to implement	⬭	⬭	⬭	⬭	⬭
Able to access teaching resources that can be controlled by teachers	⬭	⬭	⬭	⬭	⬭

14. **Higher Education Institution's Mobile App Course Teaching Methodologies through**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Avoid Preaching	⬭	⬭	⬭	⬭	⬭
Setting Small Goals	⬭	⬭	⬭	⬭	⬭
Clear Guidelines for students	⬭	⬭	⬭	⬭	⬭
Encouraging information seeking through student phone internet	⬭	⬭	⬭	⬭	⬭
Making help available for studetts	⬭	⬭	⬭	⬭	⬭
Starting programming early	⬭	⬭	⬭	⬭	⬭
Making programming exercises mandatory	⬭	⬭	⬭	⬭	⬭
Using relevant teaching examples	⬭	⬭	⬭	⬭	⬭
Using repetitive excercises	⬭	⬭	⬭	⬭	⬭
Student Collaborative/Pair Programming	⬭	⬭	⬭	⬭	⬭
Teaching students how to addressing student team challenges (ownership, communication, team appreciation, preferred platforms)	⬭	⬭	⬭	⬭	⬭
Online teaching (including through social networks and collaborative development environments)	⬭	⬭	⬭	⬭	⬭
Student Collaborative/Pair Programming through face to face teaching	⬭	⬭	⬭	⬭	⬭
Introducing programming from a mobile perspective	⬭	⬭	⬭	⬭	⬭
Starting as early as the pre-requisite knowledge has been gained	⬭	⬭	⬭	⬭	⬭
Teaching students perception of program correctness	⬭	⬭	⬭	⬭	⬭
Teaching students through mental models	⬭	⬭	⬭	⬭	⬭
Teach programming as a way of thinking	⬭	⬭	⬭	⬭	⬭
Teaching students debugging strategies	⬭	⬭	⬭	⬭	⬭

15. **Higher Education Institution's Mobile App Course that**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Offer free and paid for online textbooks and videos	⬭	⬭	⬭	⬭	⬭
Offer free and paid for physical textbooks and videos	⬭	⬭	⬭	⬭	⬭
Offer programming competitions	⬭	⬭	⬭	⬭	⬭
Offer real app implementation projects	⬭	⬭	⬭	⬭	⬭
Offers mobile app idea sharing platforms	⬭	⬭	⬭	⬭	⬭
Offer mobile app course to all students	⬭	⬭	⬭	⬭	⬭
Provides study improvement techniques	⬭	⬭	⬭	⬭	⬭

16. **Other Higher Education related Mobile Application Ecosystem Enhancement Factors**

Industry: Mobile Application Ecosystem Enhancement Factors

Please rank the following as components that can enhance Botswana's mobile application ecosystem

17. **Access to Finance by Mobile App Developers in the form of**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Donations	⬭	⬭	⬭	⬭	⬭
Angel/Venture Capital	⬭	⬭	⬭	⬭	⬭
Competition Prizes	⬭	⬭	⬭	⬭	⬭
Seed Funding focused on mobile app developers	⬭	⬭	⬭	⬭	⬭
Start-up Loans	⬭	⬭	⬭	⬭	⬭
Early stage funds and accelerators	⬭	⬭	⬭	⬭	⬭
Family and Friends loans	⬭	⬭	⬭	⬭	⬭
Bank loans	⬭	⬭	⬭	⬭	⬭

18. **Supporting/Mentoring Mobile App Developers's Business Acumen in**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Partnership Skills	◯	◯	◯	◯	◯
Management Skills	◯	◯	◯	◯	◯
Financial Skills	◯	◯	◯	◯	◯
Interlectual property Skills	◯	◯	◯	◯	◯
Marketing Skills	◯	◯	◯	◯	◯

19. **Commercial and Technical Support for Mobile App Developers in the form of**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Hands On Mentorship	◯	◯	◯	◯	◯
Like-Minded People Meetups	◯	◯	◯	◯	◯
Incubators	◯	◯	◯	◯	◯
Procurement Policies that support Mobile App Developers	◯	◯	◯	◯	◯
Mobile Entrepreneurship Hubs	◯	◯	◯	◯	◯
Stimulating innovative local mobile solutions through competitions	◯	◯	◯	◯	◯
Stimulating innovative local mobile solutions through hackathons	◯	◯	◯	◯	◯

20. **Mobile Service Providers (e.g Mascom, BeMobile and Orange) Collaboration with Mobile App Developers in Accessing**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Voice related services	◯	◯	◯	◯	◯
Payment and Billing services	◯	◯	◯	◯	◯
Content Distribution networks	◯	◯	◯	◯	◯
Messaging services	◯	◯	◯	◯	◯
Network Infrustructure	◯	◯	◯	◯	◯
Identity/User Authentication services	◯	◯	◯	◯	◯
Customer trust and loyalty	◯	◯	◯	◯	◯
Location awareness services	◯	◯	◯	◯	◯

21. **Mobile Service Providers (e.g Mascom, BeMobile and Orange) to provide housing/office space to Mobile App Developers in forms of**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Server leases	⬭	⬭	⬭	⬭	⬭
Rack Housing	⬭	⬭	⬭	⬭	⬭
OS admin support	⬭	⬭	⬭	⬭	⬭
Air conditioning	⬭	⬭	⬭	⬭	⬭
Power	⬭	⬭	⬭	⬭	⬭
Internet Connectivity	⬭	⬭	⬭	⬭	⬭

22. **Mobile Service Providers (e.g Mascom, BeMobile and Orange) 's to drive**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Zero Rating Services	⬭	⬭	⬭	⬭	⬭
Make internet accessible to more users	⬭	⬭	⬭	⬭	⬭
provide more bandwidth for mobile internet users	⬭	⬭	⬭	⬭	⬭

23. **General business in Botswana to adopt mobile business and payment systems**

Mark only one oval.

- ⬭ Not Important
- ⬭ A bit Important
- ⬭ Moderately Important
- ⬭ Important
- ⬭ Very Important

24. **Family and Friends Support**

Mark only one oval.

- ⬭ Not Important
- ⬭ A bit Important
- ⬭ Moderately Important
- ⬭ Important
- ⬭ Very Important

25. **Mobile Device Manufacturing of of mobile phones with**

Check all that apply.

- [ ] Faster processing power
- [ ] Longer battery life
- [ ] Bigger screens
- [ ] Lower prices
- [ ] Lighter

26. **Other Industry related Mobile Application Ecosystem Enhancement Factors**

Government: Mobile Application Ecosystem Enhancement Factors

Please rank the following as components that can enhance Botswana's mobile application ecosystem

27. **Government as a public entrepreneur and venture capitalist by**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Setting up accelerators					
Early Stage funding					
Setting up mobile entrepreneurship hubs					

28. **Government Policies and Regulations on Network Congestion to**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Avoid dropped calls					
Avoid non delivery of text messages					
Avoid absence of signals					
Avoid limited internet speeds					

29. **Government Policies and Regulations on Mobile Network Spectrum Management by**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Reclaiming ad relicensing unused spectrum					
Encouraging mobile virtual network operators					
Issuing more licenses					

30. **Government Policies and Regulations to**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Enable entrepreneurship visas					
Encourage competition					
Enhance mobile network infrastructure					
Support mentor ship					
Support training on intellectual property rights					
Offer free legal advice					
Support mentorship for all					
Ensure efficiency					
Mandate national roaming agreements					
Offer financial and political support for rural mobile infrustructure					
Create positive macroeconomic conditions					

31. **Government National ICT strategies driving broadband through**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Establishing national broadband targets					
Setting up digital divide funds					
Encourages net neutrality					

32. **Government Policies and Regulations such as national ICT strategies driving broadband through first, second, last and invisible mile connectivity by**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
National satellite dishes					
Domain name registration					
Submarine cable landing stations					
Intercity networks					
National backbones					
More points of presence					
SIM card registrations					
Requisting operators to share sites and masts					
Enforcing cost-based interconnection fees					
Cyber-security					

33. **Government National ICT strategies that closes the digital divide through**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Adopting m and e-Gov by enabling companies to develop gov apps	⬭	⬭	⬭	⬭	⬭
Drive local content	⬭	⬭	⬭	⬭	⬭
Drive demand for mobile services	⬭	⬭	⬭	⬭	⬭
Advance mobile hardware	⬭	⬭	⬭	⬭	⬭

34. **Government' s investment and tax policies that favours**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Boost internet usage through importation of mobile phones and network infrastructure	⬭	⬭	⬭	⬭	⬭
Mobile service providers's to zero rate	⬭	⬭	⬭	⬭	⬭
Mobile service providers's to boost internet usage	⬭	⬭	⬭	⬭	⬭
Company registrations	⬭	⬭	⬭	⬭	⬭
Favourable licensing costs	⬭	⬭	⬭	⬭	⬭
Mobile entrepreneurship	⬭	⬭	⬭	⬭	⬭

35. **Government to have policies and regulations**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Enable procurement frameworks that encourages mobile entrepreneurship	⬭	⬭	⬭	⬭	⬭
To enable entrepreneurship visas	⬭	⬭	⬭	⬭	⬭
That are pro-competitive	⬭	⬭	⬭	⬭	⬭
Such as purchasing policies that encourages mobile entrepreneurship	⬭	⬭	⬭	⬭	⬭

36. **Government to have policies and regulations that support**

Mark only one oval per row.

	Not Important	A bit Important	Moderately Important	Important	Very Important
Training on intellectual property rights	⬭	⬭	⬭	⬭	⬭
Free legal advice	⬭	⬭	⬭	⬭	⬭
Mentorship for all	⬭	⬭	⬭	⬭	⬭
Enhances mobile network infrastructure	⬭	⬭	⬭	⬭	⬭

37. Other Government related Mobile Application Ecosystem Enhancement Factors

THANK YOU! Your participation in this survey is highly appreciated

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Appendix 0-12 – Companies Involved in the Research Study

No.	Company Name
1	Acutec Systems
2	Advanced Network Tec
3	Africa Emerging Venture
4	Agileum
5	AppBrain
6	Arcripex
7	Barclays
8	Be-Mobile
9	BITRI Technologies
10	Black Oak Consulting
11	BNLS (Ministry of Youth)
12	BOCRA
13	BOFINET
14	Botho University
15	Botswana Accountancy College
16	Botswana Development Corporation
17	Botswana Innovation Hub
18	Botswana IT Society
19	Branstone Group
20	Bright Labs
21	CabIT Africa
22	CEDA
23	Clientel Comms
24	Cloud Consulting Bot
25	Conichi
26	Creative Hub Films
27	Demographix Communications
28	Department of Telecommunications and Postal Services
29	DevelopIT
30	Digital Horn
31	Dimension Data
32	Ditec Mobile
33	Donsimoni Academe
34	FocusSurveys
35	GlowFlox
36	Hwalma Technologies
37	ICL Botswana
38	Inifinity Tech
39	Intellegere Holdings
40	Kaismo
41	Kgalagadi KickStart
42	Kitso Tech
43	Local Enterprise Authority

44 Mascom
45 Mind Q
46 Ministry of Transport and Communications
47 Ministry of Youth
48 MobiSoft
49 National Development Bank
50 National Youth Center
51 NCONGO Youth in Business
52 Netel
53 Ntebogang Technologies
54 Orange
55 Peo Venture Capital
56 Rare Group
57 Sentenel Academy
58 Skymart BW
59 Skymouse IT
60 Standard Chartered
61 TceBoe
62 Tsale Media
63 Venture Partners Botswana
64 Versatile Tech Investment
65 VIBTech Mobile
66 Webmaster
67 Webscape
68 Youth Development Fund