MOBILE LEARNING AS A PARADIGMATIC MECHANISM TO FACILITATE TECHNOLOGY-BASED LEARNING IN A DEVELOPING COUNTRY

by

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DECLARATION

I, Suzaan Le Roux, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, it represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signed **Date**

ABSTRACT

During the last few years it has become evident that first-year undergraduate computer science programming learners in the Financial Information Systems (FIS) programme at the Cape Peninsula University of Technology (CPUT) in South Africa, encounter numerous barriers to successfully practice their programming skills, as well as to design, develop, test and electronically submit their computer science programming assignments. As a result, the formative and summative assessment marks of these learners over the past few years indicate a concerning downward trend year on year, a challenge with which most first-year learners find it difficult to come to terms with. This is primarily due to a plethora of obstacles that impede on learners' ability to complete and electronically submit their programming assignments, especially off-campus, as well as the inability to practice their programming skills outside the boundaries of the classroom. Upon investigation it was determined that this trend is primarily attributed to three major stumbling blocks, namely the limited availability of computers, the absence of the required software needed to complete programming assignments off-campus, and the limited availability of Internet access off-campus.

Action research is used as the primary research method for this research study of which the research problem reads as follows: Current learning mechanisms to facilitate technology-based learning do not comply with the demands faced by tertiary institutions of developing countries. In mitigation of the research problem, the action research method will be underpinned by activity theory. The rationale for using action theory for this action research study is nested in the fact that activity theory also serves as a pedagogical underpinning to m-learning, where technology is perceived as a tool or artefact to mediate human activity. Activity theory in m-learning has been applied as an analytical lens to extricate the intricate relationships of subjects, tools, relationships, and other socio-technical infrastructure manifested through the utilisation of mobile devices. Since activity theory is mainly a descriptive tool, it focuses on practice and represents a qualitative approach that presents a different lens for analysing learning processes and learning outcomes, making the activities people are engaged in the focal point. The lens of activity theory can provide insights into change in educators' practices or into how their teaching is "restructured" when a new technological tool becomes part of their teaching activity. From an activity theory perspective in analysing m-learning, mobile devices are perceived as tools that aid collaborative learning environments, however this can only happen when the technology is designed to fit with the context of its intended use, as well as support an extensive range of learner learning activities. In the education field, activity theory can therefore facilitate understanding of how technological advances influence change.

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DEDICATION

In loving memory of my late grandmother, Tilla van Tonder.

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SYNOPSIS

During the last few years it has become evident that first-year undergraduate computer science programming learners in the Financial Information Systems (FIS) programme at the Cape Peninsula University of Technology (CPUT) in South Africa, found it difficult to practice their programming skills, as well as design, develop, test and electronically submit their computer science programming assignments. As a result, the formative and summative assessment marks of these learners over the past few years indicate a concerning downward trend year on year.

This is primarily due to a plethora of obstacles that impede on learners' ability to complete and electronically submit their computer science programming assignments, especially off-campus, as well as the inability to practice their programming skills outside the boundaries of the classroom. Since the majority of these learners are from previously disadvantaged communities and can simply not afford computers (hardware), Internet connections and relatively expensive commercial software applications, they are dependent on campus computer laboratories, whose access is not always practical due to time, distance and location constraints. From the above, a broad base analogy can be drawn that learners are not availed the freedom to choose when, where, and how they study, therefore creating the requirement for mobility. Consequently it can be argued that current learning mechanisms to facilitate technology-based learning do not meet the demands faced by tertiary institutions in under-developed countries. It is therefore increasingly becoming apparent that it would be prudent to diversify and improve the learning experiences of these learners. It is thus imperative to determine whether mobile learning (m-learning) implementation, which entails a holistic approach, can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.

The formulation of a technology-based m-learning conceptual model will be based on analogies drawn from an action research study involving first-year undergraduate learners in a technology-based subject. The conceptual model will serve to illustrate the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country. Several data collection methodologies will be used to gather information from which it will be analysed using descriptive and inferential statistics.

The content of Chapter 1, along with the relative positioning of the various topics which will be addressed therein, is graphically depicted in Figure 1.

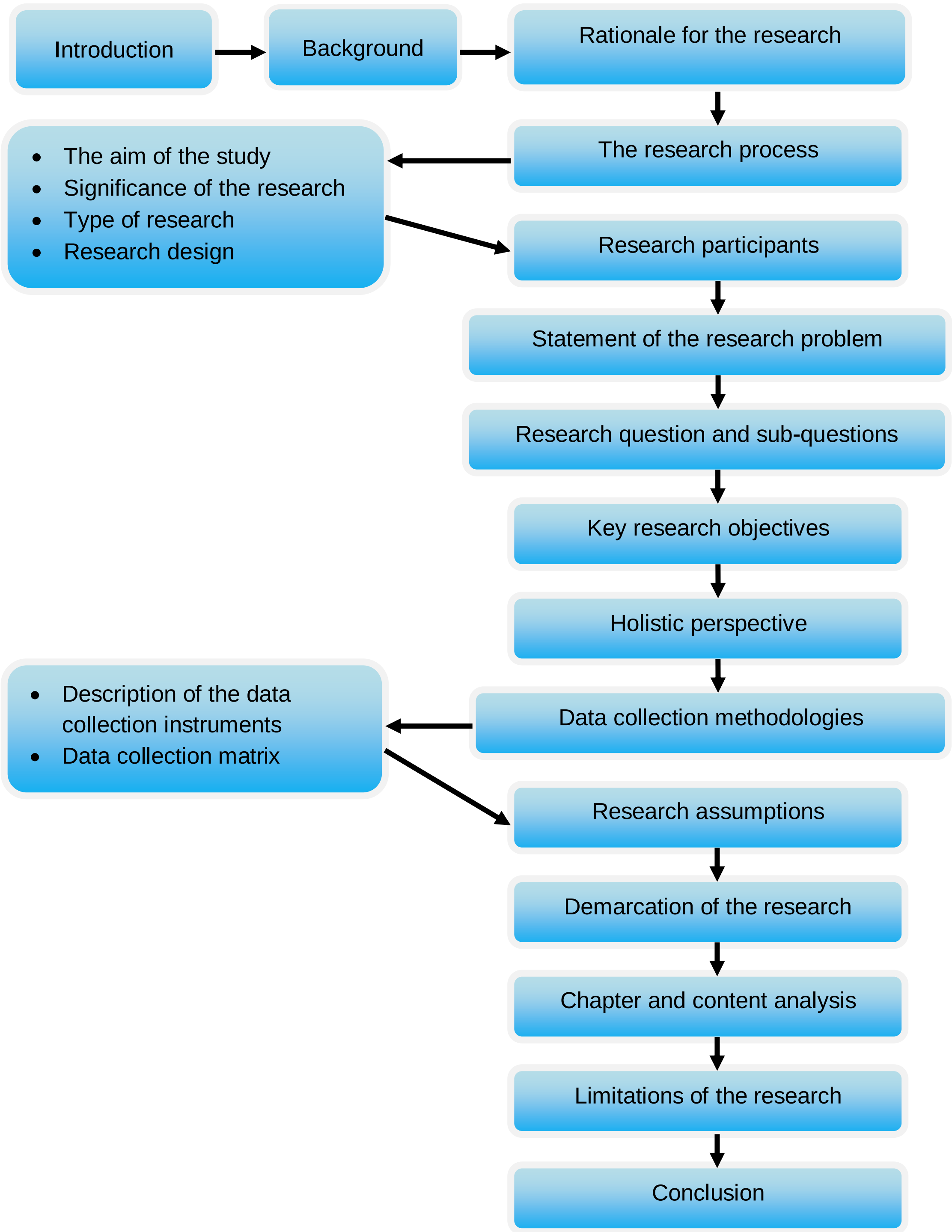

Figure 1: Detailed layout of Chapter 1 - Scope of the research

1 CHAPTER ONE
SCOPE OF THE RESEARCH

1.1. Introduction

The analytical process, which will be followed within the ambit of this thesis, is graphically depicted in Figure 1.1, placing the chapters in context with the overall thesis objectives, and furthermore indicating the relative positioning of this chapter.

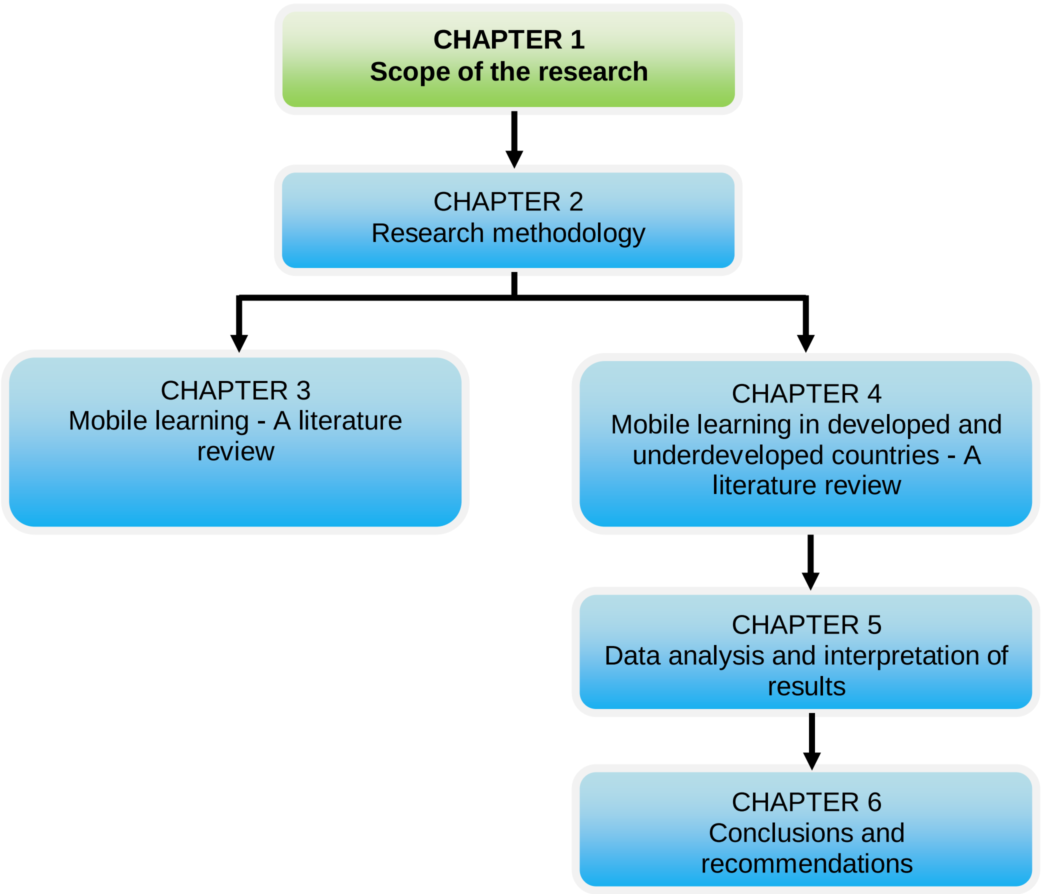

Figure 1.1: Chapter 1 - Scope of the research

This research reports on an action research study that investigates the utilisation potential of mobile learning (m-learning), and whether it can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries. Furthermore, it reports on the implementation, challenges and opportunities of m-learning in a first-year computer science programming subject to primarily support the teaching and learning needs of predominantly previously disadvantaged learners. The focus of the study is threefold: First, it is 'theoretical' in nature, since different views expressed in the literature are compared and contrasted. Second, the focus is 'conceptual', due to the fact that the perspectives on m-learning in a technology-based subject are drawn from the results obtained from an action based research inquiry process. Third, it is 'empirical', since the study explores the potential benefits of m-learning as a paradigmatic mechanism to facilitate technology-based learning. For this purpose, questionnaires, formative and summative assessment, observation, focus groups, academic learner research journals, as well as synchronous and asynchronous communication, will be utilised within the ambit of the research study. Henceforth, the term mobile/electronic devices will be used in this thesis as representative of 'any' mobile devices and technologies used for m-learning, and include mobile/cell phones, smartphones, Personal Digital Assistants (PDAs), tablets, mobile computers and digital media devices.

1.2 Background

The use of mobile technologies is gradually drawing a great deal of attention across every sector of education not only in developed countries, but also in under-developed countries. With respect to technologies, the term 'mobile' generally refers to personal and portable electronic devices such as mobile phones/smartphones, PDAs, tablets, mobile computers and digital media devices that readily fit into ones pocket. These technologies enable one to connect to a variety of information sources and enable communication almost anywhere, and at any time.

Mobile electronic devices, in particular mobile/smartphones and PDAs, offer a possible solution to apply mobile technologies in developing countries, and are the most commonly used technologies applied to m-learning (Traxler & Leach, 2006:99). M-learning is viewed as 'learning', facilitated by the use of mobile electronic devices. Furthermore, it is concerned with the mobility of learning, the mobility of devices and technologies, learners’ experience of learning with mobile devices (Traxler, 2007:1), and learner mobility (Laouris & Eteokleous, 2005:Online; Sharples, Taylor & Vavoula, 2005:Online; Traxler, 2007:1). The benefit of such mobile electronic devices lies in that they are not location-specific and are increasingly viewed as an affordable means to bridge the 'digital divide' (Brown, 2005b:299). According to Cochrane (2010:134), "it is the potential for mobile learning to bridge pedagogically designed learning contexts, facilitate learner-generated contexts, and content (both personal and collaborative), while providing personalisation and ubiquitous social connectedness, that sets it apart from more traditional learning environments". The question however remains if m-learning can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions in developing countries.

If the emerging practice of m-learning based around mobile/smartphones and PDAs in developing countries is evaluated, a different perspective emerges based on entirely different paradigms. According to Ford and Botha (2008:160), there is "a need for new approaches to integrate technology into the classroom, particularly in an African environment". The South African educational situation could provide insightful lessons to learn from for the implementation of m-learning in developing countries. A number of educational challenges need to be faced in South Africa apart from the poor education that was provided to the majority of South Africans in the apartheid era and the backlog educators still have to deal with. Many schools (especially in the rural areas), lack the necessary infrastructure for the provision of computers and Internet access. Due to cost implications, personal computers are just not as common as in developed countries. The majority of the South African learner population are still computer and Internet illiterate, due to the high cost of telecommunication services and the narrow bandwidth through which most people get access to the Internet (Matthee & Liebenberg, 2007:149). Traxler and Kukulska-Hulme (2005)[1] cited by Traxler (2007:Online), report that the radically different physical infrastructure and cultural environment contained within the context of Internet connectivity, the scarcity of personal computers, fixed line telephones and electricity, has meant that prescriptions for m-learning are more cautious than in the developed world. New challenges have emerged in providing equivalent access and support to learners based in developing countries.

Contrary to trends in developed countries, where the Internet and computer connectivity is almost ubiquitous, mobile/smartphones are currently the most important networked knowledge-exchange technology used in the developing world. From a developing country perspective, features such as limited or no dependence on permanent electricity supply, easy maintenance, affordability and accessibility are the most important considerations for using mobile/smartphones as potential learning tools (Mutula, 2002:79; Stone, Lynch & Poole*,* 2003:Online; Masters, 2005:Online). Mobile/smartphones are used by a large percentage of South Africans irrespective of race, gender, age, or income group. Data from the International Telecommunication Union (ITU) reflect that in 2004, South Africa's mobile phone density was 36% compared to the 6% of Africa (ITU, 2004:Online). In 2008, mobile phone subscriptions have grown exponentially to an astonishing 91 out of every 100 inhabitants (ITU, 2008:Online), and in 2011, this number has grown even further to a staggering 127 out of every 100 inhabitants (ITU, 2011b:Online). This implies that some inhabitants have more than one mobile phone. The ease with which South Africans adopt mobile technology suggests a wide range of possibilities for development using mobile technology, including m-learning in education.

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[1] Traxler, J. & Kukulska-Hulme, A. 2005. Mobile Learning in Developing Countries. In Chin, G. (ed.). *A report commissioned by the Commonwealth of Learning.* Vancouver, BC: Commonwealth of Learning.

Although m-learning is rapidly moving away from small-scale pilot studies into institution-wide implementation worldwide (Stone, 2004:145), it distinctively does not reflect the current situation in South Africa as a developing country. The situation in developing countries is of course fairly different and quite a few researchers have asked probing questions on the role of technology enhanced learning in such settings (Brown, 2005b:299; Masters, 2005:Online; Laouris & Laouri, 2006:Online). Most research implicitly focuses on conceptions of m-learning based on the culture and affordances of developed countries (Traxler, 2007:Online). The attention of the reader is drawn to the use of the word 'affordances' in this thesis. The word 'affordances', while not defined in the dictionaries consulted, is regularly referred to in academic works relating to m-learning. In this context, the word affordance will forthwith be used to denote the relationships between the properties of an educational intervention and the characteristics of the learner that enable particular kinds of learning by the learner (Kirschner, 2002:19). "Reported findings originating mainly out of Europe, North America and Australasia ... are not representative of developing countries and their scenarios" (Kukulska-Hulme & Traxler, 2005b:208). Despite its increasing popularity, a review of relevant literature returned that there is little academic support on how mobile technologies can be utilised for technology-based subjects, especially in developing countries.

1.3 Rationale for the research

Programming is one of the essential areas taught in university studies of Computer Science and other Engineering degrees, as well as in diplomas in Computer Science. At present, it is a knowledge acquired through both practical and theoretical class application.

During the last few years it has become evident that first-year undergraduate computer science programming learners in the Financial Information Systems (FIS) programme at the CPUT in South Africa, encounter numerous barriers to successfully practice their programming skills, as well as to design, develop, test and electronically submit their computer science programming assignments. As a result, the formative and summative assessment marks of these learners over the past few years indicate a concerning downward trend year on year, a challenge with which most first-year learners find it difficult to come to terms with. This is primarily due to a plethora of obstacles that impede on learners' ability to complete and electronically submit their programming assignments, especially off-campus, as well as the inability to practice their programming skills outside the boundaries of the classroom. Upon investigation it was determined that this trend is primarily attributed to three major stumbling blocks, namely the limited availability of computers, the absence of the required software needed to complete programming assignments off-campus, and the limited availability of Internet access off-campus. Currently, learners have to use Visual Basic 2005 (a popular event-driven visual programming language from Microsoft Corporation that is used to develop Windows, mobile, web, office and database applications), and a computer connected to the Internet in order to be able to practice their computer science programming skills, as well as to complete and electronically submit programming assignments.

The possibilities availed by mobile technologies, allowing learners to be connected 24 hours/7days a week, independent of time and location, is considerable and were viewed as possible options that could overcome many of the difficulties that learners are facing in getting access, for example, to Internet-enabled computers, programming software, practical assignments, lecture notes, syllabus, etc. Due to these possibilities, it was decided to incorporate mobile technology in a technology-based subject in order to determine whether m-learning can bridge the existing learning gap.

More than 33,526 learners are currently (2012) registered at the CPUT of which over 85% are from previously disadvantaged communities. The majority of these learners can simply not afford computers (hardware), Internet connections and relatively expensive commercial software applications. This by implication implies that the majority of learners are unable to practice and improve their programming skills, and are not able to complete and electronically submit programming assignments outside the boundaries of the classroom. As a result, learners are dependent on campus computer laboratories, to which access is not always practical due to time, distance and location constraints, culminating in learners not availed the freedom to choose when, where, and how they study, thus creating the requirement for mobility. Consequently, it can be argued that current learning mechanisms to facilitate technology-based learning do not meet the demands faced by tertiary institutions in under-developed countries. It is therefore increasingly becoming apparent that it would be prudent to diversify and improve the learning experiences of these learners.

Roschelle (2003:260), is of the opinion that mobile technology has the potential to accomplish a significant impact because of its portability, multipurpose features, low cost, and the fact that it attends to the 'deep-rooted gap' of inequality. Roschelle (2003:260), further states that mobile technology enables a transition from the “occasional, supplemental use associated with computer laboratories, to frequent and integral use of computational technology”. The rapid progress in Information and Communication Technology (ICT) has enabled even the most remote individuals to be reached (Attewell, 2005:8), and can be regarded as a mechanism that can be utilised to assist educators to provide quality and flexible education to meet the diverse needs of learners (O'Neill, Singh & O'Donoghue, 2004:313). Furthermore, to deal with learners who are academically under prepared for tertiary education (Miller & Murray, 2005:Online), and to design effective teaching methods, which engage learners in their learning process and experiences (DeBourgh, 2008:76). M-learning encourages active learner engagement during the learning process (Bang, Dalsgaard, Engelbrecht, Lemminger & Skaanes, 2009:60; Draganova, 2009:85), by giving learners the opportunity and power to take more responsibility for their own learning (Coulby & Davies, 2011:3). Learners are able to access learning materials as well as to generate their own content. In addition, mobile devices are less costly than for instance a desktop computer, and its affordances, usability and accessibility are such that they can potentially complement or even replace traditional computer technology (Tétard, Patokorpi & Carlsson, 2008:1).

Wyatt, Krauskopf, Gaylord, Ward, Huffstutler-Hawkins & Goodwin (2010:109), are of the opinion that m-learning still lacks empirical evidence to support its use in classrooms, and even though mobile technologies give learners and educators more liberty and flexibility in a educational environment, “new pedagogies and approaches to delivering and facilitating instruction” should stem from the implementation of mobile devices (Corbeil & Valdes-Corbeil, 2007:54). Özdemir (2010:36), believes that further research is needed to clarify the benefits, challenges, and limitations of using mobile devices as learning tools and to construct suitable learning pedagogies. Moreover, Sharples, Arnedillo-Sánchez, Milrad & Vavoula (2009:238), express the opinion that the design of m-learning activities should be driven by specific learning objectives. This entails that mobile technology should be utilised to engage learners more and to encourage activities that would not have been possible without the use of the technology. The necessity to increase the scope, scale, quality and equity of education remains vital to the m-learning challenge of reaching educational goals. The almost ever-present availability of mobile phones in Africa, especially among the youth, holds the potential for broadening the learning opportunities of especially underserved communities. Moreover, m-learning is promoted by a new wave of innovative ways in which youth are using mobile phones to communicate and share knowledge for educational use. For these reasons, mobile technology seems not only viable, but a highly feasible option worth exploring for especially previously disadvantaged learners in a technology-based subject in a developing country.

The justification for this exploration is based on the understanding that mobile technologies have the potential of broadening educational opportunities for disadvantaged and marginalised learners. The aim is therefore to utilise mobile devices in order to extend ways in which undergraduate computer science programming learners could be supported and as a result, increase throughput and success rates. Mobile devices are most effective when combined with group activities and have the potential to improve education for the millions of under-privileged users in the developing world (Mafenya, n.d.:Online). It is therefore imperative to determine whether m-learning can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.

All humans have the right to access learning materials and information to improve their quality of life regardless of their culture, status, and where they live. Technology is inclined to reinforce existing social and cultural inequities. It is essential to understand and pro-actively seek to address such challenges (Adam, Butcher, Tusubira & Sibthorpe, 2011:32). M-learning, through the use of mobile technologies, will allow learners to access learning materials and information from anywhere and at any time they wish, by making it simple for them to transport their learning materials. Learners will not have to wait for a 'certain time' to learn or go to a 'certain place' to learn. In addition, mobile technologies also assist 'just-in-time' learning by enabling learners to make use of unforeseen free time, in view of the fact that learners invariably have their mobile devices with them. With m-learning, learners will be empowered since they can learn whenever and wherever they wish. Not only can m-learning research within a technology-based subject place tertiary institutions at the forefront of pedagogical practice, but it can most importantly address learner requirements for mobility, flexibility and ubiquity - anywhere, anytime access to information.

While these statements ring true for most developed countries, the South African dispensation is however subject to the following caveats:

- **Low level of technology penetration.** Africa has a low level of technology penetration when compared to other developing countries having a negative impact on the educational sector (Botha & Ford, 2008:Online).
- **Lack of infrastructure.** There is a need for reliable electricity supply and connectivity in South Africa. Electricity in Africa continues to be the most important challenge that has an enormous impact on access to mobile devices, as power backup will only increase the running cost of these devices. Approximately 600 million people in Africa (about 60% of the continent's population) lack access to electricity. This total is expected to reach 700 million by 2030. Africa's rural poor are particularly energy starved, accounting for 88% of those without electricity (Lighting Africa, 2011:Online)
- **Lack of reliable and affordable Internet access.** Less than 12% of the African population are Internet users (ITU, 2011a:Online). Bandwidth costs for broadband in Sub-Saharan Africa are 30 - 40 times more than that of the United States (Cottrell & Kalim, 2010:Online). Calandro, Gillwald, Moyo and Stork (2010:Online), report in their 2009/2010 Comparative Sector Performance review that Sub-Saharan Africa trails North Africa with Internet penetration rates below 3% on average, and a broadband penetration rate below 2%. Calandro *et al.* (2010:Online), position low bandwidth and

high prices as one of the major challenges African countries face due to the limited reach of the traditional fixed-line networks and the absence of access to undersea data cables.

- **Lack of Wi-Fi availability on campus (for learner use) and limited Wi-Fi availability off-campus.** Wi-Fi coverage is limited to certain areas, and therefore to a certain extend limits learners to enjoy the full potential of m-learning. This culminates in learners having to make use of their personal mobile data in order to gain access to online learning material.
- **Logistics and deployment challenges.** There are often logistical challenges in terms of distributing hardware and learning content to both educators and learners in a tertiary education environment (Adam *et al.*, 2011:32).
- **Social, economic and cultural issues.** Technology is inclined to reinforce existing social and cultural inequities. It is essential to understand and pro-actively seek to address these challenges (Adam *et al.*, 2011:32).
- **Financial resources and academic preparedness.** Tertiary education learners are often constrained in terms of financial resources and academic preparedness for entering tertiary institutions. These constraints that adversely impact on the adoption of mobile technology in developing countries should be prioritised for resolution rather than being accepted as unavoidable (Barker, Krull & Mallinson, 2005:Online).
- **Robbery/Crime.** Theft in South Africa is a serious problem, especially theft of mobile devices. According to Muller (2012:Online), "South Africa is ahead of the curve when it comes to fighting smartphone theft". In addition, mobile devices owned by the university are also prone to damage, misuse and being lost. Due to safety and security issues, the use of mobile devices in this research study was restricted to the campus area and during university hours during the first year (2011), because of the danger to use mobile devices in South African public spaces and even to transport them due to risk of theft/robbery. Despite the fact that there is a high probability that mobile devices could either be lost or stolen during the research process, losing all the work that has been completed during the first year proved to be a major concern with potential fatal consequences for this research study.

1.4 The research process

1.4.1 The aim of the study

The introduction and incorporation of m-learning within the context of traditional face-to-face tertiary education, has facilitated a change in the role and understanding of the nature of teaching of the educator and of learners' previous learning experience (Cochrane, 2010:134).

This research study will investigate the potential of m-learning and whether it can bridge the existing learning gap to facilitate technology-based learning within tertiary education courses in developing countries. The study will outline how this could be achieved in an undergraduate first-year computer science programming subject (Software Skills 1) at the CPUT, and how it will explore the potential of wireless mobile technology (mobile/smartphones and PDAs) integration in the institution.

In order to achieve the aforementioned, the research aims indicate the following:

- Supply learners with mobile technology (PDAs) and to incorporate such technology, together with their personal mobile/smartphones, into the FIS programme at the CPUT.
- Collect evidence of the m-learning process (in- and out-of-class activities and learner experiences) in a technology-based subject, while utilising mobile technology as a teaching and learning mechanism.
- Record the input, reaction and output of primarily previously disadvantaged learners while utilising mobile technology in teaching a technology-based subject.
- Evaluate and interpret the data gathered.
- Create a conceptual model to illustrate the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country.

1.4.2 Significance of the research

The significance of this research is nested in not only providing educators with a much needed information resource, but also to utilise mobile technology to the advantage of learners. The research results of this study will contribute to the knowledge base of m-learning and mobile technology utilisations for educational purposes, especially in a developing country such as South Africa.

This research study will mainly focus on whether m-learning can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries. There is limited literature on m-learning in technology-based subjects, and this research therefore endeavours to add to the existing body of knowledge. A conceptual model will be created from data gleaned from literature and results of the pilot studies, questionnaires, formative and summative assessment, observation, focus groups, academic learner research journals, as well as synchronous and asynchronous communication, to support m-learning education in technology-based learning by integrating in- and out-of-class activities and learner experiences.

By integrating wireless mobile technology into learner course delivery, will provide greater flexibility in the learning environment (Norris & Soloway, 2005:Online), and furthermore will enhance the learning environment of learners (Hashim, 2007:2). The possibilities offered by mobile technology (allowing learners to be connected 24 hours/7days a week, independent of time and location), is considerable and can overcome many of the difficulties that learners are facing in getting access for example to software, practical assignments, lecture notes etc. By providing learners with access to remote resources while 'on the move', will increase their capability to physically shift/transfer their own learning environments, thus facilitating the opportunity to take the learning experience outside the boundaries of the classroom.

In this research, learners will be exposed to mobile technologies (mobile/smartphones and PDAs) and methods of m-learning, which will enhance their learning environment and attempts to empower themselves. Furthermore, research should provide valuable insight to tertiary educators who wish to introduce mobile technologies to tertiary education in especially developing countries. It aims to present important aspects that need consideration in utilising mobile technologies that will assist in the implementation of mobile technology in technology-based subjects, which would best suit a developing country like South Africa. M-learning is of great importance for economic development and growth for both individuals and society. The global economy is in dire need of a labour force that is educated, highly skilled and technologically literate. Furthermore, as employment opportunities evolve in response to the ever-changing economy, employees need to learn new skills throughout their lives. M-learning is seen as a response to society's need for both formal and informal lifelong, rapid learning (Cohen, 2010:45). This research could therefore potentially aid in the up scaling of previously disadvantages learners when they are exposed to new technology. This notion maps to the employment equity goals/aims of the country to prepare learners for the future job market in South Africa.

The results of this study will provide insight into the following:

- The extent of mobile technology utilisation within tertiary institutions and their associated salient impediments.
- The extent to which m-learning is deployed in developed countries to facilitate technology-based learning.
- The extent to which m-learning is deployed in under-developed countries to facilitate technology-based learning.
- The typical potential usage patterns for m-learning learners in a technology-based subject.

- Challenges/problems experienced when incorporating m-learning in a technology-based subject in a developing country.
- The extent (i.e. learning/performance, satisfaction, interest) to which m-learning contributes in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.
- A conceptual model to enable a better understanding of m-learning utilisation and how it can serve as a paradigmatic mechanism to facilitate technology-based learning in a developing country.

1.4.3 Type of research

In this research study, 'applied research' (Collis & Hussey, 2009:5-8), will serve as the basis of the research. Applied research is considered the most appropriate research approach for this research study, as it has been designed to apply its findings to serving a specific, existing problem as expanded upon in the background to the research problem (refer Paragraph 1.6). Furthermore, the very essence of applied research involves the application of existing knowledge to improve technology-based learning by means of m-learning, which maps to the requirements of the research question (refer Paragraph 1.7), and the primary research objectives as listed in Paragraph 1.8 of this thesis.

As opposed to conducting the research in the physical and natural worlds, this research study would take place in the 'social world', as it would involve determining 'how things are, and why', and "to understand the systems in which people operate" (Babbie, 2005:12-15). The research would furthermore be theoretical (as opposed to empirical) in nature, as the theoretical researcher would study the subject of research (mobile technology utilisation), through the writings of others and through discourse with learned and informed individuals, who can comment on the subject area (Remenyi, Williams, Money & Swartz, 2009:31-32). As certain elements of this research study would also reflect clear tangent planes with 'empirical research', the analogy can be drawn that 'empirical' and 'theoretical' is in a dialectical relationship with each other (Remenyi *et al*., 2009:37). As in the instance whereby the concepts 'empirical' and 'theoretical' can be viewed as being in a dialectical relationship, so can the concepts 'positivism' and 'phenomenology' be viewed as concepts with clear tangent planes between them, rather than two extreme and separate approaches. This aspect has a direct bearing on the choice if this research study should fall within the 'quantitative' or 'qualitative' (or both) research paradigms.

The focus of the study will be primarily exploratory, focusing on aspects of a descriptive study. This study will be conducted mainly within the qualitative research paradigm, however quantitative measurements were taken where possible in order to triangulate data. The researcher is of the opinion that to fully attain the overall usability, sustainability and effectiveness of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country, the qualitative design could not suffice in isolation of the quantitative elements, calling for a quantitative perspective thereto.

1.4.4 Research design

Action research has been identified to be the most appropriate research methodology for this study. Action research is defined by Leedy and Ormrod (2010:114), as "a type of research that focuses on finding a solution to a local problem in a local setting". Falling within the phenomenological (qualitative) research paradigm, action research is a type of applied research, designed to find an effective way of bringing about change. The main aim of action research is to enter into a problematic situation, attempt to bring about change to that situation, to the benefit of the organisation by developing results or a solution that is of practical value to the people with whom the researcher is working, and at the same time developing theoretical knowledge. More specific, the action researcher is thus involved in a real manner, where there is not only an expectation that a 'contribution to knowledge' should be made, but also to directly 'produce usable knowledge that can be applied and validated in action' in the mitigation of the research problem within a real world context. Through direct intervention in problems, the researcher aims to create practical, often emancipatory, outcomes, while also aiming to reinform existing theory in the domain studied.

This research study also represents a longitudinal study that falls within the positivistic (quantitative) paradigm, since it covers research conducted over a period of six years (2007 - 2012). This study can equally be applied within the context of the phenomenological (qualitative) paradigm as described in the previous paragraph. It aims to "research the dynamics of the problem by investigating the same situation or people several times, or continuously, over the period in which the problem runs its course. A distinctive feature of this approach is that there is a chain of events. Each link in the chain represents an examination or re-examination of a related group or social process, or an aspect of a broader category of groups or social processes. The early studies in the chain are mainly exploratory, but as the chain of studies progresses, grounded theory is generated. The student is cautioned that longitudinal studies may impact adversely on set timeframes" (Watkins, Viljoen, Greef & Rotherham, 2010:27).

The research study will involve a series of action research cycles, using mobile technology to harness the potential of current and emerging m-learning tools. Action research is generally associated with a cyclical process of different phases that include planning, action, observation, reflection, and back to revised planning, action, observation and reflection (Dick, 2002:Online). According to Carr and Kemmis (1986:162), as well as Kemmis and McTaggart (1997:5), action research is a form of collective and self-reflective enquiry undertaken by participants in specific situations in order to improve the rationality and justification of their own social and educational practices, as well as their understanding of these practices and the situations in which these practices are carried out. Kemmis and McTaggart (1988:5-6), are of the opinion that an approach can only be termed action research when it is collaborative, and that it is of importance to understand that action research of a group is achieved through the critically examined action of individual group members.

True to the characteristics of action research, this research study moved through two cycles over a period of two years (2011 - 2012) with successive groups of learners during the second semester of each year. This study is supported by the requirements of action research as described in Chapter 2 of this thesis and uses a variety of research instruments for data collection within each cycle. The notion of this research is not to offer some scientifically valid generalisation, but to directly assist and benefit learners. This was one of the reasons why action research was regarded as the most appropriate research method for this research study. In addition, action research is seen as a problem-solving mechanism since it has the potential to encourage educators to question their actions and then to take action to improve their reciprocal teaching practices. As a result, action research is viewed as a process in which teaching and learning can be investigated to improve learners' teaching and learning experience in the researcher's own educational setting. More specific, the research design is aimed at the purpose of improvement (Hall, 1997:125).

The following features supported the use of action research as a methodology in this research study:

- It creates theory both about and through educational practice (Zuber-Skerritt & Farquhar, 2002:111).
- Since the researcher is also a tertiary educator, improved knowledge could directly lead to improved teaching practices (Feldman & Minstrell, 2000:Online).
- Zuber-Skerritt and Farquhar (2002:107), as well as Feldman and Minstrell (2000:Online), assert that learners might experience more learning support in this fashion.

The aforementioned essential features of the action research approach best fit this research study and are supported by Edge (2001:5), who emphasises that the purpose of action research, "is not simply to describe, interpret, analyse and theorize - the stuff of traditional research - but to act in and on a situation to make things better than they were”.

1.5 Research participants

According to Robertson, Trotman and Galbraith (1997:43), action research needs individuals who wish to alter the status quo to improve learning and are in common agreement about collective decisions. Researchers and participants are generally equally involved in effective action research and they all negotiate meaning from the data through communication and information flow (Dick, 2002:Online; Gabel, 1995:Online).

The research participants were all stakeholders sharing a common role or activity i.e.:

- The target group included first-year undergraduate learners from the FIS programme at the CPUT in the Software Skills I module from 2011 until 2012.
- The subject co-ordinator and educator who is the author of this thesis.

1.6 Statement of the research problem

To define the research problem, the researcher used the guidelines as proposed by Garbers (1996:293), and are presented in Table 1.1.

Table 1.1: Questions used as guidelines for the research problem
(Adapted from Garbers, 1996:293)

Question	Answer
What was this study about?	Investigating m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country.
Who was involved in this study?	First-year undergraduate learners registered for the Financial Information Systems course at the Cape Peninsula University of Technology from 2011 until 2012.
When was this study conducted?	The action based research study was conducted over a period of two years (2011 until 2012) during the second semester of each year.
Why was research going to be conducted?	The research was an attempt to determine whether m-learning can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.

How was research conducted?	The research was conducted by means of action research to: • Determine the extent of mobile technology utilisation within tertiary institutions and to identify their associated salient impediments. • Determine the extent of m-learning deployment in developed countries to facilitate technology-based learning. • Determine the extent of m-learning deployment in under-developed countries to facilitate technology-based learning. • Identify the typical potential usage patterns for m-learning learners in a technology-based subject. • Determine the specific challenges/problems that are evident to implement m-learning in technology-based subjects in tertiary institutions of developing countries. • Determine the extent (i.e. learning/performance, satisfaction, interest) to which m-learning contributes in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.

Against the background to the research problem elaborated upon above, the research problem to be researched within the ambit of this thesis, reads as follows: "*Current learning mechanisms to facilitate technology-based learning do not comply with the demands faced by tertiary institutions of developing countries*."

1.7 Research question and sub-questions

The primary research question, which will be researched in support of the mitigation of the research problem, reads as follows: *"Can mobile learning bridge the existing learning gap to facilitate technology-based learning in tertiary institutions in a developing country?"*

In support of the primary research question, the following research sub-questions will be researched:

- What does current learning mechanisms used in tertiary institutions entail and what are their associated salient impediments?
- To what extent is m-learning deployed in developed countries to facilitate technology-based learning?
- To what extent is m-learning deployed in under-developed countries to facilitate technology-based learning?
- What are the typical potential usage patterns for m-learning learners in a technology-based subject?

- What specific challenges/problems are evident to implement m-learning in a technology-based subject in tertiary institutions of developing countries?
- To what extent (i.e. learning/performance, satisfaction, interest) does m-learning contribute in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries?

1.8 Key research objectives

The key research objectives of this research study are elaborated upon below:

- To determine the extent of mobile technology utilisation within tertiary institutions and to identify their associated salient impediments.
- To determine the extent of m-learning deployment in developed countries to facilitate technology-based learning.
- To determine the extent of m-learning deployment in under-developed countries to facilitate technology-based learning.
- To identify the typical potential usage patterns for m-learning learners in a technology-based subject.
- To determine the specific challenges/problems that are evident to implement m-learning in a technology-based subject in tertiary institutions of developing countries.
- To determine the extent (i.e. learning/performance, satisfaction, interest) to which m-learning contributes in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.

1.9 Holistic perspective

For ease of reference of the reader and to provide a holistic perspective of the key elements of this research study, see Table 1.2.

Table 1.2: Research problem, research question, sub-questions, methods and objectives

Research Problem	Current learning mechanisms to facilitate technology-based learning do not comply to the demands faced by tertiary institutions of developing countries.	
Research Question	Can mobile learning bridge the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries?	
Research Sub-Questions	**Research Methods**	**Objectives**
What does current learning mechanisms used in tertiary institutions to facilitate technology-based learning entail and what are their associated salient impediments?	Literature review	To determine the extent of mobile technology utilisation within tertiary institutions and to identify their associated salient impediments.
To what extent is m-learning deployed in developed countries to facilitate technology-based learning?	Literature review	To determine the extent of m-learning deployment in developed countries to facilitate technology-based learning.
To what extent is m-learning deployed in under-developed countries to facilitate technology-based learning?	Literature review	To determine the extent of m-learning deployment in under-developed countries to facilitate technology-based learning.
What are the typical potential usage patterns for m-learning learners in a technology-based subject?	• South African pilot study • Questionnaire • Observation • Focus groups • Academic learner research journals • Synchronous and asynchronous communication	To identify the typical potential usage patterns for m-learning learners in a technology-based subject.
What specific challenges/problems are evident to implement m-learning in a technology-based subject in tertiary institutions of developing countries?	• Literature review • South African pilot study • Questionnaire • Observation • Focus groups • Academic learner research journals • Synchronous and asynchronous communication	To determine the specific challenges/problems that are evident to implement m-learning in a technology-based subject in tertiary institutions of developing countries.
To what extent (i.e learning/performance, satisfaction, interest) does m-learning contribute in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries?	• South African pilot study • Formative and summative assessment • Questionnaire • Observation • Focus groups • Academic learner journals • Synchronous and asynchronous communication	To determine the extent (i.e. learning/performance, satisfaction, interest) to which m-learning contributes in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.

1.10 Data collection methodologies

1.10.1 Description of the data collection instruments

Rather than using a single method for collecting and analysing data, action research is a holistic approach to problem-solving. It therefore allows for a variety of research tools to be deployed as the study progresses. A combination of quantitative and qualitative techniques, falling within the ambit of the action research paradigm, was used in collecting data and evidence for analysis and interpretation in this research study. Mobile evaluation designs increasingly comprise mixed methods, which are useful for data validation, and capturing different perspectives of the learning experience (Vavoula & Sharples, 2009:56). Therefore, within this thesis formative and summative assessment, questionnaires, observation, focus groups, academic learner research journals, as well as synchronous and asynchronous communication served as data collection methodologies. To ensure research validity, multiple data collection methods (methodological triangulation) will be adopted. Table 1.3 outlines the data collection instruments used to collect data and which were applied in the context of this research study. It is followed by a brief description of the main methodologies together with its main purpose to aid the reader's understanding of the data collection methodologies deployed within the context of this research study.

Table 1.3: Description of the data collection instruments used in the context of this research study

Data collection instrument	Description
Literature review	Evaluation of the content of relevant journal articles, books, theses and electronic documents available on the Internet regarding m-learning.
South African pilot study	A pilot study was conducted to: • Investigate the potential of m-learning and whether it can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries. • Identify the typical potential usage patterns for m-learning learners in a technology-based subject. • Determine the specific challenges/problems that are evident to implement m-learning in a technology-based subject in tertiary institutions of developing countries. • To determine the extent (i.e. learning/performance, satisfaction, interest) to which m-learning contributes in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.
Formative and summative assessment	• Formative assessments (class tests and practical computer science programming assignments) were used to evaluate learners' knowledge on the prescribed source on a continuous basis throughout the semester. • Summative assessments (formal tests) were used to test learners' theoretical and practical knowledge on all the learning units covered.

Questionnaires	Multiple-choice and close-ended questions were used to determine: • Learners' use, perception and attitude towards mobile technology within a technology-based subject. • The extent of mobile technology utilisation within tertiary institutions and to identify their associated salient impediments. • The typical potential usage patterns of m-learning learners in a technology-based subject. • The specific challenges/problems that are evident to implement m-learning in a technology-based subject in tertiary institutions of developing countries. • To determine the extent (i.e. learning/performance, satisfaction, interest) to which m-learning contributes in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.
Observation	Observation of the learners was conducted by the researcher to gather information on learners' attitudes and how they use and interact with mobile technology. Video material and photos were included as observation examples in order to provide an accurate description of events, as well as to assist in the triangulation of data.
Focus groups	Focus groups took place during the second action research cycle after all the questionnaires have been conducted and were based upon the further exploration of issues that had emerged from questionnaire data. It focused on learners' experience with the mobile technologies and how they use and interact with these technologies. Learner responses were collected for qualitative analysis similar to research conducted by Boone (1995:95), i.e. for "Comments", "What did you like?", "What did you dislike?", etc.
Academic learner research journals	Academic research journals were kept by learners to keep track of their m-learning activities and thoughts during mobile technology utilisation. Journal entries were reviewed and assisted in: • Identifying common trends in mobile technology utilisation amongst learners. • Isolating areas where problems regularly occur. • Identifying where more work needed to be done or where real strengths have been developed and some obstacles have been overcome. This assisted the researcher to identify the typical potential usage patterns for m-learning learners, and in setting new goals for future research projects and developments.
Synchronous and asynchronous communication	Records of comments and thoughts generated by learners by means of Instant Messaging (IM) (i.e. WhatsApp) and e-mail.

- **Formative and summative assessment:** According to Vavoula and Sharples (2009:56), there are certain challenges when evaluating m-learning during the assessment of learning processes and outcomes. Vavoula and Sharples (Ibid) postulate that in a traditional classroom environment, there are entrenched and accepted methods for assessing learning activities. Scriven[2], cited by Vavoula and Sharples (2009:57), provides a clear distinction between formative assessment (to measure success of the teaching process, as well as the effectiveness of the learning process), and summative assessment (to evaluate and summarise learner achievements), with formative

[2] Scriven, M. 1967. The methodology of evaluation. In Tyler, R.W., Gagne, R.M. & Scriven, M. (eds.). *Perspectives of Curriculum Evaluation*. Chicago: Rand McNally: 39-83.

assessment providing better potential to support and complement teaching and learning (Black & Wiliam, 1998:41). Summative assessment, such as formal tests and examinations, is mainly used in formal learning environments where learning objectives and required outcomes are well specified in advance. Conversely, m-learning can be both personal and elusive, making it impossible to determine in advance where learning can take place, or how it develops, or what results it generates, or even to track the progress of learning, since it occurs across multiple contexts and technologies (Vavoula & Sharples, 2009:57-58). Carnegie Mellon University (2012:Online), supports the notion of Vavoula and Sharples (2009:57-58), and states that, "the assessment of teaching and learning can be viewed as two complementary and overlapping activities that aim to benefit both the quality of learners' learning and the professional development of the instructor". By only assessing learning is not adequate, because the definitive success of learners is also dependent upon their motivation and dedication to learning. Reciprocally, assessing teaching behaviours and course activities in isolation is also inadequate in that while certain qualities of the educator may be appreciated by learners, such qualities may not be advantageous to their learning and growth. Executed concurrently, the assessment of teaching and learning can assist educators to develop and refine their teaching practices and aid in improving learners' learning and performance. In this research study, formative assessment refers to the gathering of feedback that can be used by the educator and the learners to guide improvements in the on-going teaching and learning context by means of class tests and computer science programming assignments. Summative assessment in turn refers to measuring the level of success/proficiency that has been obtained at the end of an instructional unit, by comparing it against a predetermined standard or benchmark. In this research study formal test marks (summative), as well as assignment- and class test marks (formative) will be used to facilitate the assessment process.

- **Questionnaires:** Questionnaires provide an alternative to focus on learner perceptions of the learning experience as opposed to learning outcomes with regard to cognitive gains (Vavoula & Sharples, 2009:58). Questionnaires fall within the ambit of a broader definition of 'survey research' or 'descriptive survey'. Remenyi *et al.* (2009:290), define the concept of a 'survey' as, "the collection of a large quantity of evidence usually numeric, or evidence that will be converted to numbers, normally by means of a questionnaire". A questionnaire is a list of carefully structured questions, chosen after considerable testing with a view to elicit reliable responses from a chosen sample. The aim is to establish what a selected group of participants do, think or feel. According to Vavoula and Sharples (2009:58), when referring to m-learning literature, attitude surveys are widely utilised to measure learner attitudes towards mobile technology and their satisfaction/enjoyment of the m-learning experience. A quantitative approach suggests structured ‘closed’ questions, while a qualitative approach suggests unstructured ‘open-ended’ questions (Waktins, 2012:74). Questionnaires, prepared for FIS learners enrolled for the Software Skills 1 subject, contained open- and close-ended questions. Questions formulated in line with the Likert scale were used to determine: 1) The extent of mobile technology utilisation within tertiary institutions and to identify the associated impediments to facilitate technology-based learning; 2) to identify the specific challenges that are evident when implementing m-learning in tertiary institutions in South Africa; 3) and to determine the extent (i.e. learning/performance, satisfaction, interest) to which m-learning contributes in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries. Learners were asked to complete questionnaires to evaluate learner satisfaction with the mobile technology utilisation deployed within a technology-based subject, as well as the usefulness and usability aspects of mobile devices as a learning tool in a computer science programming subject. Questions were so formulated as to evaluate different aspects of usability, learner attitudes, general experience, satisfaction with mobile technology utilisation, and the impact mobile technology had on their teaching and learning experience.

- **Observation:** Observation also serves an alternative means to scrutinise the m-learning experience for evidence (Vavoula & Sharples, 2009:58). Griffin (1999:117), proposes that the researcher should observe instances where learners instigate and take responsibility for their own learning, are actively involved in learning, establish links and transfer skills and ideas, and share learning with educators and peers. In this research study learners were observed in both formal and informal settings "to identify observable critical incidents that appear to be breakthroughs (indicating productive new forms of learning or important conceptual change) or breakdowns (where a learner is struggling with the technology, is asking for help, or appears to be labouring under a clear misunderstanding)" (Flanagan[3], cited by Vavoula and Sharples, 2009:58). Participant observation (including photographing and videotaping from a discrete distance) was used to gather information on learner attitudes and how they use and interact with mobile technology in a technology-based subject. This type of observation by implication involved the researcher, and aims to provide the means of obtaining a comprehensive understanding of values, motives and practices of those being observed (Watkins, 2012:70).
- **Focus groups:** Focus groups are regarded as an effective method for triangulating data (Wilson, 1997:214), and were therefore used to collect and record data gleaned from learners. According to Morgan (1988:12), focus groups involve the unequivocal use of group interaction to construct data and insights that would be less reachable without the communication found in a group. This is in particular relevant to this research study as

[3] Flanagan, J.C. 1954. The critical incident technique. *Psychological Bulletin,* 51(4):327-358.

any viewpoint expressed within the focus group can either reinforce or counter those which had been made in the questionnaires, thus further validating the research process (Dale, 2008:5). Morgan (1998:35), further states that focus groups are an exceptionally flexible research method, with extremely flexible boundaries. In this research study focus groups were conducted after all the questionnaires have been completed and are based upon the further exploration of issues that emerged from the already collected data. The focus is on learner experiences with mobile technologies, and how they use and interact with such technologies.

- **Learner research journals:** According to Vavoula and Sharples (2009:58), learner-created artefacts, such as keeping log files of mobile technology activity, can provide valuable information in assessing learning. Learners were encouraged to keep a diary/journal as they utilised mobile technology and completed computer science programming assignments in order to formally document thoughts, feelings and decision. These research journals are also commonly referred to as 'learner diaries' or 'learner logs'. The aim of this approach was to capture data on learner usage, feelings and decisions made while utilising mobile technology. These journals make both the successful and (apparently) unsuccessful avenues of learning and discovery visible, so that they can be revisited and serve as the subject of analysis (Altrichter, Posch & Somekh, 1993:12). Data gleaned from this approach assisted the researcher in reflecting on past events and ideas which in turn guided subsequent actions, analysing strengths and weaknesses, and dealing with negative feedback.
- **Synchronous and asynchronous communication:** Communication is classified as either being synchronous or asynchronous, depending on the time delay between the communication being sent or a response being returned. Attending for example tertiary education classes are a form of synchronous communication were educators lecture and learners learn in real time in a traditional classroom setting. Email, on the other hand, is mainly viewed as being asynchronous in nature, since a response normally takes a few hours or even a day or two, or nearly synchronous if the recipient responds as soon as the e-mail is received. Instant messaging (IM) (synchronous communication) afford communication and the ability to gather information by means of a mixture of sources either instantaneously or with a delay (Rosen, Carrier & Cheever, 2010:111). During this research study, the WhatsApp IM application (synchronous communication) was used in addition to e-mail (asynchronous communication) to communicate and provide feedback to learners. WhatsApp is a synchronous communication tool where text messages can be sent and delivered instantaneously between users. A major advantage of this type of communication is its minimal cost ranging from 97% - 99% less than text messages or Short Message Service (SMS), thus providing learners the opportunity to access professional support in an affordable manner. IM technology afforded learners the

opportunity to access professional support in an affordable manner, and enabled them to send any subject-related questions to the researcher (the educator). The researcher made her supporting service available 7 days a week/24 hours a day (24/7) during the second action research cycle in 2012. Learners were able to reflect their learning and discuss any computer science programming issues with their educator or peers from any location at any time. It provided learners the opportunity to interact and collaborate within a social space and can, according to Butgereit (2007:Online), be successfully used for tutoring. The support service provided by the educator aimed at assisting learners in their learning process, as well as to provide an attractive and effective learning tool that can enrich their learning environment and experience. Laine and Suhonen (2008:152), postulate that this can “boost collaboration and interaction” amongst learners.

1.10.2 Data collection matrix

The data collection matrix following on to and in support of the description of the data collection instruments as depicted in Table 1.3, and is tabulated in Table 1.4.

Table 1.4: Data collection matrix

	Literature review	**South African pilot study**	**Formative and summative Assessment**	**Questionnaires**	**Observation**	**Focus groups**	**Academic learner research journals**	**Synchronous and asynchronous communication**
What does current m-learning mechanisms used in tertiary institutions entail and what are their associated salient impediments?	X			X				
To what extent is m-learning deployed in developed countries to facilitate technology-based learning?	X							
To what extent is m-learning deployed in under-developed countries to facilitate technology-based learning?	X							
What are the typical potential usage patterns for m-learning learners in a technology-based subject?		X		X	X	X	X	X
What specific challenges/problems are evident to implement m-learning in a technology-based subject in tertiary institutions of developing countries?	X	X		X	X	X	X	X

To what extent (i.e. learning/performance, satisfaction, interest) does m-learning contribute in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries?		x	x	x	x	x	x	x

1.11 Research assumptions

According to Leedy and Ormrod (2001:62-63), "assumptions are what the researcher takes for granted". In considering the research assumptions pertaining to research in general (Ontology, Epistemology, Human nature and Methodology) (Burrell & Morgan, 1979:6-7), the perspective most suitable for this research study is considered to be 'Methodology'. In terms of this perspective, the following are of importance:

1. Ideographic:

- One can only understand (the) social world by obtaining first-hand knowledge of the subject under investigation.
- One has to get close to one's subject and explore its detailed background and 'life' history.
- Emphasises the analysis of subjective accounts generated by 'getting inside' situations and involving oneself in the everyday flow of life.
- Stresses the importance of letting one's subject unfold its nature and characteristics during a process of investigation.

2. Nomothetic:

- Emphasises the importance of basing research upon systematic protocol and technique.
- Epitomised by the approach and methods employed in the natural sciences.
- Focus on the process of testing hypotheses in accordance with the rules and directives pertaining to scientific rigor.
- Preoccupied with the construction of scientific tests and the use of quantitative techniques for the analysis of data.
- Surveys, questionnaires, personality tests and standardised research instruments of different kinds are prominent tools.

Within this context the following assumptions pertain to the research in this thesis:

- This study is concerned with the use and impact of mobile technologies in teaching first-year undergraduate computer science programming learners in a developing country (South Africa).

- Since the researcher is closely connected to the participants (the implementation of m-learning in a technology-based subject was the researcher's initiative), the researcher avoided interpreting biased results.
- The educator in this study (who is also the researcher in this study) is competent to teach the technology-based subject (Software Skills 1) in question and has mastered the programming principles and concepts of the subject being taught.
- The learners taking part in the research should be capable of mastering the programming principles and concepts in the technology-based subject (Software Skills 1) they are studying.
- The subject matter (m-learning in education) has extensively been researched in both developed and developing countries, however not much research has been conducted in technology-based subjects.

1.12 Demarcation of the research

Research was only conducted in South Africa and only focused on full-time first-year undergraduate computer science programming (Software Skills 1) learners enrolled for the FIS programme (2011 - 2012) at the CPUT. A relatively small group of learners participated in this research study (2011, n = 33; 2012, n = 48). During the two-year period single-user device usage was possible due to low learner numbers. Learners made use of their own mobile/smartphones, and were each supplied with a PDA for the duration of the course. While this will limit the generalisability of conclusions, it is considered to be sufficient to produce a conceptual model for m-learning application in a technology-based subject in a developing country.

1.13 Chapter and content analysis

The chapter and content analysis applicable to this research thesis are the following:

Chapter 1 – Scope of the research: In this chapter, the scope of the research is discussed and the research contextualised, in particular as it pertains to a specific environment. Furthermore, the research problem is elaborated upon, which will not only form the crux of the research study, but will set the scene for the research. In addition, the research process, research questions, research objectives, data collection methodologies, assumptions, demarcation, and limitations of the research, are elaborated upon.

Chapter 2 – Research methodology: In this chapter, the reader is provided with a holistic perspective of the research methodology deployed. The research methodology will not only provide context to the research problem and the purpose/objectives of the study, but will provide a comprehensive background to aid the understanding of the reader on the action research process and why it is appropriate in the particular environment in which the research took place.

Chapter 3 – Mobile learning: A literature review: In this chapter, a literature review will be conducted on the primary theme of the thesis, providing an empirical underpinning to the research problem. More specific, the literature review (the current status of the research area) will provide academic context to the unique aspects that would mitigate the research problem.

Chapter 4 – Mobile learning in developed and underdeveloped countries: A literature review: In this chapter a literature review will be conducted on m-learning initiatives in both developed and underdeveloped countries. In addition, the literature review will provide evidence on worldwide m-learning projects that have been conducted in technology-based subjects (computer science programming).

Chapter 5 – Data analysis and interpretation of results: From both a quantitative and qualitative perspective, this chapter reflects the approach to data collection. Furthermore, data gleaned from the data collection exercise, will be analysed and interpreted.

Chapter 6 – Conclusions and recommendations: In this concluding chapter, key aspects pertaining to the research will be revisited. Research findings will be brought into the context of the overall research, recommendations will be made, a conceptual model will be developed to illustrate the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country, and final analogies will be drawn.

1.14 Limitations of the research

This study faces three important limitations:

- The participants of the study are first-year learners of the FIS programme at the CPUT. No other qualifications or tertiary institutions were considered.
- Learners were expected to have mobile phones with sufficient airtime to make use of the IM platform, WhatsApp. While some learners were not willing to use their airtime for academic purposes, most did not have the financial means to buy additional airtime for their mobile phones.

Through the validation of data by means of triangulation, the validity of the study will be addressed. It is acknowledged that this research study will be impacted upon by the abovementioned limitations. However, despite these limitations, the researcher believes that the lessons learned from this research study can provide insight into other similar contexts, contributing to the (still emergent) body of academic knowledge on educational m-learning.

1.15 Conclusion

This chapter provided an introduction to the research study discussed in this thesis. In the chapter the research process, research problem, research questions, research objectives, data collection methodologies, assumptions, demarcation, and limitations of the research were elaborated upon.

In the next chapter, the research methodology will be discussed and expanded upon, to provide the reader with background information to the relative positioning of the primary theme of the research study.

CHAPTER TWO
RESEARCH METHODOLOGY

SYNOPSIS

An action research study, within the framework of activity theory, was conducted at the CPUT within a technology-based subject (computer science programming) to glean data pertaining to m-learning implementation and whether it can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions in developing countries. The reader will be provided with an outline of action research as a research method, and why it was deemed most appropriate when used in conjunction with a mixed methods approach.

More specific, the following aspects will be elaborated upon within the ambit of this chapter:

- Purpose and objectives
- The quantitative (deductive) and qualitative (inductive) research paradigms
- The action research method
- Appropriateness of action research for the research study
- Activity theory as the underpinning theory for this research study

Furthermore, to the detailed discussion on the research methodology, the very essence of activity theory, which will serve as the underpinning theory to the research study, will be analysed in detail. In addition, the research environment will be expanded upon, to provide the reader with background information to the relative positioning of the primary theme of the research study. It will provide a detailed description of the research project undertaken to establish a m-learning environment for first-year undergraduate computer science programming learners enrolled for the FIS programme at the CPUT.

The content of Chapter 2, along with the relative positioning of the topics, is graphically depicted in Figure 2.

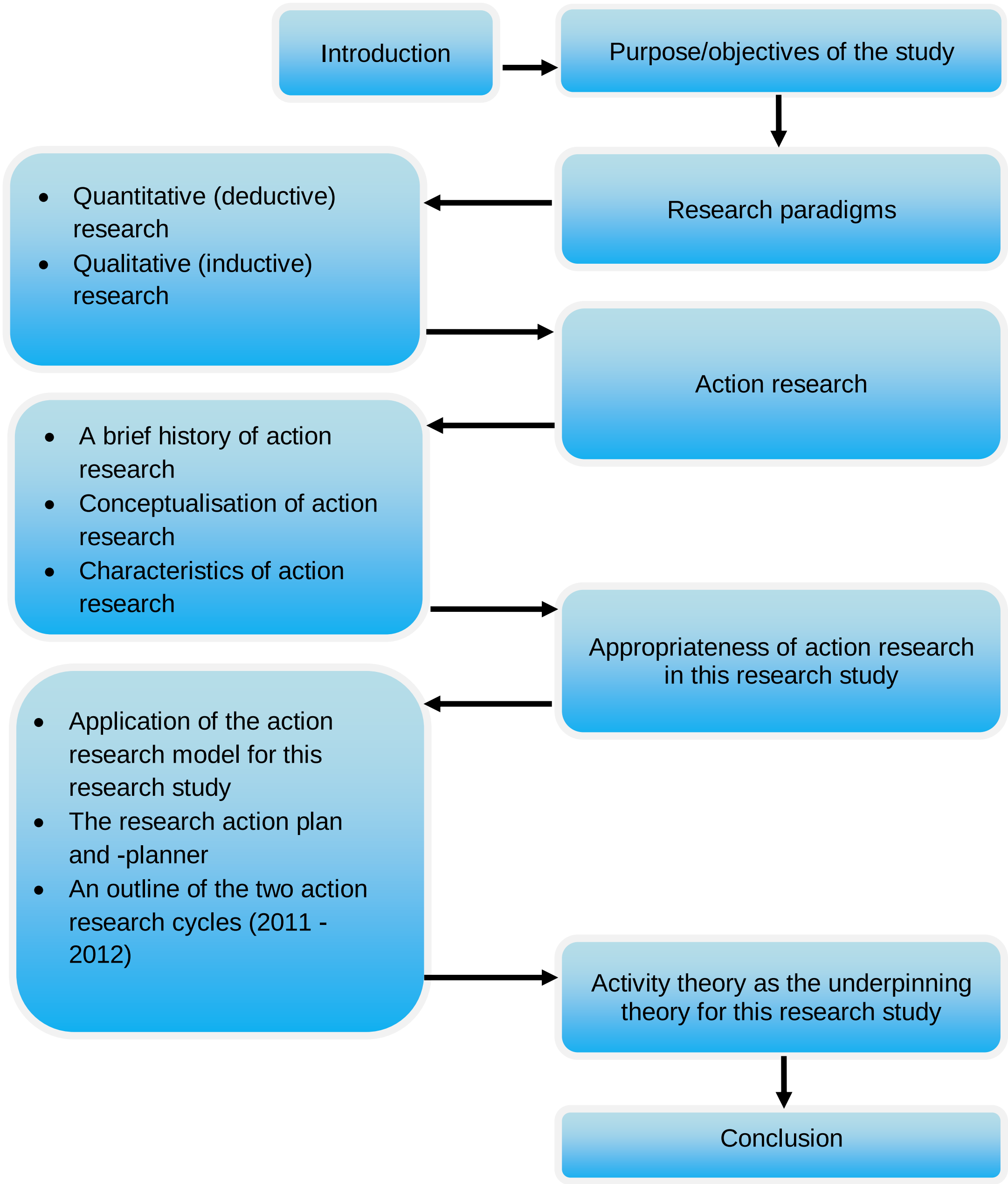

Figure 2: Detailed layout of Chapter 2 - Research methodology

2. CHAPTER TWO
RESEARCH METHODOLOGY

2.1 Introduction

The analytical process followed thus far is graphically depicted in Figure 2.1, placing the chapters in context with the overall thesis objectives, and furthermore indicating the relative positioning of this chapter.

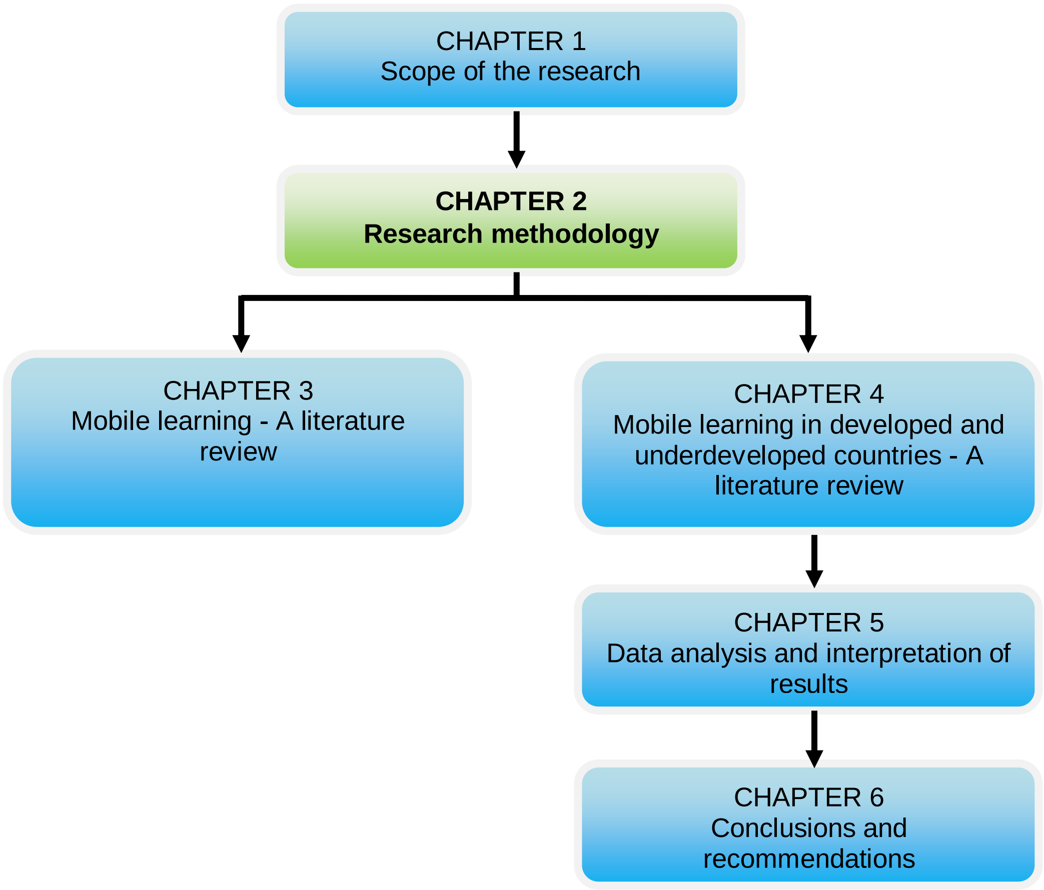

Figure 2.1: Chapter 2 - Research methodology

This research reports on an action research study, within the activity theory framework, that investigates the utilisation potential of m-learning and whether it can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions in developing countries. Furthermore, it reports on the implementation, challenges and opportunities of m-learning in a first-year computer science programming subject to support the teaching and learning needs of mainly previously disadvantaged learners. The focus of the study is threefold: First, it is 'theoretical' in nature, since different views expressed in the literature are compared and contrasted. Second, the focus is 'conceptual', due to the fact that the perspectives on m-learning in a technology-based subject are drawn from the results obtained from an action based research inquiry process. Third, it is 'empirical', since the study explores the potential benefits of m-learning as a paradigmatic mechanism to facilitate technology-based learning. For this purpose, questionnaires, formative and summative assessment, observation, focus groups, academic learner research journals, as well as synchronous and asynchronous communication, will be utilised.

In addition, the research environment will be expanded upon, to provide the reader with background information to the relative positioning of the primary theme of the research study. It will provide a detailed description of the research project undertaken to establish a m-learning environment for first-year undergraduate computer science programming learners enrolled for the FIS programme at the CPUT. It offers an outline of Action Research as a research method and why it was deemed most appropriate when used in conjunction with a mixed methods approach (Wiśniewska, 2011:69). This chapter provides the rationale for the selection of this approach and how each of these elements map to one another.

Research often includes a number and an integration of research methodologies. The following will be elaborated upon in this chapter:

- The purpose/objectives of the study
- Quantitative (deductive) and qualitative (inductive) research paradigms considered for this study
- Action research
- The rationale for an appropriate research methodology for this study
- The proposed application of the research methodology to this study
- The application of Activity Theory as the underpinning theory in this study

A graphic depiction of the research design used in this study is presented in Figure 2.2. Text highlighted in bold indicate the parameters relevant to this research study.

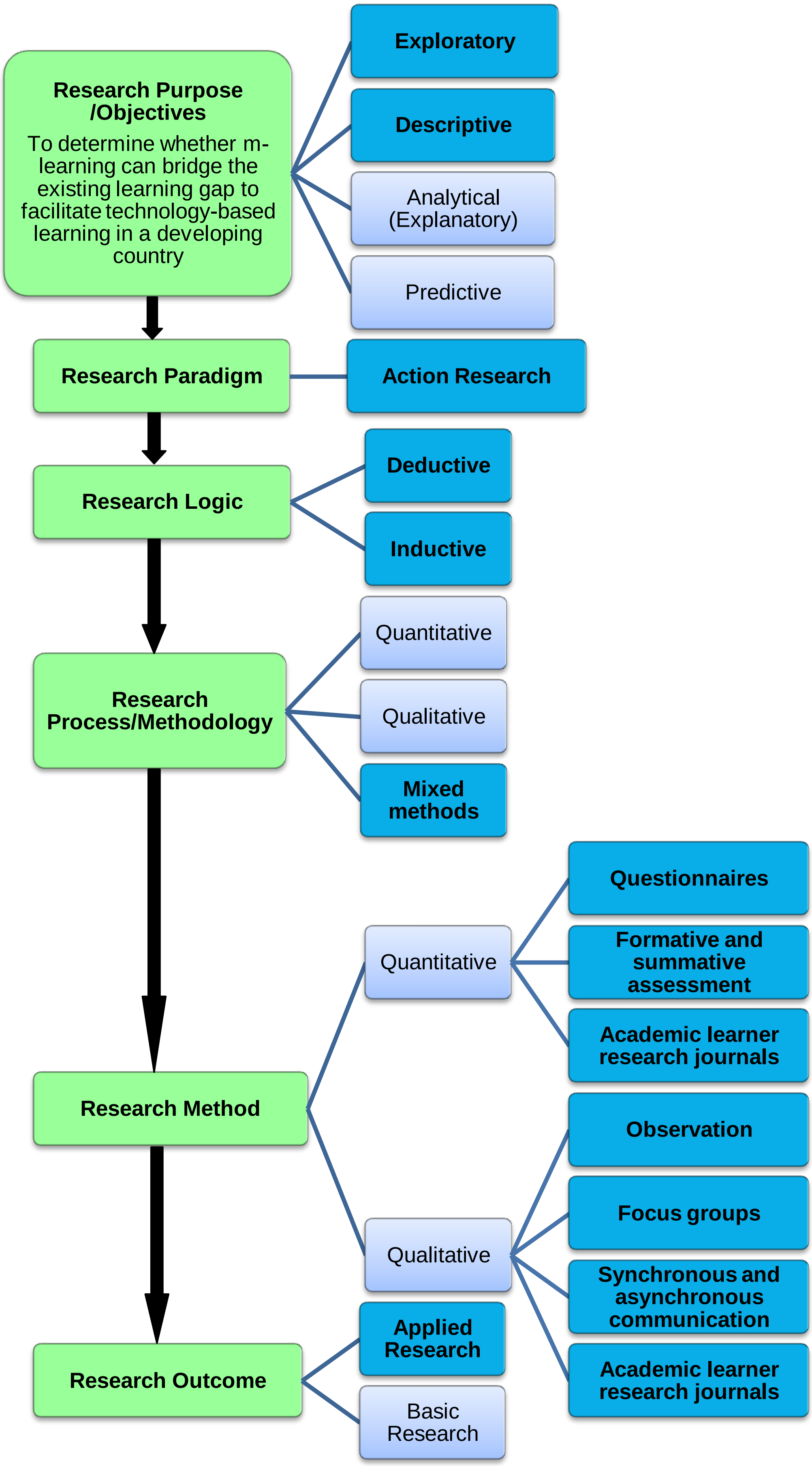

Figure 2.2: Graphic depiction of the research design used in this study

2.2 Purpose/objectives of the study

Educational research can have exploratory, analytical (explanatory) or descriptive objectives. Table 2.1 presents a comparative analysis of the characteristics of these objectives from Mouton and Marais (1993:45;123), Garbers (1996:295-296), as well as Collis and Hussey (2009:10-15). It elucidates the decision to classify this study as primarily exploratory, supported by elements of a descriptive study by indicating the context with a cross (X).

This study aims to achieve the following:

- Gain new insights and give an accurate description of the phenomenon, i.e. utilisation of m-learning in a technology-based subject in tertiary institutions of developing countries. This includes focusing on:
  - The typical potential usage patterns of m-learning learners in a technology-based subject.
  - The specific challenges/problems that are evident in implementing m-learning in a technology-based subject in tertiary institutions in South Africa.
  - The extent (i.e. learning/performance, satisfaction, interest) to which m-learning can contribute in bridging the existing learning gap to facilitate technology-based learning in order to produce real and sustained improvements in education.
- Create a conceptual model to illustrate the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country.

Table 2.1: Comparison of research objectives in context of this study
(Partially adapted from De Jager, 2002:18)

Objective	Characteristic	This study	Data collection methods	This study
Exploratory studies	The focus is on a relatively unknown research area to: • Gain new insights • Elucidate the central concepts and constructs • Determine priorities for future research • Develop new hypotheses • Undertake preliminary investigation prior to a more structured study	 X X X X	• Questionnaires • Field work in an authentic environment, less control and longitudinal • Qualitative / Inductive research	X X X
	Methodology • Review of related literature • Questionnaire(s) • Analysis of present examples	 X X X		
	Considerations • Open and flexible researcher and research strategy to examine new ideas • Activities that will provide insight and better comprehension	 X X		
Analytical (explanatory) studies	The focus is to: • Understand the phenomena by discovering and measuring casual relations among them • Indicate cause and effect between variables	**N/A**	• Experimental and quasi-experimental • Experimental control • Structured direct and indirect observation • Qualitative / Inductive research • Surveys are representative, longitudinal, cross-sectional and independent of a specific context	**N/A**
	Methodology Indicate the relation between variables in terms of the quantification of data, e.g. direct or indirect proportionality	**N/A**		
Descriptive studies	The focus is on an accurate description of: • Individuals, groups or a phenomenon	 X	• Observation, questionnaires, focus groups, academic learner research journals, as well as synchronous and asynchronous communication • Representative of group, longitudinal • Quantitative / Deductive research • Qualitative / Inductive research	X X X X
	Methodology • Statistical analysis and classification • Correlation between the variables	 X X		

2.3 Research paradigms

The use of quantitative (deductive) or qualitative (inductive) research differentiates the choice of data collection and data interpretation in research. In order to validate the most appropriate type of research, the concepts of deductive and inductive logic have to be clarified. Deductive and inductive logic differentiate between the aims of the reasoning in this study. In the opinion of this author, it is Leedy and Ormrod (2010:96), who provides the most practical perspective (see Table 2.2) of the differences between the qualitative and quantitative research paradigms in terms of the 'research focus'.

Table 2.2: Distinguishing characteristics of the qualitative and quantitative research paradigms (Adapted from Leedy & Ormrod, 2010:96)

Research Focus	Quantitative research paradigm	Qualitative research paradigm
Purpose of the research	To explain and predict To confirm and validate To test theory	To describe and explain To explore and interpret To build theory
Nature of the research process	Focused Known variables Established guidelines Predetermined methods Context-free Detached view	Holistic Unknown variables Flexible guidelines Emergent design Context-bound Personal view
What is the data like, and how is such data collected?	Numeric data Representative, large sample Standardised instruments	Textual and/or image-based data Informative, small sample Loosely structured or non-standardised observations and interviews
How is data analysed to determine its meaning?	Statistical analysis Stress on objectivity Deductive reasoning	Search for themes and categories Acknowledgement that analysis is subjective and potentially biased Inductive reasoning
Method of communicating findings	Numbers Statistics, aggregated data Formal voice, scientific style	Words Narratives, individual quotes Personal voice, literary style

From the above, the analogy can be drawn that there is much overlap between qualitative and quantitative research methods. Most qualitative-style researchers examine quantitative-type data and vice versa, however they differ in significant ways. This is supported by Babbie (2005:25), who expresses the opinion that, "recognizing the distinction between qualitative and quantitative research doesn't mean that you must identify your research activities with one to the exclusion of the other. A complete understanding of a topic often requires both techniques".

2.3.1 Quantitative (deductive) research

Quantitative research acts on deductive logic with a clear conceptual framework and seeks to substantiate what is right or wrong with human behaviour (Garbers, 1996:186; Mouton & Marais, 1993:164). Deductive research represents a study in which a conceptual and theoretical structure is developed, and then tested by empirical observation (Collis & Hussey, 2009:10-15).

One might start with postulating a theory about the topic of interest. One would then narrow that down into more specific hypotheses, which one could test. This is then further narrowed down in order to collect observations to address the hypotheses. This ultimately leads one to the ability to test the hypotheses with specific data - a confirmation (or not) of one's original theories (William, 2006:Online). Deduction is a method of applying a general rule (major premise) in a specific situation (minor premise), from which conclusions can be drawn. It is of importance to note that with deductive reasoning, no new information is provided in that it only rearranges information that is already known into a new statement or conclusion. The analysis of quantitative data aims to prove relationship between variables. Table 2.3 provides a summary of the quantitative research methodology as upheld by Mouton and Marais (1993)[4] cited by De Jager (2002:22).

Table 2.3: Summary of the quantitative research methodology
(Adapted from Mouton and Marais (1993) cited by De Jager (2002:22))

Principle	Description
Rationale	To explain and describe the phenomenon being researched
Concepts and constructs	One and only one connotation
Hypothesis	Well formulated in the beginning of the study and unconditionally true or false
Observation	Objective, researcher observes from a distance, well-planned observation and examples, pre-determined, structured and categorised information
Outcome of the study	Accept or reject the hypothesis

The following aspects were considered for the quantitative data analysis in this research thesis:

- Collecting data as the result of questionnaires, the formative and summative assessment process, as well as academic learner research journals.
- Data analysis and interpretation.

[4] Mouton, J. & Marais, H.C. 1993. *Basiese Begrippe: Metodologie van die Geesteswetenskappe*. Pretoria: RGN Uitgewers.

- Creating a conceptual model to illustrate the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country.

2.3.2 Qualitative (inductive) research

Qualitative research acts on inductive logic with no exact and pre-determined conceptual framework and seeks to improve the understanding of human behaviour (Garbers, 1996:186; Mouton & Marais, 1993:164). It produces descriptions of how and why people do certain things (Winberg, 1997:29). Inductive research represents a study in which theory is developed from the observation of empirical reality (Collis & Hussey, 2009:10-15). Qualitative research is inductive and enables researchers to develop their understanding of a particular phenomenon during the course of the research process. Researchers therefore do not (as a rule), gather data in order to support preconceived hypotheses or theories (Winberg, 1997:41). In this form of logical reasoning, specific conclusions are generalised to the level of general conclusions. It involves learning and developing theories from observation and experience.

Inductive reasoning moves from specific observations to broader generalisations and theories. Informally, one would refer to this as a 'bottom up' approach. In inductive reasoning, one begins with specific observations and measures, begins to detect patterns and regularities, formulates some tentative hypotheses that one can explore, and finally ends up developing some general conclusions or theories. It goes from the 'specific' to the 'general', while deductive reasoning goes from the 'general' to the 'specific' with a major premise and a minor premise that prove or disprove the conclusion. Inductive reasoning is usually understood to support rather than prove a conclusion, and can be used in collaboration with statistical analysis to demonstrate probability. By its very nature, inductive reasoning is more open-ended and exploratory, especially at the beginning. Deductive reasoning is narrower in nature and is concerned with testing or confirming hypotheses. Even though a particular study may look like it is purely deductive (e.g., an experiment designed to test the hypothesized effects of some treatment on some outcome), most social research involves both inductive and deductive reasoning processes at some time during the research project.

A qualitative data analysis aids in making sense of large amounts of data, reducing data volume, identifying significant patterns and constructing a framework for communicating the quintessence of what the data reveals (Sebastian, Egan, Welch & Page, 1996:148). Table 2.4 provides a summary of the qualitative research methodology principles as upheld by Mouton and Marais (1993) cited by De Jager (2002:20).

Table 2.4: Qualitative research methodology principles
(Adapted from Mouton and Marais (1993) cited by De Jager (2002:20))

Principle	Description
Rationale	To understand the phenomenon being researched
Concepts and constructs	Meaningful words that result in more depth
Hypothesis	General aim of research and will emerge as the research proceeds
Observation	Subjective; the researcher was involved in activities, spontaneous and coincidental observation and providing of examples, unstructured and open-ended
Outcome of the study	To determine relationships between variables (constructs)

The following aspects were considered for the qualitative data analysis:

- Collecting data as the result of observation, focus groups, academic learner research journals, as well as synchronous and asynchronous communication.
- Data analysis and interpretation.
- Creating a conceptual model to illustrate the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country.

2.4 Action research

2.4.1 A brief history of action research

The origins of action research are vague, although most resources refer to Kurt Lewin, a social psychologist and educator, as the originator of action research which was first mooted during the 1940s. Lewin is believed to be the first person to use the term 'action research' (O'Brien, 2001:Online; Smith, 2007:Online), "to describe work that did not separate the investigation from the action needed to solve the problem” (McFarland & Stansell, 1993:14).

In the mid-1950s, Stephen Corey, a researcher at the Teachers College at Columbia University, was amongst the first to use action research in an educational environment. Corey was of the opinion that action research would bring about change since it allowed educators to be involved in the research and application of information. However during this time, action research was seen as unscientific and proletarian and did not re-emerge in education until the 1970s when educators began to question the standard research methods as a means to solving educational issues (Ferrance, 2000:7-8). Action research has obtained a significant position within the community-based and participatory action research sphere as well as a form of practice oriented to the enhancement of educative encounters (Carr &

Kemmis, 1986[5] cited by Smith, 2007:Online), providing support for action research to be applied within the context of this research study.

2.4.2 Conceptualisation of action research

To provide the reader with insight into the evaluation of action research and its potential to be used as a research method within the research domain of 'educational practices' as applied within the ambit of this thesis, a conceptualisation of the concept is tabulated in Table 2.5 for ease of reference.

Table 2.5: The conceptualisation of action research

Author(s)	**Conceptualisation of action research**
Carr and Kemmis (1986:162)	Action research is a self-reflective form of inquiry undertaken by participants in social or educational settings to **improve** their **practices** or **understanding** of these practices.
Coghlan and Brannick (2002:6-7)	Action research has two goals: to solve a **problem** and to **contribute** to science.
Cohen, Manion and Morrison (2001:227)	Action research aims to "bring about practical **improvement**, innovation, **change** or development of social **practice**, and the practitioners' better **understanding** of their practices".
Collis and Hussey (2009:65)	Action research is a type of "applied research, designed to find an effective way of bringing about a conscious **change** in a partly controlled environment".
Corey (1953:9; 70)	Action research is a process through which instructors study their own teaching **practice** to solve personal challenges in the classroom.
Dick (1993:Online)	Action research aims to address both **action** and **research**: • Action: to bring about **change** in some community or organisation or program. • Research: to increase **understanding** on the part of the studier or the client, or both (and often wider community).
Dick (2000:Online)	Action research is: • **Cyclic:** Comparable steps have a tendency to occur in similar sequence. • **Participative:** Clients and informants are involved as active partners in the process. • **Qualitative:** It deals more with language than numbers. • **Reflective:** Critical reflection upon the process and outcomes are essential parts of each cycle.
Feldman and Minstrell (2000:Online)	During action research, improved knowledge could directly lead to improved teaching **practices**.
Gummesson (2000:116)	• Action researchers take **action**. • Action research involves two goals: To solve a **problem** and to **contribute** to science. • Action research aims at developing holistic **understanding** during a project. • Action research is fundamentally about **change**.

[5] Carr, W. & Kemmis, S. 1986. *Becoming Critical. Education, knowledge and action research.* Lewes: Falmer.

Hatten, Knapp and Salonga (1997:Online)	Action research highlights the essential feature of action and research, which involves the systematic testing of ideas in practice to **improve** social conditions and increase knowledge.
Kemmis and McTaggart (1997:5-6)	• Action research provides a means of working, which "links **theory and practice** into one whole: ideas-in-action". • Action research, "is a form of collective self-enquiry undertaken by participants in social situations in order to **improve** the rationality and justice of their own social and educational **practices**, as well as their **understanding** of these practices and the situations in which these practices are carried out".
Lewin (1946:34-46)	Action research, is "a comparative research on the conditions and effects of various forms of social **action** and research leading to social action", by means of a process of "a **spiral** of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action".
Zuber-Skerrit (2000:2;16)	• Action research is a "**cyclical iterative process** of **action** and reflection on action". • Action research is "**collaborative**, critical and self-inquiry by **practitioners** into a major **problem** or issue of mutual concern in their organisation".
Zuber-Skerrit and Farquhar (2002:111)	Action research is a method in which educators consider their individual teaching **practices**. This method creates theory both about educational practice and through educational practice.

The following logical analogies can be drawn from Table 2.5:

- Action research entails real-life action, i.e. to bring about a change by solving a problem.
- Action research is about longitudinal research, i.e. cyclic, iterative and to modify and improve understanding of theory and practice.
- Action research is a collaborative group activity and involves individuals with different perspectives.
- Action researchers take action.
- Action research always involves two goals, namely to 'solve a problem' and to 'contribute to science'. Action research:
  - Is interactive as it requires co-operation between the researcher and the participants.
  - Applicable to the understanding, planning and implementation of change in an organisation.
  - Can include all types of data collection methodologies, and requires the total involvement of the researcher.
  - " ... is a form of collective self-enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social and educational practices, as well as their understanding of these practices and the situations in which these practices are carried out".

2.4.3 Characteristics of action research

According to Coghlan and Brannick (2002:6-7), Dick (2000:Online), Zuber-Skerrit (2000:16), as well as the NSW Department of Education and Training (2010:2), action research demonstrates characteristics, which are demonstrative of its application potential. The key characteristics of action research are tabulated in Table 2.6 for ease of reference.

Table 2.6: The characteristics (key points) of action research
(Partially adapted from De Jager, 2002:24-25, and NSW Department of Education and Training, 2010:2)

Characteristics	This study
Active A process designed to generate change in small steps. Action researchers take action.	The action research process consisted of two research cycles. The first cycle was viewed as exploratory in nature in which the data gathered influenced the approach for the second cycle. Each cycle where disseminated into several interventions allowing the researcher to generate and implement change/improvement in small steps.
Collaborative It involves the responsible participants who act to improve education and learner outcomes contributing to the solution of the problem.	All the participants in this study contributed to the solution of the problem and were actively involved.
Compiling evidence Practices and ideas were put to the test by the researcher collecting evidence that could indicate where something went wrong.	• The researcher collected data to apply and attain a better understanding (questionnaires, observation, focus groups, academic learner research journals etc.). • The learners collected evidence of their m-learning activities by means of academic learner research journals.
Changing • A research design that may be continually adapted to accommodate new information. • Improving education and learning from the consequences of change.	• The research design changed to adjust to the situation because of new evidence. • The learners accepted challenges to change and acknowledged that their learning experience had improved.
Critical analysis Analysing situations in a collaborative environment results in better practices.	All participants contributed to better practices through critical analysis and comments.
Cyclic / Self-reflective spiral • A process, which rotates between plan implementation and critical reflection. • Involves several cycles with each expounding an issue leading to a better understanding and more meaningful outcomes. • Similar steps tend to recur in a similar sequence; shorter cycles tend to be more effective and promote rigour. • The cyclic nature of action research supports responsiveness and flexibility, which will adjust misleading research questions at the beginning, and help to refine questions in each cycle for better action and research.	This study was conducted over a two year period (2011 - 2012) consisting of iterative and cyclic activities that ultimately contributed to improvement in m-learning practices in a technology-based subject in tertiary education.

• A critical reflection upon the process (planning, acting, observing, reflecting) and outcomes is an important part of each cycle. This is more flexible than other research methods, and leaves the researcher to make appropriate choices.	
Experiential As in real-life experience.	This was a real-life experience conducted over a two year period (2011 - 2012).
Flexibility • Methods, data and interpretation are refined according to the understanding/knowledge gained during the research process. • It is more flexible than conventional research and being adaptive allows changes.	The flexible nature of this study provided for changes in the process to develop a better understanding of m-learning practices in South African education.
Focused On a single issue of teaching and learning improvement.	This research study focused on investigating the potential of m-learning and whether it can bridge the existing learning gap to facilitate technology-based learning, and as a result also improve educational practice (by producing real and sustained improvements in education).
Formative Changes occur constantly.	Changes occurred continuously during the study and incorporated the option to adapt.
Informal No hierarchy, everybody contributing towards the solution of the problem.	The research and learners contributed to the solution.
Integrated Conducted as part of an instructor's normal daily practice.	This study forms part of the daily activities of the educator (which is also the author of this thesis) and learners both on-campus and off-campus in a technology-based subject at the CPUT.
Keeping record / Research journals • Record of activities and changes. • Describe what is happening as accurately as possible. • Record of progress and reflections, useful for reflections.	• The researcher kept accurate record of all activities as far as possible. • Learners kept record of all their m-learning activities.
Learning Simultaneous construction of new knowledge by instructors about their practice.	The researcher studied and learnt from her own practice demanding the development and application of new knowledge as part of a cyclical process. The researcher experienced professional growth through reflection by learning to understand a phenomenon and about why and how to apply self-constructed knowledge.
Participative • The researcher is involved as an active participant in the research process to improve his/her own practices. • Participants can become co-researchers.	Learners became co-researchers in the application of the learning content.
Planned An organised approach to answering a question.	This study comprised two action research cycles throughout which an action plan served as a flexible mind map. In addition to the action plan, an action research planner provided the researcher with guidelines on how to aid the action research process.
Political process Changes affect individuals, sometimes creating resistance to change.	Learners articulated their concerns about changes, but were not opposed to change.
Problem solving Solve problems in completely unknown situations.	All participants gained problem solving skills.

Qualitative / Quantitative • Qualitative: Deals more with language than with numbers. • Although action research tends to be more qualitative, it may sometimes be a mix between qualitative and quantitative research. • Qualitative information increases responsiveness.	Both quantitative and qualitative data collection methods were used in this study.
Reasoned justification Evidence validates the judgements.	Enough evidence was collected to validate judgements.
Relevant Meets the needs of instructors and/or their learners.	This research study provides educators with a much needed information resource on mobile technology utilisation in a technology-based subject. Research results contribute to the knowledge base of m-learning and mobile technology utilisations for educational purposes, especially in a developing country such as South Africa.
Self-confidence Contributes to participants' empowerment of self-confidence and to accept a challenge.	Self-confidence of all participants increased as was evident from the feedback.
Start small Start with one person and extend. Defining small cycles leads to powerful questions.	This study commenced with only 33 learners and one educator during the first action research cycle (2011), and continued thereafter with 48 learners during the second action research cycle (2012).
Subjective Be careful not to be subjective.	Discussions between participants prevented subjectivity.
Systematic learning A systematic learning process in which people act intentionally though staying open to surprises.	In this study, action research was utilised as a systematic process of increasing changes and people acting intentionally to bring about the changes.
Theorising • When people theorise they become enthusiastic to understand and develop rationales for practices. • Theory granted in experience and practice.	In this study action research was about the theory to change present practices of m-learning utilisation in tertiary education.

2.5 Appropriateness of action research for this research study

The keen observer will immediately recognise clear tangent planes between the characteristics of action research elaborated upon above in Table 2.6, and the application field of the research method within the context of this research study.

The purpose of this paragraph is to highlight the rationale for action research, also commonly referred to as Participatory Action Research (Kemmis & McTaggert, 2005:559; O'Brien, 2001:Online) or Action Science (Watkins, 2012:43), as the most appropriate research methodology for this study because of its cyclical iterative nature, rigour, responsiveness, flexibility to change and the possibility to alter or improve the phenomenon being researched (Dick, 1993:Online; 2000:Online; Zuber-Skerrit, 2000:2). 'Action research' is the term used to describe the integration of action (implementing a plan) with research (developing an understanding of the effectiveness of the implementation) (McKay & Marshall, 2001:47).

Depending on the nature of the study, the outcomes may be more explicitly focused on one or the other. In either case it is desirable that action informs research and research informs action (Cassidy, 2007:79). Action research is a type of applied research designed to find an effective way of bringing about change in a predetermined environment (Collis & Hussey, 2009:65-67). It is mainly appropriate for being applied in a real and natural setting, studying social and cultural phenomenon, and to add to the body of knowledge (Baskerville & Myers, 2004:329-330; Waterman, Tillen, Dickson & De Koning, 2001:11). According to Watkins (2012:42), the main aim of action research is to enter into a situation, to attempt to bring about change to that situation, and to monitor the results. The action researcher is involved in a real manner in a particular situation, where there is not only an expectation that a "contribution to knowledge" should be made, but also to directly "produce usable knowledge that can be applied and validated in action". The cyclical nature of action research allows extensive data to be gathered to construct the theoretical knowledge associated with the research domain (Suhonen, 2009:Online). In action research, practitioners frequently solve practical problems while simultaneously expanding scientific knowledge (Avison, Lau, Myers & Nielsen, 1999:94-96). Baskerville (1999)[6] cited by Suhonen (2009:Online), describes action research as an “agent of change”, which is used to resolve key questions on ‘how to’ and not ‘what and why’ type questions (Germonprez & Mathiassen, 2004:341). It could therefore be argued that action research can provide educators with new opportunities to reflect on and assess their teaching, to investigate and test new ideas, methods, and resources, to measure how efficient the new approaches were, to share results, and to make decisions about which new approaches to include in the subject's curriculum, teaching and learning, and assessment plans.

The views of Baskerville and Wood-Harper (1996:235-246), in respect of the Action Research method, are contextualised as follows:

- Action research aims to contribute both to the practical concerns of people in an immediate problematic situation, and to the goals of social science by joint collaboration within a mutually acceptable ethical framework.
- Action research simultaneously assists in practical problem-solving, and expands scientific knowledge, as well as enhancing the competencies of the respective actors, being performed collaboratively in an immediate situation. Feedback is used in a cyclical process, aimed at an increased understanding of a given social situation, primarily applicable to the understanding of change processes in social systems and undertaken within a mutually acceptable ethical framework.

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[6] Baskerville, R. 1999. Investigating information systems with action research. *Communications of the Association for Information Systems*, 2(19):1-32.

- Action research is an interventionist approach to the acquisition of scientific knowledge that has sound foundations in the post-positivist tradition. The essence of action research is a simple two stage process:
  - First, the diagnostic stage involves a collaborative analysis of the social situation by the researcher and the subjects of the research. Hypotheses are formulated concerning the nature of the research domain.
  - Second, the therapeutic stage involves collaborative change experiments. In this stage changes are introduced and the effects are studied.
  - Action research is a method that could be described as a paragon of the post-positivist research methods.
  - It is empirical, yet interpretive. It is experimental, yet multivariate. It is observational, yet interventionist.

One of the researcher's strongest motivations for using action research as a research method for this research study, is the fact that it is considered a useful framework in which to develop new strategies and competencies for complex tasks in a vague environment of fast social and technological change (Zuber-Skerritt, 1996:xiii). The challenge to the educator is to respond to the ever-changing demands of the workplace. Although a plethora of approaches are available for research, there are only a few published accounts of the successful application of newer approaches to information technology related research. One well-documented exception to this rule relates to 'action research' (Watkins, 2008:65). Action research addresses issues in educational practice (Kemmis & McTaggart, 1997:18) and has been reported to be an effective research method for technology implication studies involving economically and digitally marginalised populations (Chetty, Tucker & Blake, 2003:Online; Hartviksen, Akselsen & Eidsvik, 2002:93; Lennie, Hearn, Simpson & Kimber, 2005[7] cited by Kim, 2009:416).

The action research approach is in line with the aims of this thesis and is used to, i.e. investigate the potential of m-learning and whether it can bridge the existing learning gap to facilitate technology-based learning, and as a result improve educational practice (by producing real and sustained improvements in education), and providing a holistic overview of m-learning in the South African context with specific reference to m-learning practices in an undergraduate technology-based subject in a tertiary institution environment. According to Robertson *et al*. (1997:11; 15), "the most important benefit of action research should be the improvement of practice rather than the production of theory … as an intervention into the everyday life of people involved". It is to determine a way to inform educators and learners

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[7] Lennie, J., Hearn, G., Simpson, L. & Kimber, M. 2005. Building community capacities in evaluating rural IT projects: Success strategies from the LEARNERS project. *International Journal of Education and Development using Information and Communication Technology*, 1(1):13-31.

about m-learning implementation in a tertiary education technology-based subject from a developing country perspective. This study aims to amicably demonstrate and measure the usefulness of m-learning in an undergraduate technology-based subject at the CPUT by means of action research, address the challenges/problems experienced during the m-learning process, develop a set of guidelines for m-learning implementation in a technology-based subject, and to construct a conceptual model to enable a better understanding of m-learning utilisation in a technology-based subject in developing countries, and as a result encourage further m-learning development and utilisation after this study. The main focus is to contribute to the practical concerns of people in a problem-induced situation and to develop a theoretical contribution (conceptual model) that could aid to boost the competence and self-help ability of researchers and educators in the field of m-learning. The aim is for the conceptual model to be valuable to obtain sustainability in the m-learning implementation process and as a thinking aid for researchers and educators working in a m-learning environment.

It could therefore be argued that the notion of this research is not to offer some scientifically valid generalisation to mitigate the research problem, but to directly assist and benefit learners. Furthermore, action research is seen as a problem-solving approach since it has the potential to encourage educators to question their actions and then to take action to improve their reciprocal teaching practices. As a result, action research is viewed as a process in which teaching and learning can be investigated to improve learners' teaching and learning experience in the researcher's own educational setting. More specific, the research design is for the purpose of improvement (Hall, 1997:125).

The following features supported the use of action research as a methodology in this research study:

- It creates theory both about and through educational practice (Zuber-Skerritt & Farquhar, 2002:111).
- Since the researcher is also a tertiary educator, improved knowledge could directly lead to improved teaching practices (Feldman & Minstrell, 2000:Online).
- Zuber-Skerritt and Farquhar (2002:107), as well as Feldman and Minstrell (2000:Online), assert that learners might experience more learning support in this fashion.

The above essential features of the action research approach best fit this research study and are supported by Edge (2001:5), who emphasises that the purpose of action research, "is not simply to describe, interpret, analyse and theorise - the stuff of traditional research - but to act in and on a situation to make things better than they were". The rationale for action research and how it has been applied in this study is expanded upon for ease of reference in Table 2.7 (Dick, 1993:Online; Dick, 2000:Online; Gabel, 1995:Online).

Table 2.7: The rationale for action research and the application thereof
(Partially adapted from De Jager, 2002:26)

	This study
Goals	To bridge the existing learning gap (improve practice and learners' learning outcomes) by means of m-learning in a technology-based subject in a South African context
Method of problem identification	Identify problems currently confronted with or improvements needed both in and out of the classroom
Literature review	Review both primary and secondary sources and research what educators are doing in other tertiary institutions
Sampling	First-year learners enrolled for the FIS programme at the CPUT
Research design	Flexible, quick time frame, control through triangulation
Approach	Both deductive (questionnaires, formative assessment, academic learner research journals) and inductive reasoning (observations, focus groups, academic learner research journals, synchronous and asynchronous communication)
Data analysis	Grouping of raw data using descriptive statistics
Application of results	Practical significance
Rationale	
A need for openness	There was no predetermined plan
It can be readily adjusted to the demand of the situation	Changes were made when problems were encountered
It can be used as part of usual activities	This study is part of the daily activities of the educator and learners both on and off-campus
Practitioners of action research can learn from their experience	The participants learned from their experience while utilising m-learning technology and adapted to change as a result from their experience
Practitioners of action research can make changes that will enhance one another	Several changes were made in the process
Action research prevents any data collected to be abandoned	All the data is utilised to provide feedback
Action research can lead in the interpretation of information that will be richer in context	The final analysis resulted in constructive information that can be used to conduct future research
Action research can ensure greater involvement of all participants after an initial unclear beginning	It took a while to get all participants involved
All participants are included and become active members of the study process	All learners became actively involved as the research process evolved
The final result culminated as a result of interpreting the data collected over the study period	The final result culminating from this study must include a better understanding, and provide a holistic overview of m-learning education in a South African context, with special reference to m-learning utilisation in a technology-based subject

2.5.1 Application of the action research model for this research study

There are several examples available demonstrating the nature of action research models. In the majority of models, the process begins by identifying a problem for development, observing the current situation with this problem (a type of investigation), implementing changes/improvements, and then assessing how efficient and valuable the changes have been. The process starts off by identifying the idea or problem. In this study, the m-learning initiative developed from the following primary problems:

- Current learning mechanisms to facilitate technology-based learning do not comply with the demands faced by tertiary institutions of developing countries.
- How could reliable and sustainable m-learning be implemented in a technology-based subject in tertiary education in a developing country?

Action research is based on two core concepts, namely a cyclic and a spiral process where action and reflection occur in succession as well as collaboration/participation with stakeholders. Reflexivity is at the core of action research and is based upon a Plan-Act-Observe-Reflect cycle (Altrichter, Kemmis, McTaggert & Zuber-Skerritt, 2002:130; Costello, 2003:4-7; Crane & Richardson, 2000:2.5; 2008:7; Kemmis & Wilkinson, 1998:21; Lisle, 2000:115; Zuber-Skerritt, 2001:15). Kemmis and McTaggert (1988:10), Elliott (1991:71), as well as Altrichter *et al.* (2002:130), who's views are based on the work of Lewin (1946:38), explicated by Kemmis and McTaggert (2005:563), who describe action research as an iterative spiral of cycles, each consisting of four phases, namely plan, act, observe and reflect, is graphically depicted in Figure 2.3:

- **Plan:** This phase involves action planning (to develop a plan of critically informed action to improve what is already happening) that are expected to analyse and solve the problems discovered. Planning action follows from the analysis of the context and purpose of the project, the framing of the issue and the diagnosis, and is consistent with them (Coghlan & Brannik, 2002:17-18). Action planning can also include analysis of required goals and steps to accomplish the identified goals (Baskerville, 1999 cited by Suhonen, 2009:Online).
- **Act:** The change plan/improvement(s) is implemented in practice and interventions are made (Coghlan & Brannik, 2002:17-18).

- **Observe/Collect:** During this phase results/effects of the action-taking phase are observed and analysed/evaluated through the use of appropriate methods and techniques (Kemmis & McTaggart, 1990:27). Activities in the evaluation phase include formative evaluation, observation and critical reflection. What worked? What did not work? Why? How can we do it differently next time? (Suhonen, 2009:Online)
- **Reflect/Evaluate:** Reflect on the results/effects, both intended and unintended, as a basis for further planning and subsequent critically informed action by means of a series of cycles (Coghlan & Brannik, 2002:17-18; Kemmis & McTaggart, 1990:27). The outcomes of the action are examined with the view to determine if the original diagnosis was sound, if the action taken was correct, and whether it was taken in an appropriate manner (Coghlan & Brannik, 2002:17-18). This may lead to the identification of a new problem and the cycle may commence once again (Zuber-Skerritt, 1996:xiii). Amalgamate new knowledge attained from the evaluation phase to new action research cycles. The results of the reflection phase are used to plan the action of the next research cycle iteration. When the action has failed, the obtained knowledge may present directions for new development cycles and paths.

What makes the above action research model different from ordinary problem solving, is that the researcher work from within a conceptual framework, which both informs and is being changed by each cycle of plan-act-reflect (McKay & Marshall, 2001:47). The attention of the reader is drawn to the fact that the range of approaches outlined above typically diverges from Lewin’s commencement in emphasis, rather than substance.

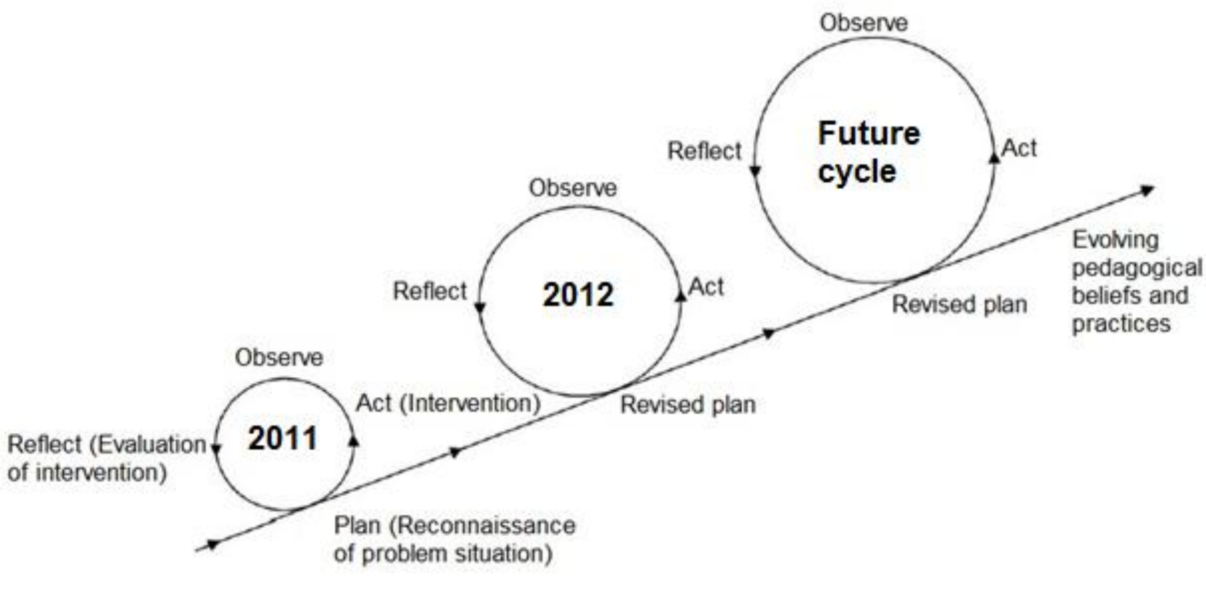

Figure 2.3: An overview of the action research model used in this study
(Partially adapted from Zuber-Skerritt, 2001:15 and Crane & Richardson, 2000:1.8)

Figure 2.3 graphically depicts how action research is applied in this research study and evolved through cycles. The rising graph represents the goal of continues improvement and development of, in the case of this study, m-learning in a technology-based subject in a developing country. The successive cycles become larger reflecting the mode in which the process changes over time as knowledge increases and more is understood about the phenomena under investigation (Crane & Richardson, 2000:1.9). According to Dick (2002:Online), the most important feature of the action research cycle is the critical reflection, which takes place prior to moving on to successive cycles. During reflection, it is important to ask questions such as: What worked? Why did it work? What did not work? Why did it not work? How might the process be improved? What is now known that was not known before? This reflection is then followed by further action based upon the "understanding achieved, the conclusion drawn" and the "plans developed ... These are tested in action" (Dick, 2002:Online). Action research typically involves both collaboration and participation. Just as the amount of action and research vary in any given study, so does too the level of collaboration and participation (Waterman *et al.*, 2001:12).

In this study, collaboration occurred at several points. Prior to commencement of the research, m-learning experts were consulted on the design of the study and the development of some of the assessments. In addition, practitioners and experts in the field were also consulted on the development of the m-learning project itself. In terms of participation, a distinction between the researcher and the participants are apparent. The research study allowed participants to provide as much input as possible into the further development of the m-learning initiative. Since none of the participants was previously involved in mobile teaching and learning, no data could be gathered regarding what they had found useful about their prior m-learning experience. Participants were involved by evaluating the m-learning programme as it progressed, indicated what they personally perceived worked, and did not work.

2.5.2 The research action plan and -planner

From the action research model it is evident that problem solving is vital in this type of research - usually a problem that is of immediate concern to the educator. According to Van Ryneveld (2000:43), action research is an effective and innovative way to make, "academic research relevant to the overwhelming problems that confront education in South Africa". It is within this paradigm that this research study was undertaken. This research was an attempt to understand, improve and reform educational practice. A lack of learning mechanisms to facilitate technology-based learning to comply with the demands faced by tertiary institutions of developing countries was identified, which mooted the researcher to find the best possible way to address the problem.

In this study the first step was to formulate a flexible action plan considering that social action is unpredictable and perilous (Kemmis & McTaggert, 1997:11). In designing the research action plan for this study, the strengths and limitations of the previously discussed action research models were taken into consideration, and it became evident that a provisional action research plan was required, rather than a rigid action research model. The action plan had to be robust enough to direct the research process, yet "flexible enough to embrace the complex, non-linear 'messiness' characteristic of most classroom contexts" (Steketee, 2004:Online). As a result the research action plan as presented in Figure 2.4 was developed.

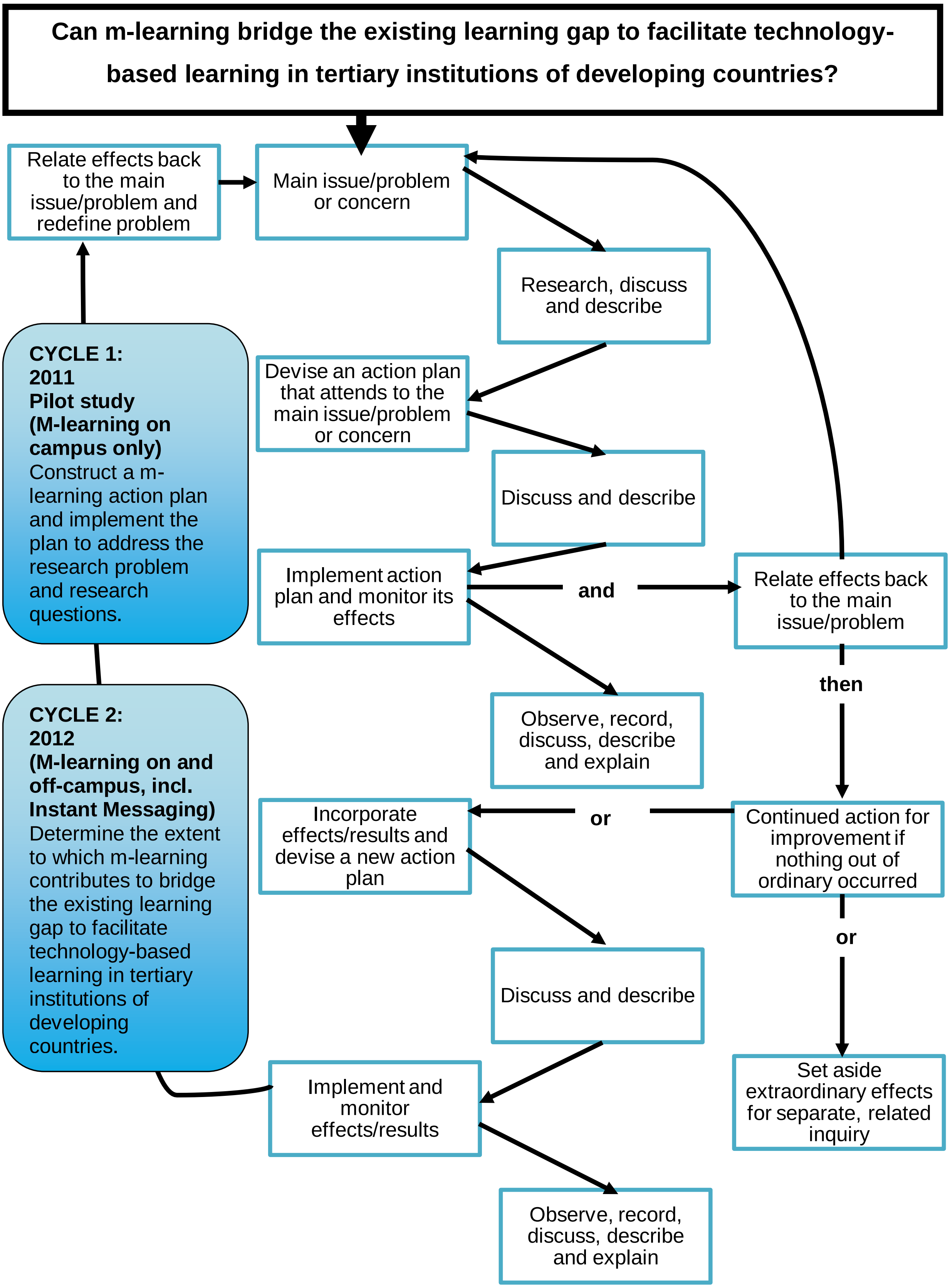

Figure 2.4: Research action plan for this study
(Partially adapted from Steketee, 2004:Online)

The research action plan graphically depicted in Figure 2.4 shows the integrated tangent planes between the planning, acting, observing and reflecting phases of the action research process, as described by Lewin (1946:34-46), Kemmis and McTaggert (1988:10), Elliott (1991:71), and Altrichter *et al.* (2002:130). The action plan reflects the necessity for logic and order, as well as the need to constantly revisit the main problem. It furthermore reflects the 'multi-layered' approach suggested by Ritchie (1995:311), because with every new action research cycle the results of preceding action research cycles are used to produce new insights, claim and plans. This study comprised two action research cycles throughout which the action plan acted as a flexible mind map.

In addition to the action plan, an action research planner, as depicted in Figure 2.5, provided the researcher with guidelines on how to aid the action research process.

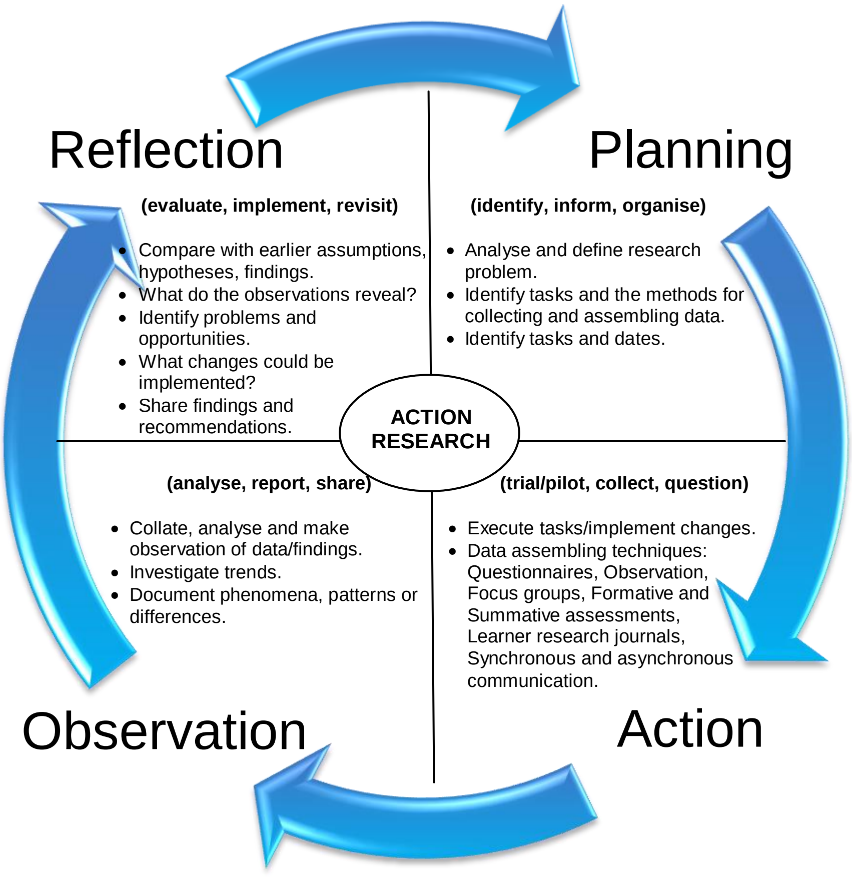

Figure 2.5: The action research planner
(Partially adapted from Pinchen and Passfield (1995:21))

2.5.3 An outline of the two action research cycles (2011 - 2012)

The action research process consisted of two phases, referred to in this study as cycles one and two. The first cycle was viewed as exploratory in nature in which the data gathered influenced the approach for the second cycle. The effectiveness of m-learning in a technology-based subject was determined, based on both quantitative (questionnaires, formative and summative assessments, as well as academic learner research journals) and qualitative investigations (observation, focus groups, academic learner research journals, as well as synchronous and asynchronous communication), which established learners' use, perception and attitude toward the utilisation of mobile technology in a technology-based subject.

For the purpose of this study, a cycle is defined as one semester (the second semester of each year) in the calendar year of presentation. This dispensation is attributed to the fact that the technology-based subject under scrutiny is only offered during the second semester of each year.

In the beginning of the second semester of each year (2011 - 2012), before the commencement of the computer science programming classes, the researcher was tasked to charge all the PDAs (52) before distributing them to the learners. Since, the researcher was the only educator lecturing first-year computer programming learners at the CPUT, it was the responsibility of the researcher to furthermore ensure that the devices were loaded with the required software, and that each PDA was in working order when handed out to the learners. PDAs were loaded with the Basic4PPC mobile application, as well as MyMobiler, a software application which allows one to control the PDA from a Windows computer. The latter proved to be extremely useful, since it allowed the researcher to mirror and share a PDA screen with the entire class, and to interact with the mobile device by using a mouse and keyboard when illustrating and explaining certain programming concepts. Learners were required to sign a "Mobile Loan Agreement", which contained all the conditions for borrowing the devices. In all cases, learners signed the contract without any hesitation or questions. Learners also had to check and verify that the serial numbers of the devices were the same as stipulated within the contract.

2.5.3.1 Outline of Cycle 1 (2011) - Pilot study

Pilot studies enable a researcher to refine clarity of purpose and to test variables, measurement processes and other research strategies (Vockell & Asher, 1995:31). It does not matter how cautiously a questionnaire is designed, inadequacies are always a possibility (Babbie, 1998:159; Yin, 1994:52). It is therefore important to conduct a full or partial pre-test (Babbie, 1998:159), where the researcher can refine data collection plans (data content and procedures). Even though Singleton, Straits, Straits and McAllister (1988:290), are of the opinion that the pre-testing of a measuring instrument involves testing it on a smaller sample with the same characteristics than that of the target group. This researcher elected to conduct a pilot study using an entire group of FIS learners.

Three weeks after classes commenced during the second semester of 2011, first-year FIS learners were informed of the intended research and the purpose thereof. Prior to the m-learning experience, the learners had only been exposed to the first learning unit obtained from the prescribed source (Shelly, Cashman & Hoisington, 2007:1-290) - "Introduction to Visual Basic 2005 Programming". In addition, learners covered the following learning units from the prescribed source when m-learning was implemented: Program and Graphical User Interface Design, Program Design and Coding, as well as Variables and Arithmetic Operations. Figure 2.6 graphically reflects the action research planner utilised during Cycle 1 and is elaborated upon thereafter:

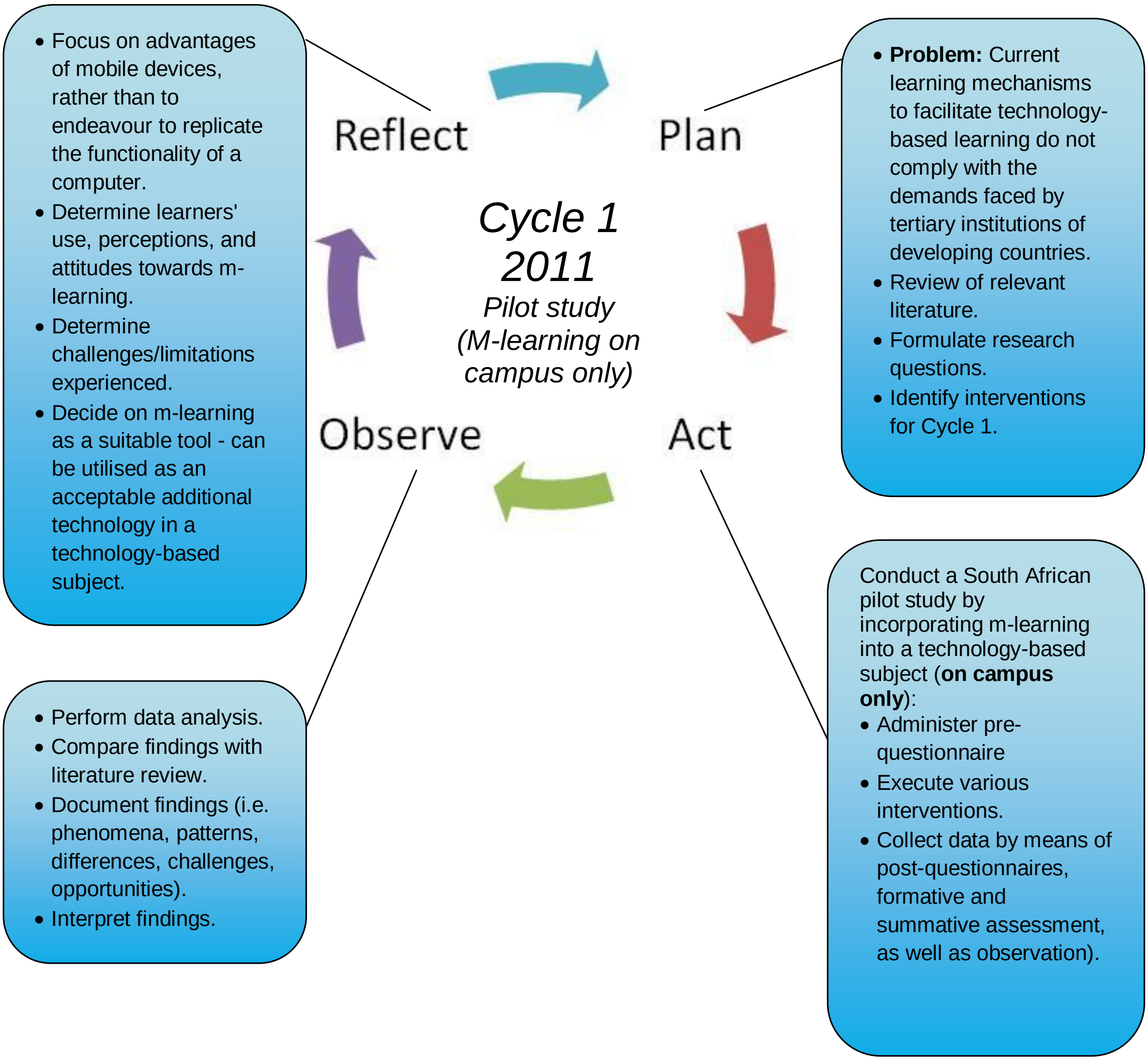

Figure 2.6: The action research planner for Cycle 1 - 2011

- **Planning:** During the planning phase, the first step was to identifying the very issue to be addressed and changed, as well as to formulate a flexible action plan considering that social action is unpredictable and perilous (Kemmis & McTaggart, 1997:11). Against the background to the research problem elaborated upon in Chapter 1, the research problem to be researched within the ambit of this thesis reads as follows: "*Current learning mechanisms to facilitate technology-based learning do not comply with the demands faced by tertiary institutions of developing countries*."

The following question was therefore identified as a priority to investigate and to determine the researcher’s main aim: "*Can m-learning bridge the existing learning gap to facilitate technology-based learning in developing countries?"*

In order to achieve the main aim of this study, it was decided to review current literature, formulate research questions to be investigated during the course of this research study, and to identify the various interventions for Cycle 1. During the planning phase, several actions were performed as suggested by Kemmis and McTaggart (1997:77), namely:

- Literature review - to establish if others have a similar problem.
- Formulation of a testable hypothesis.
- Arrangement of the setting.
- Description of the 'thematic concern' (assessment of learning).
- Outline of the action group (target population).
- Provision of a rationale for specific alterations.
- Explanation of how the process is going to be observed.
- The method(s) of evidence collection (i.e. questionnaires, formative and summative assessment, observation, focus groups, academic learner research journals, as well as synchronous and asynchronous communication).
- Develop an action plan and attempt to address the question: What are the particular things to perform in order to meet the research objectives or to solve the problem(s)?

- **Action:** The second step was to act, and entailed the implementation of the action plan. The "action" took place under normal classroom conditions and in real-time, but also under unsupervised conditions on campus. Off-campus use of the mobile devices was considered a risk due to the high prevalence of theft making this option neither practical nor feasible during Cycle 1. The researcher collected the evidence using the following methods (Kemmis & McTaggert, 1997:12-13; 78):

  - Mapping the change following the action plan.
  - Gathering and assembling evidence.
  - Questioning the process and making changes as required.

- **Observation:** The third step was to observe (Kemmis & McTaggert, 1997:12-13; 78), and conduct the analysis of the evidence and findings, as well as the interpretation of the findings. Participant observation was conducted where the researcher was fully involved with the participants and the phenomena being researched, with the objective to provide the means of obtaining a detailed understanding of values, motives and practices of those being observed.

- **Reflection/Evaluation:** The fourth and final phase in the action research cycle is the evaluation and reflection of all activities during the first cycle of the process. Information was collected, re-collected and then critically reviewed by the researcher. The improved understanding (findings or new strategy) that culminated from this critical reflection was applied and utilised in designing the subsequent action research cycle. Reflection aided in making sense of processes by means of discussion amongst participants and the researcher. Strategies were developed while addressing the following questions as suggested by Dick (2000:Online), Kemmis and McTaggart (1997:13), as well as Zuber-Skerrit, 2000:2): “What have I learnt?”, “What re-planning is necessary?”, and “What further alternative actions may be appropriate?”.

  In addition, after the information gathering process, the researcher reflected and focused on the following five questions: "What worked?", "Why did it work?", "What did not work?", "Why didn’t it work?", and "The way forward?". Reflection took place directly after information gathering, which assisted during the reflection phase as it generated a critical mode of reflection and learning.

2.5.3.2 Procedure and interventions of Cycle 1

In order to understand the implications of utilising mobile handheld devices in a computer science programming subject, a pilot study was conducted during the second semester of 2011.

The initial plan was to provide learners with mobile devices for utilisation both on and off-campus for the duration of the course (a semester), however technical support issues, an increased risk in device loss/theft, and device breakage, made this an unpractical and not a feasible option during the execution of the first action research cycle. Each learner was therefore provided with a HP iPAQ 114C Pocket PC preloaded with the Basic for Pocket PC (Basic4PPC) application for exclusive use at university both inside and outside the classroom.

The majority of programming environments are designed for desktop/laptop computers. These environments are normally not suitable for mobile devices due to its technical limitations i.e. processing power and speed and the size of memory (Laine, 2007:79). Basic4PPC is a powerful Pocket PC programming development software package suitable for Windows desktop and Windows Mobile Pocket PC devices. It provides the essential functionalities of Visual Basic 2005, and enables learners to compile and execute Basic programs directly onto their mobile devices. The Basic4PPC application facilitates the ability of learners to write Basic programs and execute them directly onto their devices and electronically submit mobile applications anytime, anywhere without the necessity of a computer. Learners can now learn Visual Basic programming through an easy to use, mobile/portable environment.

M-learning practices are potentially innovative and diverse, despite challenges/problems such as the high cost of mobile devices (i.e. PDAs and tablets), difficulties associated with the purchasing of mobile devices, compatibility of mobile devices, relatively expensive Internet connections, and learners focusing on the mobile technology instead of on the subject content (Seipold, 2012:Online). According to Seipold (2012:Online), there are three main approaches to the implementation of m-learning practice namely, the Top-down-, Bottom-up-, and Affordance approach. In this research study all three approaches were implemented. Firstly, learners were each supplied with the same mobile device (PDA) (Top-down approach), secondly, learners had access to their own mobile devices (mobile phones) (Bottom-up approach), and lastly, learners made use of mobile technologies on a daily basis as they deemed appropriate (Affordability approach). The listed concepts are expanded upon below:

- **Top-down approach**: Mobile devices are implemented into learning contexts from top to bottom. In this approach, an entire group of learners are provided with mobile devices such as PDAs or tablets that are set-up relative to already existing teaching and learning structures. This allows learners who are disadvantaged not to be excluded, as all learners have access to similar mobile devices, which in turn would ensure equal opportunities. Potential risks include that it may be possible that mobile technologies now have to be utilised in circumstances that did not previously require the use of these technologies, and that learners and educators need to adjust their teaching and learning processes to the requirements of technology and infrastructure. This can result in an extra burden on both learners and educators.
- **Bottom-up approach**: This approach makes use of available resources such as mobile devices and knowledge of learners and educators, and is therefore viewed as a cost-saving approach. Learners feel confident and show a positive attitude toward

utilising mobile devices, and can revert to their customary routines, competences and knowledge when using these devices. A major benefit is that learners get the opportunity to work in a self-directed way while utilising mobile technologies, contents and other resources supporting their creativity, as learners frequently establish exciting connections between university and daily life. It is of importance to note that that not all learners own mobile devices, with some only having access to old models that do not contain all the features that new devices provide. In addition, in this approach relatively expensive Internet connections and the variety of mobile devices and models are still a challenge.

- **Affordance approach**: Mobile devices are utilised only when it is being deemed necessary and useful, or when educators apply the devices selectively and explicitly as teaching and learning tools. In order to assure the "faultless" use of these mobile devices both inside and outside the classroom, it is of importance to guarantee stable and sustainable infrastructures. This approach allows learners to use mobile technology in their daily lives as they deem fit and appropriate, and to design lessons by referring to instructional or communicative and discursive learning.

All the learners who participated in the research study completed the following learning units obtained from the prescribed source (Shelly *et al.*, 2007:1-290): Introduction to Visual Basic 2005 Programming, Program and Graphical User Interface Design, Program Design and Coding, as well as Variables and Arithmetic Operations. These learning units were used to test the viability of m-learning.

The procedure and interventions used during Cycle 1 are graphically depicted in Figure 2.7 and is elaborated upon thereafter:

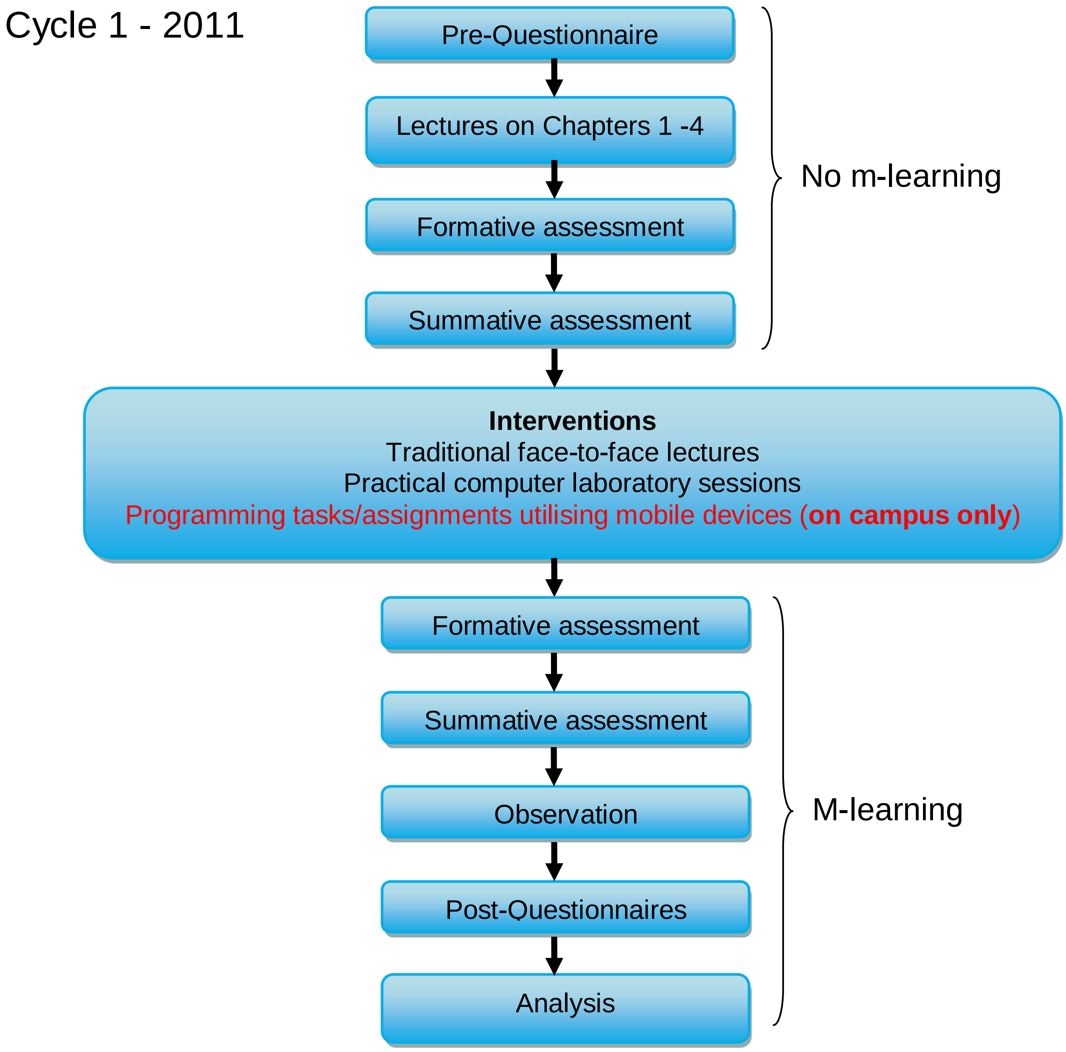

Figure 2.7: Arrangement and format of the various interventions in Cycle 1 - 2011

- **Traditional face-to-face lectures:** All the learning units obtained from Shelly *et al.* (2007:1-290) were presented by the researcher in the traditional face-to-face lecture format and were covered during the second semester of 2011. Learners were passive observers and no interaction was required. Learners were expected to familiarise themselves with the content and to prepare for both formative and summative assessments.
- **Practical computer laboratory sessions:** In addition to the traditional face-to-face lectures, learning units were also presented by the researcher in a computer laboratory.
- **Programming tasks/assignments utilising mobile technology:** Learners were expected to use their theoretical knowledge gained from the formal lecturers to complete several programming tasks/assignments on their mobile devices (PDAs). Programming tasks/assignments were returned to the researcher by means of the Blackboard Learner Management System (LMS), e-mail (only in cases when the LMS was off-line) or

Bluetooth. Feedback on the programming tasks/assignments was of a qualitative nature. Examples of learning programming tasks/assignments were shown to learners and a number of common mistakes and good features were highlighted (without learner identification) as a basis for class discussions. This proved to be a valuable classroom exercise, where learners could receive constructive feedback on how to design and develop ideal programs. As with the formal lectures, learners were expected to familiarise themselves with the programming environment (designing and developing Visual Basic/Basic programs) and to prepare for both formative and summative assessments. Sufficient time was set aside for reflection on the part of both the researcher and the learners on the effectiveness and usefulness of mobile technology in completing programming tasks/assignments. The use of action research allowed the researcher to adjust and refine the process as it progressed in response to reflections in earlier stages.

- **Questionnaires:** Learners were asked to complete both a pre-questionnaire (that address their current use and perception of mobile technology, specifically focusing on mobile phones), as well as two post-questionnaires (that address the use, perception and attitude of learners toward the utilisation of mobile technology in a technology-based subject). In the pre-questionnaire, various permutations of the popular Likert scale (Likert, 1932) were decided upon in order to encourage a more objective approach to assessing the effectiveness and usefulness of m-learning in a technology-based subject. In this respect, see Appendix A for an example of the pre-m-learning questionnaire. Reciprocally, the first post-m-learning questionnaire (see Appendix B), and the second post-m-learning questionnaire (see Appendix C) utilised various permutations of the Likert scale, as well as open-ended questions. Quantitative and qualitative methods were used to analyse the responses. The responses to the open-ended questions were interpreted and condensed in order to categorise the most important themes.
- **Formative assessment:** At the end of each learning unit learners wrote a formative assessment test (class test) to evaluate their knowledge on the prescribed source. The tests consisted of a collection of questions that required learners to outline, list, define and specify the information from these learning units, and most importantly to design and develop functional Visual Basic/Basic programming applications. Formative assessment marks are reflected within the ambit of Appendix D.
- **Summative assessment:** At the end of each term during the second semester of 2011, learners were required to write a formal test on all the learning units covered. Learners were assessed on their ability to create useful, realistic and appealing application programs using the Visual Basic/Basic programming language. Summative assessment marks are reflected within the ambit of Appendix D.

- **Observation:** Learners were observed, photographed and video recorded whilst participating in the first action research cycle of this research study. Information was gathered on learners' attitudes and how they use and interact with mobile handheld devices.
- **Analysis:** Analysis of this first action research cycle was essential in order to develop the later stages in which the m-learning initiative was devised and refined.

2.5.3.3 Outline of Cycle 2 (2012)

With a new intake of learners in 2012, the learners were prepared on the same learning units from the prescribed source (Shelly *et al.*, 2007:1-290) as the group from 2011, namely: Introduction to Visual Basic 2005 Programming, Program and Graphical User Interface Design, Program Design and Coding, as well as Variables and Arithmetic Operations. The role of social action and interaction in designing and developing useful, realistic and appealing application programs using the Visual Basic/Basic programming language, was recognised in the programming tasks/assignments during the second action research cycle. In order to facilitate the process of synchronous and asynchronous communication, IM was included during the execution of the programming tasks/assignments.

At the outset during the first week of the second semester of 2012, first-year FIS learners were informed of the intended research and the purpose thereof. In contrast with Cycle 1, learners were exposed to m-learning from the beginning of the semester, as well as the following learning units obtained from the prescribed source (Shelly *et al.*, 2007:1-290): Introduction to Visual Basic 2005 Programming, Program and Graphical User Interface Design, Program Design and Coding, and Variables and Arithmetic Operations.

Figure 2.8 reflects the action research planner utilised during Cycle 2 and is elaborated upon thereafter:

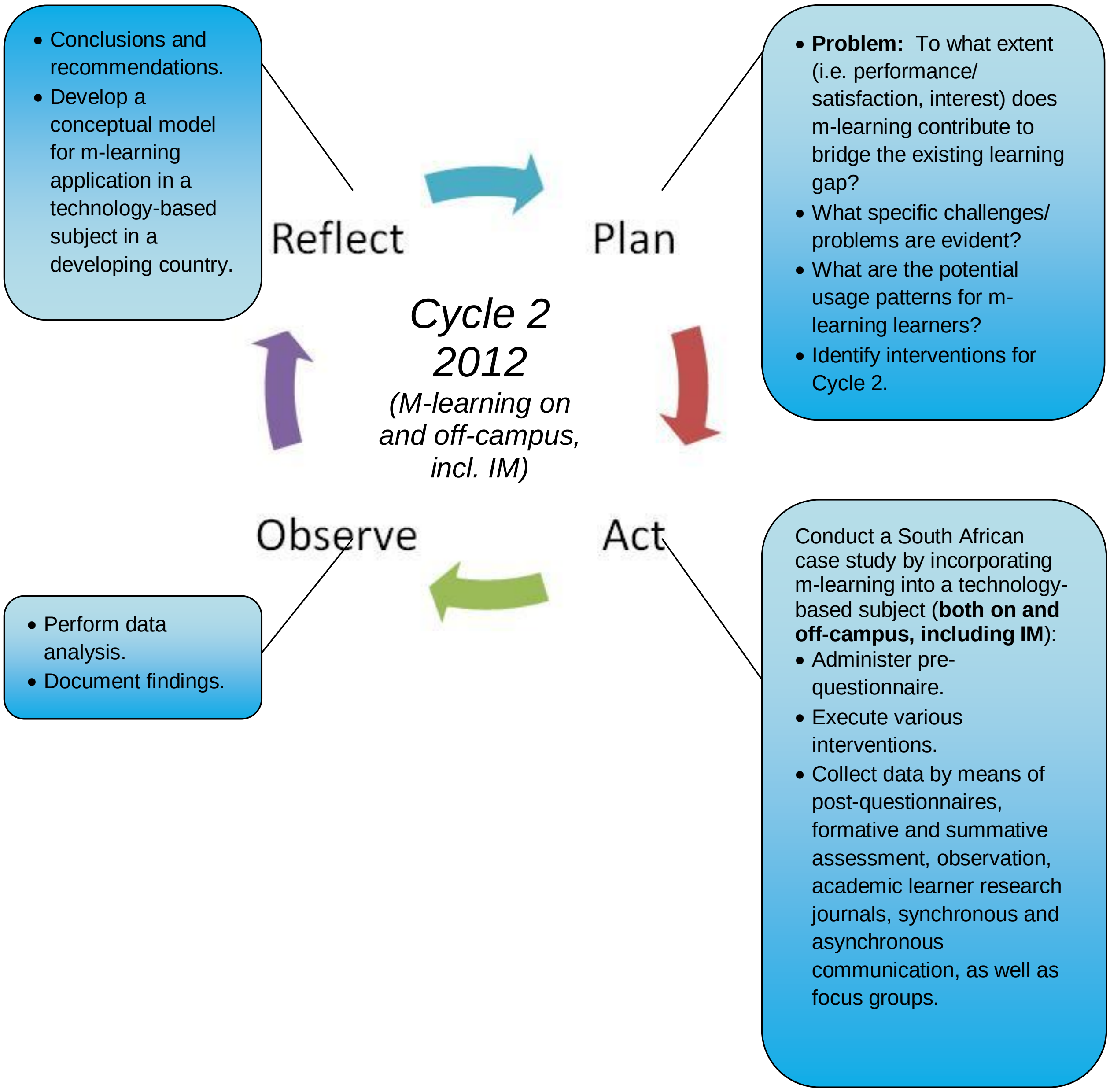

Figure 2.8: The action research planner for Cycle 2 - 2012

- **Planning:** During the planning phase, the first step was to address the issues/problems that have been identified during Cycle 1. In addition, the researcher wished to determine the extent (i.e. performance/satisfaction, interest) to which m-learning could contribute to bridge the existing learning gap in a technology-based subject, the specific challenges/problems that are evident, as well as the potential usage patterns of m-learning learners. In order to achieve the main aim of this study, it was decided to identify the various interventions for Cycle 2 that included the method of evidence collection (i.e. questionnaires, formative and summative assessment, observation, focus groups, academic learner research journals, as well as synchronous and asynchronous communication).

- **Action:** The second step was to act, and entailed the execution of the various interventions (Figure 2.8). The 'action' took place under normal classroom conditions and in real-time, but also under unsupervised conditions both on and off-campus.
- **Observation:** The third step was to observe and involved data analysis of the evidence and collecting and interpreting the findings. Participant observation was conducted in both a traditional classroom environment, as well as during practical computer science programming classes. In both instances, the researcher was fully involved with the participants and the phenomena being researched with the objective to provide the means of obtaining a detailed understanding of values, motives and practices of those being observed.
- **Reflection/Evaluation:** During this phase the researcher focused on the evaluation and reflection of all activities of Cycle 2. Information was collected, re-collected and then critically reviewed by the researcher. Reflection occurred directly after information gathering, an aspect which assisted during the reflection phase, as it generated a critical mode of reflection and learning. The improved understanding (findings or new strategy) that materialised from this critical reflection was used to assist in reaching conclusions and making recommendations, and most importantly, the development of a conceptual model to illustrate the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country. The main focus is to contribute to the practical concerns of people in a problem-induced situation and to develop a theoretical contribution that could aid to boost the competence and self-help ability of researchers and educators in the field of m-learning. The aim is for the conceptual model to be valuable to obtain sustainability in the m-learning implementation process and as a thinking aid for researchers and educators working in a m-learning environment.

2.5.3.4 Procedure and interventions of Cycle 2

With a new group of 48 learners during the second semester of 2012, they were again prepared for executing programming tasks/assignments by means of formal lectures and practical computer laboratory sessions. Throughout the semester, learners were requested to design and develop various Visual Basic/Basic applications. In addition, learners could use their mobile phones to send their questions, inputs and feedback on given programming tasks by means of IM discussions (WhatsApp). After these online discussions, learners could continue to complete their programming tasks by adding further perspectives to their applications gained through the interaction with the IM group members and input from the researcher. As found by the research conducted by Brüssow (2007:71), this approach served as a means for reasoning and a starting point for conceptual development, since the learners in the group brought different perspectives to the shared design and development of applications. This progression towards conceptual change is referred to by Kinchin (1998:2), as "a process of building collective meaning". Gravett and Swart (1997:123), are of the opinion that if this process adds up to 'true learning', conceptual change will subsequently occur.

The procedure and interventions used during Cycle 2 are graphically depicted in Figure 2.9 and is elaborated upon thereafter:

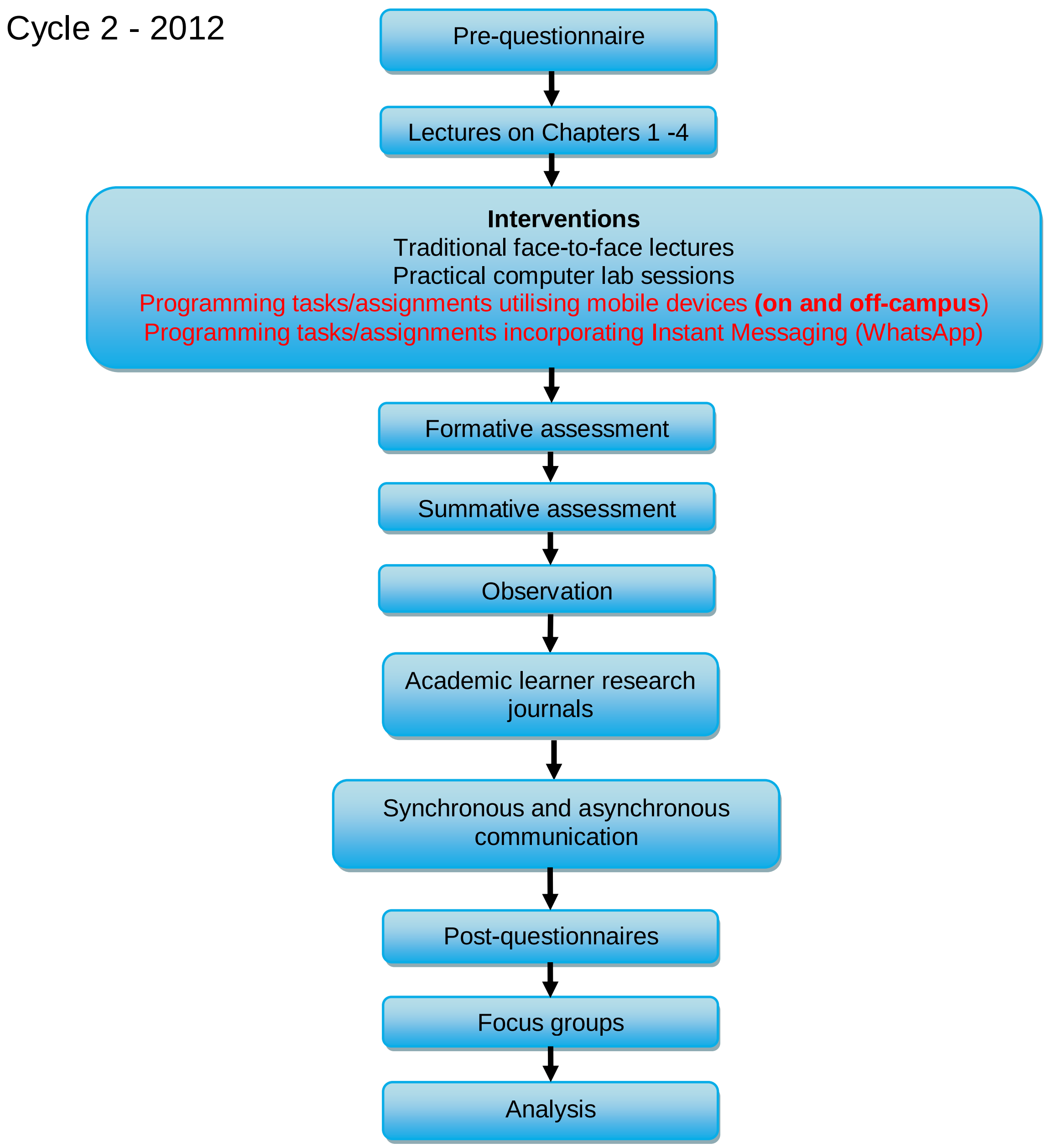

Figure 2.9: Arrangement and format of the various interventions in Cycle 2 - 2012

- **Traditional face-to-face lectures:** All the learning units obtained from Shelly *et al.* (2007:1-290), were presented by the researcher in the traditional face-to-face lecture format and were covered during the second semester of 2012. Learners were passive observers and no interaction was required. Learners were expected to familiarise themselves with the content and to prepare for both formative and summative assessments.
- **Practical computer laboratory sessions:** In addition to the traditional face-to-face lectures, learning units were also presented by the researcher in a computer laboratory.
- **Programming tasks/assignments utilising mobile technology:** Learners were expected to use their theoretical knowledge gained from the formal lecturers to complete several programming tasks/assignments on their mobile devices (PDAs). Programming tasks/assignments were returned to the researcher by means of the Blackboard LMS, e-mail (only if Blackboard was off-line) or Bluetooth. Feedback on the programming tasks/assignments was of a qualitative nature. Examples of learning programming tasks/assignments were highlighted to learners and a number of common mistakes and good features were pointed out (without learner identification) as a basis for class discussions. This proved to be a valuable classroom exercise, where learners could receive constructive feedback on how to design and develop ideal programs. As with the formal lectures, learners were expected to familiarise themselves with the programming environment (designing and developing Visual Basic/Basic programs) and to prepare for both formative and summative assessments. Sufficient time was set aside for reflection on the part of both the researcher and the learners on the effectiveness and usefulness of mobile technology in completing programming tasks/assignments. The use of action research allowed the researcher to adjust and refine the process as it progressed in response to reflections in earlier stages.
- **Programming tasks/assignments incorporating instant messaging (WhatsApp) - Synchronous and asynchronous communication:** Synchronous and asynchronous communication tools can be particularly useful in a m-learning environment to facilitate collaboration between individual learners and groups of learners. Synchronous communication occurs in real time (live communication) and requires all participants to be present at the same time irrespective of their location (i.e. IM). Asynchronous communication is not immediately received or responded to by those involved (i.e. e-mail), and therefore allows participants to interact at different times, which they deem to be convenient for them. In this respect, see the graphic representation of synchronous versus asynchronous communication in Figure 2.10.

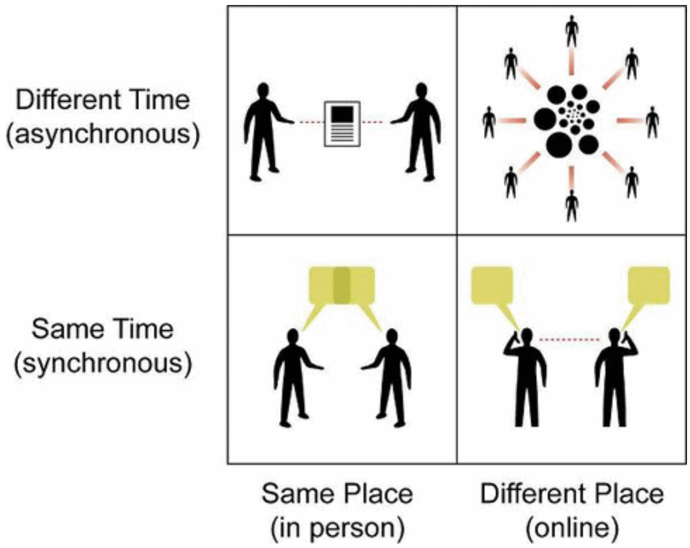

Figure 2.10: Synchronous vs. asynchronous communication
(Adapted from Smith, 2012:Online)

To enhance collaboration amongst people, many software applications offer a blend of synchronous and asynchronous technology. Most IM services offer a 'presence awareness' feature that indicates whether the users' contacts are currently online and available to communicate with one another. Commonly, both the user and contact can see each line of text right after it is typed during a conversation, "thus making it more like a telephone conversation than exchanging letters" (Wagner, 2005:46). During this research study, the WhatsApp IM application was used. WhatsApp is a synchronous communication tool where text messages can be sent and delivered instantaneously between users. A major advantage of this type of communication is its minimal cost ranging from 97% - 99% less than text messages or SMS, thus providing learners the opportunity to access professional support in an affordable manner. IM technology afforded learners the opportunity to access professional support in an affordable manner, and enabled them to send any subject related questions to the researcher (the educator). The researcher made her supporting service available 24/7 during the second action research cycle. Learners were able to reflect their learning and discuss any computer science programming issue with their educator or peers from any location at any time. It provided learners the opportunity to interact and collaborate within a social space and can, according to Butgereit (2007:Online), be successfully used for tutoring. The support service provided by the educator aimed at assisting learners in their learning process, as well as to provide an attractive and effective learning tool that can enrich their learning environment and experience. Laine and Suhonen (2008:152), postulate that this can, "boost collaboration and interaction" amongst learners.

Table 2.8 reflects the characteristics that differentiate synchronous and asynchronous learning:

Table 2.8: Characteristics that differentiate synchronous and asynchronous learning

Synchronous	Asynchronous
Learners are interactive with the educator and other learners	Learners learn independently and potentially in isolation
Learning is scheduled (fixed time)	Learning is unscheduled (anywhere, anytime)
Learning is linear	Learning may be linear or freeform

- **Pre-Questionnaire:** Learners were requested to complete a pre-questionnaire that addressed their current use and perceptions of mobile technology, with a specific focus on mobile phones. In the pre-questionnaire, various permutations of the popular Likert scale (Likert, 1932) were decided upon in order to encourage a more objective approach to assessing learners' current use and perception of mobile technology, as well as the effectiveness and usefulness of m-learning in a technology-based subject (see Appendix A).
- **Post-Questionnaires:** Two post-questionnaires were given to learners to complete after the mobile technology intervention. These questionnaires were designed to mainly evaluate learners' perceived and actual use, perceptions and attitudes toward mobile technology utilisation in a technology-based subject. The main aim was to determine learners' perceptions and attitudes towards using mobile devices for formal and informal learning in a technology-based subject, the issues/problems surrounding the use of these mobile devices both on and off-campus, and whether learner attitudes are changing over time. Reciprocally, the first post-questionnaire (see Appendix B), and the second post-questionnaire (see Appendix C) utilised various permutations of the Likert scale, as well as open-ended questions. Quantitative and qualitative methods were used to analyse the responses. The responses to the open-ended questions were interpreted and condensed in order to categorise the most important themes. Certain issues were identified from the questionnaires that required further qualitative exploration. Focus groups as research tool was therefore used to elucidate the qualitative feedback received.
- **Formative assessment:** At the end of each learning unit learners wrote a formative assessment test (class test) to evaluate their knowledge on the prescribed source. The tests consisted of a collection of questions that required learners to outline, list, define and specify the information from these learning units, and most importantly to design and

develop functional Visual Basic/Basic programming applications. Formative assessment marks are reflected within the ambit of Appendix D.

- **Summative assessment:** At the end of each term, during the second semester of 2012, learners were required to write a formal test on all the learning units covered. Learners were assessed on their ability to create useful, realistic and appealing application programs using the Visual Basic/Basic programming language. Summative assessment marks are reflected within the ambit of Appendix D.
- **Observation:** Learners were observed, photographed and video recorded whilst participating in the second action research cycle of this research study. Information was gathered on learners' attitudes and how they use and interact with mobile handheld devices.
- **Academic learner research journals:** Learners were requested to complete an electronic academic learner research journal each day whenever they interacted with the mobile technology (PDA) provided to them. Learner journals addressed issues relating to the when, where, for how long, for which event/activity, and by whom the mobile technology was used. In addition, it also provided learners with the opportunity to comment on any high or low aspects experienced during mobile technology utilisation (see Appendix E).
- **Focus groups:** Focus groups (a form of group interview) provided valuable data from the interaction between group members and group responses. Cohen *et al.* (2001:288), refers to focus groups as, "contrived settings, bringing together a specifically chosen section of the population to discuss a particular given theme or topic, where the interaction with the groups leads to data and outcomes". A major strength of focus groups is that it focuses on a particular issue and will therefore yield insights that may not otherwise have been possible through other data collection methods such as a questionnaire. Focus groups were therefore used to elucidate the qualitative feedback received from the post-questionnaires (see Appendix F).
- **Analysis:** Analysis of this second action research cycle was essential in order to develop a conceptual model that will illustrate the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country.

Many research studies that investigate m-learning have utilised interviews, questionnaires, diaries and focus groups to collect information. According to Traxler and Riordan (2003:54), Trinder (2012:41), Wali (2008:44; 74; 79), and Waycott (2004:32; 202), the weakness with such techniques is the dependence on the memory, openness, and truthfulness of the research participants. In this research study, this weakness was addressed by instantaneously providing learners with electronic academic learner research journals on their mobile devices, allowing them to immediately complete their learner journal after mobile technology utilisation. Learners therefore did not have to rely on their memory at a later stage to recall their mobile technology usage patterns. In addition, the researcher listened carefully to learners' feedback during focus groups, and rephrased some critical inputs at some juncture to secure further trust, and as a result truthful feedback.

2.6 Activity theory as the underpinning theory for this research study

Activity theory originated as a cultural, historical psychology by Vygotsky in 1978 and was further developed by Leont'ev in 1981 to focus on understanding human activity and work practices. The activity theory framework has made momentous contributions in the field of education when Engeström expanded Vygotsky's original framework in 1987 to incorporate the concepts of Leont'ev, thus offering a framework of human activity that reflects its collaborative nature. Engeström's framework consists of seven elements, as depicted in Figure 2.11. These include: 1) 'Tools' mediating the activity (anything physical, i.e. computers, PDAs or mobile phones; or mental, i.e. models or heuristics used in the transformation process), 2) 'subjects' in the activity (people that are engaged in the activity, 3) 'object' or objective of the activity (goals and intentions), 4) 'rules' and regulations (rules that delineate the activity), 5) 'community' (individuals that are directly or indirectly involved in tasks), 6) 'division of labour' (actions undertaken by individuals within the community) and (7) 'outcome' (the results and final products of the defined objectives).

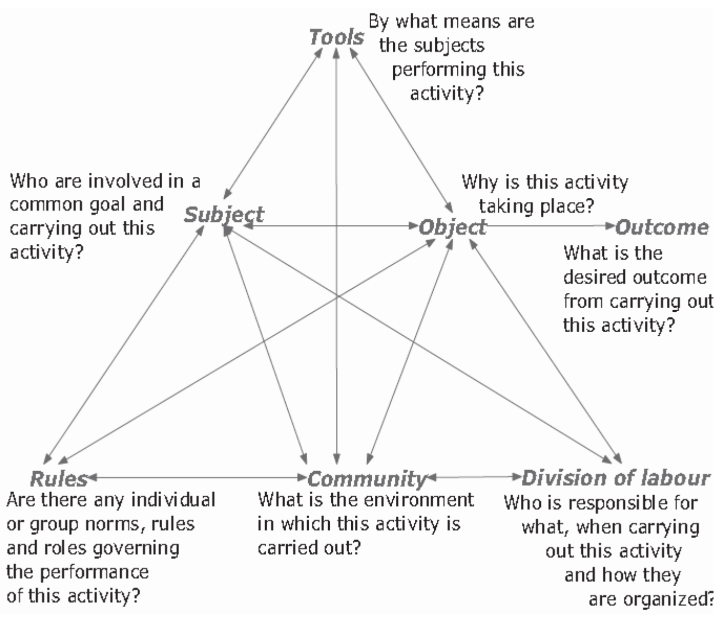

Figure 2.11: Engeström's expanded Activity Theory Framework
(Adapted from Zurita & Nussbaum, 2007:215)

This researcher will use Activity Theory as the underpinning theory to this action research study. Activity theory is proposed as a pedagogical underpinning to m-learning, where technology is perceived as a tool or artefact to mediate human activity (Engeström, 2001:137). Activity theory in m-learning has been applied as an analytical lens to extricate the intricate relationships of subjects, tools, relationships, and other socio-technical infrastructure manifested through the utilisation of mobile devices (So, Kim & Looi, 2008:102). Since activity theory is mainly a descriptive tool, it focuses on practice and represents a qualitative approach that presents a different lens for analysing learning processes and learning outcome, making the activities people are engaged in the focal point (Zurita & Nussbaum, 2007:214). The lens of activity theory can provide insights into change in educators' practices or into how their teaching is "restructured" (Buell, 2004:1984), when a new technological tool becomes part of their teaching activity. From an activity theory perspective in analysing m-learning, mobile devices are perceived as tools that aid collaborative learning environments, however this can only happen when the technology is designed to fit with the context of its intended use (Uden, 2007:82), as well as support an extensive range of learner learning activities (Uden, 2007:88). In the education field, activity theory can therefore facilitate understanding of how technological advances influence change (Bellamy, 1996:123).

One of the main premises of activity theory is that activities are of a cultural-historical nature. By referring to the work of Sharples *et al.* (2005:Online; 2007:231), and using activity theory to analyse learning as a cultural-historical system, two layers of tool-mediated activity are evident, namely the semiotic layer (socio-cultural perspective), and the technological layer (technology perspective). These layers can either be overlaid in order to scrutinise the holistic system of learning as interaction between people and technology as graphically depicted in Figure 2.12, or be forced apart to provide either a semiotic framework to analyse the activity and discourse of m-learning, or a technological framework to suggest requirements for the design and evaluation of new m-learning systems (Sharples *et al.*, 2007:232). Sharples *et al.* (2007:231), further state that the semiotic layer portrays learning as a semiotic system in which the object-oriented actions of a learner (i.e. actions to promote an objective) are mediated by cultural tools and signs. The technological layer on the other hand represents learning as an engagement with technology. Here tools (i.e. PDA, mobile phone) function as "interactive agents in the process of coming to know, creating a human-technology system to communicate, to mediate agreements between learners ... and to aid recall and reflection" (Sharples *et al.*, 2007:231).

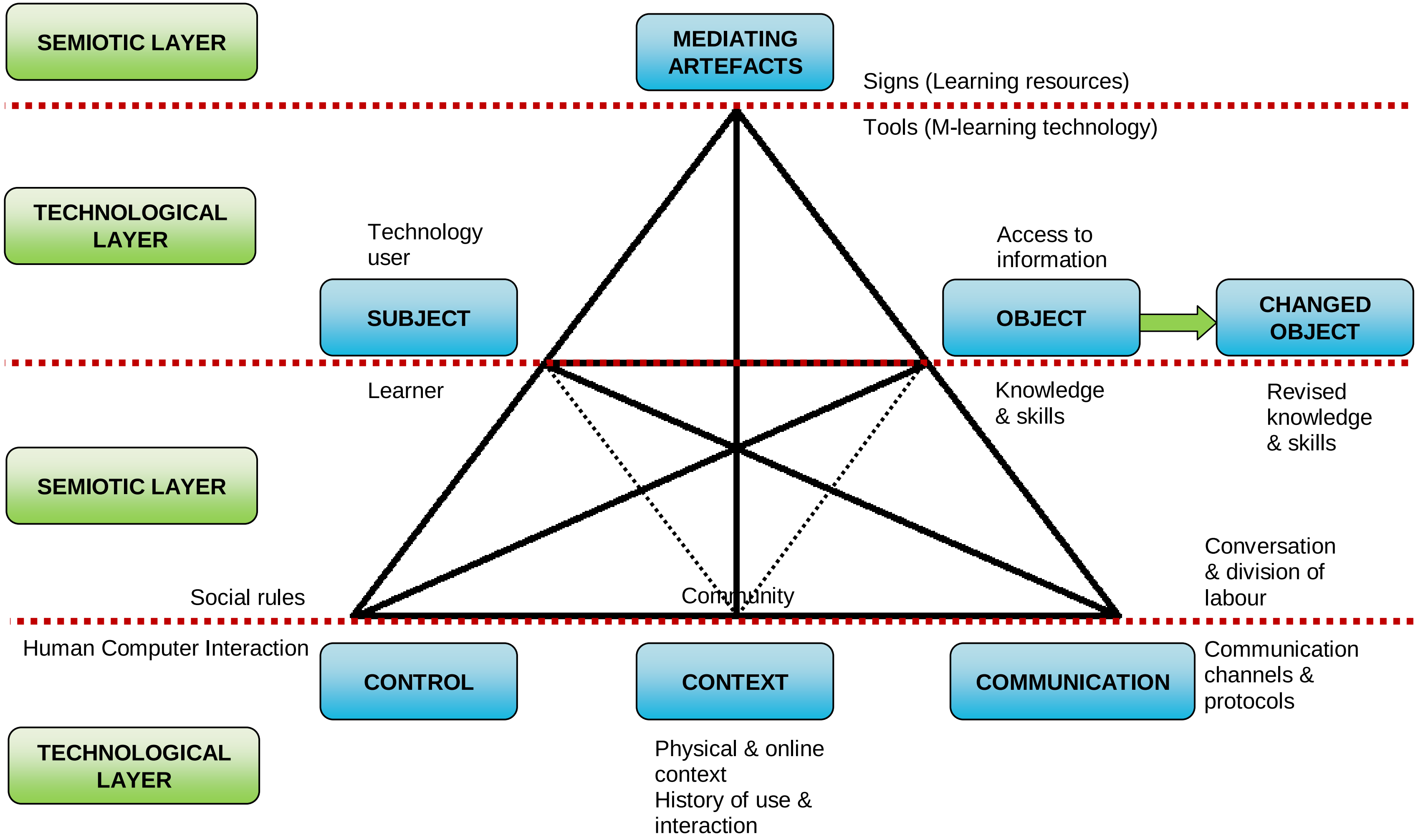

Figure 2.12: Activity Theory framework for analysing mobile learning (Partially adapted from Sharples, Taylor & Vavoula, 2007:232)

Figure 2.12 reflects that the relationship between the subject (learner) and the object (goal) of the activity is not direct, but is rather mediated through the use of tools. The subject is therefore perceived to be doing something other than merely 'using the technology'. The technology is simply the tool through which the subject achieves his/her objectives. The assessment of technology artefacts should therefore focus on the identification of usability issues, as well as the examination on how well the tool supports the subject's activities (Waycott, 2004:68). Figure 2.12 furthermore reflects that the relationship between the subject and the community is mediated by rules, and that the relationship between the object and the community is mediated by the division of labour: How the activity is distributed among the members of the community. Since this research study uses activity theory as an underpinning theory, learning control can be viewed as learners' independence toward m-learning, the learning context as m-learning system functions and learner satisfaction toward system functions, as well as the communication of learning as interactive and communicative activities of m-learning. Learners are therefore viewed as active learners and not passive knowledge receivers as they gain new knowledge by means of sufficient learning technologies or tools that educators supply within essential learning activities to guide learners to master new knowledge. By evaluating the history or rather the evolution of learning activities, it seems to point to a new generation with a culture where activities will be mediated by tools anywhere, anytime. Activity theory therefore facilitates the understanding of the culture of the 'media generation' we are trying to teach (Matthee & Liebenberg, 2007:151).

In the activity theory framework for analysing m-learning, Engeström's original activity theory framework of 'Rules', 'Community' and 'Division of Labour' have been adapted into 'Control', 'Context' and 'Communication'. Each of these three influencing components is graphically depicted in Figure 2.13, and is thereafter discussed in more detail (Taylor, Sharples, O'Malley, Vavoula and Waycott, 2006:145). Figure 2.13 could be viewed as a representation of an activity theory framework that has been applied to this research study for analysing m-learning in a technology-based subject (computer science programming).

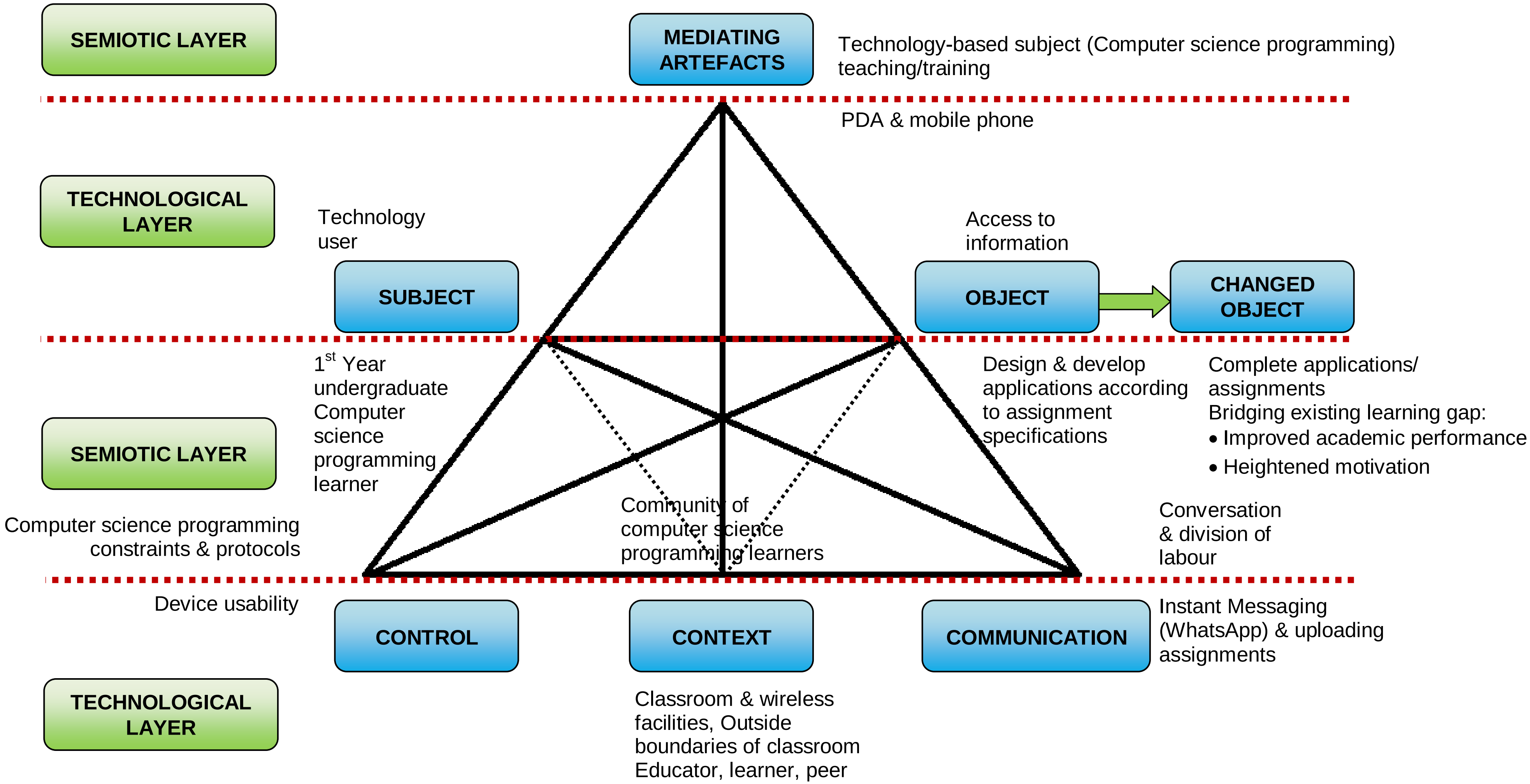

Figure 2.13: Activity Theory framework for analysing mobile learning in a technology-based subject (computer science programming) (Partially adapted from Sharples, Taylor & Vavoula, 2007:232)

- **Control**

  The control of learning is generally focused on the educator, but may also be distributed among the learners. Control rules function in any context or community, referring to the explicit regulations, policies, and conventions that limit activity, as well as the implicit social standards, standards, and relationships among members of the community (Jonassen, 2002[8] cited by Liaw, Hatala & Huang, 2010:448). Consequently, control may also pass between learners and technology.

  - **Technological layer:** Laurillard (2002)[9] cited by Taylor *et al.* (2006:153), states that one of the most boasted benefits of technology enhanced learning is to place learners in control of their learning. By placing learners in control of their learning can to some degree be perceived as a technological benefit, which originates from the approach in which learning is delivered, for example if learners are allowed to access learning materials at their own pace, revising and re-checking work at anytime, anywhere. In order to retain this benefit, it is important to ensure device or application usability, where the device or user interfaces must be effective and fit for purpose. In addition, system performance standards must be adhered to.
  - **Semiotic layer:** The exploitation of technology also occurs within a social system of other learners. This entails that learners can be influenced without difficulty not only by what other users are essentially doing, but also their attitude towards it. Social rules (i.e. university policies, course framework, class rules etc.) preside over what is acceptable (i.e. learners must meet programming assignment deadlines). Learner attitudes toward the technology can be influenced by other people's opinions (i.e. do people mainly show a positive or negative attitude towards technology use?).

- **Context**

  The context of learning can hold multiple communities of actors (both people and interactive technology) who intermingle around a joint objective, therefore making it an evolving and essential property of interaction. From the m-learning system perspective, the context of learning is based on the quality of system interactive functions, physical context, or learning content. It is known that the higher the quality of the system's functions is, the more learner satisfaction there is (Liaw *et al.*, 2010:448).

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[8] Jonassen, D.H. 2002. Learning as activity. *Educational Technology*, 42(2):45-51.
[9] Laurillard, D. 2002. *Rethinking University Teaching: A conversational framework for the effective use of learning technologies.* 2nd ed. London: Routledge/Falmer.

- **Technological layer:** Context is facilitated by means of interaction between people, technology, objects and activities. It refers to either the characteristics of the learning environment (where learning occurs) or the social setting of learning activities, for example by utilising mobile devices, learners can learn and complete assignments in the classroom or elsewhere on campus, at home/residence, or even while travelling. As described earlier, there are two contextual aspects of importance, namely the physically embodied technological context, and the human semiotic context (i.e. the community) within which learning occurs (Taylor *et al.*, 2006:154). Furthermore, context refers to how social rules control what users are expected to do.
- **Semiotic layer:** The community may consist of various 'related' co-workers or co-learners who might or might not share the same current ‘object’ or objective, but to a large degree form part of what a person may like to accomplish.

- **Communication**

  If the system permits certain types of communication, learners can adjust their communication behaviours accordingly and from time to time find ways to subvert the technology (e.g. finding new ways of connecting across networks).

  With the communication of learning, the technological system facilitates various forms of communication (i.e. IM), while learners embark on adapting their communication and learning activities accordingly. As the technology become more familiar to learners, they create novel ways of interacting through creating new rules and exclusive communities. This technology appropriation does not only lead to new ways of learning, but it also establishes trepidation with existing technologies and practices. On a broader scale, mobile technology supports interactions and communication (i.e. file and information retrieving and knowledge sharing) (Liaw *et al.*, 2010:448).

Table 2.9 presents a summary of the three components based on activity theory and m-learning.

Table 2.9: The components based on activity theory and m-learning perspectives
(Adapted from Liaw *et al.*, 2010:448)

Component	Activity theory perspectives	M-learning perspectives
The control of learning	• Learners directly access learning materials conveniently • Learners control the learning pace and style • Learners are independent and competent	• Systems provide self regularity or autonomous learning functions • Learners use systems personally and independently
The context of learning	• Context is an integral property of interaction • Context embraces the multiple communities of actors who interact around a shared objective	• Systems offer functions for learning activities, such as the retrieval of content or information sharing knowledge • Systems provide high quality functions to encourage and enhance learners' usage
The communication of learning	• Learners adapt their communication and learning activities • Learners invent new ways of interacting that creates new rules and exclusive communities	• Systems supply various interaction and communication to support diverse learning activities • Systems provide meaningful communication • Learners use systems individually or collaboratively

2.7 Conclusion

In this chapter, a holistic perspective of the research environment was provided and the following analogies can be drawn:

- Action research is considered to be the most effective research approach when the final results arise from the data because of appropriate choices (Dick, 2000:Online). The final results in this study will not be prescriptive, but will emerge from the collection and interpretation of the data.
- All data collection and interpretation of data were executed in plausible ways, i.e. the objective is to search for evidence, incorporate practice with the literature and amalgamate interpretations with quality data (Dick, 1993:8).
- Action research can be used for investigative or pilot research, or for diagnosis and evaluation (Dick, 2000:Online). This study was conducted with the purpose to investigate the implementation of m-learning in an undergraduate computer science programming subject in a South African educational context.
- Mashile (2001:132;137), as well as Zuber-Skerrit and Perry (2000:84), are of the opinion that the ideal is that the primary action research project has to be part of the PhD candidate's fulltime work, as it is in this case a real-life scenario where a significant problem in the workplace exists.

- Most action research is qualitative in nature, however could also represent a juxtapositioning of qualitative and quantitative research.

In the next chapter a literature review will be conducted on m-learning serving as the primary theme of the thesis, providing an empirical underpinning to the research problem.

CHAPTER THREE

MOBILE LEARNING - A LITERATURE REVIEW

SYNOPSIS

In this chapter a literature review will be conducted on the primary theme of the thesis, namely m-learning serving as a paradigmatic mechanism within a technology-based subject, providing an empirical underpinning to the research problem.

The content of Chapter 3, along with the relative positioning of the topics, is graphically depicted in Figure 3.

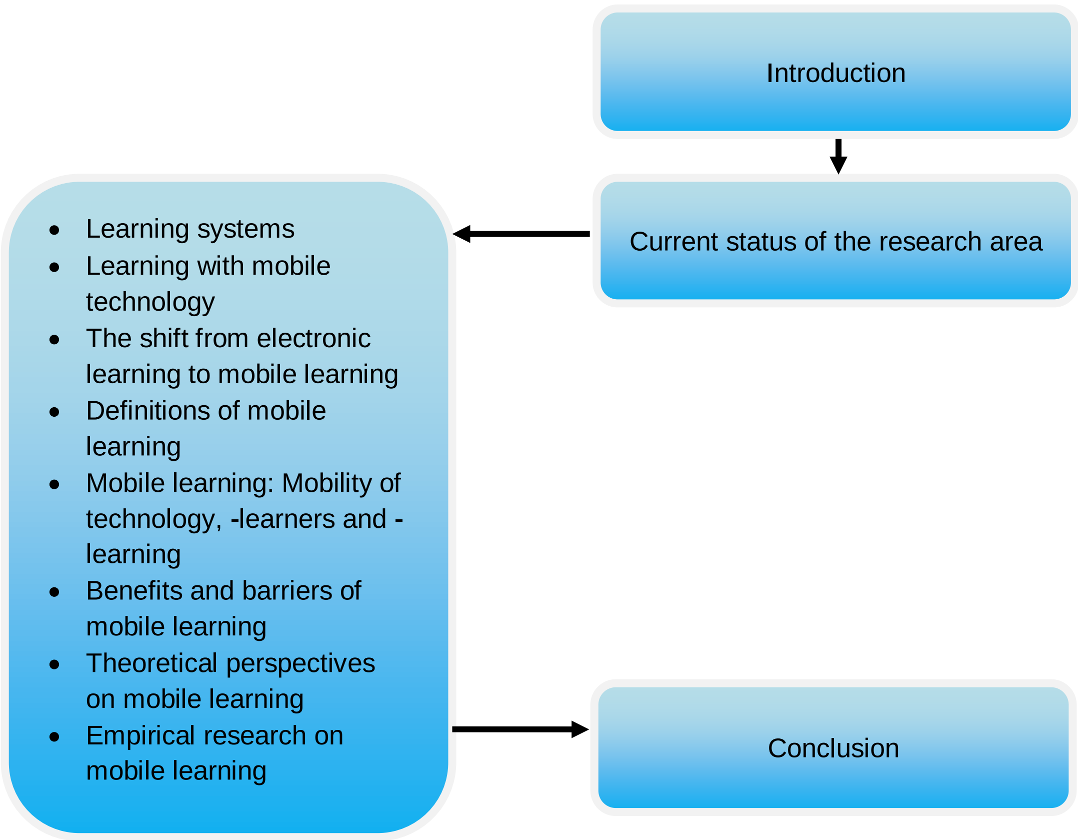

Figure 3: Detailed layout of Chapter 3 - Mobile learning - A literature review

3. CHAPTER THREE

MOBILE LEARNING - A LITERATURE REVIEW

3.1 Introduction

The analytical process followed thus far, is graphically depicted in Figure 3.1, which places the chapters in context with the overall thesis objectives, and furthermore indicates the relative positioning of this chapter.

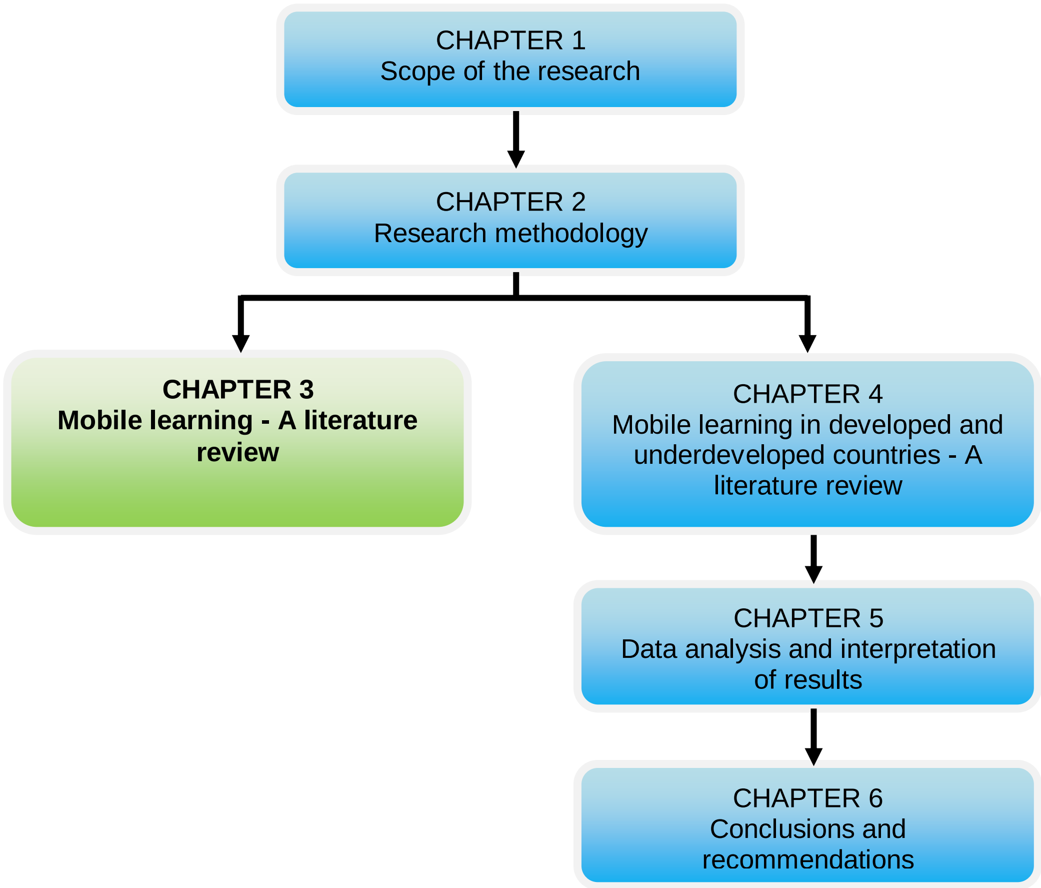

Figure 3.1: Chapter 3 - Mobile learning - A literature review

During the past decade, the demand for mobile devices has increased, resulting in a decrease in the cost thereof. Combined with an increase in technological capabilities, mobile devices have become an attractive tool for business and society alike, including education. Several educational institutions are starting to embrace these mobile devices as learning tools both inside and outside the boundaries of the classroom. Not only are these devices used to support teaching and learning, but are also used to enhance learner understanding and to improve learner motivation. Using mobile devices as learning tools during the teaching and learning process are commonly referred to as mobile learning or m-learning. In terms of this chapter, with its primary theme, namely m-learning serving as a paradigmatic mechanism within a technology-based subject, the following aspects pertaining thereto will be elaborated upon:

3.2 Current status of the research area

3.2.1 Learning systems

According to Alonso and Norman (1996)[10] cited by Singh and Zaitun (2006:27), there are typically four types of learning systems, namely conventional learning, instructional learning, e-learning and m-learning, which is graphically depicted in Figure 3.2. Masrom and Ismail (2010:11-12), describe the nature of these learning systems as follow:

- **Conventional learning:** This mode of learning essentially focuses on a face-to-face approach. Learners are required to travel to a single location and physically attend lectures in a classroom. Learners frequently experience good socialisation with each other, which allow them to learn from each other and as a result, establish knowledge sharing. It provides learners with more opportunities to meet their educators and to directly discuss issues with them.
- **Instructional learning:** This mode of learning has successfully been used to provide learners with a one-to-many instruction environment, learning without limiting time and location, various knowledge sources, open learning systems, multimedia information delivery, cooperative learning, as well as storing and rapidly accessing large amounts of learning materials (Wo, 2003). Learners are able to access learning resources off-campus, thus reducing the need to travel.
- **E-learning:** This mode of learning is intended to reach learners who encounter difficulties in attending conventional learning. E-learning enables learners to not physically attend classes, and as a result they are not faced and restricted by time and geographical constraints. It is characteristically a web-based system carried out over the Internet (or the Intranet within the campus environment) supported by a virtual environment. This provides the flexibility and the capability of integrating text, picture, animation, audio and video to create multimedia instructional material (Sun & Chen, 2007). Frequently, e-learning incorporates a blended learning approach, which includes e-classroom and face-to-face meetings (Sulcic, 2007).

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[10] Alonso, D.L. & Norman, K.L. 1996. Forms of control and interaction as determinants of lecture effectiveness in the electronic classroom. *Computers & Education*, 27(3-4):205-214.

- **M-learning:** Is a mode of learning that uses mobile or wireless technology as a tool for supplementing learning. It supports unremitting learning through mobile digital tools and environments. It offers an extensive variety of learning activities that support the learning process by means of motivation, control, ownership, fun and communication (Jones, Issroff & Scanlon, 2007:18).

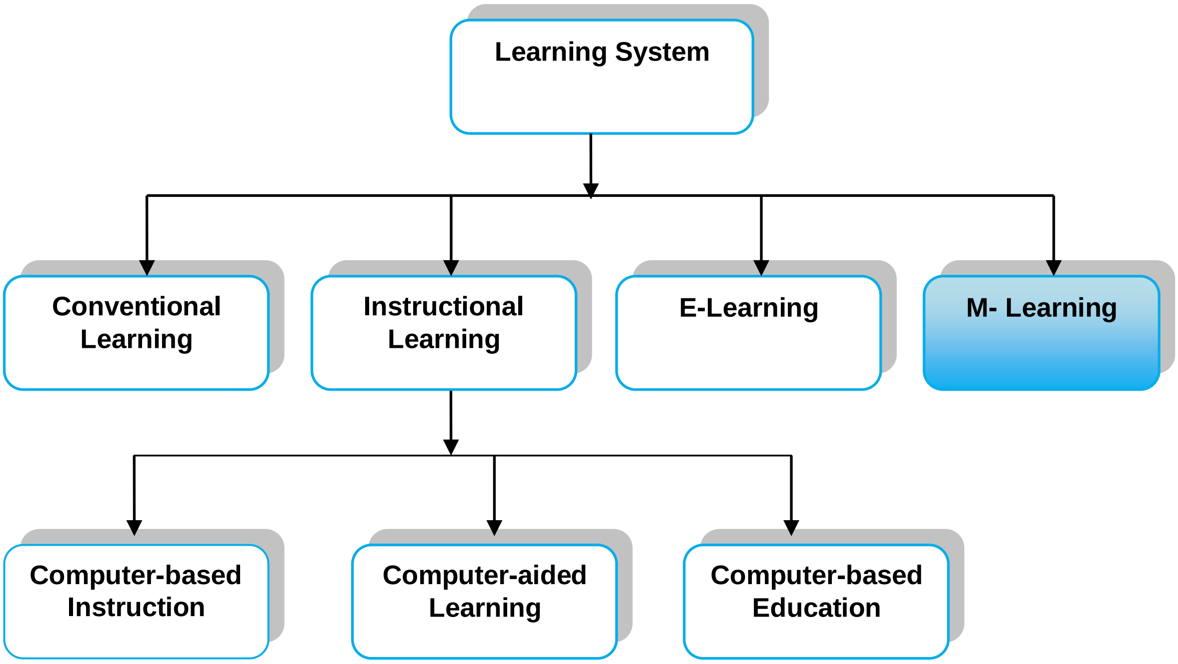

Figure 3.2: The four types of learning systems
(Adapted from Masrom & Ismail, 2010:11)

3.2.1.1 Advantages and disadvantages of learning systems

The learning systems described in Paragraph 3.2.1 have several advantages and disadvantages. According to Singh and Zaitun (2006:28), m-learning could address some of these disadvantages. Table 3.1 reflects the advantages and disadvantages associated with the listed learning systems.

Table 3.1: Advantages and disadvantages of learning systems
(Adapted from Singh & Zaitun, 2006:28-30)

Learning system	Advantages	Disadvantages
Conventional learning	• Learners travel to a single location and attend lectures in a classroom. • Good socialisation amongst learners and it allows them to learn from each other. • Group discussions, team projects, group presentations, individual assessment through quizzes and tutorials (Heckman & Owens, 1996).	• The educator talks and writes on a blackboard while the learner furiously takes down notes or sits back or falls asleep. • Poor interaction among learners and educators during class. • Learning is done in an asynchronous mode – i.e. educator actively present the information and learners passively observe. • Educators do not know how a particular lesson went. • Lack of learning resources in a conventional classroom. • Not meant for individualised learning (Alonso & Norman, 1996). • Learners must keep pace with the educator. • Learner interaction is limited in a large classroom. • Small group interaction is not suitable in large classrooms. • Poor feedback from learners on the delivery of lectures.
Instructional learning		
1) Computer-based instruction	• Reduces the need for learners to travel to the university. • Videos and animation can assist learners to recall information. • System can log learner access to learning resources.	• System usability is not user friendly. • Learners find it difficult to remember information as they scroll back and forth when answering questions. • Multimedia images and videos slow down computer performance (Pane *et al.*, 1996). • Educators are needed for explanation on working problems in classrooms (Nizar & Clum, 1999). • Do not inform learners of new content when logging into the courseware systems (Huckvale *et al.*, 1997).
2) Computer-aided learning	• Specific to a learning domain area. • Uses the Internet to disseminate information and learning materials. • High quality resources such as web documents, video conferencing e-mail, news groups, chat, notes, cooperative applications that allow learners and tutors to participate.	• Not compatible with older software versions. • Slows down bandwidth. • High quality resources such as web documents, video conferencing e-mail, news groups, chat, notes, cooperative applications that allow learners and tutors to participate.

3) Computer-based education	• Can take place at home or at university. • Contains digitised sound and graphics. • Distance education materials can be presented synchronously i.e. creating a classroom on the computer or asynchronous mode. • Synchronise educator's voice and video with a slide show. • Includes a table of contents for quick access to teaching and learning materials.	• Lack of a table of contents to search for required teaching and learning materials. • Lack in allowing learners to socialise, learners feel isolated (Chen, 2003).
Electronic learning	• Can be accessed at fixed locations with Internet connections such as computer laboratories, at home or cyber cafés (Moore & Richardson, 2002). • Can use several tools such as mini lectures, electronic conventional discussion or active cooperation.	• Depend on constant Internet connection to provide service. Cannot be used when Internet connection is not available. • Depend on a fixed location with Internet access and does not support m-learning. • Not meant to be used for extended courses. • Learners may be confused on actual submission of assignments. • Not much interaction with educators and learners. • Reduces social interaction. • Educators are not available when learners need assistance.
Mobile Learning	• Educators can incorporate multimedia demonstrations in their lectures and receive real-time feedback from their learners using quizzes or surveys (Adewunmi *et al.*, 2003). • Learning can be done anytime and anywhere. Supports continuous learning. • Able to collaborate with educator's notebook during class. • Communication and teaching support while outside the classroom. • M-learning is able to synchronise team members' appointments and schedules (Lehner *et al.*, 2001). • Classroom does not have to have a fixed seating arrangement (Kar, 1999). • Individual learner activities can take place such as web browsing, independently running example programs or working through example problems in class (Brown, 2001). • An educator can get immediate feedback on the lesson being taught.	• Small screens limit the amount and type of information that can be displayed. • There are limited storage capacities for mobile phones and PDAs. • Bandwidth may degrade with large number of users (Mc Cartney, 2004). • PDAs and mobile phones are less robust than desktop computers. • Batteries have to be charged regularly as data can be lost if this is not done timeously.

	• Learners can be assessed on multiple-choice- and true/false questions in the classroom. • Real-time experiments can take place in classrooms. • Educators can provide examples such as simulations and web-based documents that can be accessed at specific time to improve retention (Brown, 2001). • Learners do not have to waste time copying what the educator writes on the whiteboard (Brown, 2001).	

3.2.2 Learning with mobile technology

Over the last decade, mobile devices have become ubiquitous artefacts that are present in the everyday lives of the vast majority of people across the world. The first generation (1G) of mobile phones enabled calls to be made on the move, but their bulky size made it doubtful that they would become commercially viable. During the 1990's, the second generation (2G) mobile phones became smaller, lighter and more functional and affordable. Currently, third generation (3G) and fourth generation (4G) mobile phones have unleashed the most significant changes, enabling wireless Internet connectivity permitting users to be online anywhere, anytime. The term 'mobile technologies' are defined by Bottentuit Junior and Coutinho (2008:160) as, "portable technology that can be moved from one place to another without any loss".

Mobile technologies are increasingly being used in both developed and developing countries. In both spheres, there is an immense need to introduce mobile technology in education (Margolis, Nussbaum, Rodríguez & Rosas, 2006:175). This approach has resulted in an increase of the use of mobile technologies in the educational environment (Wali, Winters & Oliver, 2008:41), and the creation of new learning experiences (Rogers, Price, Fitzpatrick, Fleck, Harris, Smith, Randell, Muller, O'Malley, Stanton, Thompson & Weal, 2004:4), all over the world.

There is significant interest in taking advantage of and utilising the nearly worldwide demand and profusion of mobile technologies in an educational environment. In an effort to search for the best solution to apply mobile technologies in an educational environment, educators are experimenting with a wide range of applications and new teaching and learning techniques within various academic fields. It covers the personalised, connected, and interactive use of handheld computers in classrooms (Perry, 2003:3; Trinder, Magill & Roy, 2005:92), new learning environments (i.e. mathematics or language learning systems) or new added features to assist learners (Alemi, Sarab & Lari, 2012:99; Chen, Chang & Wang, 2008:77; Chen & Hsu, 2008:153; Zhang, Song & Burston, 2011:203), in fieldwork (Chen, Kao & Sheu, 2003:347; Bradley, Haynes & Boyle, 2005:Online; De Crom & De Jager, 2005:Online; 2006:65; Kukulska-Hulme & Traxler, 2005a:Online; Smordal & Gregory, 2005:99), in collaborative learning (Pinkwart, Hoppe, Milrad & Perez, 2003:383), SMS education (Begum, 2011:105; Levy & Kennedy, 2005:76; Botha, 2006:1; Librero, Ramos, Ranga, Triñona & Lambert, 2007:231; Naismith, 2007:155; Hartnell-Young & Heym, 2008:1; Cavus & Ibrahim, 2009:78) and in numerous other disciplines.

Until recently, most mobile technologies had a solitary function by explicitly acting as a phone, digital camera, PDA, Global Positioning System (GPS) devices etc. Mobile devices have now converged into a single device that offers a number of different functions and provides new opportunities for both personal and informal learning (Cook, White, Sharples, Sclater & Davis, 2007:62). Mobile technologies have several advantages, such as the independence in learning anywhere, anytime (Özdemir, 2010:35), more rapid and convenient communication, as well as quick access to a variety of sources. The ability to use mobile devices anywhere, anytime is one of the main features that differentiate mobile personal devices from stationary office-based devices (Hyyppä, Tamminen, Hautala & Repokari, 2000[11] cited by Fetaji & Fetaji, 2009:400). It is therefore evident that mobile wireless devices are highly individualised and collaborative communication tools that complement existing technologies, and enable learning outside the classroom (Virvou & Alepis, 2005:55). It can have an impact on collaborative activities, since learners can for example exchange and share information by reaching one another via a wireless network, a mechanism referred to by Squire, Johnson, Holland, Nataf and Klopfer (2002:7), as "social interactivity".

In view of the fact that mobile devices are not connected to a physical location, the opinions in this respect of Yordanova (2007:IV.23-1), map with the opinions of Liaw *et al.* (2010:446), in that it enables wireless and ubiquitous learning. Mobile technology supports "just-in-time" learning, which means that learning material is delivered to learners at exactly the time in which they are needed, and is thus presented to learners at the most suitable moment. Anytime, anywhere access to learning material endorses personalised learning (Naismith, Lonsdale, Vavoula & Sharples, 2004:36), interactivity, learner-centred and self-paced learning, ubiquitous learning or mobility in learning (Liaw *et al.*, 2010:447-448), flexibility (Cobcroft, 2006:17; Fetaji, Ebibi & Fetaji, 2011:178; Peters, 2007:12-14; 12-14; Seppälä & Alamäki, 2003:330), as well as collaboration (Corbeil & Valdes-Corbeil, 2007:54; Hyyppä *et al.*, 2000 cited by Fetaji & Fetaji, 2009:400; Fetaji & Fetaji, 2008:127; Järvelä, Näykki, Laru &

[11] Hyyppä, K., Tamminen, S., Hautala, I. & Repokari, L. 2000. The effect of Mental Model Guiding User's Action in Mobile Phone Answering Situations. *Proceedings of the 1st Nordic Conference on Computer Human Interaction*. Stockholm, Sweden: NordiCHI 2000.

Luokkanen, 2007:71). Learning is therefore not inhibited by schedules and physical spaces, but is instead omnipresent and ongoing (Hyyppä *et al.*, 2000 cited by Fetaji & Fetaji, 2009:400). It develops into more situated, self-directed, collaborative and lifelong learning that forms part of our daily lives (Domik & Fischer, 2011:4). Similar research results by Waycott and Kululska-Hulme (2003:30) indicate that anytime, anywhere access to learning allows learners to schedule their study time around other activities, making it a promising educational tool (Soloway, Norris, Blumenfield, Fishman, Krajcik & Marx, 2001:17). Research conducted by Perry (2003:7) and Zurita and Nussbaum (2004:235), suggest that mobile technologies can significantly impact the support of the teaching and learning process, and that it can be used as an effective educational tool that consecutively can have a positive impact on learning both in and out of the classroom (Vahey & Crawford, 2002:7; Virvou & Alepis, 2005:55).

Mobile technologies, from a South African perspective, have the potential to provide South African learners with increased access to information and learning materials, as well as to support teaching and learning while on the move from any location at any time. It does not only enable learners to view course content in times of down time, thus getting more out of the original lecture, but also to view learning material repeatedly at their own pace. Wicker (2005:32) and Matesic (2003:20-21), are of the opinion that these technologies potentially may increase efficiency and productivity within the educational environment. Mobile technologies have the potential to provide learners with new opportunities to connect and to create (Downes, 2005:Online). This is especially essential for learners living in remote areas. These learners can utilise mobile technologies with wireless capability to connect with their peers in other locations, therefore feeling less isolated and better supported (GSMA Mobile Education, 2011:7), which in turn may result in more learners completing their education. Research conducted by Thornton and Houser (2004:3; 2005:226), returned that wireless mobile technology can effectively be applied to deliver learning material to learners whose mother tongue is not English. This aspect can be beneficial in a developing country like South Africa, where the majority of learners do not receive education in their home language. Although m-learning is a relatively new concept in Africa, it "will continue to grow in form, stature and importance", and will later become the learning environment of choice (Brown, 2004:Online).

According to Jarvis, Holford and Griffin (2003:4), there appears to be a paradigmatic shift away from training and education to learning, from educator-centred to learner-centred education, from rote learning to learning as reflection, and from face-to face learning to distance and e-learning. A leading feature of this shift is the innovative application of technology to enhance the delivery of education. The advent of mobile technologies has created opportunities for delivery of learning via devices such as handheld devices and can take the form of PDAs, mobile phones, smartphones, audio players (such as the Apple iPod), video and multimedia players, handheld computers and even wearable devices. It has revolutionised education and transformed traditional classroom-based teaching and learning into anywhere, anytime education (Cavus & Ibrahim, 2009:78). As a result, it influences mobility, learner motivation and collaboration amongst learners in an educational environment (Barker *et al.*, 2005:Online). They should be connected wirelessly, thus ensuring mobility and flexibility. Mobility adds a further dimension to the experience and flexibility of learning by allowing a truly learner-centred approach to learning. Here learners have more choice over where, when and how they learn (Bradley *et al.*, 2005:Online). Mobile devices can be stand-alone and possibly synchronised periodically, intermittently connected to a network, or always connected (Zawacki-Richter, Brown & Delport, 2009:Online).

As learners have access to a multitude of devices, it is important to identify and classify those technologies that are relevant to m-learning. Naismith *et al.* (2004:7), classify the range of mobile technologies using two orthogonal dimensions, namely personal vs. shared and portable vs. static. This classification of mobile technologies is graphically presented in Figure 3.3.

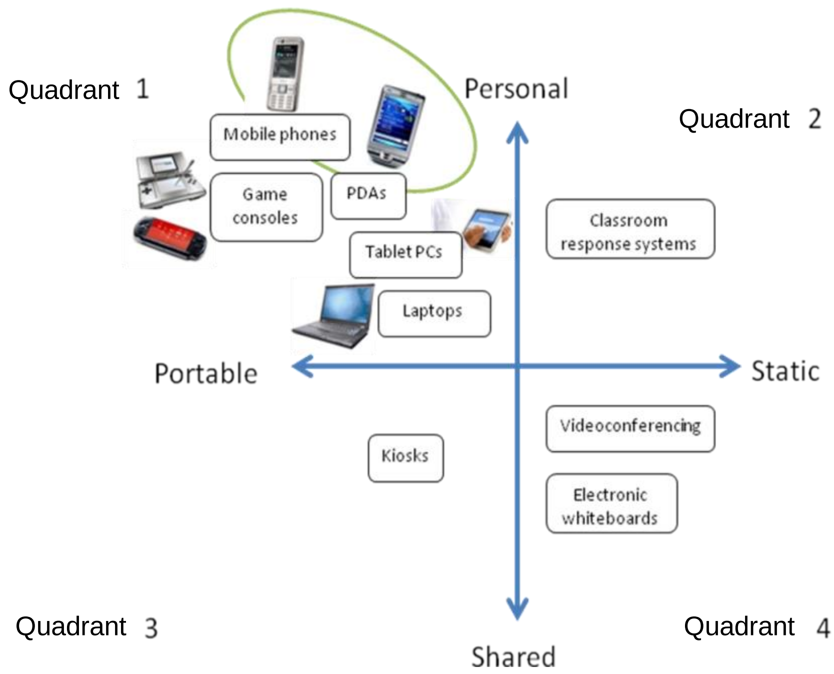

Figure 3.3: Classification of mobile technologies
(Adapted from Naismith *et al.*, 2004:7)

In referring to Figure 3.3, Quadrant 1 shows devices that can be classified as both portable and personal. These types of devices include mobile phones, PDAs, tablet PCs, laptops and handheld video game consoles. Quadrant 2 shows classroom response systems that, "consist of individual learner devices that are used to respond anonymously to multiple choice questions administered by an educator on a central server" (Naismith *et al.*, 2004:8). Quadrant 3 shows technologies that can provide learning experiences for learners on the move, however the devices are not physically movable. This for example includes street kiosks, interactive museum displays, and "other kinds of installations that offer pervasive access to information and learning experiences. For more shareable interactions, the devices themselves must become larger and hence less portable". Examples include electronic classroom whiteboards and videoconferencing facilities, as shown in quadrant 4 (Naismith *et al.*, 2004:8).

JISC (2005:Online), identified three key features of mobile technologies, namely portability (since PDAs are pocket sized), anytime-anywhere connectivity (PDAs with General Packet Radio Services (GPRS) or Wireless Fidelity (Wi-Fi) connectivity allowing flexible and timely access to online learning resources), and immediacy of communication (through phone or e-mail) that emphasise their potential as a teaching and learning tool. These features lead to the effective management and empowerment of learners, particularly in dispersed communities.

3.2.3 The shift from electronic learning to mobile learning

Since 2000, literature on m-learning (in particular literature available on the Internet) has been increasing exponentially. M-learning is different from e-learning, since it is not just electronic, it is mobile (Shepherd, 2001:Online). “Ten years ago mobile learning was about displaying e-learning on a small screen” (Woodill, 2011:12). Woodill (2011:184), defines m-learning as a, “philosophical approach to the possibility of learning anytime anywhere - knowing that you can find information when you need it”. Milrad (2003:151), as well as Hoppe, Joiner, Milrad and Sharples (2003:255), define e-learning as, "learning supported by digital electronic tools and media", and m-learning as "e-learning using mobile devices and wireless transmission". Brown (2005b:299), Kadirire (2009:15), and Gupta (2012:179), agree with this notion and view m-learning as an extension of e-learning, where the focus is on the use of mobile devices such as mobile phones, PDAs, iPods, tablets, and laptops/notebooks that allow a greater degree of access to learning resources. Winters (2006:5-6), identified the following four dominant perspectives on how m-learning should be considered in relation to e-learning and how it changes pedagogies:

- Technocentric (m-learning means using mobile devices).
- Relationship to e-learning (m-learning as an extension of e-learning).
- Augmenting formal education (adding something to face-to-face teaching).
- Learner-centred (m-learning as learning by a mobile individual).

Ally (2004:5), defines m-learning as the delivery of electronic learning materials, with built-in learning strategies, on mobile computing devices to allow anywhere, anytime access. The main difference therefore between e-learning and m-learning is that in e-learning, the mobility of the learner is more restricted, whereas in m-learning it allows learning to occur anywhere, anytime. E-learning is seen as the predecessor of m-learning and is characterised by some researchers as 'an extension of e-learning'. Laouris and Laouri (2006:Online), describe the move from e-learning to m-learning as a revolution since it implies not only a change in terminology, but a change of mindset when designing and planning learning environments and goals. Sharma and Kitchens (2004:205), assign this inevitable change in paradigm to the unique facilities provided by mobile technology such as the provision of communication facilities at anytime, anywhere, and the provision of learning content dependent on the learner's mobile device, context and location. It is clear that the exposure to a greater variety of media is causing a different type of learner, who collects and processes information in a different way. Mellow (2005:469), describes this new generation of learners as the 'media generation', whereas Prensky (2001:1) uses the metaphor of 'digital natives' to get a better understanding of the type of learner educators are dealing with. Mobile technology is part of the 'digital natives' lives and it seems logical that educators should explore the possibilities of applying these technologies in educational settings (Mellow, 2005:470). The situation in developing countries are of course somewhat different and quite a number of researchers have asked probing questions on the role of technology enhanced learning (if any) in such settings (Brown, 2005b:299; Masters, 2005:Online; Laouris & Laouri, 2006:Online). M-learning is the point where mobile computing and e-learning overlap to allow an anytime, anywhere learning experience (Quinn, 2000:Online; Harris, 2001:Online).

Even though the majority of researchers view m-learning as the amalgamation of mobile technologies and appropriate pedagogy to enable learners to interact with each other and their learning environments at any time from any location, some also associate m-learning with ubiquitous learning (Ng, Nicholas, Seng & Torabi, 2009:43). For example, delays during commuting and travelling become potential learning opportunities. In general, any opportunity, which would otherwise be 'wasted', has now become a potential learning opportunity as a result of m-learning. Metcalf (2002)[12] cited by Rajasingham (2011:3), refers

[12] Metcalf, D. 2002. mLearning: learning anywhere. *Proceedings of the Online Learning Conference*, Anaheim, California, USA.

to this as using mobile devices for "stolen moments of learning". It can therefore be defined as any activity that allows learners to be more productive when consuming, interacting with, or generating information, by means of a mobile device that has reliable connectivity, and fits in a pocket or purse, and is carried by the learner on a regular basis (Wexler, Brown, Metcalf, Rogers & Wagner, 2008:7). E-learning provides new methods for education based on computer Internet technology. M-learning, a sub-category of the larger concept of e-learning, has the ability to learn everywhere and at any time without permanent physical connection to cable networks. Quinn (2000:Online), defines m-learning as, "the intersection of mobile computing and e-learning: accessible resources wherever you are, strong search capabilities, rich interaction, powerful support for effective learning, and performance based assessment – e-learning independent of location in time and space".

E-learning is considered to be "tethered" (connected to a device) and is normally presented in a formal and structured manner enabling real-time (synchronous) or self-paced (asynchronous) learning. Conversely, m-learning is mostly un-tethered, informal and self-paced. Since mobile devices can make learning even more widely obtainable and accessible, many view it as a natural evolution of e-learning (Mostakhdemin-Hosseini & Tuimala, 2005:203).

One of the primary reasons why m-learning is such a popular alternative compared to e-learning, is that the immobility of personal computers restricts learners to the potential of making use of anywhere, anytime learning (Rawlinson & Bartel, 2006:41). Within an e-learning environment, learners are limited to the use of a personal computer and/or Internet at an immobile location (Motiwalla, Tello & Carter, 2006:Online). Learners can thus not access learning material, assignments or quizzes while on the move. M-learning overcomes this restriction by allowing learners to download information to their mobile devices and complete their course work at a location of their choice. Mobile devices allow communication and interaction between the learner and educator, between other learners in the same course, and immediate access to course information anywhere and anytime (Motiwalla *et al.*, 2006:Online). Learners can even access course material away from campus where they can find a wireless connection. E-learning takes learning away from campus. Furthermore, m-learning takes this feature one step further by taking learning away from a fixed location. E-learning can serve as an alternative to classroom instruction, however m-learning can be a complementary activity to traditional instruction and e-learning. This means that if instructors make learning material, assignments, quizzes etc. available on a virtual LMS such as Blackboard, learners can access their learning material, interact with peers or educators, and download or upload assignments and quizzes via their wireless mobile devices. M-learning can therefore be viewed as, "a means to enhance the broader learning experience, [and] not a primary method for delivering courses/distance learning" (Mellow, 2005:471). However, the main pedagogical difference between e-learning and m-learning is that the former occurs in front of a computer or in the classroom, while the latter occurs in the field or at any location of your choice.

The main difference between e-learning and m-learning can therefore be identified as that, in order to deliver e-learning, the learner is brought to the device, whereas with m-learning learning material is brought to the learner (Masrom & Ismail, 2010:15). Table 3.2 provides a comparison between e-learning and m-learning, while Table 3.3 reflects from a pedagogical perspective the differences between e-learning and m-learning.

Table 3.2: Comparison of e-learning and m-learning
(Adapted from Boyinbode & Akinyede, 2008:386-387; Mobl21, 2012:Online)

E-learning	M-learning
It cannot be used anytime, anywhere (Lecture in classroom or Internet laboratories)	It can be used anytime, anywhere
Private location	No geographic boundaries
Desktop computers are more expensive than the majority of mobile devices	Most mobile devices have lower prices than desktop computers
Desktops are not portable	Mobile devices are portable
It cannot provide location dependent education	It can provide location dependent education using GPRS technology
It is not flexible	It is flexible and can engage learners on the move
One learner to one computer	One learner to more than one mobile device
E-mail-to-e-mail	Instantaneous messaging
Travel time to reach the Internet site	No travel time with wireless Internet

Table 3.3: E-learning versus m-learning
(Adapted from Masrom & Ismail, 2010:16)

Pedagogy	E-learning	M-learning
Course location	HTML website	WML website
Class materials	Online notes, URLs and presentation slides	URL links to course website
Class experience	Whiteboards, group touring, virtual demos, chat rooms, discussion boards, and e-mail	SMS, alerts, discussion boards, course calendar
Assignments or projects	E-mail attachments or posting with web forms	Instant messaging for project coordination
Learner assessment	On-line exams, chat room or discussion board participation	On-line exams, chat room or discussion board participation

The issues engendering m-learning such as profiling of learners (Becking, Betermieux, Bomsdorf, Birgit, Heuel, Langer & Schlageter, 2004:1760), accessibility and user control (Syvänen & Nokelainen, 2004:191), integrating mobile devices with broader educational scenarios (Hoppe, 2007:32), usability factors (Kukulska-Hulme, 2007:1), learning design (Milrad, 2007:29), evaluation of m-learning (Taylor, 2007:26), and learning across contexts (Walker, 2007:5), offer insights which help to differentiate m-learning from other forms of learning. Examples of case studies which reflect some of these issues can be found in the research of Smith (2003:1), Kukulska-Hulme and Traxler (2005a:Online), Matsuura, Kanenishi, Niki, Miyoshi, Mitsuhara, Ogata, Yano and Morikawa (2005:3029), McFarlane, Roche and Triggs (2007:3), Rekkedal and Dye (2007:1), as well as Wishart, Ramsden and McFarlane (2007:95).

Kinshuk (2003:Online), remarks that, "there is much evidence that mobile technology is going to provide a natural extension for e-learning in the long run". Sharma and Kitchens (2004:205), in their research found that the shift from e-learning to m-learning can be accompanied by change in terminology. Laouris and Eteokleous (2005:Online), expanded upon the comparisons of Sharma and Kitchens (2004:205), and provide an example of terminology that are used to characterise the two types of learning environments, which are tabulated in Table 3.4 for ease of reference.

Table 3.4: Terminology comparisons between e-learning and m-learning
(Adapted from Laouris & Eteokleous, 2005:Online)

E-learning	M-learning
Computer	Mobile
Bandwidth	GPRS, 3G, Bluetooth
Multimedia	Objects
Interactive	Spontaneous
Hyper-linked	Connected
Collaborative	Networked
Media-rich	Lightweight
Distance learning	Situated learning
More formal	Informal
Simulated	Realistic situation
Hyper learning situation	Constructivism, situationism, collaborative

According to Laouris and Eteokleous (2005:Online), e-learning was dominated by words such as "multimedia, interactive, hyperlinked, and media-rich". However, m-learning terms demonstrate a shift away from a media interest experience, or a structured, benchmarked set of activities, to the following terms, namely "spontaneous, intimate, situated, connected, informal, lightweight, personal" (Laouris & Eteokleous, 2005:Online). The characterisations of m-learning found in the literature are mainly associated with words such as “spontaneous, personal, focused, context-aware, situated, private, opportunistic, informal, pervasive, bite-sized, and portable”. This is in contrast with words from literature associated with e-learning such as “media-rich, interactive, connected, usable, structured, broadband, intelligent”. Although this approach “underpins a conceptualization of mobile learning in terms of the learners’ experiences and an emphasis on 'ownership', informality, mobility, and context, it will always be inaccessible to e-learning” (Traxler, 2007:4).

In addition to Laouris and Eteokleous' (2005:Online), attempts to compare e-learning and m-learning Traxler (2007:4), further distinguishes these two modes of learning by providing an overview of technology comparisons (Table 3.5). Two years later Traxler (2009:5), indicates that in his initial comparison (Traxler, 2007:4), the two learning modes are limiting, due to it being exclusively based on the learner’s experience with e-learning and m-learning. Furthermore, at that time it does not deal with space and time in which learning takes place. Traxler (2009:5), claims that e-learning nearly always occur when space and time have been devoted to learning, while m-learning can happen anytime, anywhere, amongst “daily tasks, places, and situations”.

Table 3.5: Terminology comparisons between e-learning and m-learning
(Adapted from Traxler, 2007:4)

E-learning	M-learning
Structured	Personal
Media-Rich	Spontaneous
Broadband	Disruptive
Interactive	Opportunistic
Intelligent	Informal
Usable	Pervasive
	Situated
	Private
	Context-Aware
	Bite-Sized
	Portable

Kukulska-Hulme and Traxler (2005a:Online), recognise that m-learning has different strengths if compared to e-learning, as shown in Figure 3.4, and identified that the strengths of m-learning and e-learning can be overlapped in terms of the learner experience.

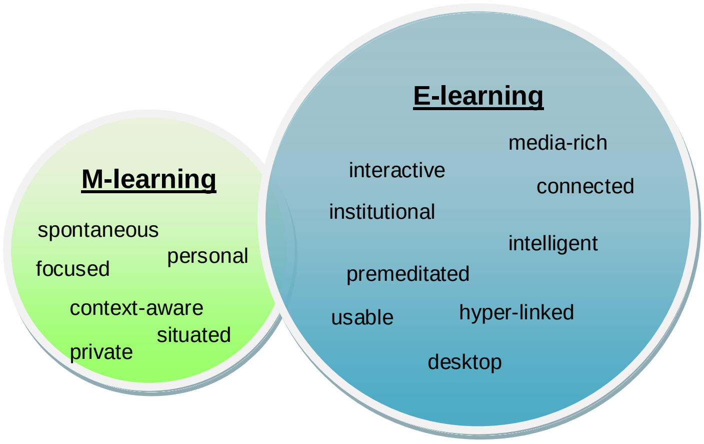

Figure 3.4: The different strengths of m-learning and e-learning
(Adapted from Kukulska-Hulme & Traxler, 2005a:Online)

3.2.4 Definitions of mobile learning

The emergence of a new approach to learning has led to new perspectives presented through different theoretical lenses. The pedagogical potential offered by mobile technology, is one such perspective termed 'mobile learning' (Cook *et al.*, 2007:62). The concept of 'm-learning' is novel and new in the education world. How it is eventually conceptualised will determine perceptions and expectations, and will determine its evolution and future. The inability of researchers to agree on a general definition for m-learning shows that m-learning and its applications are still in an evolutionary phase (Peng, Su, Chou, & Tsai, 2009:171).

Various definitions can be found in literature on m-learning from technical, spatial and context driven perspectives, however they all mainly focus on the notions of mobility, ubiquity, and wireless ability*.* If one separates 'mobile learning' into the concepts of 'mobile' and 'learning', the learning aspect is the most important concept in the developing world. The computing device just happens to be mobile (Ford & Leinonen, 2009:196). According to Mockus, Dawson, Edel-Malizia, Shaffer, An and Swaggerty (2011:5), "M", short for the word 'mobile', means "on the move" and refers to mobile devices that are portable/mobile, can access the Internet whenever and wherever a learner is away from a computer, and devices that are always on the move. Mockus *et al.* (2011:5), further state that when the word 'learning' is appended to the definition, it then refers to "knowledge on the move" where m-learning could include acquiring knowledge while for example commuting or waiting at a specific location or event.

When one combines the two words 'mobile' and 'learning', it is relatively easy to distinguish why this mobile learning approach can more easily and flexibly fit into the active lifestyles of learners. M-learning can therefore be perceived as ubiquitous learning based on a relevant pedagogical approach that is supported by appropriate mobile technology (Petrova & Li, 2009:768). Shearer (2010)[13] cited by Mockus *et al.* (2011:5), postulates that it provides learners with a just-in-time type of teaching and learning experience to supplement traditional classroom-based education. This definition places an emphasis on pedagogy as a dimension of m-learning (Goh & Kinshuk, 2006:180; Sharples *et al.*, 2007:235).

The Oxford dictionary (2012a:Online; 2012b:Online; 2012c:Online) defines the terms 'mobile', 'mobility' and 'learning' as follows:

Definition of **mobile**
adjective
1 able to move or be moved freely or easily:
he has a weight problem and is not very mobile
highly mobile international capital

- (of the face or its features) indicating feelings with fluid and expressive movements:
  her mobile features worked overtime to register shock and disapproval
- (of a shop, library, or other service) accommodated in a vehicle so as to travel around and serve various places:
  a mobile library visits once a fortnight
  a cup of tea from the mobile canteen
- (of a military or police unit) equipped and prepared to move quickly to any place it is needed:
  at first the regiment's role was to act as a mobile reserve

2 relating to mobile phones, handheld computers, and similar technology:
the next generation of mobile networks
a mobile device
3 able or willing to move easily or freely between occupations, places of residence, or social classes:
an increasingly mobile society

Definition of **mobility**
noun
[mass noun]
the ability to move or be moved freely and easily:
this exercise helps retain mobility in the damaged joints

- the ability to move between different levels in society or employment:
  industrialization would open up increasing chances of social mobility

[13] Shearer, R.L. 2010. *Philosophies and theories at the basis of student-centered educational models: Where theory and practice meet in instructional design for distance education.* XV International Congress on Technology and Distance Education.

Definition of **learning**
noun
[mass noun]
the acquisition of knowledge or skills through study, experience, or being taught:
these children experienced difficulties in learning
[as modifier]:
an important learning process

- knowledge acquired through study, experience, or being taught:
  I liked to parade my learning in front of my sisters

It is possible to categorise m-learning as any form of learning through devices which are very small, independent from electrical supply, and small enough to accompany people anytime and anywhere (Roschelle, 2003:260; Trifonova & Ronchetti, 2003:1794; Liang, Liu, Wang, Chang, Deng, Yang, Chou, Ko, Yang & Chan, 2005:181). While m-learning can be considered as a subset of e-learning, the rising potential of mobile technologies tends to indicate that m-learning, (while mostly situated within the e-learning framework), also has tangent planes with the 'just enough, just in time, just for me' model of flexible learning as graphically depicted in Figure 3.5, "and is therefore just one of a suite of options that can be adapted to suit individual learning needs" (Peters, 2007:3).

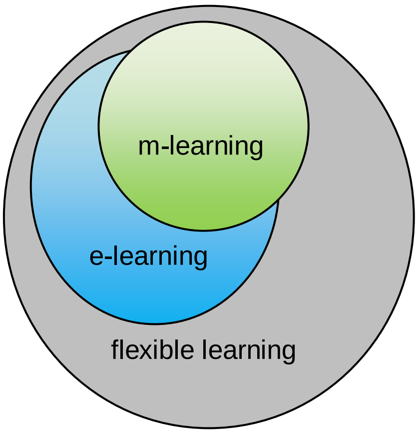

Figure 3.5: The 'just enough, just in time, just for me' model of flexible learning (Adapted from Peters, 2007:3)

M-learning has evolved as an extension of the e-learning frontier from a minor research interest to a set of significant projects in workplaces, museums, cities, schools, and rural areas worldwide (Sharples, 2007:4). The interest in the educational potential of mobile technology is seen as a conscious effort aimed at 'domesticating' mobile devices for educational purposes (Bachmair, 2007:106). Mobile devices combined with web 2.0 technologies are viewed as offering new learning possibilities, which represent a dynamic change in the strategies employed by learners and their creation and utilisation of learning products (Conole, De Laat, Dillon & Darby, 2008:511). There is great interest from educators and technical developers in utilising the unique characteristics and capabilities of mobile technologies to facilitate new and engaging forms of learning (Naismith *et al.*, 2004:6).

Quinn (2000:Online), has defined m-learning as, "e-learning through mobile computational devices", a definition similar to the notion that, "there is common agreement that m-learning is e-learning through mobile computational devices" (Trifonova & Ronchetti, 2003:1794). Taking a more spatial perspective, O'Malley, Vavoula, Glew, Taylor and Sharples (2003:Online), as well as O'Malley, Vavoula, Glew, Taylor, Sharples and Lefrere (2003:6), define m-learning as, "any sort of learning that happens when the learner is not at a fixed predetermined location or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies". It is, "concerned with learner mobility, in the sense that learners should be able to engage in educational activities without the constraints of having to do so in a tightly delimited physical location" (Kukulska-Hulme & Traxler, 2005b:1). From this the analogy can be drawn that, "mobile learning is not just about learning using portable devices, but learning across contexts" (Walker, 2007:5). It is possible for learners to create their own goals, objectives and aims. Learners therefore guide themselves through environments and they choose their paths of learning (Thomas, 2005:332). Other features, which distinguish m-learning from other forms of e-learning include site-specific learning and the degree of ownership and control over the learning process (Laurillard, 2007:156-157), personalisation, adaptation, engagement, self-evaluation and reflection by the learner (Stead, 2006:Online), change in the physical relations between educator and learner, learner generated context, and learner generated understanding (Winters, 2006:7-8), and the affective factors offered by the m-learning experience (Jones *et al.*, 2007:17).

Georgiev, Georgieva and Smrikarov (2004:IV.28-2), define m-learning as the delivery of learning to learners who roam and therefore can use mobile technology everywhere and at any time without permanently being physically connected to cable networks. It is not limited to a specific hardware device and can be used by learners to access additional tools in an educational environment (Mostakhdemin-Hosseini & Musatajärvi, 2003:191) to access learning material irrespective of location and time (Alexander, 2004:30; 32; Chen *et al.*, 2008:77; Liaw *et al.*, 2010:446). It is learning that happens anywhere, at any time, and anyhow (Stoyanov, Ganchev, Valkanova & O'Droma, 2010:250), and presents new ways to extend teaching and learning outside the boundaries of the classroom into the conversation and interactions of daily life (Sharples *et al.,* 2009:237). Sharples (2005:147; 151), postulates that mobility refers to informally arranged and distributed learners, and the interaction between learners and portable technology, as well as all distinctive aspects of m-learning. M-learning is also defined as ubiquitous learning activity based on a relevant pedagogical approach that is supported by an appropriate mobile technology (Petrova & Li, 2009:768). Shih and Mills' (2007:Online), definition for m-learning includes both the mobility and computing aspects of m-learning and reads as follows: "The capabilities for learning anytime and anywhere, just in time, just for me, and multimedia (text, voice, image, or video) messaging are essential characteristics. The use of various types of communication (i.e., phone call, voice/text messaging, multimedia messaging, e-mail, Web access), that provide real-time online interaction in a series of short burst learning activities, with features such as voice/video recording for story telling or even a 'mobblogging journal', complete the roster of characteristics that define effective use of mobile technologies in teaching and learning."

It is evident that some m-learning definitions therefore focus on the technology and its associated hardware (Alexander, 2004:29; 31; Peng *et al.*, 2009:172; Traxler, 2007:1; 4; Wang, Wu & Wang, 2009:93), namely that it is learning delivered or supported exclusively or mostly by handheld and mobile technologies such as PDAs, smartphones or wireless technological instantiations (Pinkwart *et al.*, 2003:384; Traxler, 2009:2), or the mobility of the technology (Winters, 2006:5; Peng *et al.*, 2009:173; Sharples *et al.*, 2009:234-235; Traxler, 2009:2; Vavoula & Sharples, 2009:62), whereas others focus on the mobility of learning (Peng *et al.*, 2009:174; Sharples *et al.*, 2009:235; Traxler, 2007:1; Vavoula & Sharples, 2009:62; Wang *et al.*, 2009:93; Winters, 2006:5) and the mobility of the learner (Traxler, 2007:1). Low (2007:Online), defines m-learning as the "mobility of learning, and not merely the mobility of technology". The author further states that, "how we achieve that mobility of learning must consider the context of the learning, and not just the use of mobile technology, if it is to achieve its full potential". Traxler (2005:262), initially defined m-learning as, "any educational provision where the sole or dominant technologies are handheld or palmtop devices". However, later Traxler (2005:265) points out some of the notions of defining m-learning by stating that even though these definitions and description are conceivably "technocentric, not very stable and based around a set of hardware devices", it positions m-learning somewhere on the e-learning portability spectrum. In addition, it might also emphasise its technical limitations instead of encouraging its inimitable pedagogic advantages and characteristics. Walker (2007:5), believes that m-learning tends to be defined by the context in which it is used, user experiences, its uses and backgrounds. El-Hussein and Cronje (2010:14), are of the opinion that m-learning, as an educational activity, only seems sensible when the technology in use is entirely mobile and when the users of the technology are demonstrating mobility while they learn.

The contention that a "socially and educationally responsible definition of m-learning must view the learner as the one being mobile and not his/her devices" (Laouris & Eteokleous, 2005:Online), and the ability for anytime, anywhere learning is still applicable in the developing world, however more as a positive side-effect. A study conducted by Waycott and Kululska-Hulme (2003:30), found that anytime and anywhere access to learning material is an important benefit of handheld devices since it allows learners to schedule their study time around other activities. The fact that mobile devices enable anytime, anywhere learning and that it support collaboration and communication between learners, makes it a promising educational tool (Soloway *et al.*, 2001:17).

M-learning empowers learners by giving them control of 'when' and 'from which' location they wish to learn. All humans have the right to access learning materials and information to improve their quality of life regardless of their culture, their status, and where they live. Educators in turn are reciprocally empowered since they can use the mobile technology to communicate with learners from anywhere and at any time. At the same time, educators can access learning resources at anytime and from anywhere to plan and deliver their lessons. This dispensation may be true in the developed world, but if emerging practice of m-learning in developing countries is evaluated, a different perspective emerges on entirely different paradigms.

In evolving definitions of m-learning, technology-focused approaches are being observed to be gradually superseded by interpretations that seek to locate m-learning within broader educational frameworks, taking account of social and philosophical dimensions (Laouris & Eteokleous, 2005:Online; Traxler, 2005:261). The context for this is the rapidly changing landscape of teaching and learning. Vavoula, Sharples, O'Malley and Taylor (2005:1), have studied m-learning as part of everyday learning in order to uncover, "how people learn on the move or outside their normal learning environment, with the technologies that are currently available, such as mobile phones and PDAs". Vavoula (2005:17), compared episodes of m-learning (when the learner is not at a fixed location or when he/she takes advantage of mobile technologies) to non-m-learning, and found "indications that mobile learning is more interactive, involves more 'bustle', more contact, communication and collaboration with people".

On reflection of the various definitions attributed to m-learning and for clarity of purpose, Table 3.6 reflects an overview of the various m-learning definitions that can be found in literature.

Table 3.6: Overview of m-learning definitions from key contributors

Author (Year)	**Definition**
Alexander (2004:29)	Any form of learning that is wireless and ubiquitous and occurs when mediated through a mobile device. A form of learning that established the legitimacy of 'nomadic' learners.
Ally (2009:58; 287)	The process of using a mobile device to access and study learning materials and to communicate with fellow learners, educators or institutions, from anywhere at any time.
Andronico, Carbonaro, Colazzo, Molinari, Ronchetti & Trifonova (2004:90)	Any form of teaching and learning that occur through a mobile device or in a mobile environment.
Attewell, Savill-Smith & Douch (2009:1)	"The exploitation of ubiquitous handheld (or very portable) hardware and wireless mobile learning networks to facilitate, support, enhance and extend the reach of teaching and learning."
Chuang (2009:51)	"Learning that happens across locations, or that takes advantage of learning opportunities offered by portable technologies."
Costabile, De Angeli, Lanzilotti, Ardito, Buono & Pederson (2008:145)	" ... the combination of e-learning and mobile computing".
Deegan & Rothwell (2010:17)	"Learning with the aid of a mobile device."
Keegan (2006:5)	" ... the provision of education and training on PDAs/palmtops/handhelds, smartphones and mobile phones."
Kukulska-Hulme, Sharples, Milrad, Arnedillo-Sánchez & Vavoula (2011:159)	" ... the study of how the mobility of learners, augmented by personal and public technology, can contribute to the process of gaining new knowledge, skills and experience."
Kukulska-Hulme & Traxler (2005b:42)	"Mobile learning can be spontaneous, portable, personal, situated; it can be informal, unobtrusive, ubiquitous and disruptive. It takes much nearer to 'anytime, anywhere' learning, but it is still too early to predict how our understandings of learning and teaching will evolve as a consequence."
Laouris & Eteokleous (2005:Online)	M-learning is a function of time, space, learning environment, content, technology, mental factors and method.
Laurillard (2007:172)	"M-learning, being the digital support of adaptive, investigative, communicative, collaborative, and productive learning activities in remote locations, proposes a wide variety of environments in which the teacher can operate."
Naismith *et al.* (2004:36)	" ... highly situated, personal, collaborative, and long-term; in other words, truly learner-centred learning."
Nyíri (2002:124)	" ... learning that arises in the course of person-to-person mobile communication."
O'Malley *et al.* (2003:Online)	Occurs when, " ... the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies."
Peng *et al.* (2009:175)	Using "ubiquitous computing technologies to learn the right thing at the right time at the right place".
Quinn (2000:Online)	"It's e-learning through mobile computational devices: Palms, Windows CE machines, even your digital cell phone."
Sharma & Kitchens (2004:205)	" ... learning supported by mobile devices, ubiquitous communications technology and intelligent user interfaces."
Sharples *et al.* (2007:224) Sharples *et al.* (2007:230)	" ... the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies." Learning with portable technology, and learning that is characterised by the mobility of people and knowledge.

Sharples *et al.* (2009:235)	" ... the study of how the mobility of learners augmented by personal and public technology can contribute to the process of gaining new knowledge, skills and experience."
Stoyanov *et al.* (2010:250)	Learning that happens "anywhere-anytime-anyhow ".
Traxler (2005:262)	" ... any educational provision where the sole or dominant technologies are handheld or palmtop devices."
Wagner (2007:Online)	Learning or delivery of content that is facilitated by the use of portable technologies such as mobile phones, PDAs or iPods.
Wains & Mahmood (2008:31)	" ... a type of e-learning which blends wireless and mobile technology for the learning experience".
Wang *et al.* (2009:93)	The anytime, anywhere delivery of content to learners through Wi-Fi connections and/or mobile devices.
Winters (2006:8)	Learning that is "mediated through mobile technologies, which are in themselves interwoven with other learning tools".
Woodill (2011:184)	"... philosophical approach to the possibility of learning anytime anywhere knowing that you can find information when you need it".
Yordanova (2007:IV.23-1)	" ... learning that is wireless and ubiquitous".

From Table 3.6 it is clear that research on m-learning focuses on the mobility of devices and technologies (Sharples *et al.*, 2009:234-235; Traxler, 2007:1; Vavoula & Sharples, 2009:62; Wang *et al.*, 2009:93), but also recognises that it is the mobility of learners (Sharples *et al.*, 2009:235; Sharples *et al.*, 2007:221; Traxler, 2007:1) and their learning (Sharples *et al.*, 2007:221; Traxler, 2007:1; Vavoula & Sharples, 2009:62) that is of importance, especially in a tertiary education environment, as well as in terms of the learners' experience of learning with mobile devices (Traxler, 2007:1). According to Vavoula and Sharples (2009:62), m-learning is mostly, "defined in terms of the technology that mediates the learning experience: if the technology is mobile, so is the learning. Mobility, however, is not an exclusive property of the technology, it also resides in the lifestyle of the learner, who in the course of everyday life moves from one context to another, switching locations, social groups, technologies and topics; and learning often takes place inconspicuously or is crammed in the short gaps between these transitions". El-Hussein and Cronje (2010:17), point to the fact that the three main elements of m-learning (mobility of technology, mobility of the learner and the mobility of learning) are mutually dependent and are equally significant in making mobile devices feasible tools for the delivery of tertiary education instructional contents.

Clarke (2003:Online), suggests the following possible interpretations of the term 'mobile' as it refers to electronic devices within the context of education, namely:

- A device can be used in a different location at any given time.
- A device could be anywhere (in any location from which transmission to another device is possible).
- A device can move with its user (i.e. while walking, in a car, taxi, bus, train or plane).
- A device that is easily and conveniently portable and can wirelessly transmit data.

According to Peng *et al.* (2009:172), as well as Sotillo (2003:5), m-learning focuses on the aspects of mobility and ubiquity. Mobility and portability allows learners to explore, research, and guide their own learning when and where they want (Sotillo, 2003:5; Bradley *et al.*, 2005:Online; Chen *et al.*, 2008:77; Clarke, 2003:Online; Squire *et al.*, 2002:7), consequently increasing learners' capabilities to move their learning environment as they move (Barbosa & Geyer, 2005:282). Mobile devices can thus move with a learner (e.g. taxi, bus, train, etc.) enabling them to conquer some of the difficulties they face in gaining access to for example course material, assignments, quizzes etc. Additionally, the location independence of mobile devices allows learners to make use of their spare time while on the move to do preparation or to finish assignments (Virvou & Alepis, 2005:54), and changing the nature of learners' interaction with learning material. Ubiquity on the other hand provides learners with the power to access technologies through devices with which they are comfortable at their convenience.

Roschelle (2003:260), posits that the distinguishing feature of 'mobility' offers new applications as it "enables a transition from the occasional, supplemental use associated with computer laboratories, to frequent and integral use of portable computational technology". In addition, mobility can bridge formal and informal learning experiences (So *et al.*, 2008:108), and create a virtual collaborative learning environment between educators and learners. As opposed to immersing oneself into an environment that floods the senses with stimuli, such as that of a virtual reality experience, "the m-learner engages with the content in a constantly changing environment" (Nash, 2007:812). Should a m-learning course be designed optimally, it will take advantage of continuously changing instructional contexts or environments to allow the learner to map the content so that he/she is obligated to, "integrate the world outside with the world of material on the device in order to successfully demonstrate the achievement of learning objectives" (Nash, 2007:812). A well-designed m-learning course will bring together the learner's physical environment (which changes frequently, since it is mobile), with the concepts to be understood and processed (Nash, 2007:812). Kukulska-Hulme *et al.* (2011:159), utilise 'context' as an overarching term to cover interconnected features of mobility, as elaborated upon below:

- **Mobility in physical space:** Learners on the move trying to fit learning into available time slots, or to use these open time slots to reflect on what life has taught them. The location may be pertinent to the learning, or simply a surrounding.
- **Mobility of technology:** Portable tools and resources are available to be moved around, conveniently packaged into a single lightweight mobile device. Learners can also transfer attention across devices by moving from example a laptop, to a mobile phone, to a notepad.

- **Mobility in conceptual space:** Learning topics and themes contend for users' shifting attention. Attention shifts from one theoretical topic to another driven by personal interest, inquisitiveness or commitment.
- **Mobility in social space:** Learners perform within various social groups such as in a classroom or family context.
- **Learning dispersed over time:** Learning is a growing process that involves connections and reinforcement amongst a variety of learning experiences (Dierking, Falk, Rennie, Anderson & Ellenbogen, 2003:110) across both formal and informal learning contexts.

From the aforementioned descriptions it is evident that 'mobility' on the one hand refers to the capabilities of 'mobile' technology (i.e. mobile phones, PDAs, tablets, etc.) within the physical contexts and activities of the learners as they participate in tertiary education institutions. Conversely, it refers to activities of the learning process, and learner behaviour as they utilise mobile technology in order to learn. Furthermore, it also refers to the learner attitudes whom are themselves highly mobile as they use mobile technology for learning purposes (El-Hussein & Cronje, 2010:14).

Due to the broad scope of m-learning and the various ubiquitous mobile technologies available, this research study will refer to m-learning in a general manner with the main focus being on the utilisation of PDAs and to a lesser extent mobile phones. M-learning is therefore viewed as the utilisation of ubiquitous wireless mobile handheld technologies (PDAs and mobile phones) to facilitate, support, enhance and extend the reach of tertiary teaching and learning in a technology-based subject in a developing country, anywhere, anytime.

3.2.5 Mobile learning: Mobility of technology, - learners and -learning

As referred to in Paragraph 3.2.4, El-Hussein and Cronje (2010:17), highlight the fact that there are three main elements of m-learning, namely the mobility of technology, the mobility of the learner, and the mobility of learning, and that these three elements are mutually dependent and are equally significant in making mobile devices feasible tools for the delivery of tertiary education instructional contents. These three elements are elaborated upon in detail below:

3.2.5.1 Mobility of technology

The mobility of technology refers to the mobile nature of installed hardware and software that allows a continuous wireless Internet connection. M-learning can be viewed as a key enabler of the paradigmatic change in education of the 21st century that currently exploits handheld computers, tablets and mobile phones, as well as other devices that draw on the same functionality. According to Traxler (2007:3), m-learning using handheld computers is fairly immature in terms of its technologies and pedagogies, but is developing fast. M-learning draws on the theory and practice of pedagogies utilised in technology enhanced learning as well as those used in the classroom, and occurs as mobile devices are transforming notions of space and communication (Brown & Green, 2001:33; Traxler, 2007:2-3). Wagner (2005:40), states that, "the mobile revolution is finally here. Wherever one looks, the evidence of mobile penetration and adoption is irrefutable: mobile phones, PDAs, MP3 players, portable game devices, handhelds, tablets and laptops abound. No demographic is immune from this phenomenon. From toddlers to seniors, people are increasingly connected and are digitally communicating with each other in ways that would have been impossible to imagine only a few years ago".

In this research study, mobile technology primarily refers to PDAs and mobile phones. These mobile devices can be used to access the Internet, communicate, and deliver learning material enabling learners to learn anywhere, anytime. The mobility of these devices makes them extremely useful devices, and as a result attractive teaching and learning instruments amongst learners (El-Hussein & Cronje, 2010:17). Due to the fact that PDAs and mobile phones were used as intervention mechanisms with learners of the CPUT during the two action research cycles, these devices are elaborated upon in detail as representative of mobile devices used for m-learning.

- **Personal Digital Assistants (PDAs):** Until recently, before the arrival of tablets, PDAs have been widely used in teaching and learning environments because of its functionality and ease of use. PDAs are portable, shirt-pocket-sized, lightweight, programmable, Bluetooth-enabled, Wi-Fi–equipped mobile devices. It has touch-sensitive screens that juxtapose computing capability, Internet access, and networking features in a single system that contains a calendar, notepad, address book, and productivity tools. PDAs can synchronise with desktop computers enabling learners to synchronise important files quickly and effortlessly between the desktop computer and the mobile device itself. Smartphones used in conjunction with PDAs, enhance the basic functionality of the PDA, by enabling wireless communication properties such as IM, e-mail, and web browsing, to name just a few. PDAs are viewed as efficient organisational tools for educators that effectively support how educators work and use information in the teaching and learning environment (Pownell & Bailey, 2000[14] cited by Ray, 2005:3). PDAs have the ability to integrate a number of features and can therefore act as a holistic learning tool allowing learners to store information, retrieve up-to-date

[14] Pownell, D. & Bailey. 2000. The next small thing: Handheld computing for educational leaders. *Learning and Leading with Technology,* 26(7):46-49.

information, manage tasks, and above all, access course content and assignments, thus promoting learning. It is anticipated that the benefit of being able to complete work anytime, anywhere will not only keep learner motivation and focus high, but will facilitate an avenue to quicker restructuring of information, which is instrumental in understanding newly acquired knowledge (Vygotsky, 1978), which is also thought to be a significant part of the reflective process (Kolb, 1984).

Furthermore, it merges several computing and communication tools into a single device. For teaching and learning purposes, PDAs can be used to play audio (podcasts) and video, permit learners to open and edit text documents, access e-mail and Web content, support IM, as well as for mass storage when using a Secure Digital (SD) memory card. Moreover, PDAs support interactive, collaborative learning. Learners can use these devices to take notes in class (either by means of the screen keyboard, stylus or external peripherals), record lectures, design and develop applications, present assignments, conduct research, download information, access course related material, share content, as well as create documents and spreadsheets. What makes PDAs a popular choice in education is the fact that it has a relatively large screen (for a portable device) that facilitates easy reading. According to Cochrane (2005:152), the benefit of PDAs lies within its small size, cost and mobility/portability if compared to other computing devices. From an educational perspective, PDAs are believed to have other advantages, such as information access, learning activities support, infrared beaming support (providing learners with a simple and convenient way to share information), unconstrained by time, data transformation, communication abilities, and relatively long battery life. Infrared and Bluetooth capabilities do not only allow learners to quickly share content by “beaming” files between devices, but this process also promotes collaboration and information sharing leading to an improvement in the quality of completed work, such as written drafts and reflective discussions (Soloway, 2000:Online). Reflection is well known to support the active learning experience as it enables learners to experience, construct, test, and revise knowledge (Thompson & Jorgensen, 1989:24-26).

In addition, PDAs can be used to improve both teaching and learning. From a teaching perspective, PDAs provide communication opportunities between educators and learners 24/7. Whenever educators have information to share or learners have questions, they can effectively communicate with each other. PDAs therefore enable anywhere and anytime teaching. From a learning perspective, PDAs can undeniably assist learners more readily. PDAs allow learners to view assignments, schedules, lectures, and learning material anytime. PDAs allow learners to no longer be concerned about access to computer laboratories for completing assignments and quizzes, working through course material or accessing the Internet. In addition, PDAs can also assist learners to improve the usage of their time, because whenever learners have an open timeslot to study, they can access all their learning materials using their PDAs. These devices support cycles of doing and reflecting by encouraging learners to revisit their work more frequently (Soloway, 2000:Online).

PDAs have several advantages in facilitating collaborative m-learning environments. According to Attewell (2005:13-14), m-learning facilitates independent and collaborate learning experiences, it can help learners to stay focused for longer periods, and it can help to improve learners' self-esteem. Cobcroft (2006:57), as well as Klopfer, Squire and Jenkins (2002:95), suggest five educational affordances that PDAs and m-learning offer, namely:

- **Portability:** To take a computer to different locations and move around within a location.
- **Social interactivity:** To exchange data and collaborate with others face-to-face.
- **Context sensitivity:** To gather data that is unique to the current location, environment, and time, including real and simulated data.
- **Connectivity:** To connect mobile handheld devices to data collection devices, other handheld devices, and to a common network that creates a true shared environment.
- **Individuality:** To provide unique 'scaffolding' that is customised to the user's investigation path.

Though mobile handheld devices have proved to be an effective resource for teaching and learning, there are also as with any modern-day technology, potential problems/challenges/weaknesses/barriers associated in implementing mobile technology, particularly mobile handheld devices such as PDAs. These include factors such as the risk of theft (Dyson, Litchfield, Lawrence, Raban & Leijdekkers, 2009:260; Gregson & Jordaan, 2009:237), printing problems, inefficient input mechanisms, and small screen size (Corbeil & Valdes-Corbeil, 2007:52; 54; Crowe & van’t Hooft, 2006:106; Song, 2007:38; Rawlinson & Bartel, 2006:41; Grasso, Yen & Mintz, 2006:200; Cochrane, 2005:152; Chen *et al.*, 2008:77; Kinshuk, Suhonen & Sutinen, 2004:1581; Özdemir, 2010:35; Swan, van’t Hooft, Kratcoski & Unger, 2005:100). Furthermore, are factors such as reliability, damage, power supply (Gregson & Jordaan, 2009:237), slow data input (Swan *et al.*, 2005:100; Rawlinson & Bartel, 2006:41; Kinshuk *et al.*, 2004:1581), short battery lifetime (Corlett & Sharples, 2004:60; Rawlinson & Bartel, 2006:41; Grasso *et al.*, 2006:200; Perry, 2003:3; Chen *et al.*, 2008:77), cost of hardware and software (Gregson & Jordaan, 2009:237; Perry, 2003:3), and security (Bradley *et al.*, 2005:Online; Cochrane, 2005:152; Kinshuk *et al.*, 2004:1581). In addtion, factors such as limited storage space (Bradley *et al.*, 2005:Online; Kinshuk *et al.*, 2004:1581; Rawlinson & Bartel, 2006:41), low computational power/cability, restricted network bandwidth (Corlett & Sharples, 2004:60; Song, 2007:38; Chen *et al.*, 2008:77; Grasso *et al.*, 2006:200), Wi-Fi network security protocols, the necessity for further protocol development and support structures within institutions, stability of certain models, and new technology acceptance should be considered (Cochrane, 2005:152; Barker *et al.*, 2005:Online; Perry, 2003:15).

- **Mobile phones:** Mobile phones (also referred to as cellular phones or cell phones) are devices that can make and receive telephone calls over a radio link whilst moving around a wide geographic area. Mobile phones also support a wide variety of services such as text messaging, Multimedia Messaging Service (MMS), e-mail, Internet access, short-range wireless communications (infrared, Bluetooth), business applications, gaming and photography. Mobile phones that offer these and more specialised computing capabilities are referred to as smartphones. According to Messinger (2011:35), the benefits of using a smartphone to engage in m-learning activities include: (1) It is compact, lightweight, and easy to carry in one's pocket; (2) an overabundance of communication and computing technologies are combined in a single device; (3) it can access the Internet (go online); (4) new applications are being created daily to help support learning environments; (5) it is ubiquitous; and (6) its common operability improves overall efficiency. Despite these benefits, the drawbacks should also be noted: (1) The relatively small screen makes reading challenging, (2) text and data entry is time consuming as a result of the keyboard size, and (3) a smartphone is not as cost-effective when compared to a personal computer when taking into consideration monthly service charges and data usage fees.

  Wagner (2005:43), argues that the keen interest in mobile possibilities for teaching and learning, are mainly due to the continuing growth of broadband wireless networks, the sudden increase of power and capacity of next generation mobile phones, and the fact that mobile phones are already completely embedded in modern-day life as part of established social practice. These factors make mobile technology ideal for the collection and distribution of educational content (Cobcroft, 2006:58).

  Figure 3.6 graphically depicts the many different functions of PDAs or smartphones and how these devices can effortlessly connect to the Internet. According to Kukulska-Hulme and Traxler (2005b:1), when these devices are, "combined with wireless connectivity, learning activities can be monitored and coordinated between locations". However, there are still several challenges that need to be conquered before m-learning becomes as widely accepted as e-learning. In this respect Motiwalla (2007:594), is of the opinion that this transition will not happen overnight, since anywhere, anytime access to learning material are still only available to the minority, and it will continue to be so until wireless mobile technology becomes more affordable, sophisticated and accessible.

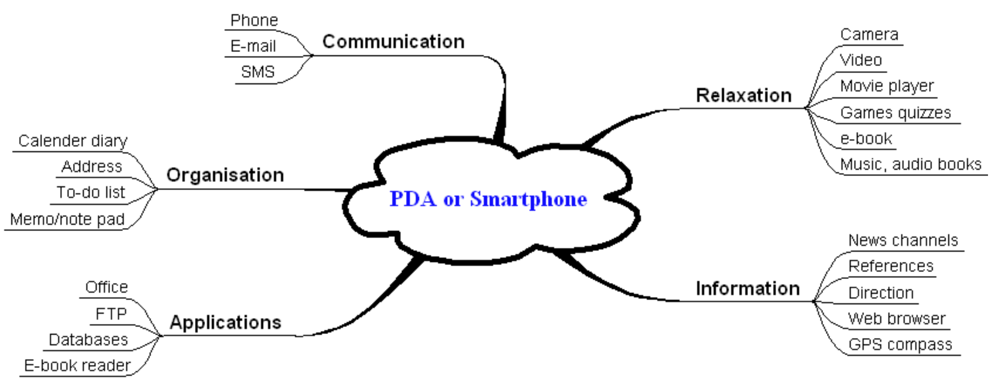

Figure 3.6: PDA or Smartphone functions
(Adapted from Trinder, 2005:7)

To summarise, mobile devices such as PDAs or smartphones, can be used in an educational setting to influence the practice and organisation for teaching and learning on the move, encourage instant collaboration/communication, conduct assessments/evaluations, and to provide access to support/knowledge (Rajasingham, 2011:7). Figure 3.7 graphically depicts the mobility/portability of mobile devices such as the PDA and the smartphone/mobile phone, in an e-learning and m-learning environment.

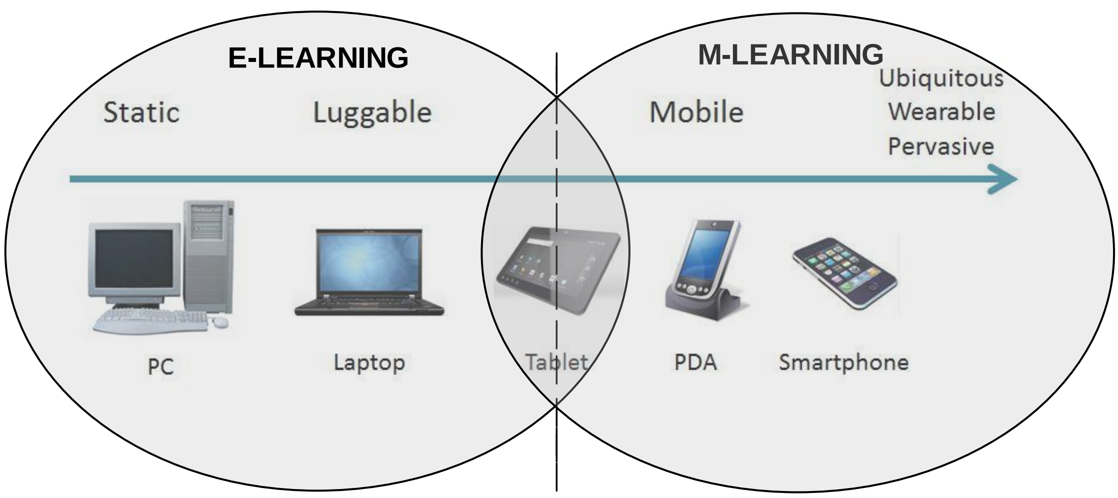

Figure 3.7: Mobility/Portability: E-learning vs. M-learning

3.2.5.2 Mobility of learners

Mobility of learners implies that learners are no longer physically attached to a specific learning location. Learners can be mobile and learn at the same time when they have access to a wireless mobile device. E-learning is mostly associated with non-mobile/non-portable personal computers that are predominantly bound by location and time. This intimates that learners must always work and learn at a specific time, and at a specific location - determined by availability and connectivity (personal computers with fixed landline Internet connections are constrained by its location). Furthermore, personal computers are too large and heavy to easily move around, forcing learners to work and learn at the same location and during the same time slots on campus.

Soloway *et al.* (2001:16), argue that desktop computers cannot be classified as 'personal' when used in formal educational settings, since it is usually shared amongst several learners. In most tertiary institutions, the majority of the computers are located in computer laboratories that are in isolation from the main setting of a learner's daily activities. In contrast, the portability of PDAs makes them truly personal and accessible, enabling m-learning across different locations and times. Some authors argue that PDAs can overcome the limitations of non-mobile/non-portable computers in the classroom (Curtis, Luchini, Babrowsky, Quintana & Soloway, 2002:23; Roschelle, 2003:260). This allows for "learner centric activity because it is both mobile and nomadic, and not pedagogically teacher-centric as in the case of traditional lectures and hardware installed in one particular location under the aegis of the university’s authorities" (El-Hussein & Cronje, 2010:18-19). Mobile learners, "are not only remote from their instructors; they also fully control the access of information on their mobile devices", allowing learners to benefit from a certain degree of freedom and independence (El-Hussein & Cronje, 2010:19).

3.2.5.3 Mobility of learning

Mobility of learning is the outcome of mobility of both the technology and the learners. This type of learning setting can either be pre-planned or opportunistic in nature. Learning can occur in flexibly timetabled sessions at home, work/university or while travelling, thus supporting “learning on the go”. "By placing mobility of learning as the object of analysis, one may understand better how knowledge and skills can be transferred across contexts such as home and school, how learning can be managed across life transitions, and how new technologies can be designed to support a society in which people on the move increasingly try to cram learning into the interstices of daily life." (Sharples *et al.*, 2005:Online).

For Walker (2007:5), m-learning is not just about the ability to successfully use a wireless mobile device, but also about the inimitable type of learning experienced by mobile learners as learning is received and processed within the context in which the learner is situated. M-leaning enables learning to occur anytime wherever learners are, providing support for effective learning and performance-based assessment.

3.2.6 Benefits and barriers of mobile learning

M-learning and mobile technologies do not only serve as a tool that can do more than promoting communication and supporting information exchange, but it also has the ability to perform various functions such as podcasting, watching videos, accessing the Internet, sending and receiving e-mail, etc. Kukulska-Hulme and Traxler (2005b:138), as well as Stead (2006:Online), postulate that m-learning can accomplish functions that other educational methods cannot fulfill. These authors believe that m-learning empowers and engages learners and it makes them more at ease to engage in discussions using mobile devices than by means of traditional educational methods. They further agree that m-learning are best suited towards a blended learning approach and that mobile devices are most effective when combined with traditional educational activities, paper-based materials, and group activities.

Other benefits of m-learning when compared to e-learning, according to Georgiev *et al.* (2004:IV.28-4), are:

- The majority of mobile devices are lower priced than desktop computers.
- Smaller in size and lighter weight than desktop computers.
- Ensures better learner engagement since m-learning is based on up-to-date technologies, which learners use in everyday life.
- GPS technology of mobile devices can offer location dependent education.

Due to the lighter weight and smaller size of mobile phones, PDAs and tablets, it can support the entire m-learning process with ease, instead of transporting files, paper and textbooks (Loomba & Loomba, 2009:56). According to McMahon and Pospisil (2005:429-430), learners will engage in learning activities at times when they normally would not have done anything else. They further explain that learners will be motivated to learn due to the attractiveness of mobile devices and the possibility of communication from places where it was previously impossible. Nikana (2000)[15] cited by Zhu, Guo and Hu (2012:18), proposes that m-learning may lead to a better understanding of learning material, and further states that learner

[15] Nikana. 2000. Co-operative group work. *Collaborative Learning,* January.

motivation may increase when utilising mobile devices. This is in view of the fact that learners are able to participate in group discussion and dialogue with their peers and educators on a more regular basis, which in turn allows for quick and valuable feedback.

Masrom and Ismail (2010:16), list several benefits provided in m-learning environments that are not present in other types of e-learning:

- **Performance support:** The m-learning performance support system integrates mobile devices with work in order to assist learners to perform tasks by providing information, guidance and learning experiences anywhere, anytime (Ryan, 2007).
- **Communication:** M-learning enables information access anywhere, anytime where it would not be possible without a mobile device.
- **Appeal:** The ability to appeal (to learn anywhere, anytime without feeling embarrassed or awkward) is critical for the learning process.

Nikana (2000) cited by Pollara (2011:22-23), lists the following potential advantages of m-learning in an educational environment:

- **Increased understanding and depth of knowledge:** Different collaborative methods and delivery approaches can lead to an increased understanding and depth of knowledge of course content amongst learners.
- **Increased learner retention:** Learner retention may increase as a result of increased learner motivation and understanding.
- **Increased motivation through discussion:** Learner motivation may increase through the utilisation of mobile devices, since learners can participate in group discussions and dialogue more frequently.
- **Quick and effective feedback:** Learners receive immediate and valuable feedback, which can strengthen learning and increase memory retention.
- **Effective assessment tool:** Mobile devices can be utilised as an effective assessment tool allowing educators to identify the level of the learner's knowledge.
- **Better articulation of learner ideas/thoughts:** Mobile devices enable learners who converse less in a classroom environment to articulate themselves and their ideas in a more comfortable manner.
- **Cost effective:** Mobile devices are relatively inexpensive if compared to the price of textbooks, desktop, or laptop computers.
- **Reinforcement:** It acts as a means of reinforcing existing material.
- **Communication:** Mobile devices have the ability to deliver course content and communication between educators and learners (Najmi & Lee, 2009).

- **Alternative views:** It allows for different perspectives to be examined and tested for effectiveness, through discussion.

In addition to the above m-learning potential advantages, Woodard (2011:Online), as well as Klopfer *et al.* (2002:95), list the following m-learning advantages:

- **Connectivity:** Learners can access learning material, podcasts and video clips from anywhere and at any time.
- **Social interactivity:** Interaction with fellow learners and educators will be of great assistance, since learning is made easier when information is shared and questions answered. This enables learners to collaborate when completing assignments, even at remote locations.
- **Portability:** Portability is a major advantage, as PDAs are compact and lightweight devices that enable learners to take notes or enter data directly onto the device.
- **Individuality:** Learners can learn at his/her own pace allowing learners who learn faster not to unnecessarily waste time going repeatedly through basic lessons.
- **Support:** Educator support can now be expected outside classrooms and other learning environments (Woodard, 2011:Online).
- **Fewer expenses:** M-learning allows for a reduction in learning material as well as travelling expenses (Woodard, 2011:Online).

Attewell (2005:13), recognises the following benefits of m-learning, which can be summarised as follows:

- M-learning helps learners to identify the areas where they need assistance and support.
- M-learning helps to combat resistance to the use of ICT, and can help bridge the gap between mobile phone literacy and ICT literacy.
- M-learning helps to remove some of the formality from learning experience and engage reluctant learners.
- M-learning helps learners to remain focused for long periods.
- M-learning helps to raise self-esteem and self-confidence.

Conversely, a major challenge in m-learning and mobile technology use is the inability to keep up with ever increasing advances in technology. Technology is progressing so rapidly that one is yet to comprehend the educational possibilities of advanced mobile devices such as smartphones, the use of personal mobile devices for educational purposes, informal learning that presently exists in the classroom, and the results of full-scale initiatives or longitudinal studies (Pollara, 2011:25). Traxler (2009:3), states that "there are still significant challenges of scale, sustainability, inclusion and equity in all their different forms in the future, and of context and personalisation in all their possibilities, of blending with other established and emerging educational technologies and of tracking the changes in technology".

The most common barriers to the use of m-learning according to Masrom and Ismail (2010:19), are a combination of technical and education challenges, which include end-user cost, a lack of knowledge about technology and software, complexity to set up a m-learning system, no time to learn how to use the device, technology failure, loss of personal touch, multiple standards (i.e. screen size, operating systems, input medium), narrow bandwidth, repurposing existing e-learning for mobile device usage, convenience requirements, measuring learning outside the boundaries of the classroom, tracking of results, as well as privacy and data protection. Masrom and Ismail (2010:20-22), categorise these barriers as technological constraints, a fragmented learning experience, lack of well-developed meta-cognitive skills, screen size, costs, and security. Woodard (2011:Online), expands on these m-learning barriers by adding limited storage capacity, short battery life, devices becoming outdated quickly and learners have to keep fighting obsolescence, as well as the inability of printing learning material, simply because it requires a network connection.

Figure 3.8 is representative of a conceptual diagram consisting of three main constructs, namely benefits, barriers, and m-learning use that contrast benefits of m-learning with their barriers and m-learning use.

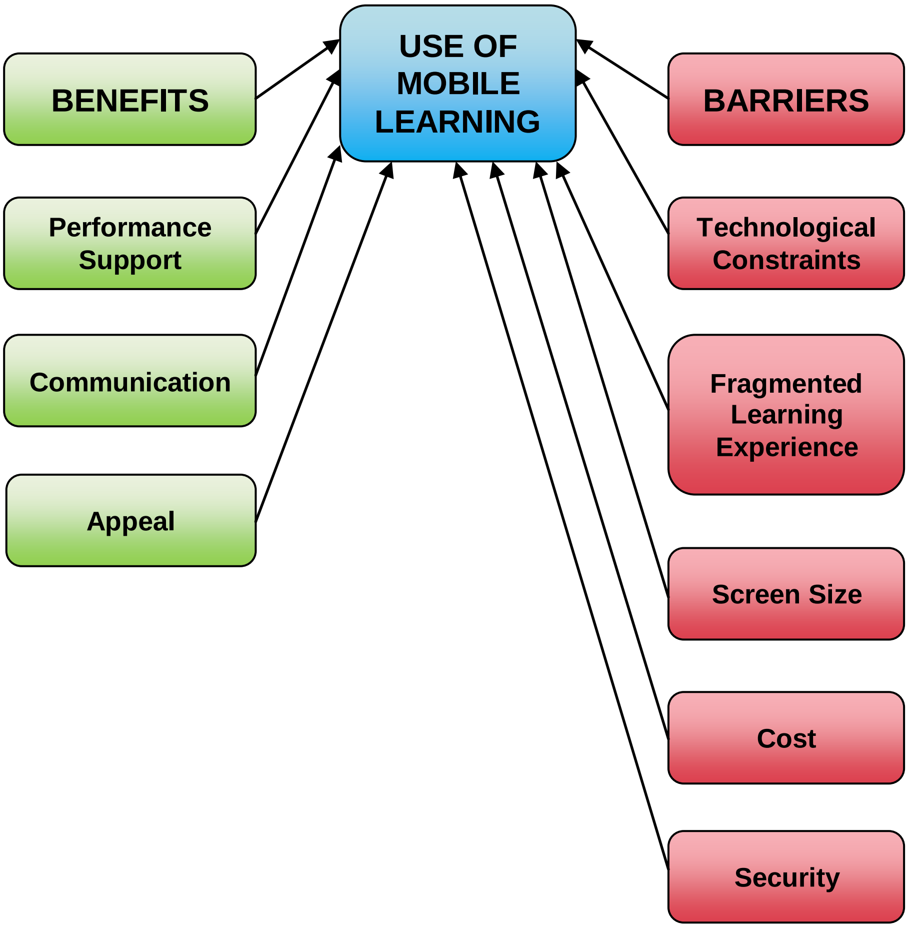

Figure 3.8: The benefits and barriers of m-learning
(Adapted from Masrom & Ismail, 2010:22)

Dieterle, Dede and Schrier (2007:39), are concerned that the personal nature of mobile devices may hamper collaboration by isolating learners from meaningful social interactions, however most learners use mobile devices as their main communication tool to make phone calls, send and receive text messages and e-mail, as well as communicating via social networks. In order for small-scale pilots to institution-wide mobile teaching and learning implementation to be successful, Naismith *et al.* (2004:4) have identified the following key issues:

- **Context:** Learner anonymity and privacy may be influenced when gathering and utilising contextual information.
- **Mobility:** M-learning offers anywhere, anytime access to teaching and learning activities, both inside and outside the classroom, which in turn poses challenges to usual teaching practices.
- **Learning over time:** Effective tools are required by lifelong learners to reflect on their m-learning experience.

- **Informality:** M-learning encourages informal learning, which in turn can make m-learning lose its benefits if it is too widespread.
- **Ownership:** Mobile devices offer personal control and ownership in order to support personal and group learning. Personal ownership is essential to commitment and engagement, but poses challenges when learners bring their mobile devices to the classroom.

Naismith and Corlett (2006:Online), have broadened the aforementioned critical success factors and identified the following five critical success factors for successful m-learning:

- **Access to technology:** Mobile technology should be available anywhere, anytime. This can be achieved by either developing specialised software for learners' personal mobile devices, or by providing learners with mobile devices that can be used at home or while commuting.
- **Ownership:** Learners should either own the technology, or treat it as if it was their own. It has been found that when learners use mobile technology for entertainment and socialising purposes, it does not appear to lessen its value as a learning tool, but rather aid in bridging the gap between institutional and personal learning.
- **Connectivity:** It is important to make available wireless or mobile phone connectivity that provides access to learning resources, links learners across contexts, and allows learners to capture material that can be published on a personal media space to be presented or shared.
- **Integration:** M-learning should be incorporated into the curriculum, the learner experience into a learner's everyday life, or a combination of all of these. This can be achieved by expanding a successful form of learning onto mobile devices, or to provide mobile technology that enhances the learner experience.
- **Institutional support:** M-learning projects need strong institutional support that includes aspects such as the design of relevant resources in mobile format, staff training and technical support.

3.2.7 Theoretical perspectives on mobile learning

If mobile devices are applied and used effectively, it can help change and refocus pedagogies. The affordances of mobile devices allow for the transformation of learning activities, and this 'pedagogic shift' has a distinctly social element. Even though learning remains an individual activity, the context in which it occurs is based around 'conversations' (Belshaw, 2011:23).

M-learning is a relatively new field of research and its theoretical and philosophical foundations have not yet been established (Muyinda, 2007:97). Therefore, the construction of underlying theories is still emerging. The vast amount of functionality and the size of mobile devices permit for an assortment of different learning activities, however according to Traxler (2009:6), this makes the construction or specification of a m-learning theory especially challenging. According to Naismith *et al.* (2004:19), there is no concrete, “theory of mobile learning”, and the authors argue that m-learning can relate to more than one learning theory. However, there is a mechanism to integrate the use of mobile technologies with existing theories of learning into different approaches. There are several learning theories in the literature of which informal learning and constructive learning are the most popular ones that are most relevant to m-learning. Sharples *et al.* (2007:221), identified four criteria that need to be satisfied in order to formulate a theory of m-learning, namely:

- To identify what is different about mobile and other types of learning.
- To account for learning that occurs outside the classroom environment.
- To base m-learning on current identified learning practices such as being learner, knowledge assessment, and community centred.
- To account for the widespread use of mobile devices.

Learning occurs through interaction with others, and because this type of learning can happen anytime and anywhere, much of m-learning takes place as informal learning. Constructive learning is based on the idea that people learn by constructing new ideas based on their current and past knowledge. Thus, learning involves constructing one’s own knowledge from one’s own experiences. Learners therefore motivate themselves during the learning process.

The most relevant m-learning approach to be applied within the context of this study is the 'blended learning approach'. This learning approach represents the opportunity to integrate the innovative and technological advances offered by e-learning with the interaction and participation from traditional learning (Thorne, 2003:16). Naismith *et al.* (2004:32), emphasise that the blended approach facilitates learning with mobile technologies. The blended learning approach engages different activities from a number of different theories and practises. A review of relevant m-learning projects indicates that successful and effective projects did not exclusively use mobile devices in order to enhance learner learning, but followed a blended learning approach by using mobile devices in conjunction with fixed technologies. Mobile devices should be used to complement fixed technologies rather than to replace it (UNESCO, 2012a:33).

In an attempt to consolidate the m-learning domain, a number of authors have demonstrated how existing theories of learning could be used to evaluate the applicability of mobile technology in the educational context. In a literature review on mobile technologies and learning Naismith *et al.* (2004:18), have identified a number of examples of how mobile technology can be appropriated in a learning context from a behaviourist, constructivist, situated, collaborative, informal and lifelong learning, as well as teaching and learning support perspectives. This dispensation is graphically depicted in Figure 3.9 and further elaborated upon in Table 3.7.

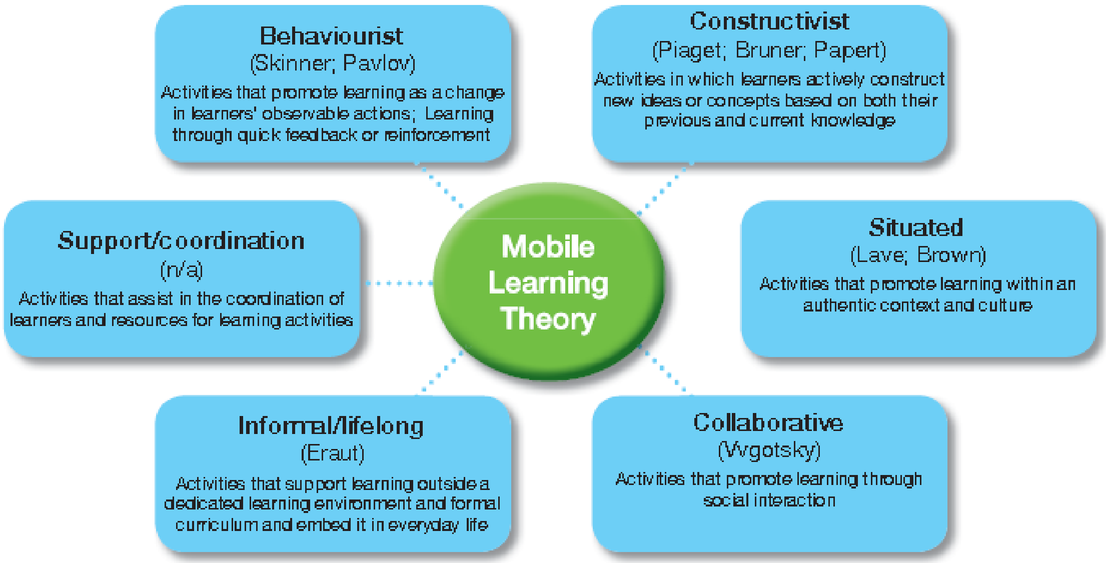

Figure 3.9: An activity-based categorisation of learning that can apply to mobile technologies (Adapted from Schofield, West & Taylor, 2011:25)

Table 3.7: An activity-based categorisation of mobile technologies and learning (Adapted from Naismith *et al.*, 2004:18)

Theme	Key Theorists	Definition	Focus	Activities
Behaviourist learning	Skinner, Pavlov	Activities that promote learning as a change in learners' observable actions.	Information and content delivery in m-learning	• Drill and feedback • Classroom response systems (text messages)
Constructivist learning	Piaget, Bruner, Papert	Activities in which learners actively construct new ideas or concepts based on their previous and current knowledge.	Information and content delivery in m-learning	• Participatory simulations • Mobile investigations • Games

Situated learning	Lave, Brown	Activities that promote learning within an authentic or context aware context and culture.	Social context and social participant dependent m-learning	• Problem and case-based learning • Context awareness
Collaborative learning	Vygotsky	Activities that promote learning through social interaction.	Collaboration and interaction dependent m-learning	• Mobile Computer-Supported Collaborative Learning (MCSCL) • Additional means of communication and instant e-information gathering and sharing
Informal and lifelong learning	Eraut	Activities that support learning outside a dedicated learning environment and formal curriculum.	Information and interaction with educational content in informal m-learning setting Lifelong information and interaction with educational content in m-learning	• Supporting intentional and accidental learning episodes • Extensions to the classroom, ability to access information anytime, anywhere, self-selection of learning opportunities
Learning and teaching support	N/A	Activities that assist in the coordination of learners and resources for learning activities.		• Personal organisation • Accessing data, managing schedules, access to materials • Support for administrative duties (i.e. attendance monitoring)

The notion that learning can be created by means of interaction is the primary theme of the 'Constructivism' learning theory. This theory over time developed into ‘Constructionism’, which highlights the value of experiential learning and the creation of learning objects (Belshaw, 2011:23). Several authors also recommend 'Conversation' theory (Pask, 1976:11; Sharples, 2000:180; Sharples, Corlett & Westmancott, 2002:224; Laurillard, 2007:153) and social constructivism (Brown & Campione, 1996:289-325; Brown, 2005b:300; 306), as appropriate theories, which can be applied to mobile environments, since it allows individualised communication and collaborative learning (Palloff & Pratt, 2001a:3; 2001b:Online). The ruling principles of Connectivism (Siemens, 2004:Online) and Navigationism (Brown, 2005a:9) have also been recommended as possible theories applicable to mobile environments due to the fact that people are gradually learning more through communities of practice, personal networks and work-related tasks. In addition, there is an emphasis on knowing when and where to access knowledge (Siemens, 2005:8). The Connectivist theory states that, “knowledge is distributed across a network of connections, and therefore that learning consists of the ability to construct and traverse those networks” (Downes, 2012:9).

Activity theory (Engeström, 2001:137), where the technology is perceived as a tool to mediate human activity, is considered the most appropriate pedagogical underpinning theory for this research study, as the theory is also associated with m-learning (Sharples *et al.*, 2005:Online; Traxler, 2009:6). Table 3.8 provides context to the various theories and their appropriateness to the concept of m-learning.

Table 3.8: Mobile learning theories
(Adapted from Keskin & Metcalf, 2011:203-205)

Theme	Definition	Focus	Example
Cognitivist learning	Learning is the acquisition or reorganisation of the cognitive structures through which humans process and store information (Good & Brophy, 1990)	**Information and content delivery in m-learning** Using multimedia learning (Dual code, Cognitive Load Theory): Images, audio, video, text, animation	• Multimedia (text, video, audio, animation, images) • SMS, MMS, e-Mail • Podcasting • Mobile TV
Problem-based learning	Learning aims to develop learners' critical thinking skills by giving them an ill-defined problem that is reflective of what they would encounter as a practicing professional (Koschmann *et al.*, 1996)	**Problem-based context and solved-based content dependent m-learning** • Problems – Solutions • Case centred activities • Collaborative social interaction	• Medical education • Business administration • Nursing • Simulations • SMS • MMS • Voice response systems
Context awareness learning	Gathering information from the environment to provide a measure of what is currently going on around the learner and the device (Naismith *et al.,* 2004)	**Context awareness in m-learning** • Context-dependent content management • Contextual event notification • Context-aware communication • Navigation and retrieval of learning materials • User interface adapted according to time and location contexts	• Multimedia museum and gallery • Pre-class podcasts • Films • e-books • Podcasting
Socio-cultural theory	Learning occurs first through interpersonal interaction with social environment than intrapersonal (internalisation) (Vygotski, 1978)	**Social context and social participant dependent m-learning** • Mobile experts • Community of practice • Workplace learning • Mobile communication	• Mobile performance support system • Virtual experts • Mobile forum • E-mail • Social network (Web 2.0 tools)
Conversational learning	Learning is in terms of conversations between different systems of knowledge (Sharples, 2002)	**Interaction and communication dependent m-learning** • Solving a problem • Exploring an environment • Communication between peers via mobile phones	• Laboratory classes • Field trips • Mobile computer supported collaborative learning • Calling, Interactive Voice Response (IVR)

Activity theory	Learning occurs with three features - involving a subject (the learners), an object (the task or activity) and tool or mediating artefacts and human behaviour is situated within a social context that influences their actions (Vygotsky, 1978)	**User actions in social context dependent m-learning** • Active participation • Social context • Activities	• Museum Art Gallery exhibit via SMS, polls, calling • Mobile games • Multimedia
Connectivism	Learning is a process of connecting specialised nodes or information sources (Siemens, 2004)	**Diversity of information sources in m-learning** • Connecting specialised nodes • Information sources • Facilitate continual learning environment • Knowledge management activities • Decision-making	• Social networks (Blogs, Wikipedia, Twitter, YouTube) • Podcasting • E-mail • Mobile Forums • Discussion Platforms
Navigationism	Learning is a process of connecting specialised nodes or information sources (Brown, 2005)	**Complex of information sources in m-learning** • Connecting specialised nodes • Information sources • Facilitate continual learning environment • Knowledge management activities • Decision-making • Manage information (identify, analyse, organise, classify, assess, evaluate, etc.) • Sense making and chaos management	• Social networks (Blogs, Wikipedia, Twitter, YouTube) • Podcasting • E-mail • Mobile Forums • Discussion Platforms
Location-based learning	Location-based learning holds promise for just-in-time learning tied to a learner's physical location (Johnson *et al.*, 2009)	**Location context in m-learning** • Conceptual knowledge • Conceptual application • Constructive environment • Partnership with location • Immersive activities	• Field trips • Archaeology studies • Location based games • Virtual world • Google Map, GPS, Radio Frequency Identification (RFID), network triangulation

For the purpose of this research study a blended learning methodology was adopted, where traditional face-to-face classroom teaching and learning is combined with computer-mediated activities, such as m-learning and online learning. This methodology has the potential to offer many sources to learners (Tayebinik & Puteh, 2012:105), and includes a mixture of tools for simulating and maximising learners' learning potential. According to Azizan (2010)[16] cited by Tayebinik and Puteh (2012:105), technology utilisation in traditional classrooms provide

[16] Azizan, F.Z. 2010. Blended Learning in Higher Education Institutions in Malaysia. *Proceedings of the Regional Conference on Knowledge Integration in ICT*.

additional resources for learners, which in turn can result in the improvement of learner confidence, competence, as well as their learning potential.

3.2.8 Empirical research on mobile learning

The extended capabilities of mobile technology have created a rising interest in m-learning research, and in view of the fact that mobile phones are now entirely part of our daily lives and social practices (Wagner, 2005:42), researchers are examining the potential of mobile technology to support teaching and learning. Traxler (2009:4), postulates that even though m-learning was previously considered only a subsidiary of e-learning, worldwide research and initiatives are changing the way in which m-learning is understood.

According to Pollara (2011:22), m-learning research is limited and often only focuses on a one-time classroom activity or project that appears to focus specifically on learner perceptions and learning pertaining to a, "specific intervention, largely ignoring large-scale mobile learning initiatives, the potential for infusion into classes as an academic tool for any subject, and informal learning that is already being done by students on personal devices" (Pollara, 2011:28).

The following paragraphs will provide a summary of the most recent m-learning studies with specific reference to learner perceptions of m-learning and learner learning with mobile technology.

3.2.8.1 Learner perceptions of mobile learning

Several m-learning research studies present encouraging results for mobile technology utilisation for teaching and learning support (Kennedy, Krause, Judd, Churchward & Gray, 2008:108-120; Kukulska-Hulme, Traxler & Pettit, 2007:52; Yordanova, 2007:IV.23-1; IV.23-6). Pollara (2011:28), is of the opinion that if mobile devices can be incorporated in conventional teaching and learning, it should first be determined whether learners can, will, and wish to use these devices for educational purposes. Some authors (Aker, Ksoll & Lybbert, 2011:5; Kong, 2012:172; Lindquist, Denning, Kelly, Malani, Griswold & Simon, 2007:384; Mellow, 2005:470; Shuler, 2009:5; Valk, Rashid & Elder, 2010:Online), are of the opinion that mobile devices may enhance communication, learners' learning experience and knowledge understanding in different subject areas through expanding access, promoting efficiency, improving the quality of learning, and in turn promoting lifelong learning skills. Conversely, there are authors in the likes of Cramer and Hayes (2010:41), Curran, Middleton and Doherty (2011:57), Gerard (2006:43) and Prensky (2005:Online), who believe that mobile devices can be disapprovingly used by learners for cheating or non-educational use, and that it can also be too personalised, potentially making learners feel unfavourable to using them if its use is mandatory in the classroom.

Table 3.9 provides a holistic overview of 30 research studies conducted over the past five years (2008-2012), that primarily investigate learner attitudes and perceptions toward m-learning, as well as learner engagement and performance while utilising mobile phones and/or PDAs/tablets, in an educational environment. Shaded areas are adapted from Pollara (2011:28-31).

Table 3.9: Recent research on learner attitudes and perceptions toward mobile learning using mobile phones and/or PDAs
(Partially adapted from Pollara, 2011:28-31)

Author (year)	**Technology used**	**Perceptions identified in the research study**	**Outcome(s) measured**	**Results/ Conclusion**
Al-Fahad (2009)	Mobile phone	• Learners found m-learning to be effective and embraced the technology. • Learners noted portability.	Attitude	Positive
Bottentuit Junior & Coutinho (2008)	Mobile phone	• 39% of learners have heard about the term 'm-learning'. • 25% reported using a mobile device for some sort of learning. The majority believed in the educational value of mobile devices and would prefer using it in the classroom. • Learners were positive towards the utilisation of mobile technology in the future - anytime, anywhere.	Attitude Engagement	Positive
Bunce & Reid (2009:25)	Mobile phone Netbook	• Contributed to learners' development of enquiry skills including: communication, collaboration, questioning, reflection and self-management of learning.	Engagement	Positive
Cavus & Ibrahim (2009)	Mobile phone	• Learners felt that m-learning brought better flexibility to their learning. • Learners found the system enjoyable and their interest in utilising mobile phones assisted them in learning new words. • Learners requested m-learning to be used in other classes as well.	Attitude Performance	Positive
Cavus & Uzunboylu (2009)	Mobile phone	Learner attitudes toward the usefulness of a MLS improved by the end of the experiment.	Attitude	Positive

Clarke, Keing, Lam & McNaught (2008)	Mobile phone	• 84% of learners found the use of the SMS to be useful in teaching and learning. • 83% enjoyed it. • Learners viewed this as the preferred method of communication due to its convenience and portability.	Attitude Engagement	Positive
Cochrane & Bateman (2010:5; 9)	Mobile phone	• Smartphones have the capacity to facilitate learner-centred social constructivist pedagogies. • Learners indicated that the choice of smartphone was critically important in the acceptance of its use in m-learning. • M-learning increased learner engagement.	Attitude Engagement	Positive
De-Marcos, Hilera, Barchino, Jimenez, Martinez, Gutierrez & Oton (2010:1069)	Mobile phone	• Statistically significant impact on attainment for younger learners (aged 14-15 years) • Learners found the experience to be positive.	Attitude Performance	Positive
Dyson *et al.* (2009:262)	PDA	• M-learning can support active, educational experiences through fieldwork and by teaching learners about mobile technology. • Improve the learning experience of learners in large lectures allowing interaction with the educator and their peers. • Make learning more interesting and fun.	Attitude Performance	Positive
Guenter, Winkler, Ilgner & Herczeg (2008)	PDA	Learners reported a high level of competence with handling mobile devices.	Attitude	Positive
Hartnell-Young & Heym (2009:Online)	Mobile phone	Learners reported that they enjoyed the m-learning project and that their involvement motivated them to use mobile phones as an educational tool.	Attitude	Positive
Herrington (2009:28; 34)	Mobile phone	• Learners saw the affordances of multimedia available on smartphones as powerful enablers for teaching and learning tasks. • Learners highlighted the benefits of mobile technology for use in spontaneous contexts across time and space.	Attitude Engagement	Positive
Hlodan (2010:682)	Smartphone (iPhone)	• Mobile devices engage learners and promote learning. • Measurable improvement of learner performance.	Performance	Positive

Hsu, Wang & Comac (2008)	Mobile phone	• 76% of learners found it easy to audioblog, 76.4% preferred audioblogs to audiotapes. • 82.41% believed it was a good language learning tool. • 64.7% reported stronger confidence in using English.	Attitude Engagement Performance	Positive
Iqbal & Qureshi (2012:159)	Mobile phone PDA	Learners have shown a keen interest in mobile technology utilisation.	Attitude	Positive
Li, Pow, Wong & Fung (2010:179)	Tablet	There was a shift to self-regulated learning. Learners were motivated and developed high levels of IT competence.	Attitude Performance	Positive
Liaw, Hatala & Huang (2010:446)	PDA	M-learning enhances learners' satisfaction, encourages learners' autonomy and enriches interaction and communication activities.	Attitude	Positive
Lu (2012:34)	Mobile phone PDA	The majority of the participants totally agree with the usage of mobile devices.	Attitude	Positive
Messinger (2011:xviii)	PDA	• Learners demonstrated a keen interest in m-learning. • Learners believe mobile technology will increase motivation, improve overall performance levels, and generate a more positive teaching and learning culture.	Attitude	Positive
Morrone, Gosney & Engel (2012:1-3)	Tablet (iPad)	• Promoted learner engagement in the classroom, the lab, or the field. • Learners more interested in learning tasks and as a result tend to spend more time and effort on them. • Learners enjoyed using a different medium of technology and found it exciting, helpful and interesting to use.	Attitude Engagement	Positive
Nortcliffe, Middleton & Woodcock (2011:Online)	Mobile phone	• Learners appreciated feedback given by means of smartphone audio applications.	Attitude	Positive
Pollara (2011:viii)	Mobile phone	• Learners reported that they are performing a wide variety of educational tasks using mobile devices. • Learners are of the opinion that a more formal use of mobile devices both inside and outside the classroom could be beneficial. • Learners believe that it would be easy to use mobile devices for educational purposes. • Learners feel ready to adopt the use of mobile devices for learning.	Attitude Engagement	Positive

Rogers, Connelly, Hazlewood & Tedesco (2010)	PDA	Learners were excited and have shown interest in m-learning activities.	Attitude Engagement	Positive
Perkins & Saltsman (2010:47)	Smartphone (iPhone)	• Learners were positive about the overall success and impact of m-learning. • Significant positive findings were observed for dimensions of learner engagement.	Attitude Engagement	Positive
Stoica (2008:47; 49)	PDA	• 91% of the learners agreed that PDAs can be used for educational purposes. • 67.50% mentioned that they like to use PDAs for university lessons. • Increased learner interest. Motivated learners to study more. • Provided a more easy and quick way of accessing information. • Kept learners focused.	Attitude Engagement	Positive
Uzunboylu, Cavus & Ercag (2009)	Mobile phone	• The majority of learners enjoyed using the mobile devices for teaching and learning. • Learners recognised the potential use of mobile technologies for teaching and learning in any subject and the importance of using discussion tools in m-learning.	Attitude	Positive
Wang, Shen, Novak & Pan (2009)	Mobile phone	• Learners demonstrated a keen interest in m-learning. • Learners unexpectedly provided open feedback to the educator in a class forum. • Learners were satisfied with m-learning activities conducted in class.	Attitude Engagement Performance	Positive
Woodcock, Middleton & Nortcliffe (2012:13)	Mobile phone	Learners demonstrated an appreciation towards the benefits and the further possibilities that exist within m-learning.	Attitude	Positive
Wyatt *et al.* (2010:113)	PDAs	Little change in PDAs, however learners did see the benefits as resources or collaborative learning tools.	Attitude Performance	Positive
Zhu *et al.* (2012:50)	N/A	• Learners are positive towards the use of m-learning. • Learner acceptance was determined by their attitudes and the usefulness they perceived.	Attitude	Positive

From the research studies described above (Table 3.9), it is clear that m-learning encompass all sectors of education and that there are several themes and features worth noting. The most important are that learners' perception of m-learning when utilising mobile phones and/or PDAs in general, have been found to be positive in a teaching and learning environment. Research indicate that m-learning result in a keen interest amongst learners, and prove that learners recognise the potential of m-learning as new mobile technologies are integrated into teaching and learning. Several learners indicated that m-learning creates more interest in the learning process amongst learners. Furthermore, learners demonstrate a positive attitude towards m-learning integration into the classroom and found learning with mobile devices to be an easy and pleasant experience. These positive experiences can encourage learner participation and the acceptance of m-learning. Some learners found the use of mobile devices to be convenient and that it allowed them flexible and portable/mobile learning, however if additional personal expense was required from learners to perform their teaching and learning tasks, it would act as a deterrent.

3.2.8.2 Learner learning with mobile technology

One question educators often ask is whether learners can learn effectively and efficiently when utilising mobile devices. Table 3.10 summarises 18 research studies conducted over the past five years (2008-2012), that highlights the benefits of learner learning outcomes or processes by utilising mobile phones and/or PDAs/tablets in an educational environment. Shaded areas are adapted from Pollara (2011:33-35).

Table 3.10: Recent research on learner learning and mobile devices
(Partially adapted from Pollara, 2011:33-35)

Author (year)	Technology used	Benefits identified in the research study	Outcome(s) measured	Results/ Conclusion
Alemi *et al.* (2012:99)	Mobile phone	Improvement in learner performance.	Performance	Positive
Begum (2011:105)	Mobile phone	Mobile phone has great potential as an instructional tool allowing learners to promote their learning.	Performance	Positive
Al-Fahad (2009)	Mobile phone	Learners became active and not passive learners.	Attitude	Positive
Cavus & Ibrahim (2009:78; 88)	Mobile phone	Learner enjoyed using the system and their interest in utilising mobile phones assisted them in learning new words.	Attitude Performance	Positive
Cavus & Uzunboylu (2009)	Mobile phone	• Links critical thinking skills with m-learning and predicts that critical thinking skills increase when learners are engaged in m-learning. • Learner creativity improved.	Attitude	Positive
Chen *et al.* (2008:77)	Mobile phone PDA	M-learning can enhance academic performance, task accomplishment rates, and learning goals achievement rates.	Performance	Positive

Clarke *et al.* (2008:6139)	Mobile phone	Learners found the use of mobile phones and the SMS to be useful in teaching and learning.	Attitude	Positive
Dyson *et al.* (2009:262)	PDA	Improved the learning experience of learners in large lectures allowing interaction with the educator and their peers.	Attitude Performance	Positive
Guenter *et al.* (2008)	PDAs	Multi-modal and multisensory experiences, high level of collaboration, control over learning process.	Attitude	Positive
Hlodan (2010:682)	Smartphone (iPhone)	Promoted learning and indicated an improvement in learner performance.	Performance	Positive
Hsu, Wang & Comac (2008)	Mobile phone, telephone	Increased understanding of content.	Attitude, Engagement Performance	Positive
McConatha, Praul & Lynch (2008)	Web enabled mobile phones	Learners who used mobile technology scored higher than those who used traditional methods of study.	Performance	Positive
Morrone *et al.* (2012:1-3)	Tablet (iPad)	Learners changed from passive to active learners.	Attitude Engagement	Positive
Ozcelik & Acarturk (2011:2083)	Mobile phone	Learners in the paper-plus-mobile phone condition had higher retention test scores than the participants in the paper-plus-computer condition.	Performance	Positive
Stoica (2008:49)	Mobile phone	Motivated learners to study more.	Attitude Engagement	Positive
Wang *et al.* (2009)	Mobile phone (text messages)	Learners changed from passive to active learners.	Attitude, Engagement Performance	Positive
Wyatt *et al.* (2010)	PDA	Enhanced collaborative learning process.	Attitude Performance	Positive
Zhang *et al.* (2011:203)	Mobile phone	Improvement in performance.	Performance	Positive

All of the abovementioned studies address the benefits of learner learning associated with the use of m-learning. As elaborated upon earlier in this chapter, Naismith *et al.* (2004:18), have identified a number of examples of how mobile technology can be appropriate in a learning context however, in the studies analysed, learning tasks were found to be behaviourist, constructivist or a combination of the two. Learners mostly utilised mobile technology for interacting with learning content, the educator and other learners. The researcher found that the majority of the studies focus on the use of mobile phones and PDAs (as reflected in Table 3.9 and Table 3.10), while only a few focus on the use of iPods or other mp3 players for teaching and learning purposes. Research indicates that learners became more excited, engaged, and active learners during the learning process when utilising m-learning.

3.3 Conclusion

In this chapter, a literature review on m-learning was conducted and the following analogies can be drawn:

- Despite several m-learning barriers (i.e. small screen, limited storage capacity, fragility, batteries have to be charged regularly, technology failure, input medium, cost, complexity to set-up a m-learning environment), m-learning by far has more key advantages, which include the ability to allow learners to learn anytime, anywhere, and at their own pace. M-learning furthermore provides more rapid and convenient communication, quick access to a variety of educational sources, portability, motivation as well as support.
- M-learning consists of three main elements, namely the mobility of technology, the mobility of learning and the mobility of the learner, which are mutually dependent and are equally significant in making mobile devices feasible tools for teaching and learning.

In the next chapter, a literature review on m-learning in developed and under-developed countries will be conducted on the primary theme of the thesis, and once again provide an empirical underpinning to the research problem.

CHAPTER FOUR

MOBILE LEARNING IN DEVELOPED AND UNDERDEVELOPED COUNTRIES - A LITERATURE REVIEW

SYNOPSIS

In this chapter a literature review will be conducted on m-learning in both developed and underdeveloped countries mapping the primary theme of the thesis being m-learning as a paradigmatic mechanism within a technology-based subject, providing an empirical underpinning to the research problem.

The contents of Chapter 4, along with the relative positioning of the topics, are graphically depicted in Figure 4.

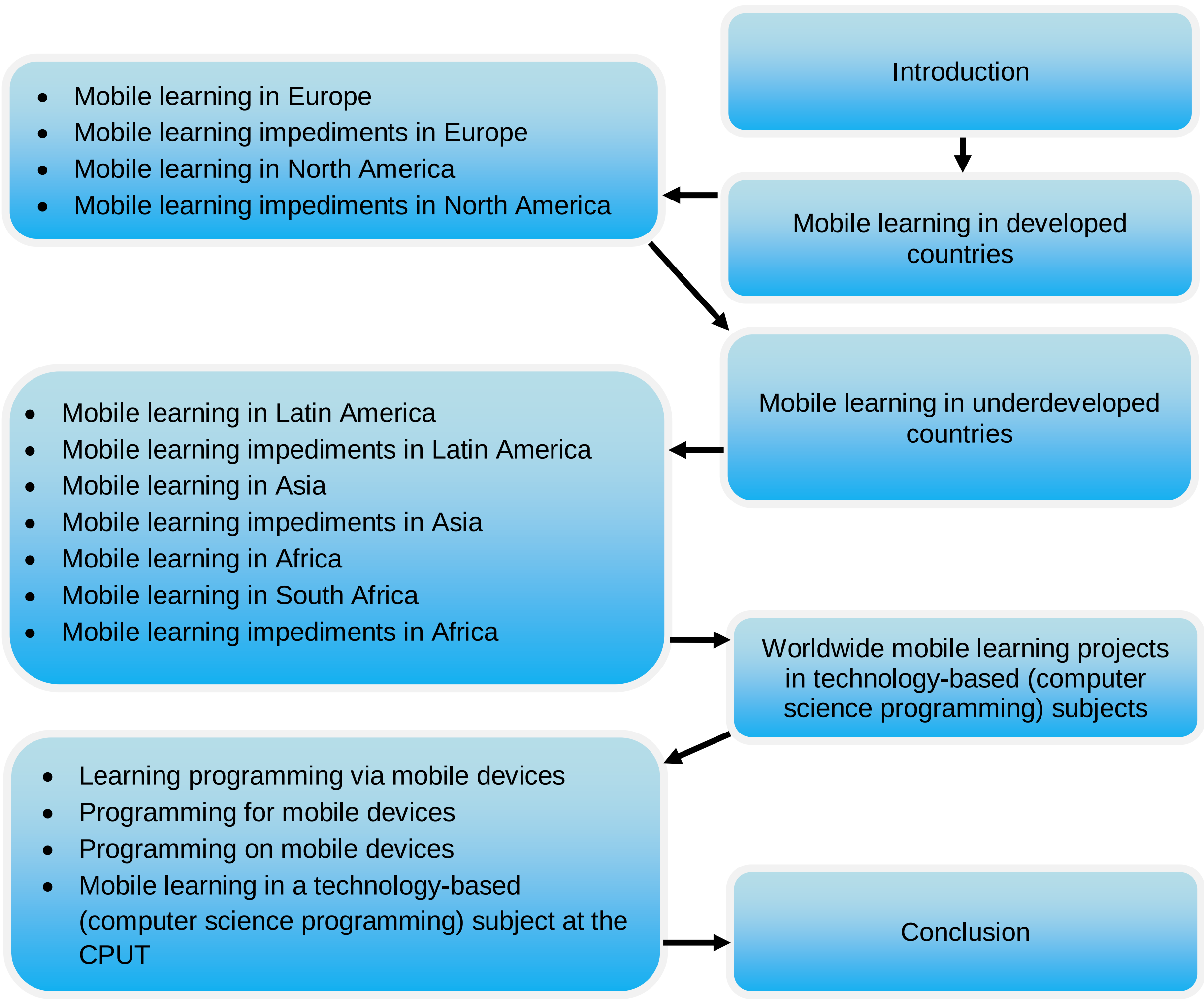

Figure 4: Detailed layout of Chapter 4 - Mobile learning in developed and underdeveloped countries - A literature review

4. CHAPTER FOUR

MOBILE LEARNING IN DEVELOPED AND UNDERDEVELOPED COUNTRIES - A LITERATURE REVIEW

4.1 Introduction

The analytical process followed thus far is graphically depicted in Figure 4.1, placing the chapters in context with the overall thesis objectives, and furthermore indicating the relative positioning of this chapter.

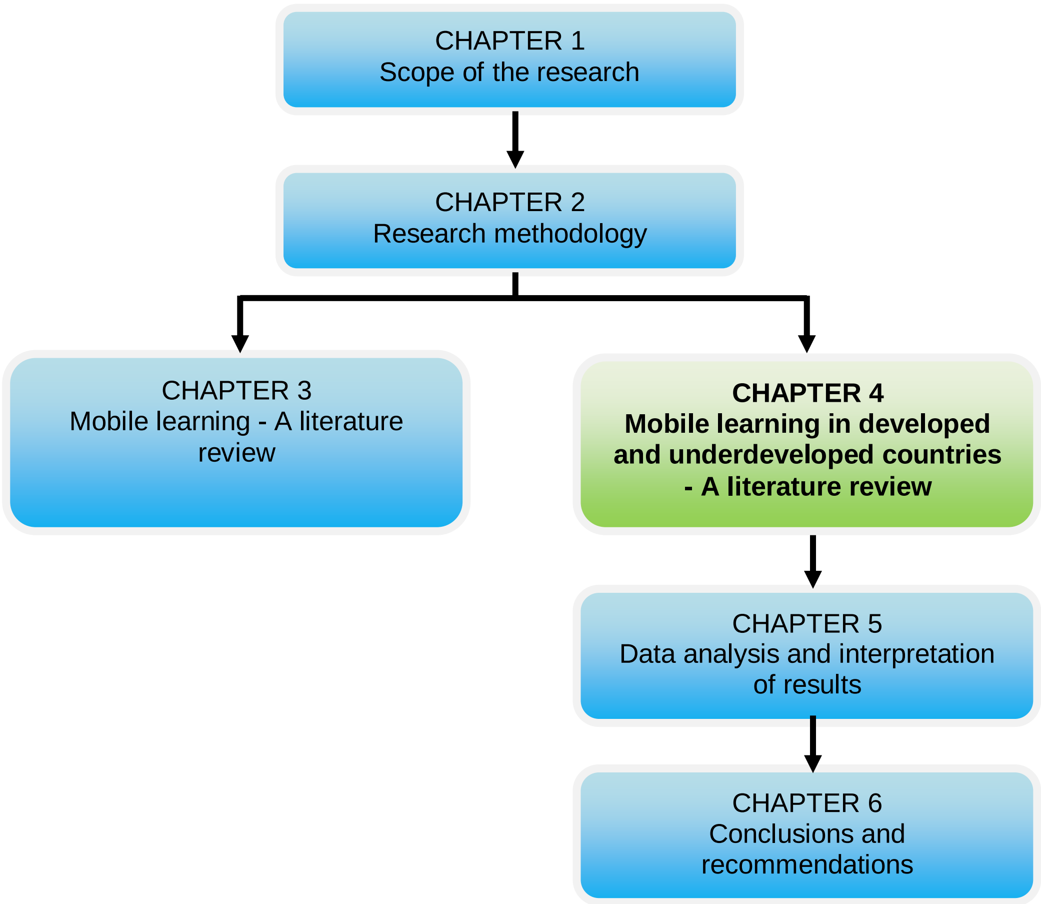

Figure 4.1: Chapter 4 - Mobile learning in developed and underdeveloped countries - A literature review

This chapter provides an overview of m-learning efforts around the world (developed and underdeveloped countries), and consolidates lessons learned from different m-learning initiatives and projects to provide educators with a valuable mechanism for leveraging mobile technology to enhance learning, currently and in the future. Specific focus is levelled at the utilisation of m-learning in South Africa from an educational perspective, addressing issues in primary, secondary, and tertiary education. Since there is sparse literature on m-learning in technology-based subjects that addresses programming on mobile devices, this research study endeavours to investigate and provide insight on whether m-learning can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.

4.2. Mobile learning in developed countries

4.2.1 Mobile learning in Europe

Europe (Figure 4.2) currently has the largest economy on earth, and it is the richest region if measured by assets under management (Fineman & Leondis, 2009:Online). Six European countries rank in the top fifteen of the world's largest national economies in Gross Domestic Product (GDP) and Purchasing Power Parity (PPP), which include Germany (ranked number 6), Russia (ranked number 7), UK (ranked number 9), France (ranked number 10), Italy (ranked number 11), and Spain (ranked number 14) (CIA, 2012:Online).

Figure 4.2: The European continent

Several research studies involving the use of mobile technology in education have been conducted in Europe. The European Union (EU) has already moved from e-learning and distance learning to m-learning (Fetaji *et al.*, 2011:180). According to UNESCO (2012a:7), the United Kingdom has initiated the most and the largest m-learning projects in Europe to date. This is mainly due to the interest and economic support from the UK government and various sturdy research teams. Other European countries show limited, if any, interest in m-learning at a policy level. Projects such as MOBIlearn and MoLeNET have shaped the research and development of m-learning in Europe and laid the foundation for the widespread implementation of m-learning in traditional teaching and learning. There is a vast number of large- and small-scale m-learning projects throughout Europe that utilise mobile devices to provide additional means for learner-educator communication, and that support and expand learning outside the boundaries of the classroom. Despite projects such as the M-learning project (Attewell, 2005:6) and HandLeR (Sharples, Corlett & Westmancott, 2002:221), in the UK, the Flex-Learn project (Gjedde, 2008:Online) in Denmark, the MUSIS project in Sweden (Milrad & Jackson, 2008:84), as well as the Personal Training Assistant (PTA) project (Derycke, Chevrin & Vantroys, 2007:43) and p-LearNet project (Rouillard & Laroussi, 2008:543) in France, this research study will mainly focus on large educational (primary, secondary and higher education) m-learning projects that made use of mobile phones, PDAs and tablets, which established and serve as the foundation for the widespread implementation of m-learning in a traditional teaching and learning environment over the past five years (2008 until 2012). This statement excludes the MOBIlearn project, which ran from 2002 until 2005. The projects demonstrate learning across different educational contexts (i.e. schools, universities and informal learning locations), with diverse target groups (children and adult learners).

Table 4.1 provides an overview of research conducted in Europe mainly over the past five years (2008 - 2012), on different m-learning initiatives in an educational environment, and is thereafter elaborated upon in detail.

Table 4.1: Recent research conducted in Europe on different mobile learning initiatives

Year	Project/Initiative	Country	Technology used	Project description
2002 - 2005	MOBIlearn	United Kingdom	Mixture of fixed and portable technologies	Discover new ways mobile technologies could be used to meet the needs of learners both in- and outside the classroom.
2007 - 2010	MoLeNET	United Kingdom	Mixture of mobile technologies	Utilisation of ubiquitous handheld devices to support and extend the reach of teaching and learning, allowing learning to take place anywhere, anytime.

2007 - 2008	MELaS	United Kingdom	Mobile phone (SMS/text messaging)	Refine a sustainable institutional SMS strategy to improve retention and development by broadening and enriching the contact and support of learners both on- and off-campus, as well as to provide learning content that complements other media and permits learners to take advantage of ‘dead’ time and short periods off-campus.
n.d.	Becta	United Kingdom	Mobile phone	Focus on the impact of one-to-one individual ownership of mobile devices.
2003 - 2012	Learning2Go	United Kingdom	PDA Smartphone Tablet	Develop innovative ways of delivering learning both in- and outside of the traditional face-to-face classroom, by mainly focusing on how to incorporate fieldwork and multidisciplinary activities into m-learning projects.
2008 - 2011	LET’S GO	United Kingdom	Low-cost laptop Mobile phone	Facilitate science learning by means of geo-positional data sensing, multimedia communication, information visualisation and Web 2.0 tools.
2007 - 2010	PI	United Kingdom	Mobile phone	Aid learners in having an improved understanding of themselves and "the world around them through a scientific process of gathering and assessing evidence, conducting experiments and engaging in informed debate".
2008 - n.d.	ARena	The Netherlands	Smartphone	Focus on augmented reality (the use of mobile devices and mobile applications to "superimpose data, images and other enhancements over a real-world environment").
2007 - n.d.	Gidder	Norway	Mobile phone (MMS)	Methods and approaches used in the design of a wiki-based learning environment for upper secondary learners that interpret art in classroom and museum contexts.
2009 - 2013	MOTILL	UK, Italy, Ireland and Hungary	N/A	Focus on how mobile technologies might have an impact on the dissemination of a social model where learning and knowledge are available to all.
August 2009 - July 2011	Goldau iPhone project	Switzerland	iPhone	Supply learners with an iPhone for use both in- and outside of the classroom.
2008 - 2011	LET’S GO	Sweden	Mobile phone Handheld computer	Investigate the development of mobile applications and interactive environments to support collaborative learning.

2006 - 2011	AMULETS	Sweden	Smart phone PDA GPS device	Explore how educators can develop and implement novel education scenarios by combining in- and outside classroom activities that utilise ubiquitous computing and mobile technologies in conjunction with fixed computers.
2011 - 2012	E-Reader Reading project	Norway	Tablets E-readers	Teach learners to read both in- and outside of the classroom.
2006 - 2012	myPad/ VetConnect	United Kingdom	Smartphone (SMS, MMS)	Allow clinical veterinary learners to capture details about their cases during clinical rotations, to use podcasts to recapitulate or supplement lectures, and to investigate how to support and engage higher education learners during off-campus learning activities.

UNITED KINGDOM

- **MOBIlearn (2002 - 2005):** MOBIlearn was a major m-learning project that was conducted from July 2002 to 2005 in order to discover new ways mobile technologies could be used to meet the need of learners. The initiative was funded by the European Commission, and involved nine European countries, the United States and Australia. The main focus of the project was to support and expand learning outside the boundaries of the classrooms. One of the consequences of the project was a "shift in focus from learning with handheld devices, towards support for the mobility of learning" (Kukulska-Hulme, Sharples, Milrad, Arnedillo-Sánchez & Vavoula, 2009:18). The MOBIlearn m-learning architecture supported the creation, brokerage, delivery and tracking of learning and information contents, by means of ambient intelligence, location-dependence, personalisation, multimedia, IM (text, video) and distributed databases. Field projects involved a blended learning approach, location-dependent learning and, "learning to interpret information sources and advice" (MOBIlearn, n.d.:Online). The initiative indicated how a mobile learner may interact with a mixture of fixed and portable technologies and accentuated the challenge of connecting learning across contexts. Despite the evolvement of mobile technologies since the MOBIlearn project, existing m-learning projects still struggle with similar changes, such as how to create seamless and continuous educational opportunities to support lifelong learning in all contexts (UNESCO, 2012a:14).
- **MoLeNET (2007 - 2010):** The Mobile Learning Network (MoLeNET) was conducted from 2007 to 2010 and was the biggest and most diverse m-learning initiative in Europe. This initiative was financially supported by the UK Government and participating institutions, and involved roughly 40,000 learners and more than 7,000 staff members (Belshaw,

2011:46). MoLeNET defined m-learning as the utilisation of ubiquitous handheld devices to support and extend the reach of teaching and learning, allowing learning to take place anywhere, anytime (MoLeNET:Online). Research results returned an improvement in learner retention and lower drop-out rates in comparison to National figures (Attewell, Savill-Smith, Douch & Parker, 2010:30). In addition, several m-learning benefits were identified, namely: It encouraged creativity, innovation and critical thinking in both learners and educators, transformed learners from being passive recipients of information to active constructors of knowledge, allowed learners to practice real-world problem solving by allowing learning to be taken outside the boundaries of the classroom, improved learner behaviour and attitudes, and it provided flexibility, allowing learners to engage in learning activities anywhere, anytime (Attewell *et al.*, 2010:25-26). At an institutional level, benefits included an improvement in learner attendance, retention, and achievement, as well as an increase in staff motivation and communication (JISC, n.d.:Online). Though the MoLeNET project has come to an end, it still offers some services to educational institutions in the UK on a subscription basis.

- **MELaS (2007 - 2008):** Another project, Mobiles Enhancing Learning and Support (MELaS), which was also financed by the UK Government, was implemented by the University of Wolverhampton from 2007 until 2008. The university was amongst the first tertiary education institutions in the UK that experimented with SMS/text messaging for m-learning purposes. During this project, an SMS network was developed, that allowed faculty members and learners to communicate without exchanging mobile phone numbers. Furthermore, it also aided with formative assessment by enabling educators to receive prompt feedback from learners during class. In addition, the faculty and learners could communicate during text conferences by using the SMS system. Research results returned that both universities and learners could benefit from such a system (UNESCO, 2012a:17-18). Brett (2008:3), posits that the use of the SMS for teaching and learning holds immense promise for education. The project's main aim was to define a sustainable institutional SMS strategy to improve retention and development by broadening and enriching the contact and support of learners both on- and off-campus, as well as to provide learning content that complements other media and permits learners to take advantage of 'dead' time and short periods off-campus (JISC, n.d.:Online).
- **Becta (n.d.):** The Becta research and development project focused on the impact of one-to-one individual ownership of mobile devices. The research took place within two ambitious projects (Learning2Go and Hand-e-learning) that allowed all learners in a specific year group, together with their educators, to possess mobile devices. The devices (PDAs) were financially supported by parents linked to grants from the e-Learning Foundation (McFarlane *et al.*, 2007:3). Not only did the results portray the

confident and independent use of devices by learners (McFarlane *et al*., 2007:7), but also the ease of completing a project, the ability to instantaneously see what learners have done, quicker feedback, learner satisfaction and enthusiasm, and an increased sense of ownership (McFarlane *et al*. 2007:8-9).

- **Learning2Go (2003 - 2012):** Learning2Go, an inquiry-based m-learning project which began in 2003 in Wolverhampton, UK, is known to be the largest collaborative m-learning project for learners in the UK. This project involved 18 institutions ranging from nursery to secondary schools, and over 1,000 learners. The initiative is regarded as one of the original pioneers in the m-learning field. Between 2003 and 2007, Windows Mobile handheld devices were successfully introduced into Wolverhampton schools. In 2008, the project introduced mobile Internet enabled smartphones (Learning2Go, n.d.:Online). The project incorporated technology enhanced learning into the educational practices of schools, and developed innovative ways of delivering learning both in- and outside of the traditional face-to-face classroom, by mainly focusing on how to incorporate fieldwork and multidisciplinary activities into m-learning projects. Learner ownership and 24/7 access to a handheld device (Educational Digital Assistant - EDA) was essential to the approach. In addition, the project searched for solutions to actual community problems (UNESCO, 2012a:21). The project demonstrated how effectively m-learning or 1:1 learning can give educators and learners access to technology that were embedded into their daily lives (Learning2Go, n.d.:Online). The project had different aims such as formulating m-learning practice, encouraging independence and motivation, gaining parental engagement, and raising standards (Kukulska-Hulme *et al.*, 2009:20). According to Kukulska-Hulme *et al.* (2009:20), the following project practices need to be highlighted:

  - Adoption of mobile devices (24/7), which allowed children aged five to six to work at home in cooperation with their parents using expressly designed PDA-based numeracy packs.
  - Primary school children progressing to secondary school together with their PDAs.
  - A secondary school mathematics class where arithmetic exercises were performed on the networked PDAs in combination with a SmartBoard from which learners could directly copy the exercises and through which individual PDA screens could be shared.

  In 2012, Learning2Go evolved by taking on board new technologies such as the iPad and iPod touch. Many of the project's concepts are being adopted by Wolverhampton schools, and a variety of smartphones, tablets and other touch screen devices are being explored. Additionally, the project is also doing a lot behind the scenes in preparation for using Android devices.

- **LET’S GO (2008 - 2011):** The Learning Ecology with Technologies from Science for Global Outcomes (LET’S GO) project was an international m-learning project that was funded by private sources from 2008 until 2011. This project incorporated geo-positional data sensing, multimedia communication, information visualisation and Web 2.0 tools to facilitate science learning (CeLeKT, 2011:Online). Throughout this project, low cost laptops and mobile phones were used for field-based learning activities to educate learners on ecological science and scientific methods. During field trips, learners used mobile devices with mobile sensors, pen-based technologies and geo-tagged images. Data were captured and then integrated into an interactive learning environment where learners could ask questions, discuss field trip findings, and reflect on what they have learned (UNESCO, 2012a:20).
- **PI (2007 - 2010):** The Personal Inquiry (PI) m-learning project ran from 2007 until 2010, and was led by the University of Wolverhampton in the UK, and encouraged inquiry based learning by means of mobile devices. The PI project aimed to aid learners in having an improved understanding of themselves and, "the world around them through a scientific process of gathering and assessing evidence, conducting experiments and engaging in informed debate". A computer toolkit was developed in order to facilitate inquiry-based learning. Computer programs served as dynamic lesson plans, guiding and supporting learners through the inquiry process by providing them with a set of structured activities, data visualisations, and means of communication. An authoring toolkit allowed teachers to select, write or modify the computer scripts in order to monitor and guide learner activities (UNESCO, 2012a:20). Results confirm a positive effect on learning outcomes, continuous enjoyment of science lessons, fluid transition between individual, group and class activities, as well as learning support across formal and informal settings (Sharples & Scanlon, 2011:Online).

DENMARK

The UNESCO (2012a:7), report reflects that Denmark currently shows the most potential as a country in the field of m-learning primarily due to government support in that they put national guidelines and instructional materials in place to support the use of mobile devices in a teaching and learning environment. However, though Denmark appears to be fairly advanced in the utilisation of m-learning, there is very little published material that describes the outcomes of these projects (UNESCO, 2012a:19).

THE NETHERLANDS

The Netherlands also promotes m-learning by means of nationally-funded Research and Development projects. The SURF Foundation together with Kennisnet, a public Dutch foundation that supports primary, secondary and vocational schools in the use of ICT, is working on the ARena m-learning project (UNESCO, 2012a:18).

- **ARena (2008 - n.d.):** The ARena m-learning project focused on augmented reality (the use of mobile devices and mobile applications to, "superimpose data, images and other enhancements over a real-world environment" (UNESCO, 2012a:18). This is normally achieved by utilising the camera and GPS features on a smartphone. According to Ternier, Specht, de Vries, de Jong and Börner (2010:42-43), learners used smartphone cameras to investigate their environment, however learner interaction was not faultless and as a result, the educational value of ARena is questionable.

NORWAY

Gidder (2007 - n.d.): The Gidder (Groups in Digital Dialogues) research project was conducted in Oslo, Norway, and explored the potential of mobile and social technologies to support learning (Pierroux, 2009:291). The project presents methods and approaches used in the design of a Wiki-based learning environment for upper secondary learners that interpret art in classroom and museum contexts (Pierroux, 2009:292). Prior to the museum visit, learners worked with information in group Wiki spaces and selected artwork that they would explore more thoroughly at the museum. Learners then made use of blogs, labels, and other resources to interpret selected artwork (Pierroux, 2008:332). At the museum, learners explored the exhibition and their selected artworks and used their mobile phones to send MMS with labelled information to the Wiki's blog, which is then shared with the entire class. Back at school the Wiki was used to discuss and develop their interpretations (Kukulska-Hulme *et al.*, 2009:24).

From the aforementioned European project results, it is evident that m-learning barriers include a lack of interest and awareness on the part of policymakers and the public, as well as negative social attitudes that view mobile devices as disruptive. In addition, none of the projects are restricted to exclusive mobile device use to implement the entire learning experience. However, it is still expected that the number of European m-learning projects will persist to grow as mobile devices become increasingly more powerful and user friendly, as well as less costly. Conversely, research has shown that mobile devices should not replace desktop computers, but that it should be utilised in such a way that it will complement fixed technologies (UNESCO, 2012a:8). Research results also show that mobile technologies have been used in numerous m-learning projects in Europe to support learning across various contexts with diverse target groups.

OTHER EUROPEAN UNION (EU)-FUNDED MOBILE LEARNING PROJECTS

The following EU m-learning projects call for closer scrutiny, and are elaborated upon below:

- **MOTILL (2009 - 2013):** The Mobile Technologies in Lifelong Learning (MOTILL) project is a project funded by the European Commission, and involves four countries, namely UK, Italy, Ireland and Hungary. The project commenced in March 2009 and focuses on how mobile technologies could have an impact on the dissemination of a social model, where learning and knowledge are available to all, despite of a learner's social and financial background, age, gender, religion, ethnicity or disability (MOTILL, 2012:Online).
- **Goldau iPhone project (2009 - 2011):** This project was part of a two year case study in Switzerland where learners of the ages 11 to 12 were supplied with an iPhone for use both in- and outside of the classroom. The project was financially supported by the telecommunications company Swisscom (Honegger & Neff, 2011:41). According to the researchers, the learners were academically exceptionally well prepared for the upper school, and proved to be academically stronger than previous classes.
- **LET'S GO (Sweden) (2008 - 2011)**: At the Linnaeus University's School of Mathematics and Systems Engineering in Sweden, researchers have been involved in several theoretical and practical research projects on the educational use of mobile phones and handheld computers, of which one included the LET'S GO project. Their main interest is to investigate the development of mobile applications and interactive environments to support collaborative learning (UNESCO, 2012a:22).
- **AMULETS (2006 - 2011):** This project was supported by the Swedish KK-foundation and Växjö University, and explored how educators can develop and implement novel education scenarios by combining in- and outside classroom activities that utilise ubiquitous computing and mobile technologies in conjunction with fixed computers. Learners and staff made use of smartphones, PDAs and GPS devices during outdoor activities, and afterwards providing them with the opportunity to review and to continue the learning experience in the classroom. This process supported exploration, debate, collaboration and reflection (IAmLearn, 2012:Online).
- **E-Reader Reading project (2011 - 2012):** Tablet devices and e-readers were used in Norway to teach learners to read both in- and outside of the classroom. Researchers are of the opinion that mobile technology can motivate boys who do not have the patience to read and learn, which consecutively may assist in reducing Norway's achievement gap between boys' and girls' reading skills (bt.no, 2011:Online).
- **myPad/VetConnect (2006 - 2012):** This project was built with smartphone access in mind and was sponsored by Orange Personal Communications Services Ltd in the UK. The application was specifically developed for clinical veterinary learners to capture details about their cases during clinical rotation. In addition, this project made use of podcasts to recapitulate or supplement lectures, and to investigate how to support and

engage higher education learners during off-campus learning activities. In general, learner and staff feedback was positive. Learners indicated that mobile devices were useful for accessing e-mail and web content, and the application would be beneficial to their learning, however fewer were positive about recording clinical experiences using mobile devices (Whittlestone, Bullock, Pirkelbauer & May, 2008:135).

Furthermore, various European projects use mobile technologies to supply supplementary channels for learner-teacher communication and to support or strengthen learning both in- and outside of classrooms. There are quite a number of projects that involved the use of text messaging/SMS to enable administrative communication between the faculty and learners, as well as in-class communication (Kukulska-Hulme *et al.*, 2011:162). In a higher education setting, SMS projects usually exploit learners' personal mobile phones and existing networks, however cost is frequently viewed as an impediment to widespread implementation (UNESCO, 2012a:22-23).

It is evident from other smaller-scale EU-funded projects that mobile devices should not be utilised as an exclusive learning tool or as the primary method for learning content delivery. Although opposing results from two European Commission projects, which were led by the telecommunications provider Ericsson, were returned, it appeared for the most part to be unsuccessful in terms of learner experience and the strategy of delivering educational content to a specific mobile device. These two projects focused on the exclusive delivery of educational content via mobile phones (UNESCO, 2012a:16). According to Kukulska-Hulme *et al.* (2011:157), learners do not wish to be attached to a single device or system, but instead prefer to access educational opportunities from a wide variety of sources. Therefore, it could be argued that the most effective approaches to m-learning are to utilise the distinctive functionalities of mobile technology in order to support communication and to facilitate the creation and utilisation of media (i.e. images, videos and audio files).

4.2.2 Mobile learning impediments in Europe

According to the 2012 UNESCO Report (UNESCO, 2012a:Online), there are two key impediments to m-learning in Europe, namely the lack of policy support and governmental investment in m-learning, as well as negative social attitudes among policymakers, parents and educators about the use of mobile technology in schools.

- **Lack of policy support and governmental investment:** The first barrier to m-learning in Europe is that only a small number of countries in Europe have included m-learning in their national education agendas, except for the UK, Netherlands and Denmark. However, not even these three countries could sustain m-learning initiatives on a

National scale. The European Commission has been successful in moving forward the concept of m-learning in general, however they have not yet issued any guidelines for the effective use of mobile technologies in teaching and learning. Despite the success of EU m-learning projects, none of the EU-funded projects described in the previous paragraph, have been extended to cover an entire country. Although there is substantial evidence of the potential benefits of m-learning, there is a lack of support for m-learning at the policy level. National policies still lack considerable steps to amalgamate lifelong learning and mobile technologies (Arrigo, Di Giuseppe, Fulantelli, Gentile, Merlo, Seta & Taibi, 2010:1), which paints to: 1) The majority of countries that no longer treat ICT in education as a special policy area, 2) the economic crisis and subsequent shortfalls in public budgets that might have postponed or muffled several ICT and m-learning initiatives that may have otherwise enjoyed government support, 3) the lack of m-learning on educational agendas in Europe, or 4) it may be probable that only some educators or school administrators have requested political support to integrate mobile technology into teaching and learning, since government policies are essential to ensure the equitable development and distribution of m-learning resources throughout a country (UNESCO, 2012a:29-30).

- **Negative social attitudes:** The second barrier to m-learning in Europe is negative social attitudes among policymakers, parents and educators about the use of mobile technology (i.e. mobile phones) in schools. Mobile phones are generally considered to be disruptive to education and are restricted in many European schools. Parents and educators view mobile phones as distracting 'toys' with limited educational value since it permit inappropriate activities such as cyber-bullying and cheating to occur. As a consequence of these negative social attitudes, policymakers appear to be hesitant to endorse policies that encourage and support m-learning, and some governments may even oppose m-learning efforts (UNESCO, 2012a:30).

4.2.3 Mobile learning in North America

In North America (Figure 4.3), the United States, Canada and Mexico all have significant and multifaceted economic systems. The United States has the largest economy in North America, and is currently the most technologically developed economy (CIA, 2012:Online). Three North American countries rank in the top fifteen of the world's largest national economies in Gross Domestic Product (GDP) and Purchasing Power Parity (PPP) which includes the USA (ranked number 2), Mexico (ranked number 12), and Canada (ranked number 15) (CIA, 2012:Online).

Figure 4.3: The North American continent

While m-learning is still in its infancy of development, numerous educators and learners in North America (USA and Canada) are starting to comprehend its potential for enhancing teaching and learning (UNESCO, 2012b:7). The proliferation of mobile technology use, and more specifically smartphones, amongst North Americans is beyond comprehension. According to the CTIA (2011:Online), mobile phone subscribers in the USA totalled 327.6 million in 2011, therefore surpassing the US population total that consists of 315.5 million inhabitants. These statistics embody a prospective opportunity for educators to take advantage of the connectivity and content that m-learning affords. Although mobile technology adoption in Canada is also high, it is not on the same level as that of the USA and has in the region of 26.5 million subscribers, which is indicative of more than 70% of the total population (CTWA, 2012:Online). Despite this exponential growth in the mobile phone sector, there is still only a very small number of in-depth case studies and limited guidance on how to develop a successful m-learning programme by utilising smartphones and other Wi-Fi-enabled mobile devices (Ally & Palalas, 2011:Online).

According to the UNESCO report (2012b:16), most m-learning projects in North America are led and implemented by individual schools, school districts and universities, with the United States' federal government and private corporations also financially supporting school- and district-level m-learning initiatives (UNESCO, 2012b:11). Most states and provinces are under local control and policies, and some of these policies can prohibit the use of mobile technologies. In New York City the Mayor Michael Bloomberg forced a citywide ban on mobile phones in schools, because he views mobile devices as major disruptions that avoid other learners in the classroom to learn (Monahan & Chapman, 2011:Online). Alternatively to the aforementioned scenario, mobile technology can facilitate m-learning by allowing learners to use their own mobile technology in an educational environment, which in turn encourages learners to utilise their own mobile devices at school/university (UNESCO, 2012b:16).

Table 4.2 provides an overview of research conducted in North America mainly over the past five years (2008 - 2012), on different m-learning initiatives in an educational environment, and is thereafter discussed in more detail.

Table 4.2: Recent research conducted in North America on different mobile learning initiatives

Year	Project/Initiative	Country	Technology used	Project description
2007 - 2010	Qualcomm's Wireless Reach Project K-Nect	USA	Smartphone	Aims at helping bridge the digital divide and to promote social inclusion by increasing learner access to educationally relevant content both on and off school campus. Furthermore, it aims to enable communication with educators and peers by means of online tools and resources for 24/7 learning.
2010 - 2012	Learning On-the-Go	USA	Laptop Tablet Smartphone Netbook	Allows learners to learn in a real-world context, both in- and outside the classroom.
2007 - n.d.	M-learning at Abilene Christian University (ACU)	USA	Mobile phone	Using podcasts to support classroom education and enabling learners to come to the classroom more prepared (2007). Harnessing mobile devices in an attempt to mobilise the classroom by means of blogs (2009).
2011 - 2012	M-learning @ Algonquin College	Canada	Mobile phone	Access and engage with course content and learning activities 24/7.
2012	C2C programme	USA	Refurbished PCs	The main goal is to provide low-cost Internet access, digital literacy training and refurbished computers to low-income families.
2003 - n.d.	Edumóvil	Mexico	PDA Mobile phone	Improving individual and collaborative teaching and learning at the primary-school level by means of mobile technologies.
2010 - 2012	M-iLab	Mexico	Smart phone (iPhone)	Illustrate the physics theory of simple harmonic motion and momentum by means of smartphones.
2010 - n.d.	Blackboard Mobile Learn+	Mexico	Smartphone (iPhone)	Allow learners to access course content and activities from their iPhones.

USA AND CANADA

North America embarked upon three broad approaches to programme design and implementation, namely school-provided device initiatives, Bring-Your-Own-Technology (BYOT) initiatives, and shared-expense plans for devices and broadband access, each of which are elaborated upon below:

- **School-provided device initiatives**

  Numerous schools, districts and universities in the USA provide mobile devices for all their learners to ensure that they all have similar devices and equal access to m-learning opportunities. Two of these opportunities, are discussed below:

  - **Qualcomm's Wireless Reach Project K-Nect (2007 - 2010):** This project's focal point was to provide third-generation (3G) wireless smartphones to underserved communities across the globe, and to invest in projects that promote entrepreneurship, assist in public safety, enhance the delivery of health care, enhance teaching and learning, and improve environmental sustainability. The project aimed at helping bridge the digital divide and to promote social inclusion by increasing learner access to educationally relevant content, both on and off school campus, and to enable communication with educators and peers by means of online tools and resources for 24/7 learning (Qualcomm, 2012:Online). In 2008, results reflected that there was a positive correlation between learners who actively participated in the project and their final algebra proficiency levels on a standardised exam. Schools where this initiative was implemented reported an increase of 30% in learner mathematics test scores. Learners also reported on discovering new innovative ways to use smartphones and the 24/7 Internet connectivity that assisted in increasing their understanding of algebra, especially by using social networking tools such as blogging and IM. During the second phase of the project in 2009, educators announced that the smartphones and the problem-based learning approach have transformed the way they taught mathematics. In 2011, the third phase results revealed that 85% of the learners felt more successful in mathematics and over 50% were considering a career in the mathematics field as a result of participating in the project (Qualcomm, 2012:Online).
  - **Learning On-the-Go (2010 - 2012):** An investment of federal funds into this project signalled a new US government interest in m-learning. A pilot project was launched in 2010 that supported off-campus wireless Internet connectivity for m-learning devices. Elementary, middle and high school learners of which most were from economically disadvantaged communities, were supplied with mobile devices (i.e. laptops, tablets, smartphones, netbooks) in order to allow them to learn in a real-world context, both

in- and outside the classroom. It is believed that these mobile devices could help in advancing digital equity, particularly for learners from economically disadvantaged communities (Tessler, 2011:Online). One school in Texas received funding to develop a programme in which educators and learners could make use of a LMS to create and manage assignments. Other middle and high school learners were provided with ubiquitous access to online learning devices (such as smartphones and netbooks) by making use of a virtual classroom software program (FCC, 2011:Online).

From the above studies it is evident that there are several advantages to m-learning initiatives based on school-provided devices. Initiatives where learners were provided with devices, learners who made use of mobile devices have shown better performance/achievement if compared to similar learners who did not use mobile devices for educational purposes.

- **Bring-your-own-technology (BYOT) initiatives**

  Despite the fact that a large number of North American educators still view mobile phones as a source of disruption in the classroom, and the fact that it is banned from most schools (Johnson, Smith, Willis, Levine & Haywood, 2011:15), there are several who have implemented mobile technology and highlights the positive effect it had on learner engagement and learning (UNESCO, 2012b:22). However, Willis (2012:Online), warns that the implementation of BYOT initiatives should employ a systemic approach by having a clear and comprehensive implementation plan, re-visiting and changing policies to support the BYOT initiative, managing the initiative, performing cost estimations, attending to possible equity issues, and evaluating the impact of the initiative.

  - **M-learning at Abilene Christian University (ACU) (2007 - n.d.):** The Abilene Christian University (ACU) is seen as the hub of expertise in the education sector (Schofield *et al.*, 2011:33). Since 2007, ACU started exploring the possibilities of mobile technologies in the classroom with the aim of better preparing its learners for "a rapidly changing workplace and careers that would call upon technologies not yet developed" (Schofield *et al.*, 2011:33). Podcasts were used to support classroom education and enabled learners to come to the classroom more prepared. Results suggest that learners who made use of the podcast required less re-direction and interaction in a classroom setting. On average, learners accessed a podcast 2.8 times. This strengthens and supports the learning process, since it allows learners to review a podcast as often as they require. In 2009, ACU started to harness mobile devices in an attempt to mobilise the classroom by means of blogs. Learners made use of blogs to post pictures, video, podcasts, and comments as a means of facilitating group discussion in the subject field. ACU views this as a method to have a class, without having to be in class.

- **M-learning at Algonquin College (2011 - 2012):** In Canada, 80% of learners at Algonquin College are in possession of their own mobile device. The college exploited this opportunity to broaden the learning opportunities of learners and to increase their learning time (Ally & Palalas, 2011:Online). From 2013 all first-year learners at the college will be expected to have a wireless mobile computing device such as a laptop or tablet that meets the hardware specifications of their program/course. Learners will use these mobile devices to access and engage with course content and learning activities. The college has a Mobile Learning Centre, where learners can engage in m-learning activities and collaborate with peers by means of mobile technologies (Algonquin College, 2012b:Online). To ensure equity, the Mobile Learning Centre permits learners to borrow mobile devices if they do not have their own.

The biggest advantage of the BYOT approach is its low-cost and quick implementation, since learners already own technology that they can use for educational purposes. Learners also already know how to use their own mobile devices. Furthermore, it can speed up a school or university's progress towards a 1:1 or m-learning environment. Learning content will move to online-based applications, thus further enabling widespread access. This can be achieved by using the technologies that learners already have and by allowing schools to swiftly focus on instructional strategies and professional development rather than on the selection and procurement of mobile devices. This approach also diminishes the burden of providing technical support, since learners characteristically know how to use their personal mobile devices (VonBank, 2012:Online).

Conversely, the disproportion in mobile phone ownership can differ extensively between schools and tertiary institutions, therefore potential inequities need to be addressed when a BYOT approach is considered. A possible solution to this problem is to confidentially provide a learner with a mobile device to complement the mobile device he/she brings to the classroom, or alternatively a device can be borrowed, as with the m-learning initiative at Algonquin College should a learner not own his/her own device. This would ensure that a learner is not being ridiculed or embarrassed about not owning his/her own device (UNESCO, 2012b:23).

- **Shared-expense plans for devices and broadband access**

  Several schools and universities in the USA make use of a mutual approach to m-learning in which they financially support part of the cost of the mobile device and the required access plan, whilst learners or their parents are accountable for the balance of the cost. As a general rule, such learners or parents who cannot meet the expense of the device can obtain financial support for their share. The BYOT approach may be less practical when used with a younger generation, since they are less likely to have their own mobile devices. In the USA, there are several initiatives that supply learners with broadband Internet access who do not have it at home, and a number of businesses are starting to put forward shared plans, whereby parents and districts share the costs, or they provide reduced rates for learners who have a district device (UNESCO, 2012b:24) of which the C2C programme serves as an example.

  - **C2C programme (2012):** Americans are falling behind in broadband adoption at home. The Knight Foundation (2012:Online), states that high-speed broadband Internet is available to over 94% of households in the USA, however only 67% of these have adopted broadband at their homes. In order to address the predicament, the Knight Foundation provided a grant to support the Connect2Compete (C2C) project, a public-private partnership dedicated to providing digital opportunity to all US citizens, thereby eliminating the digital divide and creating opportunities for all Americans. C2C's main goal is to provide low-cost Internet access, digital literacy training and refurbished computers to low-income families. A programme like this can assist in minimising the costs of BYOT or shared-expense approaches to m-learning (UNESCO, 2012b:23).

MEXICO

- **Edumóvil (2003 - n.d.):** The Edumóvil project commenced in Mexico in 2003, and has been supported by Motorola, a telecommunications company based in the USA, since 2007. This initiative developed Spanish, mathematics, history and natural science m-learning applications, which were tested in schools to measure its impact (UNESCO, 2012c:16). According to Gerónimo, Aquino, Becerra and Calvo (2005)[17] cited by Ruiz-Rodríguez and Fernández-y-Fernández (2007:Online), the project's main aim was to improve individual and collaborative teaching and learning at the primary-school level by means of mobile technologies. The project initially started off by utilising PDAs.

[17] Gerónimo, G., Aquino, L.A., Becerra, L. & Calvo, I. 2005. El proyecto Edumóvil: Consideraciones Iniciales. Taller de Ingenieria de Software en el VI Encuentro Internacional de Computatión (ENC 2005). Avances en la ciencia de la computatión.

- **M-iLab (2010 - 2012):** This project was used to teach learners the physics theory of simple harmonic motion and momentum by means of a mobile application. Together with the M-iLab application, the mobile phone became part of the physics experiment, because when the phone is moved in a particular way, the motion detection software registers the movement and records it for further analysis. (UNESCO, 2012c:19). In addition, the project aimed at increasing learner interest and performance in physics assessments (n.a., 2011a:Online).
- **Blackboard Mobile Learn+ (2010 - n.d.):** The Blackboard LMS initiative allowed learners to access course content and activities from their iPhones (UNESCO, 2012c:20).

4.2.4 Mobile learning impediments in North America

As with Europe, several of North America's policymakers, parents and educators are concerned about the possible negative effects of mobile device utilisation in schools. These concerns include factors such as: 1) Uncertainties about the usefulness of a device with a small screen for learning, 2) the potential for distraction caused by the mobile devices, 3) negative social attitudes such as cyber-bullying, cheating and online learner safety, and 4) liability (UNESCO, 2012a:25). Each of the listed impediments are elaborated upon below (UNESCO, 2012a:25-27):

- **Small screen:** According to Corbeil and Valdes-Corbeil (2007:52; 54), there are several educators and policymakers that are apprehensive about the usefulness of the small screen of a mobile device when compared with larger laptop screens. Wallace (2011:Online), is of the opinion that educators should compare the benefits of portability against those of a full-sized laptop screen or keyboard, and furthermore should ensure that applications are adaptable to a small screen.
- **Distractions:** Mobile phones being viewed as a distraction to education are probably the key concern to educators and policymakers when considering m-learning. This is primarily why these mobile devices are banned from most schools in North America (Johnson *et al.*, 2011:15; Wallace, 2011:Online), and are believed to disrupt rather than enhance learning.
- **Negative social attitudes and online safety:** Inappropriate learner behaviour such as cyber-bullying, cheating, and ‘sexting’ (sending sexually explicit messages or photographs via text message) are all major concerns for administrators, educators and parents when considering m-learning implementation and use.
- **Liability:** School districts regularly view the possible accountability associated with learner online safety as a barrier to m-learning. Liability and concern for online learner

safety have led to exceptionally restrictive policies banning mobile devices in numerous US and Canadian districts and schools.

4.3 Mobile learning in underdeveloped countries

Limited research has been conducted on the potential of wireless technologies in education in underdeveloped countries. Wood (2003:Online), believes that the use of wireless technologies in an educational environment can contribute to breaking down the digital divide in a developing country. The lack of resources in education in developing countries is a significant issue of concern. Computers often need to be shared by learners, making it easy to believe that software and hardware can have a considerable impact on education in developing countries (Jaimes, Kinshuk & Sow, 2003:473-474). As reported by Keegan (2003:Online), “ICT 'haves' and 'have nots' resulting from a lack of access to computers, are the issues that need to be addressed using handheld devices”.

4.3.1 Mobile learning in Latin America

Two Latin American countries rank in the top fifteen of the world's largest GDP (PPP), namely Brazil (ranked number 8) and Mexico (ranked number 12). Brazil's economy outweighs that of all other South American countries, and is expanding its presence in world markets (CIA, 2012:Online). Mexico is geographically located at the most southern tip of the North American continent, but is also considered as part of Latin America (Figure 4.4). For the purposes of this study, Mexico will in this thesis be classified and discussed as a North American country.

Figure 4.4: The Latin American continent

Since the 1990s, Latin American countries have made significant progress in education. Access to primary education is on the brink of being universal and in the last decade, there has been a considerable increase (59% in 1999 to 73% in 2009) in access to secondary education (Klein, 2011:Online). Despite this growth, Latin American countries still face major challenges related to quality, efficiency and equity in its educational systems (UNESCO, 2012c:8). In 2009, more than 90% of secondary learners in Latin America had access to ICT at school due to public policies that were specifically aimed at providing technology to the educational system (Claro *et al.*, 2011[18] cited by UNESCO, 2012c:8).

The majority of schools in Latin America have computers installed in laboratories, which implication means that educators must reserve computer access in advance and move their classes to a separate room for a restricted time period (Watson, 2001:257). This problem has been addressed by 1:1 (one laptop per child) initiatives that aspire to bridge the 'digital divide' between rich and poor learners by providing a more flexible, self-directed and learner-centred learning approach by means of ICT. Argentina, Peru, Uruguay and Venezuela have all implemented 1:1 initiatives. Due to the high cost of laptop computers, Latin America has started to look at more affordable alternatives, such as m-learning. Not only do mobile devices such as mobile phones increase access to the Internet and educational content mainly due to its widespread use, but it also to a great extend reduces equipment cost, training and technical support, and makes learning both in- and outside of the classroom possible.

Table 4.3 provides an overview of research conducted in Latin America mainly over the past five years (2008 - 2012), on different m-learning initiatives in an educational environment. Each initiative is thereafter elaborated upon in more detail.

[18] Claro, M., Jara, I., Espejo, A. & Trucco, D. 2011. *Aporte del Sistema Educativo a la reducción de las brechas digitales: Una mirada desde las mediciones PISA* [The Education System's contribution to reducing the digital divide: A view from the PISA measurements]. Santiago, ECLAC-CEPPE.

Table 4.3: Recent research conducted in Latin America on different mobile learning initiatives

Year	Project/Initiative	Country	Technology used	Project description
2011 - 2012	Entorno Móvil Interactivo de Aprendizaje (EMIA-SMILE)	Argentina	Smartphone	Improving learners' writing and scientific thinking skills through smartphones connected to a local network to support inquiry-based learning.
2010 - 2012	Puentes Educativos	Chile	Smartphone	Improving learner learning in mathematics, science and English through mobile phones.
n.d.	Eduinnova	Chile	PDA Netbook	Investigates the innovative use of handheld computers to promote collaborative learning, asking learners to answer educator-generated questions with the help of their peers.
2011 - 2012	Raíces de Aprendizaje Móvil (Roots of Mobile Learning)	Colombia	Smartphone	Improving learner learning in mathematics, science and English through mobile phones.
2007 - n.d.	PocketSchool	El Salvador	TeacherMate mobile device	Aimed to support learners from remote rural areas who lack access to regular educational services. PocketSchool provided learners with a mobile device which could be used to read digital books and play educational games to develop literacy and mathematics skills.
2009	Celumetraje	Argentina	Mobile phone	Developing learners' technological skills while working collaboratively in groups to direct and publish short films using built-in video cameras on mobile phones.
2012	CrowdMemo	Argentina	Mobile phone	Learners, together with their families and peers, used mobile technologies (mobile phones and digital cameras) to bring together the cultural heritage of their communities.
2010 - 2011	Videojuegos para el Desarrollo de Habilidades en Ciencia a través de Celulares (ViDHaC2Video)	Chile	Mobile phone	Educational video games were developed for primary-school learning to assist them in expanding their problem-solving skills, improving science learning, as well as content management support amongst learners by means of mobile phones.
2008 - 2012	Evaluación de Aprendizajes a través de Celulares	Chile	Mobile phone	Assess learner learning in Spanish and mathematics using mobile phones.
2008 - 2009	Proyecto Facebook	Argentina	Mobile phone	Engage learners in the course and develop their technological skills by having them record and upload short videos via their mobile phones.

2008 - n.d.	BlueGénesis	Colombia	Mobile phone Smartphone PDA iPod Laptop	Academic platform that facilitates communication and exchange information and course contents amongst educators and learners throughout a university to support teaching and learning.
2011 - 2013	Proyecto Raíces de Aprendizaje Móvil	Colombia	Smartphone	Alter and improve educational practices in Social Studies and Mathematics classrooms through the use and appropriation of high-quality digital content downloaded by means of smartphones.
2011 - n.d.	Postítulo de Especialización Superior en Educación a Distancia	Argentina	Smartphone	Learners use their smartphones to access course content and activities in a specific blended-learning graduate course.

There were three major mobile phone projects in Latin America the past five years namely, the Entorno Móvil Interactivo de Aprendizaje (EMIA-SMILE) (Argentinia) project, which aimed at improving learners' writing and scientific thinking skills through smartphones connected to a local network to support inquiry-based learning, as well as the Puentes Educativos (Chile) and Raíces de Aprendizaje Móvil (Colombia) projects, which aimed at improving learner learning in mathematics, science and English through mobile phones.

ARGENTINA

Entorno Móvil Interactivo de Aprendizaje (EMIA-SMILE) (2011 - 2012): This project, also known as the Mobile Interactive Learning Environment project, was developed by Seeds of Empowerment, a non-profit organisation funded by Stanford University in the USA. The project was led by Telecom, the major local telephone company for the northern part of Argentina, and supported by the provincial Ministries of Education (UNESCO, 2012c:15). It aimed to improve learners' writing and scientific thinking skills through the use of smartphones that are connected to a local network to facilitate inquiry-based learning. Learner activity was monitored by educators from a laptop computer, which used synchronised feedback from learners to guide class discussions (Leighton, 2012:Online). Learners actively engaged with educational material, "by generating their own questions and research activities to deepen their knowledge and understanding", using collaborative and interactive strategies (UNESCO, 2012c:15).

CHILE

- **Puentes Educativos (2010 - 2012):** This project, also referred to as the Educational Bridges project, was launched in 2010, and has been implemented in more than 160 public schools in Chile. It was led by an educational Non-Governmental Organisation

(NGO) named the Asociación Chilena Pro Naciones Unidas (Chilean Association for the United Nations, ACHNU), and was linked with the BridgeIT international initiative (a partnership to provide multimedia educational programs to schools around the world by leveraging the power of mobile phone technology). It provided training to educators to assist them with the planning of mathematics, science and English lessons. In the classroom, educators made use of smartphones with a wireless connection, and a video projector to download and display educational videos to motivate learners and extend content specific or scientific experiments. Results show that both educators and learners who participated in the project, have shown a greater motivation, and that learners spent more time focusing using mobile technology (Leighton, 2012: Online).

- **Eduinnova (n.d.):** In this Chilean project a 1:1 model was followed by providing learners with a netbook, which ensured that the initiative can offer a cost-effective solution for providing a 1:1 environment in the classroom that bridges the digital divide within schools (Rodríguez, Nussbaum, López & Sepúlveda, 2010:169). The project's main aim was to investigate the innovative use of handheld computers to promote collaborative learning (Nussbaum, Gomez, Mena, Imbarack, Torres, Singer & Mora, 2010:297), asking learners to answer educator-generated questions with the help of their peers. Learners worked in groups to answer a series of questions presented on their PDAs/netbooks. Their activities were followed by the educator on his/her own laptop. The project initially employed Pocket PCs (PDAs), but due to the high price tag of these devices, it made it hard to expand the initiative. It was therefore decided to rather make use of netbooks, which were by implication more affordable than smartphones. Research results indicated an improvement in the degree of enthusiasm, engagement and communication skills. Learners were perceived to take an active role in the process. This project was at a later stage expanded to approximately 100 schools in Chile and 55 schools in other South American countries. Research results indicate a positive impact on learner learning, and that it has been successfully utilised to assist educators to update their knowledge of circular content and exchange information on methodological strategies.

COLOMBIA

Raíces de Aprendizaje Móvil (2011 - 2012): This project, commonly referred to as the Roots of Mobile Learning project, was launched in 2011 with initial implementation planned for 75 schools. It was led by the Ministry of Education as a national pilot programme in conjunction with Nokia, Movistar and Telefónica foundations, and Pearson. As with the Puentes Educativos project in Chile, this project was also associated with the BridgeIT international initiative which, "seeks to raise the quality of educational practice through the use and appropriation of digital content teaching through teacher training and the incorporation of mobile devices in the classroom" (CVNE, 2011:Online).

OTHER LARGE SCALE LATIN AMERICAN MOBILE LEARNING PROJECTS

There was also another large-scale mobile technology project that made use of mobile devices other than mobile phones (i.e. netbooks and PDAs) to facilitate teaching and learning, namely the PocketSchool project that was introduced in Latin America, Asia and Africa.

- **PocketSchool (2007 - n.d.):** This project aimed at supporting learners from remote rural areas who lack access to regular educational services. PocketSchool provided learners with a mobile device (TeacherMate) which could be used to read digital books and play educational games to develop literacy and mathematical skills. The project was concerned with "the assessment, design, development, implementation, and evaluation of m-learning technology to provide underserved indigenous children in Latin America with equitable access to basic education and literacy exposure in health and environmental safety" (Kim, n.d.:Online).

From the above literature review that covers m-learning in Latin America, it is evident that there is a noteworthy variety of m-learning initiatives in Latin America, however these projects are exceptionally rare, and information about such work is either meagre, in an exploratory stage, or outdated.

OTHER SMALL-SCALE LATIN AMERICAN MOBILE LEARNING PROJECTS

- **Celumetraje (2009):** M-learning is normally implemented by educators who feel at ease with mobile technologies and wish to explore ways of using mobile devices to motivate learners and to advance their learning. The project was launched in 2009 in Argentina, and was led by only one educator. The project's main aim was to extend learners' technological skills while having them work collaboratively in groups to direct and publish short films using built-in video cameras on mobile phones. Learners used their mobile phones to capture film scenes, and then later upload it to the Internet via a computer (UNESCO, 2012c:16-17).
- **CrowdMemo (2012):** The CrowdMemo project kicked off in Argentina and empowered the general public to rejuvenate and protect public space or significant meaningful spaces through memory and collection. School learners, together with their families and peers, used mobile technologies (mobile phones and digital cameras) to identify the important spaces that bring together the cultural heritage of their community. In addition, they have also contacted elderly citizens who told stories about these locations and,

along with them, learners have produced, filmed and edited micro-documentaries about each location or topic. These were later uploaded to the digital Cloud with Quick Response (QR) codes to link each video to spaces that the citizens view as meaningful. It is a "transdisciplinary project that connects the young and the old, the micro and the macro, the individual and the collective, the physical and the digital" (Balestrini, 2012:Online).

- **Videojuegos para el Desarrollo de Habilidades en Ciencia a través de Celulares (VIDHaC2) (2010 - 2011):** The ViDHaC2 (Video Games for Developing Science Skills through Mobile Phones) project was conducted over a 24 month period. Educational video games were developed for primary-school learning to assist them in expanding their problem-solving skills, improving science learning as well as content management support amongst learners, by means of mobile phones. The project also developed a software editor that enabled educators to effortlessly design science video games for their learners, thus improving how educators facilitate learner learning, strengthening their methodological tools and mastery of science content (ViDHaC2, n.d.:Online). This project was the only one that allowed educators to create original content that learners could access from their mobile devices (UNESCO, 2012c:17).
- **Evaluación de Aprendizajes a través de Celulares (Learning Assessment through Mobile Phones) (2008 - 2012):** This project started as a pilot study in 2008 in Chile to assess the extent of learning in Spanish and mathematics using mobile phones. In 2011 approximately 10,000 learners in 300 secondary schools throughout Chile completed the examination using their mobile phones. Learners received multiple-choice questions via text message (SMS) and texted their answers as replies (UNESCO, 2012c:18-19).
- **Proyecto Facebook (Facebook Project) (2008 - 2009):** The main aim of this initiative was to engage learners in the course and to develop their technological skills by having them record and upload short videos using mobile phones. (UNESCO, 2012c:19).
- **BlueGénesis (2008 - n.d.):** This project made use of mobile phones with Bluetooth capabilities to facilitate communication and the exchange of information and course contents amongst educators and learners throughout a university. Educators sent questions, tests, course materials and messages to learners' mobile phones from their laptops via Bluetooth. Learners in turn used their mobile phones to read materials, answer questions and receive feedback (UNESCO, 2012c:19).
- **Proyecto Raíces de Aprendizaje Móvil (Roots of Mobile Learning Project) (2011 - 2013):** The project was launched in September 2011 and aimed to alter and improve educational practices in Social Studies and Mathematics classrooms through the use and appropriation of high-quality digital content downloaded by means of smartphones. Educational institutions that participated in the study each received a Nokia C7 to be applied in educational processes. Educators were trained in the use of digital content

and technology management in order to apply it in educational processes. Educators could download digital content and then project it via a video beam or TV in order to teach learners as part of their curriculum (CVNE, 2011:Online).

- **Postítulo de Especialización Superior en Educación a Distancia (Higher Postgraduate Specialization in Distance Education (2011 - n.d.):** During the course of this project, learners used their BlackBerry smartphones to access course content and activities in a specific blended-learning graduate course (UNESCO, 2012c:20).

4.3.2 Mobile learning impediments in Latin America

From the aforementioned projects, it is evident that there are two key barriers to the development of m-learning in Latin America, namely high costs and technology related limitations (UNESCO 2012c:27-28):

- **High costs**
  The following cost-related factors impede the sustainability and growth of m-learning projects:
  - **Connectivity costs:** Connection fees are extremely high-priced and hard to sustain on a large scale when projects rely on mobile phone networks to go online. However, there are ways around these issues such as by only expecting educators to use mobile phones, or when only wireless communication between the learners' smartphones and the educator's laptop occurs by means of a Local Area Network (LAN) using a router to support in-class activities.
  - **Costs versus services:** Standard mobile phones are inexpensive and widely available, resulting in some m-learning projects choosing to use these mobile phones to reduce costs. However, this option significantly limits educational opportunities if compared to smartphones. Smartphones on the other hand offer a various options for use with educational applications and multimedia content, although they are expensive and therefore uncommon among learners, predominantly in low-income populations.
- **Technology limitations**
  The following technological limitations can impede the amalgamation of mobile phones into teaching and learning activities:
  - **Speed:** Mobile phones have relatively slow Central Processing Units (CPUs), which can be frustrating when learners go online using a mobile network, however this issue can be addressed by rather connecting through wireless broadband.
  - **Size:** A mobile phone's portability and small size enables it to access learning opportunities anywhere, anytime. On the contrary, small screens limit the

possibilities of reading and watching certain types of content. This issue can be addressed by enabling educators to connect their smartphone to a digital projector to screen videos for the entire class. However, this option necessitates additional equipment and confine m-learning to a particular time and place (i.e. the classroom).

- **Access to online services:** In cases where learners are expected to produce and publish multimedia content with their mobile phones, they would typically require access to a host website (i.e. YouTube, Facebook) that allows them to share their final product with the class. Generally these services are free, accessible and easy to use, however access to these sites may be restricted by school networks or even at their parents' home.

4.3.3 Mobile learning in Asia

Asia (Figure 4.5) is the world's largest and most populous continent. Three Asian countries currently rank in the top fifteen of the world's largest GDP (PPP), namely China (ranked number 3), Japan (ranked number 4), and South Korea (ranked number 13) (CIA, 2012:Online).

Figure 4.5: The Asian continent

In this research study, Asia refers to the areas of East Asia, Central Asia, South Asia, South-East Asia, Oceania and the Pacific Islands. Findings from popular literature on the subject of m-learning point to the fact that current m-learning initiatives in Asia aim to make learning more accessible, promote self-directed learning, and design future learning environments (UNESCO: 2012d:6).

It is evident that countries in Asia tend to fall into one of three main categories in terms of their m-learning engagement, namely: 1) Countries that have a mature mobile market, high mobile phone penetration and strong ICT infrastructure, with m-learning included within the broad context of national-level ICT policies (developed countries); 2) countries that have a growing mobile market, medium-high mobile phone penetration, and basic ICT infrastructure (emerging economies); 3) countries that have an emerging mobile market, low-medium of mobile phone penetration, and weak or basic ICT infrastructure, with dispersed m-learning activities (developing countries). In spite of these huge difference in Asian economies, none of the Asian countries have ICT or education policies in place that exclusively address m-learning, implying that m-learning is still a relatively new phenomenon in Asia (UNESCO: 2012d:6).

The ICT Development Index (IDI) is a composite index based on internationally-agreed ICT indicators making it an important tool for benchmarking the most essential indicators for measuring an Information Society. The IDI is based on 11 ICT indicators, grouped in three stages, namely: readiness (infrastructure, access), use (intensity) and impact (outcomes), and is used to measure the level and evolution over time of ICT developments, progress in ICT development in developed and developing countries, the digital divide and the development potential of ICT within and across countries (ITU, 2012:15). According to ITU (2012:21), seven Asian countries are among the top twenty-five DOI economies, namely Korea (ranked number 1), Japan (ranked number 8), Hong Kong (ranked number 11), Singapore (ranked number 12), Macao (ranked number 14), New Zealand (ranked number 17) and Australia (ranked number 21) (ITU, 2012:21). Figure 4.6 illustrates the Digital Opportunity of the top 25 economies in 2010 and 2011.

Economy	Rank 2011	IDI 2011	Rank 2010	IDI 2010
Korea (Rep.)	1	8.56	1	8.45
Sweden	2	8.34	2	8.21
Denmark	3	8.29	3	8.01
Iceland	4	8.17	4	7.96
Finland	5	8.04	5	7.89
Netherlands	6	7.82	7	7.60
Luxembourg	7	7.76	6	7.64
Japan	8	7.76	8	7.57
United Kingdom	9	7.75	14	7.35
Switzerland	10	7.68	9	7.48
Hong Kong, China	11	7.68	12	7.39
Singapore	12	7.66	10	7.47
Norway	13	7.52	11	7.39
Macao, China	14	7.51	13	7.38
United States	15	7.48	16	7.11
Germany	16	7.39	15	7.18
New Zealand	17	7.34	18	7.03
France	18	7.30	17	7.08
Austria	19	7.10	22	6.74
Ireland	20	7.09	19	6.99
Australia	21	7.05	21	6.75
Canada	22	7.04	20	6.87
Belgium	23	6.89	23	6.60
Estonia	24	6.81	26	6.36
Slovenia	25	6.70	24	6.54

Figure 4.6: ICT Digital Index (IDI) for the top 25 economies in 2010 and 2011 (Adapted from ITU, 2012:21)

Data suggest that numerous people in Asia are purchasing mobile phones before or in the place of Personal Computers (PCs). According to Giles (2011:Online), from *The Economist*, mobile phones are more accessible and more affordable tools for communication and learning than PCs. Recent figures indicate that mobile phones costs and Internet access have decreased considerably in all regions of the world, therefore making ICT access more affordable in several Asian countries (UNESCO, 2012d:11).

Several recent m-learning initiatives in Asia have demonstrated the potential of mobile technologies to improve teaching and learning. Table 4.4 provides an overview of research conducted in Asia (developing, emerging, and developed economies) over the past five years (2008 - 2012), on different m-learning initiatives in an educational environment. It especially focuses on how mobile phones in literacy education, distance education and self-directed learning have been effectively utilised to increase the educational opportunities of learners living in less developed countries. Each initiative is thereafter elaborated upon in more detail.

Table 4.4: Recent research conducted in Asia on different mobile learning initiatives

Year	Project/Initiative	Country	Technology used	Project description
Developed Asia				
2002 - 2012	Eijiro	Japan	Mobile phone	An English learning service that can be utilised by learners who wish to improve their English language skills.
2007 - n.d.	LORAMS	Japan	Mobile phone	Supporting learners with a system to share and reuse learning experiences through the linkage to videos and environmental objects.
2007 - 2012	FutureSchools@ Singapore	Singapore	Tablet	Exploring innovative pedagogical approaches to the integration of ICT into school curricula.
Emerging Asia				
2011 - 2012	T-Smart Learning	South Korea	Tablet	Providing online tools and mobile devices to assist learners in managing their own English and mathematics learning processes.
2008 - 2012	Smart Education	South Korea	Mobile phone Smartphone	Learning system that supports learning anytime, anywhere, and where collaborative, creative and critical thinking skills are fostered.
Developing Asia				
2008 - n.d.	Communicative Mobile English Learning Model	China	N/A	Utilising ubiquitous language communicating environments created by mobile devices to its full potential, and to aid learners in converting English learning activities into rich and colourful communicating activities.
2008 - n.d.	One-to-One Learning in Chinese Classical Poem Education	China	Laptop	Learners were supplied with a laptop computer with a network connection and an educator-oriented, learner-centred in-class teaching approach. This enlarged learner knowledge, deepened their cognition engagement, and promoted their development of all aspects including high-level thinking ability.
2011 - 2012	Mobile Phone Literacy	South Asia - Pakistan	Mobile phone	Promoting literacy education for women through mobile phones.
2004 - 2012	MILLEE	India	Mobile phone	Investigating how mobile phones can be used to enhance English language skills of low-income learners in rural areas.
2012	Learn Alphabets on Handsets	India	Mobile phone	Enabling rural Indian women to learn alphabets on their cell phones.
n.d.	MIND	Philippines	Mobile phone (text message/ SMS)	Extending the learning opportunities of learners by means of learning modules that were integrated with SMS technology.

2003 - 2012	Text2Teach	Philippines	Mobile phone (text message/ SMS)	Schools were provided with English, mathematics and science m-learning resources that could be downloaded by learners via mobile phone.
n.d. - 2012	English modules via text message (SMS)	Mongolia	Mobile phone (text message/ SMS)	Reaching people who do not have the funds to enrol for distance learning programmes, and to investigate the feasibility of mobile technologies in a distance learning environment.
2008 - 2017	English in Action	Bangladesh	Mobile phone	Providing affordable English lessons and other educational content by means of mobile phone.
2009 - 2012	BBC Janala	Bangladesh	Mobile phone	Aims to provide affordable, innovative English education to adult learners in Bangladesh through mobile phones.
1999 - 2020	Smart School	Malaysia	Mobile phone	Prepare learners for a knowledge-based society through the use of mobile ICT.

4.3.3.1 Mobile learning in developed Asia

JAPAN

- **Eijiro (2002 - 2012):** Japan also makes use of mobile phones to support English language learning. Eijiro, an interactive English learning service, can be utilised by learners who wish to improve their English language skills (UNESCO, 2012d:16).
- **Link of RFID and movies system (LORAMS) (2007 - n.d.):** This project was conducted by a group of researchers to support learners with a system to share and reuse learning experiences through the linkage to videos and environmental objects. The LORAMS project consisted of three phases, namely video recording, search and replay. A user starts recording video at the beginning, and then scans Radio Frequency Identification (RFID) tags where after the system then sends the data and its time information to the server. Next, the video file is uploaded to the server, which then automatically links the video to the RFID tags. For the duration of the application phase, the user is only required to scan RFID tags around him/her and/or enter keywords of the objects. The system will then retrieve the video list that is related to the objects and keywords. The selected videos are replayed accordingly. Computer science learners were selected to become skilled at how to assemble a computer, and results show that these learners with ease acquired the necessary skills for assembling computers (Ogata, Misumi, Matsuka, El-Bishouty & Yano, 2008:297).

SINGAPORE

FutureSchools@Singapore (2007 - 2012): The FutureSchools@Singapore project, a Singapore Government initiative, was launched in 2007 to incubate novel education ideas that harness ICT (Kiat, 2009:Online). Some schools in Singapore was identified as ‘future schools' and received funding to alter their school environments by incorporating ICT into the school curriculum. Initially, five schools started to explore the potential of m-learning during pilot projects by slowly moving from printed textbooks towards the use of an assortment of highly innovative learning environments that allow anywhere, anytime learning (Yeung, 2009:13). Yeung (2009:13), predicts that there may be up to 15 Future Schools by 2015, which will represent more or less 5% of Singaporean schools.

4.3.3.2 Mobile learning in emerging Asia

SOUTH KOREA

- **T-Smart Learning (2011 - 2012):** South Korea was promoted to developed country status in 2008, however they repudiate to let itself become 'developed'. Despite South Korea having the world's largest economy with an average wage that is 30% higher than that of Sweden, they still do not wish to define themselves as a developed country. The country moved from being a poor, underdeveloped country to a rich and successful one in just one generation (Sivers, 2011:Online), however despite these advancements, the country maintains an emerging market status in terms of economic development. South Korean ICT companies started to sell m-learning devices, services and platforms in order to provide mobile devices and online tools to learners in assisting them to manage their own learning processes (self-directed learning). The T-Smart Learning platform is currently used to support English and mathematics learning associated with post-school programmes (UNESCO, 2012d:16), and is South Korea's first tablet-based education platform that provides optimised service for each user, supports interactive learning anytime, anywhere that affords learners the opportunity to share study tips via a knowledge sharing system, provides core functions for learning, and generates an effective learning environment by offering continuous motivation (C114, 2011:Online). The initial project focus was on increasing and enhancing English language education in South Korea with the main aim of furthering English language proficiency and academic outcomes for Korean learners (n.a., 2012a:Online).
- **Smart Education (2008 - 2012):** The 'Smart Education' government initiative was launched in 2008 as a customised learning system that supports anywhere, anytime learning. The initiative aimed to transform the current educational culture into a twenty-first century learning environment where collaborative, creative and critical thinking skills are promoted through the use of technological tools. Smart Learning in Korea is a new paradigm that uses ICT and network infrastructure to provide anywhere, anytime education allowing learners to utilise all available learning devices. Learners can attend courses at their own pace, and can simply access course elements, which relate to them (Kim, Cho & Lee, 2012:Online). South Korean universities have also started to

investigate the potential of a 'Smart Campus' that provides a wireless, cloud-based infrastructure where learners can easily access all relevant information about their learning progress, administrative matters and other university resources via smartphones thus moving towards a more interactive, collaborative and customisable instructional programme (UNESCO, 2012d:17).

4.3.3.3 Mobile learning in developing Asia

CHINA

China is the world's most populous country and has become the world's fastest-growing major economy (n.a., 2012b:Online). China currently has the most mobile phones of any country in the world, and also has the most Internet and broadband users in the world (Barboza, 2008:Online).

- **Communicative Mobile English Learning Model (2008 - n.d.):** In this learning model learners are the subjects of learning, and m-learning resources and learning activities are used to stimulate learners' need and curiosity for independent learning (Dias, Carvalho, Keegan, Kismihok, Mileva, Nix & Rekkedal, 2008:32). The real meaning of "communicative mobile English learning mode" is to utilise ubiquitous language communicating environments created by mobile devices to its full potential, and to aid learners in converting English learning activities into rich and colourful communicating activities. Research results indicate that the new communicative mobile English learning model has a positive impact on promoting primary school learners' interest towards English learning, as well as their mastery of knowledge and their development of abilities (Liu, Yu & Ran, 2008:60).
- **One-to-One Learning in Chinese Classical Poem Education (2008 - n.d.):** During this project learners were supplied with a laptop computer with a network connection. An educator-oriented and learner-centred in-class teaching approach to a large extend enlarged the learners' knowledge scope, deepened their cognition engagement, and promoted their development of all aspects including high-level thinking ability (Dias *et al.*, 2008:33). According to Dias *et al.* (2008:33), out-of-class 1:1 learning takes two main forms, namely m-learning that is based on text messaging, and m-learning that is based on connections. The first option is the most extensively researched option whereby learners send text messages to teaching servers via mobile phones, PDAs or other handheld devices. The teaching servers then convert the text messages into data requests upon which data are sent back to the learners. Many research has been conducted on both in- and out-of-class application of 1:1 learning, however research on 1:1 learning combined with in- and out-of-class teaching are limited.

SOUTH ASIA - PAKISTAN

Mobile Phone Literacy (2011 - 2012): Pakistan is one of the developing countries in South Asia that has low literacy levels. UNESCO collaborated with Mobilink, a mobile service provider, and a local NGO to launch the Mobile Phone Literacy project in Pakistan. The main aim of this initiative was to promote literacy education for women through mobile phones. Mobile phones are an attractive and affordable resource to maintain literacy skills and to acquire information. It holds enormous potential for reaching marginalised girls and women and providing them with access to further learning and development (UNESCO, n.d.:Online). With this project, each learner was supplied with a mobile phone to receive learning resources via daily text messages (SMS) from their educators. Learners were expected to practice handwriting and re-read the messages in their workbooks, and to respond to their teachers and answer questions by means of text messages. The majority of learners indicated a significant improvement in their grades, and their willingness to continue the literacy programme after the pilot project ended - an indication of project success (UNESCO, 2012d:13).

INDIA

- **Mobile and Immersive Learning for Literacy in Emerging Economies (MILLEE) (2004 - 2012):** Similar as Pakistan, India is also a country with low literacy levels. According to Kam, Kumar, Jain, Mathur and Canny (2009:Online), the Mobile and Immersive Learning for Literacy in Emerging Economies (MILLEE) project was launched in 2004 and aimed at investigating how mobile phone-based games can be used to enhance English language skills, specifically focusing on low-income learners in rural India who have had minimal access to traditional education systems (UNESCO, 2012d:13). Results show that learners have significant gains in learning when they use mobile phone-based games.
- **Learn Alphabets on Handsets (2012):** This initiative enables rural Indian women to learn alphabets on their mobile phones, as they continue to use mobile technology to expand their empowerment outside the home. To date, more than 1000 women have started reading English and other languages with the help of their mobile phones. The initiative encourages women to buy mobile phones to serve as supplemental educational tools in order to assist them in learning various alphabets. The mobile phone is not only used to teach Indian women various alphabets, but also how they can utilise these devices to increase business and improve their personalities, as well as for their daily communication (Srivastava, 2012:Online).

PHILIPPINES

- **Mobile Technology Initiatives for Non-formal Distance Education (MIND) (n.d.):** The project aimed at extending the learning opportunities of learners who did not have the funds or could not be reached through traditional distance learning channels, by means of learning modules that were integrated with SMS technology (UNESCO, 2012d:15). The project aimed to explore how SMS technology could be utilised to reduce their dropout rates and improve the passing rates and performance of learners (Ramos, Librero, Triñona & Ranga, 2007:Online).
- **Text2Teach (2003 - 2012):** The Text2Teach project was a large-scale initiative that received extensive logistical and financial support from Nokia, a Finnish multinational communications corporation which is the world's largest manufacturer of mobile phones. The project aimed to improve the teaching of English language, mathematics and science in the Philippines through the provision of interactive easy-to-use multimedia resources designed to make learning more exciting and meaningful for young learners. Digital satellite broadcasting and mobile phone technologies were used to broadcast video materials directly to the classroom (Rodríguez, 2008:74). In 2011, the project was already in its third phase and had reached 337 out of its 350 target schools, serving over 54,000 learners and over 1,500 educators. Learners in Text2Teach-enabled schools showed improved performance, better retention of knowledge, increased learner engagement, and an improvement in class behaviour. Furthermore, local communities showed a positive attitude toward the use of this teaching technology, which assisted in bridging the learning gap between public and private schools. (Ayala Foundation, 2011:15).

MONGOLIA

English learning modules via text messages (SMS) (n.d. – 2012): Since 2006, mobile subscribers in Mongolia have risen with 35% to just above 1.1 million subscribers. Mobile content development is one of the fastest emerging services, and does not only contribute to the expansion of Mongolia's ICT industry, but also to the development of the ICT infrastructure, placing a greater emphasis on ICT education at secondary, vocational and tertiary levels (Lkhagvasuren & Sambuu, 2009:268). Internet service provision has been greatly improved in the country since 2007, and Internet connection fees are also more affordable (Lkhagvasuren & Sambuu, 2009:269). Despite the growing use of ICT in the country, there are only five computers per school on average, which are mostly used for teaching informatics, while a limited number of computers are available for use by educators (Lkhagvasuren & Sambuu, 2009:271). Lkhagvasuren and Sambuu (2009:271), further state that "due to poor infrastructure development and lack of equipment and skilled personnel, computers and the Internet are not widely used for subjects other than informatics". In 2005, Sambuu (2005:116), argued that this issue could be resolved through the provision of mobile technology. The Health Sciences University of Mongolia together with the English for Special Purposes Foundation (ESPF) developed English learning modules that could be delivered via text messages (SMS). The project aimed to reach people who did not have the funds to enrol for distance learning programmes, which commonly required computer access with an Internet connection, as well as to investigate the feasibility of mobile technologies in a distance learning environment (Valk *et al.*, 2010:Online). Participants responded positively to the text message/SMS learning modules, and indicated that they have found English language learning via SMS to be useful and effective (Ramos & Triñona, 2010:212).

BANGLADESH

- **English in Action (2008 - 2017):** Launched in 2008, the English in Action project in Bangladesh aimed to contribute to the economic growth of the country by raising the country's English language skills by 2017 through mobile technology. Furthermore, adult and community interventions were introduced by the BBC Media Action using mobile phones, a local newspaper, television and the Internet. The aim of these activities is to increase learner motivation and access to learning content, as well as to reduce barriers to English language learning (English in Action, 2012:Online).
- **BBC Janala (2009 - 2012)**: Being the first project of its kind in the world, the BBC Janala (Windows) project was launched in 2009 and provided a multi-platform that aimed to provide affordable, innovative English education to adult learners in Bangladesh by harnessing multimedia technology. Two years later, the project now offers a new way of English learning through mobile phones, the Internet and television (Walsh & Power, 2011:Online). This project forms part of the English in Action initiative.

MALAYSIA

Smart School (1999 - 2020): The Malaysian Government has developed a national plan, similar to the South Korean government's initiative on Smart Education, and commenced early in 1999. The Smart School initiative aimed to prepare learners for a knowledge-based society through the use of ICT and the strategic plan includes guidelines for four implementation phases. The first- (1999 - 2001) and second implementation phases (2002 - 2005) were followed by the third implementation phase (2005 - 2010) that planned to establish 'smart' schools by expanding digital technologies to all institutions. The fourth implementation phase (2010 - 2020) envisaged that the pedagogical ideas underlying the Smart School concept should become omnipresent in all Malaysian schools (UNESCO, 2012d:17).

4.3.4 Mobile learning impediments in Asia

UNESCO (2012d:24), reported on several m-learning impediments, which were identified during the adoption of mobile phones in Asian education, namely:

- **Cost of mobile devices and data plans:** Despite the high dispersion of mobile phones in Asia, the cost of mobile devices and mobile communication subscription still proved to be a major drawback in the adoption of mobile phones in the teaching and learning environment. Not all Asian schools, educators, and learners can afford mobile devices and data plans. In addition, some learners are in possession of a basic mobile phone, while others have access to smartphones and tablets, which introduces equity concerns.
- **Misuse of mobile phones:** Another issue is the misuse of mobile phones by learners, which mooted most schools to ban these devices as opposed to investigating the possibilities it can provide to teaching and learning.
- **Lack of high-quality educational content:** The general public is more prone to view mobile phones as exclusive communication and leisure devices, rather than powerful educational tools, due to the lack of high-quality educational content and resources that are available by means of mobile platforms (UNESCO, 2012d:24).
- **Educator and parent mindsets and attitudes:** Since educators and learners have a propensity to prioritise assessments, it can reinforce traditional educational approaches as opposed to focusing on new, innovative m-learning methods (Shin, 2011:Online). Takeuchi (2011:5), states that another barrier to m-learning is that most parents are concerned about the extensive use of mobile phones and that overuse of these devices can reduce the time spent on exercise and social interaction, which could have detrimental effects on their physical and psychological development.
- **Health-related issues:** The World Health Organisation (WHO) announced that mobile phone radiation may increase the risk for certain cancers, however no decisive scientific evidence has yet proved a relationship between mobile phone use and health issues (Dellorto, 2011:Online; Walsh, 2011:Online). Digital addiction and excessive screen time are also raising concerns since it could cause eye strain, fatigue, lack of concentration, and an inability to stay focused on tasks (UNESCO, 2012d:24).

4.3.5 Mobile learning in Africa

Africa (Figure 4.7) is the world's second largest and second most populous continent, however it is classified as the world's poorest and most underdeveloped continent. Africa contains the top ten poorest countries in the world (Maps of the World, 2011:Online). The

African Union is a 54 member federation consisting of all of Africa's states except Morocco. None of Africa's countries rank in the top fifteen of the world's largest GDP (PPP). South Africa, the most southern country in Africa, is the highest ranked African country with a GDP (PPP) that places it in the 26th position, followed by Egypt (ranked number 27) (CIA, 2012:Online) in the world.

Figure 4.7: The African continent

Several African initiatives have been supported in rural areas or in developing countries, where Internet connections are more uncommon than mobile phones. In these environments access to a traditional e-learning platform can be more complex than simply using a mobile device (Bonaiuti, Boscolo, Bouchereau, Calvani, Cayla, Giorgini, Mounier, Parnalland, Ranieri & Ravotto, 2010:Online). Beute (2004:Online), argues that the level of technology penetration in Africa is generally low if compared to developed counties, mainly due to the fact that the general population cannot afford such technology. As perceived by Barker *et al.* (2005:Online), Africa is lacking technological development that results in a negative effect on education on the continent. For more than two decades, Africa has experienced an ongoing, devastating education crisis that includes limited access to educational resources and opportunities, a lack of highly qualified educators, and low levels of literacy and basic education skills. On the contrary, with the distribution of other technologies, Africa is experiencing extremely fast growth in mobile phone usage, which potentially opens up new avenues for addressing systemic educational challenges (UNESCO, 2012e:9).

Minges (2004:16), states that "mobile technology is the information society in Africa, it is a technology that has permeated more widely than any other into new areas, and we must examine how we can utilise this technology going forward". Ford and Botha (2008:160), reiterates the sentiments of Minges (2004:16), stating that there is, “a need for new approaches to integrate technology into the classroom, particularly in an African environment”. Brown (2005b:313), agrees by confirming that the role of m-learning in Africa is, "a reality that will continue to grow in form, stature and importance", and that it will turn out to be the preferred learning environment of the future. The limited dependence of mobile phones on permanent electrical supply, its easy maintenance, affordability, user-friendliness and universality, have made these devices probably the most important ICT technology in the developing world. In Africa, according to Donner and Gitau (2009:Online), the use of mobile phones have reached new heights as mobile users now have Internet access - something their desktop computers without Internet access have not allowed them. These users are now able to communicate and access information in communities that were previously excluded by the digital divide.

During the past decade, several m-learning models have been designed and proposed for adoption in Africa. One of these models was designed by Andreas Barker and colleagues from the Department of Information Systems at Rhodes University in South Africa. They describe their model as follows: A model for m-learning adoption contains a m-learning environment, which is underpinned by the traditional learning environment and also supported by effective m-learning policies and guidelines. Within the traditional learning environment, as indicated in the model, learning can still take place through desktop PCs. The proposed model demonstrates that the mobile devices can be used as academic support for learners via online assessment, providing course content and access to the Internet. The mobile devices in the proposed model for m-learning adoption enable learner-to-learner communication, as well as learner-to-educator communication (Barker *et al.*, 2005:Online). Another model for m-learning adoption in Africa has been proposed by Brown (2005b:313), where the focus is on the design and development of germane learning environments that is, "based on sound pedagogical principles that will ensure the optimisation of learning in a m-learning environment".

South Africa has the highest concentration of m-learning projects in Africa (UNESCO, 2012e:14). The main projects launched in Africa within the m-learning field are focusing on the utilisation of mobile phones to support literacy programmes or to involve learners in collaborative writing experiences, and the utilisation of mobile devices, in particular mobile phones, to favour and support community development in remote locations that have a lack of infrastructure for physical mobility (Bonaiuti *et al.*, 2010:Online). All of these m-learning initiatives involved considerable financial, technological and human-capital investments, and are aimed at making new technologies work in resource-poor education environments, and creating a global community of practice, whose purpose was to catalyse a paradigm shift towards ‘twenty-first century learning’ (UNESCO, 2012e:11).

M-learning initiatives have emerged in a number of sectors and fields, such as the health care-, banking-, agricultural-, food security, and the media sector. These initiatives demonstrate how mobile phones are enabling new forms of service delivery across several sectors of society, suggesting the emergence of a generalised ‘mobile conception of society’ (Traxler, 2007:Online). M-learning growth in education forms part of this promising phenomenon where mobile devices increase access to information and knowledge anywhere, anytime, and also provide new opportunities for formal, informal and open and distance learning (Traxler, 2009:8). Research indicates that most m-learning projects start off as small-scale pilot initiatives in urban environments that are launched at all educational levels and environments, and primarily make use of text messaging. Very few of these initiatives consider the implications thereof for national policy (UNESCO, 2012e:16).

The rapid technological development in mobile phones together with their rapid distribution into our daily lives has prompted several sectors to take advantage of them for a variety of purposes aimed at improving organisational effectiveness and flexibility. The communication, business, financial, banking and education sectors have developed and continue to develop applications for mobile phones (Muyinda, Lynch & Lubega, 2008:359). This research study will mainly focus on formal and informal m-learning initiatives conducted over the past five years (2008 - 2012) in an educational environment. Table 4.5 provides an overview of 30 research studies conducted in Africa on different m-learning initiatives, specifically focusing on m-learning at primary and secondary school level, as well as at tertiary level. Each initiative is thereafter elaborated upon in more detail in Paragraph 4.3.6.1 and Paragraph 4.3.6.2.

Table 4.5: Recent research conducted in Africa on different mobile learning initiatives

Year	Project/Initiative	Country	Technology used	Project description
Mobile learning at primary and secondary school level in South Africa				
2009 - 2012	MoMath	South Africa	Mobile phone	Using mobile phones to provide Grade 10 learners with access to mathematics content and support.
2008 - n.d.	MOBI	South Africa	Mobile phone	Delivering mathematics learning content to Grade 10-12 learners.
2006 - 2009	MobiLED	South Africa	Mobile phone	Designing, developing and incorporating mobile phones into formal and informal learning settings.

2007 - 2012	Dr Math	South Africa	Mobile phone	Teaching mathematics via mobile phone by means of MXit, a free IM application.
n.d.	IGLOO	South Africa	Mobile phone	Supplying educators and learners with a mobile application to support them in formal and informal learning scenarios.
2009 - n.d.	Hadeda	South Africa	Mobile phone	Utilising mobile phones to improve language skills.
2010 - 2012	Yoza Cellphone Stories (M4Lit)	South Africa	Mobile phone	Learners downloaded a m-novel for leisure reading and then communicated with peers about the novel via MXit, a free IM application.
2008	M4Girls	South Africa	Mobile phone	Developing the mathematics and technological skills of girls in Grade 10 through mobile phones.
2009 - 2012	M-Ubuntu	South Africa	Smartphone	Promoting literacy by means of recycled smartphones.
2009 - n.d.	Imfundo Yami/Imfundo Yethu	South Africa	Mobile phone	Enhancing the traditional learning environment of learners by allowing them to access mathematics content on MXit through mobile phones.
Mobile learning at tertiary level in South Africa				
2002 - n.d.	SMS and IVR	South Africa	Mobile phone	Support via mobile phone to offer administrative and motivational communication to learners through SMS messaging and Instant Voice Response (IVR).
n.d.	M-learning in the Faculty of Human Sciences	South Africa	PDA	Determining the impact of PDA use on assessment quality, learner performance, and efficiency and effectiveness.
n.d.	M-learning in the Faculty of Engineering, Build Environment and Information Technology	South Africa	PDA	Focusing on Human Language Technologies (HLT), the ability to encourage collaboration with PDAs, mobile sharing of software and resources, multi-user applications and resources, as well as wireless VoIP.
2005 - n.d.	Ecotourism	South Africa	PDA	Determining how PDAs could be utilised during field trips to support and enhance the teaching and learning experience of Ecotourism learners.
2002 - n.d.	DFAQ	South Africa	Mobile phone	Exploiting mobile phones to enable anywhere, anytime learner support via a SMS messaging interface.
n.d.	OMLF	South Africa	N/A	Recording lectures and making it available to learners as an additional resource to face-to-face education through an Interactive Opencast Mobile Learning Framework via their mobile devices.
2009 - n.d.	Dunia Moja (One World)	South Africa Tanzania Uganda	N/A	Providing access to course materials, enabling field research and assignments, and facilitating communication, interaction and knowledge sharing.

2009 - 2012	ACE	South Africa	Mobile phone	Encouraging critical engagement with course content and establishing a network amongst the educators via a LMS and SMS.
2012 - 2013	M-learning at UNISA	South Africa	Mobile phone	Investigating the extent to which distance learners utilise technological tools as per university expectations and in practice as they teach.
n.d.	Mobile Technology and SMS	South Africa	Mobile phone	Investigating mobile phones as a possible means to promote quality teaching and learning which in turn can raise undergraduate throughput and improve the success rate in Online Distance Learning (ODL).
Other African mobile learning projects				
2008 - n.d.	KSTS project	Kenya	Mobile phone PDA	Providing learning content that enables learners and educators to use mobile phones or PDAs for self-learning, skills transfer, and personal development.
2008	M-learning at Aga Khan University-Institute for Educational Development	Kenya	Mobile phone	Designing and implementing a m-learning system that could substitute educator appointments, and simultaneously preserve or improve the quality of education.
n.d.	Teach It Mobile Uganda	Uganda	Mobile phone	Capitalising on pervasive mobile phone use in Uganda to enhance educational opportunities for primary learners while creating an educational network for educators.
2005 - n.d.	MSRI	Uganda	Mobile phone (SMS)	Guiding distance learners who completed their final year field research projects by means of mobile phones.
n.d.	Mobile Short Messaging Service Program	Uganda	Mobile phone (SMS)	Supporting distance education learners via SMS.
2007 - 2009	Elima kwa Teknolojia	Tanzania	Mobile phone	Providing educators with access to digital video content for on-demand screening in class via mobile phones.
n.d.	ICT Bites	Tanzania	Mobile phone	Improving the performance of secondary school educators by providing training on pedagogy and subject specific education.
2007 - n.d.	Rural Literacy programme	Morocco	Mobile phone	Increasing literacy skills amongst girls and women in rural Morocco, and enabling them to overcome deep-rooted cultural and traditional constraints.
n.d.	Jokko	Senegal	Mobile phone (text messaging)	Using SMS to support literacy skills development and information sharing in local languages among youth and adults, especially women, in villages.
2007 - 2011	Project Alphabétisation de Base par Cellulaire	Niger	Mobile phone (text messaging)	Using mobile phones to improve literacy and numeracy skills.

It is evident from the above table that most African m-learning projects make use of mobile phones with the primary aim to improve learners' literacy and mathematics skills.

4.3.6 Mobile learning in South Africa

South Africa (Figure 4.8) is located at the southern tip of Africa and has a population of over 51 million people. South Africa is a multi-ethnic nation with diverse cultures and languages. Almost 80% of the population is of black African descent (Statistics South Africa, 2011:1). Despite the fact that the country has the largest economy in Africa, just over 25% of the population is unemployed (Statistics South Africa, 2012:v). According to Statistics South Africa's 2011 Census Report (2011:1), the highest level of education (completing secondary school) amongst persons aged 20 years or older is 28.9%, 8.6% has received no schooling, and only 11.8% has completed a higher education diploma or degree.

Figure 4.8: South Africa

A worldwide assessment of the use of m-learning in tertiary education has brought into sharp focus the ever increasing use of mobile technologies in tertiary education across the globe, including developing countries like South Africa. Today there is little doubt that mobile technologies can be utilised as a very successful educational medium. Despite the growing demand of mobile phones in the developing world, the potential to address educational challenges through ICT is restricted by the level of technology adoption and resource constraints in the South African education environment. Van Biljon and Dembskey (2011:Online), are of the opinion that these challenges are mainly due to two reasons, namely: 1) The African technology penetration level is low compared to other developing countries, which has an unfavourable impact on the education sector, and 2) tertiary institution learners often experience financial and educational constraints that hamper ICT and mobile technology implementation.

South Africa has the largest mobile market in Africa, however mobile data usage is still low. Despite data usage still being low, estimates from South Africa (ITU, 2011a:Online), suggest that there are significantly more mobile Internet connections than traditional desktop computer Internet connections. Most of South Africa's fixed-line Internet users belong to the wealthy elite. According to the latest recorded data (ITU, 2011a:Online), there were an estimated 3.5 million South African fixed-line Internet users in 2004, just under 13% of the 2004 population estimate (ITU, 2011a:Online). In contrast, the mobile phone has become nearly ubiquitous. Even though it is only during the past few years that data-enabled mobile phones and prepaid data plans have made mobile Internet broadly accessible, the majority of the population access digital media and the Internet exclusively via their mobile phones (Donner & Gitau, 2009:Online; Kreutzer, 2009:Online). Between 2000 and 2010, the number of mobile subscriptions per 100 inhabitants in South Africa escalated from 18.63% to 91.24% (ITU, 2011a:Online), while in the same period, landline subscriptions actually declined, from 11.09% to 8.43%. As mobile penetration increases, so has the sophistication of mobile phones and the ubiquity of mobile Internet.

South Africa has become a home to a lively start-up/technology community, and is capable of fast technological innovation, however unfortunately still suffers severe economic inequalities. Addressing the historical educational inequalities in education amongst different races is a fundamental policy goal since the political transition in South Africa in 1994. Albeit the South African Government has made huge progress in providing computers and Internet access to public schools, several previously disadvantaged learners still lack computer access outside of regular school hours (Foko, 2009:2535), and are still not performing satisfactory at school. Even learners who meet the minimum admission requirements of tertiary institutions do not perform as well as their more affluent counterparts (Foko, 2006:4, 6). According to Foko and Amory (2005:43), these learners "do not have the necessary skills to participate in tertiary education and lack many of the basic skills to compete successfully in certain sectors of society". Cultural norms and background (i.e. gender, race, socio-economics, access and curriculum) are key factors involved in poor performance (Smith, Foko & Van Deventer, 2008:1). There is therefore a need to introduce learners with positive science and ICT from an early age, allowing learners to be comfortable and willing to engage and explore (Foko, 2009:2535).

Managing diversity in South African classrooms is a major challenge for all South African educators (Condy, Chigona, Gachago & Ivala, 2011:Online). Combining the aforementioned factors with high levels of mobile use makes it a particularly successful environment for the development and adoption of mobile social software (Walton & Donner, 2011:119). For technology to be used in education, it must be affordable and accessible, but this is a barrier for many educational institutions, educators and learners in South Africa. However, with regard to the potential of m-learning in developing countries Brown (2004:Online), argues that "Africa is actually leapfrogging from an unwired, non-existent e-learning infrastructure to a wireless e-learning infrastructure". There are already many m-learning activities and projects in Africa ranging from the use of PDAs in assessment strategies and wireless learning environments, to the use of SMS for learning support (Brown, 2008:864-865). Due to the lack of technical infrastructure for e-learning in developing countries, there is an exponential demand for m-learning.

The living and learning environments in developing countries can more often than not be quite different from that of developed countries. Where mobile technology may prove to be a complementary extension to teaching methods in developed countries, for example improving or enriching the learning experience, in many developing countries, it offers the hope of revolutionising learning altogether, even taking it into areas previously devoid of reliable or regular education services. This dispensation is primarily true of rural areas, which more often than not are characterised by a lack of fixed telephone lines, unreliable electricity supply, few if any personal computers, and most likely, no Internet access. The state of the South African technology in infrastructure therefore raises a concern as it should not put an unnecessary additional financial burden on tertiary institutions, but should instead be more useful regarding ease of use and practical functionality. According to a study conducted by Louw, Brown, Muller and Soudien (2009:239), South Africa endures poor infrastructure since the majority of learners still feel that computers and network access are inadequate for teaching and learning purposes. Moreover, learners experienced networks to be unreliable and slow, and insufficient technical support. Pejovic, Johnson, Zheleva, Belding, Parks and Van Stam (2012:2487), confirm the findings of Louw *et al.* (2009:239), regarding South Africa's bandwidth barriers. This aforementioned dispensation is graphically depicted in Figure 4.9.

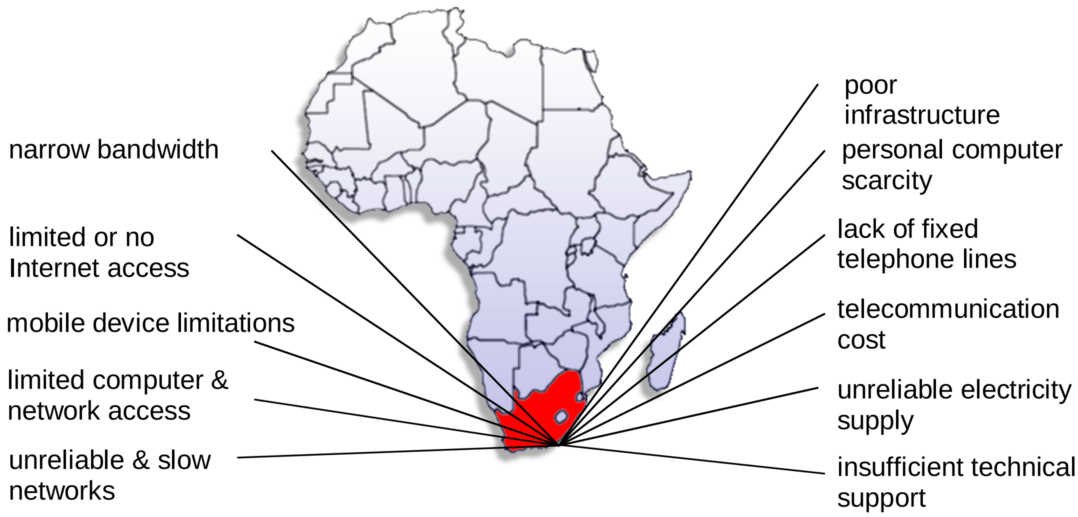

Figure 4.9: Key constraints in implementing m-learning in South Africa

What many of the technological deprived communities will have however, is mobile network coverage, and if not, their own fixed-line phones, or at least access to one. Learning by distance is nothing new in many developing countries, and the use of mobile technologies has the potential to unlock the potential yet further, expanding its reach and delivering richer, more appropriate, more engaging and interactive content (Banks, 2008:53).

However, mobile technologies, and more specifically m-learning, are dependent on two critical infrastructure elements, namely power and data (Springer, n.d.:Online). To ensure successful m-learning implementation and support, learning spaces must consider the data and power requirements imposed by the mobile technology. According to Springer (n.d.:Online), the provision of data access is a vital responsibility in the management of educational facilities, and concerns about security as well as security requirements may reduce the rate at which newer technologies are implemented and supported. There are definite differences in access for specific learner and educator groups. The impact of the digital divide, where some have broadband access, as well as access to ICT and the media and knowledge enabled by their use, and others do not, is most identifiable as it affects education. Czerniewicz and Brown (2006:5) postulate that learners from low socio-economic groups, especially second language English learners, find access to ICTs on campus to be more challenging, as they have less access to ICTs off-campus than their counterparts from higher socio-economic groups, and they also rate their abilities and skills to be lower than that of their counterparts. Moreover, learners from lower socio-economic groups also have less access to supportive social networks and to some extent have an inferior perception of the sufficiency and capability of online content.

By reducing or even eradicating the digital divide could be the main challenge in understanding the full potential of mobility and m-learning in the digital age (Springer, n.d.:Online). Furthermore, Springer states that mobile devices are dependent on electrical power to recharge its batteries. Data or power loss does not only interrupt learning, but also hampers, and in effect ends the ability to use mobile devices. In order to assure a truly mobile experience and to unlock the full potential of m-learning, the mobile learner must be untethered. Despite these barriers, the ease with which South Africans adopt mobile technology suggests a wide range of possibilities for development using mobile technology, including m-learning in an educational environment.

4.3.6.1 Mobile learning at primary- and secondary school level in South Africa

Several South African m-learning studies have been conducted at primary- and secondary school level, however the majority of these tend to be small-scale projects with a focus on reaching hundreds rather than thousands of learners. It is evident that most of the research focuses on using mobile phones to teach learners language/literacy or mathematics skills.

- **MoMath (2009 - 2012):** The Mobile and Immersive Learning for Literacy in Emerging Economies (MoMath) project, funded and developed by Nokia, was launched in 2009, in the Gauteng, North West and the Western Cape provinces of South Africa. During the course of 2010, a total of 4000 learners from 30 schools in these provinces had access to the MoMath service to practice mathematics, to test their skills by competing with other learners in mathematics, and to collaborate in mathematics related problems with their friends (NokiaConnectZA, 2010:Online). More than 10000 mathematics exercises were made available to educators and learners. In 2011, the project expanded to a fourth province, reaching about 500 educators and 25000 learners, as well as 172 schools (UNESCO, 2012e:16). Results indicate that learners had a 14% increase in mathematics competency, and enabled independent learning by allowing learners to use their mobile phones to engage in learning at their own pace, as well as educator-facilitated and peer-supported learning via MXit (UNESCO, 2012e:17). MXit, a mobile device IM application developed in South Africa, became a partner in this project, affording more learners the opportunity to participate in the project at no cost (NokiaConnectZA, 2010:Online).
- **MOBI (2008 - n.d.):** MOBI, a mobile edutainment (education and entertainment) application providing learners with anytime, anywhere learning, allows learners to listen to podcasts, view multimedia content, and communicate via IM by using their mobile phones. The main aim of the MOBI initiative was to deliver mathematics learning content to South African grade 10 to 12 learners. It was found that it is technically possible to

create a m-learning platform that works on ordinary mobile phones. The quick adoption of the initiative shows that there is an actual need for a mobile solution, and even though learners are relatively willing to adopt a mobile technology as a tool to enhance learning, they will struggle to use it on a regular basis if it is not directly incorporated into their immediate learning environment (Liebenberg, 2008:346).

- **MobiLED (2006 - 2009):** In 2006 a research collaboration, MobiLED, was initiated between the Helsinki University of Art and Design in Finland and the Meraka Institute (African Advanced Institute for Information and Communication Technology of the Council for Scientific and Industrial Research (CSIR)) in South Africa. The aim of the initiative was to design, develop and incorporate mobile phones into formal and informal learning settings with the purpose of preparing learners for "full participation in the knowledge society, towards the acquisition of 21st century skills" (Ford & Botha, 2009:Online). The project was funded by the Department of Science and Technology by covering SMS costs. MobiLED developed an audio Wiki-pedia, accessed with an SMS keyword whereby learners would then receive a call back and a speech synthesiser would 'read' an article on the subject. MobiLED has also developed a mobile tutoring service (Dr Math) to support learners with their mathematics homework, using the MXit platform. From an educational perspective, research results returned that mobile phones could serve as an extremely productive tool in the learning process. Furthermore, from a technology development point of view, the development of mobile technology tools and platforms that make provision for the various capabilities and models of mobiles phones also proved to be successful (Ford & Botha, 2009:Online). Four valuable lessons were learnt during the course of this project, namely the importance of: 1) Including all the role players in the educational environment in the process, 2) understanding the context of numerous learners and the potential consequences of introducing a new technology such as a mobile phone into the teaching and learning process, 3) having a multi-branched distribution strategy, and 4) designing solutions that are sustainable (Ford & Botha, 2009:Online).
- **Dr Math (2007 - 2012):** Launched in 2007 by the Meraka Institute of the CSIR in South Africa, this project investigated whether or not secondary school learners would use their own personal mobile phones and airtime to discuss mathematics related issues with a tutor using an IM platform named MXit. The success of this project is partly due to its accessibility and interactivity via the MXit platform. MXit, a synchronous communication tool where text messages can be sent and delivered instantaneously between users, was developed in South Africa. Current demographics on MXit usage indicate that there are about 60,220,000 MXit registered users in South Africa of which 53.7% falls within the 18 to 25 years age bracket (54% male). On average MXit processes an astounding 535,640,000 messages per day (South Africa, Namibia, Nigeria, Kenya, Lesotho and

Swaziland). A major advantage of this type of communication is that it is only a fraction of the cost of an SMS, thus providing learners the opportunity to access professional support in an affordable and cost-effective manner (MXit, 2012:Online). By means of MXit, Dr Math provided a mobile tutoring service where learners could receive live, on-demand tutoring from qualified educators and university learners (tutors). Tutors can communicate with learners by means of personal computers connected to the Internet. Dr Math also offers games and competitions on the MXit platform to attract learners to practice their mathematics skills. Project data logs indicate that learners frequently returned to these offerings to complete calculations (Ford & Botha, 2009:Online).

- **Information Gathering and Lesson Tool (IGLOO) (n.d.):** The IGLOO project involved the design, implementation and evaluation of m-learning technology, namely IGLOO for mobile devices. The main aim was to provide educators with a mobile application that is independent of GPRS connectivity or functionality and could be utilised to facilitate and support assessment practices in formal and informal learning scenarios, as well as to provide researchers with a data gathering tool through mobile technology (Ogunleye, Botha, Ford, Tolmay & Krause, 2009:355). All the users found the system reliable and satisfying to use, and that the time to learn and utilise the system was relatively quick (Ogunleye *et al.*, 2009:359).
- **Hadeda (2009 - n.d.):** The Hededa project attempts to utilise mobile phones to help improve the language skills of primary- and secondary school pupils. Hededa provides educators and parents with a facility where they can create spelling lists for learners by means of mobile phones or Internet-based workstations. The Hadeda facility then creates an entertaining mobile phone midlet (computer program) that can be downloaded by learners via their mobile phones. Hadeda articulates the words with electronic voices and allows learners to practice their spelling on a medium they enjoy (Butgereit, Botha & Van Niekerk, 2010:11). Results reflect that the Hadeda project had a positive impact on language skills learning (Butgereit *et al.*, 2010:18).
- **Yoza Cellphone Stories (Yoza)/m4Lit (2010 - 2012):** Previously referred to as the M4Lit (mobile phones for literacy) project, Yoza Cellphone Stories (Yoza) commenced in 2010 with the support of the Shuttleworth foundation, to explore the viability of using mobile phones to support reading and writing by youth in South Africa. Of South African households, 51% do not own any leisure books and only 7% of public schools have functional libraries, resulting in a lack of a strong reading and writing culture among young people, particularly those in inferior communities. On the contrary, 90% of urban youth have access to mobile phones of which 70% are estimated to be Internet-enabled. Since teenagers spend considerable time on their mobile phones, it encouraged educators to investigate the possibilities that m-learning could improve and support reading and writing amongst them (UNESCO, 2012e:24). Yoza demonstrates the

possibilities for fostering a reading and writing culture among teenagers, "in ways that recognise and embrace the unconventional forms and linguistic styles that are developing among young users" (UNESCO, 2012e:25). This was initially achieved by means of a m-novel that was published on a mobisite and on MXit to explore ways of supporting teenager leisure reading and writing around fictional texts in South Africa. The m-novel was published in two South African languages - English and isiXhosa. There is no charge for downloading m-novel stories, however users do incur mobile data costs. To address the cost issue, images have been kept to a minimum and data charges on local mobile phones range from only 5c to 9c per chapter, making Yoza m-novels a exceptionally reasonably priced option for providing reading material for teenagers (Vosloo, 2010:Online). Users were encouraged to interact with the m-novel as it unfolded and could discuss the unfolding plot, vote in polls, leave comments, and ultimately submit a written piece as part of a competition for story sequel ideas (Vosloo, Walton & Deumert, 2009:207; Yoza Project, n.d.:Online). Research findings suggest that, "literacy development requires nurturing communities of practice as well as spaces where out-of-school and leisure reading and writing are encouraged" (Walton, 2009:vii).

- **M4Girls (2008):** This project was a partnership between Nokia, Mindset Network, and the Department of Education of the North West Province in South Africa, to investigate the potential of educational content (mathematics) on a mobile phone platform to Grade 10 girls from underserved communities. The M4Girls project's aims were fourfold, namely: 1) To empower girl learners by providing them access to mathematics via mobile phones, 2) to expose them to a complementary platform of curriculum-aligned mathematics content on mobile phones, 3) to expose them to technology in the form of mobile phones, and 4) to determine whether it would lead to any significant change in their attitudes towards mobile technology, school and most importantly an improvement in mathematics. Twenty Grade 10 girls from two schools were provided with mobile phones that contained curriculum-aligned mathematics content which was developed by Mindset Network. Content was offered by means of easy-to-navigate games and videos that directly target the girls without the necessity of intervention or facilitation. Although girl learners did indicate a change in attitude towards mobile technology, results show that there was no significant change in attitudes towards technology and school as a direct result of the technology used. Exposure to mobile phones was well received. It could therefore be argued that positive attitudes towards the utilisation of mobile technology for learning purposes, together with high mobile phone usage by both educators and learners, indicate the potential of using mobile phones for e-learning or m-learning (M4Girls, 2010:Online).

- **M-Ubuntu ('I am because we are') (2009 - 2012):** The M-Ubuntu project uses low-cost, recycled smartphones to assist in South African literacy education. The project was developed in conjunction with and for learners and fellow educators, and connects South African educators with m-literacy coaches in the USA, England, Sweden and Italy to aid in opening new horizons to learners on the wrong side of the literacy and digital divide. The main aim of the project was to provide learners with the best possible access in South African and global literature, and the development of critical reading, writing and thinking skills (M-Ubuntu, 2012:Online).
- **ImfundoYam/ImfundoYethu (2009 - n.d.):** This initiative was developed with the assistance of Nokia to improve the traditional learning environment of learners through a medium that is widely accessible and that is of considerable interest to them. Learners from three South African provinces (Gauteng, North West and the Western Cape) used their own mobile phones to access the mathematics content made available via either SMS or browser based technology, or the MXit IM platform. The ImfundoYam/ImfundoYethu initiative focused on enhancing the formal learning process of mathematics at schools, and as a result to also promote education (Butcher, 2009:4; Nokia, 2009:Online). The initiative is a prolongation of earlier projects such as the M4Girls project discussed earlier (Nokia, 2009:Online).

4.3.6.2 Mobile learning at tertiary level in South Africa

When compared to research conducted at primary- and secondary school levels, research at tertiary level in a South African context is definitely lacking behind. Research conducted at the University of Pretoria (UP) and the Tshwane University of Technology (TUT), has given South Africa a leadership role in the m-learning field, which has been built upon by similar institutions throughout the country. A few m-learning initiatives at South African Universities are elaborated upon below.

UNIVERSITY OF PRETORIA

- **SMS and IVR (Instant Voice Response) (2002 - n.d.):** Since 2002, the University of Pretoria has been successfully utilising mobile phones in distance education in Africa as part of their postgraduate diploma in education. The amalgamation of SMS messaging with a paper-based programme resulted in an increase in learner attendance for contact sessions, as well as an improved response to information presented in SMS messages. Support via mobile phone was implemented to offer administrative and motivational communication to both large and small groups of learners. During this project the possible use of SMS messaging with academic functions, the integration of bulk SMS and IVR, as well as the development of a SMS assessment tool were investigated. A pilot project served to investigate four categories of asynchronous SMS academic interventions which included the IVR system through which the learner could phone a Frequently Asked Questions (FAQ) number and receive answers from a pre-programmed system. Learners also received multiple-choice questions to which they could respond via SMS. Learners could also ask questions about a pre-selected topic and receive answers automatically based on the programmed text database. The project was extremely successful in establishing that most learners had access to mobile phones. Learners were at ease using their personal mobile phones for academic purposes, as well as to make use of the SMS related services. Furthermore, results indicate that there was an increase in learner commitment that led to a larger percentage of learners completing tasks on time (Gregson & Jordaan, 2009:225).

- **M-learning in the Faculty of Health Sciences (n.d.):** In this project PDAs were used in clinical assessment sessions of medical learners. The project aimed to determine the impact of PDA use on assessment quality, learner performance, and efficiency and effectiveness (impact on administrative load, time, paper work, human errors, calculation errors, record keeping, duplication, costs, etc.). Positive feedback was received regarding efficiency, effectiveness and cost savings.
- **M-learning in the Faculty of Engineering, Built Environment and Information Technology (n.d.):** Fourth year learners have been issued with PDAs to use within a pilot wireless e-learning environment. PDAs were used for queries, content delivery, interactive distributed simulations, notices, database access, collaboration, etc. This project focuses on Human Language Technologies (HLT) (particularly in the speech recognition and speech-to-text fields, as well as voice user interfaces), the ability to encourage collaboration using PDAs, mobile sharing of software and resources, multi-user applications and resources, as well as wireless VoIP.

TSWANE UNIVERSITY OF TECHNOLOGY

- **Ecotourism project (2005 - n.d.):** The Tshwane University of Technology is the largest residential tertiary institution in South Africa, and represents learners from all demographic backgrounds of the country. De Crom and De Jager (2005:Online; 2006:65) as well as De Jager and De Crom (2006:87), report on the application of mobile devices (PDAs) during field trips as an alternative to conventional paper-based workbooks in an Ecotourism course. Their main objective was to determine how PDAs could be utilised during field trips to support and enhance the teaching and learning experience of Ecotourism learners. Two groups of learners participated in the study - one was comfortable with utilising technology and was given guidance in the use of PDAs prior to their first field trip, while the other was not as comfortable utilising technology, and was given no prior training in PDA use. Before the commencement of field trips, learners were given assignments, tests, pertinent information, references and multimedia applications via a PDA. Throughout field trips learners worked in a supportive learning environment to gain practical experience of the theory. PDAs were used to take notes, search for information, capture data, answer questions, write tests, complete surveys, and prepare their final project. Research results point to an increase in learner motivation and added outcome-based appropriate assessment opportunities when utilising PDAs. Moreover, learner attention and interest were evident when initially being exposed to PDAs. Learners used the PDAs persistently while commuting to field trip destinations and took notes, asked for statements to be repeated if they had missed something, used the existing information on the PDA to get answers to workbook or discussion questions, and participated in discussions with each other on topics provided on the PDA. In addition, learners could reflect by integrating the online LMS and PDAs to receive and submit assignments. Learner feedback shows that the use of mobile technology can support and improve their field learning experience in various ways.

UNIVERSITY OF CAPE TOWN

- **DFAQ project (2002 - n.d.):** At the University of Cape Town (UCT), m-learning has been adopted by the School of Management Studies to support a section of the curriculum of the Organisational Psychology course through the use of a Dynamic Frequently Asked Questions (DFAQ) tool. This tool provided a special-purpose question and consultation environment for learners via a SMS messaging interface. In addition, it allowed educators and learners to ask and respond to questions by means of their mobile phones (Hodgkinson-Williams & Ng'ambi, 2009:7). The project aimed at exploiting mobile phones to enable anywhere, anytime learner support. The DFAQ tool enabled learners to anonymously ask questions and receive answers to their questions they could otherwise not ask in a traditional face-to-face environment. Questions and answers were stored and provided the educator with feedback on learner learning, and also became a resource to the entire class. A Virtual Noticeboard allowed educators to post announcements and learners could access the notice board when required using their mobile phones. Furthermore, the tool allowed learners to collectively create short notes of which the resulting repository was accessible via texting. Furthermore, an Event Notifier allowed educators to plan messages about notifications, reminders and deadlines in advance and the tool could send notifications to learners at scheduled times. In essence, this study has provided useful information on how learners could take responsibility for their own learning, and learn from each other, capsizing the traditional dependence of learners on their educators (Hodgkinson-Williams & Ng'ambi, 2009:17).

- **Interactive Opencast Mobile Learning Framework (OMLF) (n.d.):** A problem that is growing exponentially in most tertiary institutions in South Africa is the registration of large numbers of learners who speak and write English as a second or even third language, and the exponential influx of foreign learners. These learners traditionally have difficulty to adopt English language as a medium of instruction, which make it onerous for them to cope with face-to-face lectures. According to Boyinbode, Bagula & Ng'ambi (2012:331), "Face-to-face lectures lack persistence and when students fail to understand the lectures during the once off face-to-face sessions, there is no opportunity to playback the lecture". This problem can potentially be addressed by recording lectures and making it available to learners as an additional resource to face-to-face education through an Interactive Opencast Mobile Learning Framework via their mobile devices. By enabling learners to study anywhere and at any time, it could improve their learning and understanding of course content.

UNIVERSITY OF THE WESTERN CAPE

Dunia Moja (One World) (2009 - n.d.): In m-learning in developing countries, the Dunia Moja project is a pioneering first. The project forms part of an initiative that were implemented in three African universities, namely the University of the Western Cape (South Africa), Mweke College of African Wildlife Management (Tanzania) and Makerere University (Uganda) in collaboration with Stanford University (USA). The project provided learners with the opportunity to learn from specialists in environmental sciences from various countries, and to discuss issues via Internet and mobile technology interactions. The project utilised high-end PDAs, "to increase communications and access to course materials, to allow study and assignment completion from the “field”, and to experiment with using various media to share local environmental research with the global project cooperative" (Stanford University, 2009:Online).

UNIVERSITY OF STELLENBOSCH

ACE programme (2009 - 2012): The Advanced Certificate in Education (ACE) programme involves a two year in-service qualification for educators that wish to improve their subject knowledge and didactical skills. Educators can enrol in different fields as part of the ACE programme, one of which is mathematics. Moodle, an open source LMS with a mobile interface, was adopted as the programme’s LMS. This enabled educators to access the LMS by means of a PC or a mobile device. Furthermore, it allowed educators to communicate (i.e. personal messages, chat session and forum discussions) that would otherwise not have been possible. The programme also includes SMS messaging for administrative purposes as well as for keeping up learner moral. The programme aims at encouraging critical engagement with the course content and to establish a network amongst the educators (Mostert, n.d.:Online).

UNIVERSITY OF SOUTH AFRICA (UNISA)

- **M-learning at UNISA (2012 - 2013):** The University of South Africa (UNISA) is Africa's largest Open Distance Learning (ODL) institution, and the longest standing dedicated distance education university in the world. One of the university's main aims is to exploit the new and emerging potential in ICT to propel the university into a truly digital future (UNISA, 2012:Online). According to Makoe (2012:Online), one of the main barriers of learning in distance education is the lack of interaction in a learning environment. Makoe further states that mobile technologies such as mobile phones hold a great deal of promise for distance education as a cognitive delivery tool to improve interactive collaborative learning, while addressing the challenge of learner remoteness. Since more than 98% of learners enrolled at UNISA already are in possession of a mobile phone, the university views the utilisation of mobile phones as a viable option to exploit in order to develop formal learning opportunities for distance education learners. One such example is a longitudinal three-year study of a postgraduate English Language course for educator trainees. This study investigated the extent to which these learners utilise technological tools as per university expectations and in practice as they teach. Research results for 2012 show that while several learners are excited about online learning, the majority appeared to be traditionalists (Makina & Lephalala, 2012:Online). Some learners view it as, "a social network that is not appropriate to a learning context; others are simply intimidated by venturing into something new, while a big majority is disabled from experimenting due to contextual factors". The inaccessibility to Internet facilities in the remote areas where they teach also proves to be a major concern. Makina and Lephalala (2012:Online), are of the opinion that online learning at UNISA should be deployed gradually and that there should be an thorough investigation of UNISA's inimitable situation as an ODL institution.
- **Mobile technology and SMS case study (n.d.):** During this case study the use of mobile phones were investigated as a possible means to promote quality teaching and learning, which in turn could raise undergraduate throughput and improve the success rate in ODL. During a qualitative case study, the learner perceptions were captured in the provisioning of distance education through the use of mobile phones. Learners were contacted by means of SMS messages and they were expected to again respond through SMS messages. Numerous learners were interviewed to scrutinise their perception and current mobile phone usage. Feedback reflected positive reactions from learners about the potential of mobile phone usage to increase throughput and learner success rates in ODL. Results returned that mobile phones can not only be beneficial as

a cost-efficient method to both educators and learners, but can also be effectively and efficiently utilised as a tool for teaching and learning in distance education. The majority of learners indicated that they have benefited from the SMS messages that have been sent to them by their educators and that it has closed the gap that existed between them and the university. Furthermore, learners proposed the use of SMS messages in other courses as well. It could therefore be argued that, "the use of mobile technologies can facilitate socialisation or can serve as a support mechanism" for learners (Mafenya, n.d.:Online).

OTHER AFRICAN MOBILE LEARNING PROJECTS

KENYA

- **KSTS (2008 - n.d.):** Since inception of the Kenya School of Technology Studies (KSTS) in 2008, it utilised the power of the Internet and mobility to provide learning content that allow learners and instructors to use their mobile phones or PDAs for self-learning, skills transfer and personal development. The goal of the project was to enhance KSTS in capacity development of relevant mobile content, it’s marketing and more importantly, examination and evaluation to improve the content and learning experience of learners (Tandaa, n.d.:Online).
- **M-learning at Aga Khan University-Institute for Educational Development (2008):** Mobile phones has brought about an enormous revolution in Kenya, replacing phones, credit cards, cash, and in some cases even bank accounts (Roettgers, 2009:Online). Due to rural locations and the large distances between the university and its learners, educators decided that they were in need of a m-learning system that could substitute educator appointments, and simultaneously preserve or improve the quality of education (Brown, 2010:3). This implied that learners required a method of receiving instructor and peer support via distance. Since the cost of owning and maintaining a computer is high compared with cost of owning a personal mobile phone, combined with the cultural changes and widespread use of mobile phones in Kenya, resulted in the design and implementation of a m-learning solution that makes use of SMS (Brown, 2010:2-3). Results from the study show that the m-learning solution was a positive step that reflected quick institutional change and learner benefit (Brown, 2010:8).

UGANDA

Several young learners from Uganda find learning outside of a school environment difficult and challenging and apparently prefer to rather learn in communities than on their own. Several mobile phone users only own a SIM and share an actual handset with others. The main reasons for not owning a phone among non-mobile owners include: 1) That their family/spouse does not permit them to make use of mobile phones (women were more likely to encounter this barrier), 2) handset costs are too expensive, and 3) monthly service cost is too high (GSMA mLearning, 2012:23). Despite these barriers, mobile Internet usage in Uganda is on the increase, with one in five young people having gone online via mobile. Most youths are aware of it, even if they have not yet experienced it. The majority of young people in rural areas do not have direct Internet access, but several can and do travel to Internet cafés in order to go online (GSMA mLearning, 2012:27). The chance to develop skills to improve their chances of getting a job or improving their current employment situation was cited as a key potential benefit of m-learning by 39% of respondents. Notwithstanding the fact that almost 97% of the overall population does not have access to electricity, there are still almost 9.4 million people that use mobile phones and 3.2 million people that have Internet access via satellite (Calnan, Kovar, Valadez & Wakulchik, 2011:1).

- **Teach it Mobile Uganda (n.d.):** This is an educational technology project that utilises mobile phones in Uganda to enhance educational opportunities for primary learners, while creating an educational network for educators. Together with the public and private sector the initiative aims to supply technology equipment to schools and to develop educational videos and resources to be integrated into lessons. Educators will be able to use the mobile phone to download videos that accompany specific lesson plans, and then play the videos by connecting the mobile phone to either a television or data projector in the classroom (Calnan *et al.*, 2011:1). Videos will initially cover science and mathematics concepts, as well as gender responsive material. Calnan *et al.* (2011:2), further propose that the immediate impact of the project will not only be to assist in spreading information where books are in short supply, but also to distribute resourceful and cost effective content to educators in primary schools, as well as expose educators and learners to popular technology and real-life situations by means of the videos. Furthermore, an increase in learner motivation and participation in mathematics and science, address female learner empowerment and the equalisation of gender disparities. In addition, the project could improve teaching methodologies and quality of teaching in the classroom, improve learning gains among learners, increase the quality of educator instruction in Ugandan primary schools, as well as to create a support network for educators in Uganda. All of the mentioned outcomes will occur while educators and learners are being exposed to new forms of technology and pedagogical methods.
- **MSRI (2005 - n.d.):** The Mobile Research Supervision Initiative (MRSI) at the Makerere University in Uganda, guided distance research learners who were completing their final year field research project through mobile phones. Most of the support was provided to research learners through SMS messages, which guided them in different aspects of research. Results indicate that the initiative created a virtual community of practice

amongst learners and their supervisors, motivated lonely distance learners in the field, created a customer care feeling amongst learners, and bred intimacy amongst the alumni and their institution (Muyinda *et al.*, 2008:359).

- **Mobile Short Messaging Service (SMS) Program (n.d.):** This initiative aimed to improve learner support by enhancing communication between educators and learners and to ensure that learners do not miss important activities or feel isolated, which may cause them to dropout (Kajumbula, 2009:Online). Results indicate that learners felt positive about receiving SMS messages from the department and that it made them feel connected to the university.

TANZANIA

- **Elima kwa Teknolojia (BridgeIT) (2007 - 2009):** This program involved an innovative process of distributing educational programming directly to the classroom through a mobile phone. Since 2007, this initiative aimed at significantly improving the quality of educator instruction as well as primary school learner achievement in mathematics, science, and life skills by utilising mobile phones. The project enabled educators to order video content through their mobile phones, which was then downloaded directly to the classroom, where it can be viewed by both educators and learners. This enabled remote schools and communities to access a large range of educational video content to improve the learning content that learners receive through textbooks and classroom resources (n.a., 2011b:Online).
- **ICT BITES (n.d.):** The ICT-Based In-Service Teacher Education for Secondary School Teacher (ICT BITES) project utilised mobile phones as communication tools and media players for in-service educator education in Tanzania. The main aim of the project was to improve the performance of secondary school educators by providing training in pedagogy and subject specific education. The mobile phones empowered the learners, enabled them to read e-mails and search for information on the web.

MOROCCO

Rural Literacy programme (2007 - n.d.): Launched in 2007, the state-funded Rural Literacy programme was launched to focus on one of the prime barriers to education facing rural women and girls, namely the lack of access to learning centres and middle schools, which are generally located very far from a learner's home (Chamley, 2012:Online).

SENEGAL

Jokko (n.d.): The Jokko initiative in Senegal uses an innovative way to teach basic literacy and numeracy through mobile phones. Results indicate that the Jokko initiative holds great promise for using SMS messaging as a means of improving literacy, numeracy and community development. It was found that women and girls who lived in villages, had the lowest rate of literacy and numeracy before the initiation of the Jokko initiative, and that their literacy and numeracy skills improved significantly during the course of the project. Vota (n.d.:Online), state that "the percentage of women and girls who scored in the highest category for literacy and numeracy increased from 12% for women and 8% for girls at the baseline, to 29% and 33% at the follow-up". Vota (n.d.:Online), further states that, "the number of participants who were able to write a text message jumped from 8% to 62%", and that women who were "disenfranchised" and uneducated in the past, could now manage their own text-based m-community.

NIGER

Project Alphabétisation de Base par Cellulaire (Basic Literacy through Mobile Phones, or ABC) (2007 - 2011): Project ABC, funded by USAID/Food for Peace, educated adult learners in Niger on how to use mobile phones as part of literacy and numeracy classes. The project included a mobile phone module that served as supplementary component to traditional literacy classes, thereby providing households with the opportunity to practice their literacy and numeracy skills by means of mobile phone calls and SMS. This addressed a vital limitation to previous functional literacy programs in Niger, where it had been difficult for adult learners to practice what they have learned by accessing timely, current, and relevant information in their local languages (n.a., 2010:Online).

During the first year of the project, learners were educated on basic mobile phone technology, including SMS. In the second year, mobile phones and a digital curriculum that included phonetic activities and assorted texts were used to further develop literacy skills (Jaschke, 2010:Online). In general, learners demonstrated a significant improvement in their writing and mathematical skills. Learners in villages who participated in the project achieved additional literacy and numeracy gains, with test scores between 9 - 20 % higher than their counterparts who were not involved in the project. Results suggest that the adult literacy curriculum is effective in increasing learning and that there were persistent impacts of the program (i.e. seven months after the first year of classes, the average test scores of learners who participated in the study were still higher than that of their counterparts). Aker *et al.* (2011:1), are of the opinion that these impacts do not appear to be driven by educator characteristics, educator attendance, or differences in class time devoted to learners. Instead this phenomenon can be mainly explained by the effectiveness of mobile phones as a motivational and educational tool, because learners who participated in the project used mobile phones in more dynamic ways and demonstrated an elevated interest in education. Results suggest that relatively cheap information technology can be exploited to improve educational outcomes and serve as an effective and sustainable learning tool among rural societies in the long term (Aker *et al.*, 2011:1).

4.3.7 Mobile learning impediments in Africa

A restrictive factor of developing African m-learning initiatives appears to be, "a lack of awareness among government decision-makers about the potential of mobile phones to support the effective and efficient delivery of quality education" (UNESCO, 2012e:27). In addition, the technical limitations of mobile phones, particularly in poorer communities, outline another barrier to m-learning. Learners often own older or lower-end handsets that have limited functionalities and small screens. Connectivity is constrained in many areas due to data costs and the limited availability of high-speed 3G networks. The absence of industry standards also proves to be a barrier to m-learning since there is a lack of standards for screen size and resolution, inconsistent support for Java, Flash, and various types of audio and video formats, incompatible Internet browsers, and a wide collection of memory sizes. As a result, a shortage of mobile phone-based educational content and applications are experienced, which creates an additional impediment to m-learning. Furthermore, communities' anti-mobile phone attitude also poses to be a major barrier to m-learning leading several schools to prohibit the use of mobile phones on their premises. These negative attitudes toward mobile phone use mainly come from reports of inappropriate or unsafe behaviour facilitated by mobile phones, and a small number of acceptable use policies have been adopted to evade the abuse of mobile phones in educational institutions (UNESCO, 2012e:27-28).

4.4 Worldwide mobile learning projects in technology-based (computer science programming) subjects

As previously commented upon, there is limited literature on m-learning in technology-based subjects. As a result, this research study endeavours to investigate and provide insight on whether m-learning can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries. Despite the increasing popularity of m-learning, and the plethora of literature available for research, a review of relevant literature returned that most educational research implicitly focuses on conceptions of m-learning initiatives in especially field work, literacy education, and mathematics education in developed countries, and that there is little academic support on how mobile technologies can be utilised in technology-based subjects, especially in developing countries. As a result, this research study will focus on worldwide m-learning research conducted in technology-based subjects, more specifically computer science programming subjects, over the past decade (2002 - 2012) (Table 4.6). Each research study is thereafter elaborated upon in more detail. It is nonetheless important to note that all these research studies only address "learning programming *via* mobile devices" (mainly by means of learning objects), and "programming *for* mobile devices". Though learners traditionally have been completely dependent on simulation software, or emulators, installed on a desktop computer to test their code, the problem with this approach is however that this does not always accurately reflect what the mobile device will show (Jentzsch & Mohammadian, 2004:20). In order to provide learners with a true m-learning experience that is better situated in reality, this research study therefore endeavours to investigate "programming *on* mobile devices", where learners can design, code, and execute programming applications directly on their mobile devices, thus allowing them to complete their programming assignments, and practice their programming skills without the necessity of a computer. There is a dearth of published material on "programming on mobile devices", with only one research article by Dyson *et al.* (2009:259), and a single unpublished thesis by Hashim (2007:2), that could be found where learners did "on device programming" and executed the programs directly on their mobile devices, as described within the ambit of this research study. In the case of Dyson *et al.*'s (2009:260) research, "access to the PDAs was only permitted in supervised laboratory sessions", and were learners forced to use simulators, "to work on their code outside class hours", thus not affording learners the opportunity to have a true m-learning experience.

Table 4.6: Recent worldwide research conducted on different mobile learning initiatives in technology-based subjects

Year	Project/Initiative	Country	Technology used	Project description
Learning programming via mobile devices				
2002 - 2005	Learning objects in JAVA computer programming	United Kingdom	PDA	Teaching first-year Java programming learners by means of learning objects on PDAs.
2012	M-learning environment for Computer Science	USA	Mobile devices	Allowing learners to learn and master computer technology courses anywhere, anytime, and as a result facilitate better learning outcomes for learners.
n.d.	Mobile prototype in JAVA computer programming	Malaysia	Mobile phone	Providing a m-learning prototype application to learners in the form of exercise and forum posts to assist them in the development of problem-solving skills in JAVA computer programming.
n.d.	Mobile CALS tool for Learning Java	United Kingdom	PDA	Creating and enhancing opportunities for learners by means of learning objects to study or learn in different locations.

Programming for mobile devices				
2012 - 2014	Computer Programmer program	Canada	Laptop Tablet	Preparing learners for a wide range of jobs in the programming profession by using mobile devices in a computer programmer program.
2010 - n.d.	MLC	USA	Mobile phone iPod etc.	Seeking to enable learners to share trusted educational services with each other by means of mobile handheld devices.
n.d.	Studio-1.00	USA	Wireless netbooks	Enhancing active learning techniques, interactive programming and the exploration of software development, through mobile notebooks and electronic classrooms.
2008	BAP	USA	Mobile devices (BlackBerry)	Assisting learners in creating practical mobile applications that deal with real-world challenges.
n.d.		Canada	Mobile devices (BlackBerry)	Developing and deploying applications for mobile devices.
2012		Philippines	Mobile devices (BlackBerry)	Mobile computing and application development using BlackBerry devices.
n.d.		Brazil	Mobile devices (BlackBerry)	Developing and deploying BlackBerry applications through a combination of theoretical concepts and practical application of the course topics.
n.d.		Brazil	Mobile devices (BlackBerry)	Designing, planning and delivering workshops on BlackBerry development for first-year learners.
n.d.		Poland	Mobile devices (BlackBerry)	Teaching Mechanical Engineering learners how to control and monitor other devices using the BlackBerry mobile phone solution.
2004 - 2008	MobiGame	Spain	Mobile phone PDA	Using mobile technologies and mobile games to improve the programming skills of learners and assisting them in passing their programming-related courses.
2010 - 2012	Mobile computing at Abilene Christian University	USA	iPad iPhone iPod Touch	Enabling learners to develop applications for iPad/iPhone/iPod Touch resulting in highly motivated, self-directed learners.

Programming on mobile devices				
2007	Programming tool for VISCOS mobile	Finland	Mobile phone	Enabling learners to write and execute JAVA programs with a mobile phone.
2007 - n.d.	Using mobile technology to learn about mobile technology	Australia	PDA	Allowing learners to learn C# by programming directly onto mobile devices.

4.4.1 Learning programming via mobile devices

- **London Metropolitan University (2002 - 2005):** This initiative started off as an online project that exposed learners to learning objects and was later expanded to be utilised on PDAs. The university made use of PDAs to teach their first-year Java programming learners by means of learning objects. Each learning object was short, self-contained resources that focused on one small learning objective or topic. Learners were excited about the opportunities that the mobility/portability PDAs provided, allowed them to learn anytime and anywhere, and as a result improved their learning experience if compared to other alternative learning methods. The only barriers identified by the learners were cost, security and limited storage capacity (Bradley *et al.*, 2005:Online).
- **University of Bridgeport (2012):** The University created a Computer Science course for an M-learning environment in order to allow learners to learn and master computer technology courses anywhere, anytime. M-learning can assist in providing a prosperous environment for teaching and learning by improving the teaching skills of educators, and supporting lifelong learning. It gave them the opportunity to develop new tools and services to facilitate better learning outcomes for learners (Alshalabi & Elleithy, 2012:Online).
- **Mobile prototype in JAVA computer programming (n.d.):** Learners at the Multimedia University in Malaysia were provided with a m-learning prototype application in the form of exercise and forum posts to assist them in the development of problem-solving skills in a JAVA computer programming subject (Poursaeed, Chien-Sing & Peng, 2009:285). The m-learning environment complemented diverse learning activities, enabled learners to collaborate, and control their own learning. The mobile prototype was widely accepted by learners and improved their efficiency (Poursaeed *et al.*, 2009:290).
- **Context-aware and Adaptive Learning Schedule (CALS) tool (n.d.):** The University of Warwick in the United Kingdom, made use of a mobile CALS tool that incorporated learning objects to support first-year undergraduate JAVA computer science programming learners through mobile devices such as PDAs. The aim of the study was to create and

enhance opportunities for learners by means of learning objects to study or learn in different locations (Yau & Joy, 2008:52).

4.4.2 Programming for mobile devices

When developing for a mobile device learners write computer programs on a computer and then upload the completed program to the mobile device where they can then execute it.

- **Algonquin College (2012 - 2014):** The Computer Programmer program at Algonquin College is a m-learning program that prepares learners for a wide range of jobs in the programming profession. Learners learn workplace-ready programming languages and practical applications, and gain important and valuable real-world knowledge and experience by means of a group application development project and an individual project exploring emerging technologies. Learners are required to make use of a mobile computing device, such as a laptop or tablet computer. Learners then use these devices to improve their learning experience, obtain and work with course materials, partake in m-learning and collaborative environments, and grow into being skilled, confident users of mobile technologies utilised within an educational environment and workplace (Algonquin College, 2012a:Online).
- **MLC (2010 - n.d.):** In 2010, learners who enrolled in the Distributed Systems course at the University of Illinois participated in a research project funded by Vodafone and Qualcomm to develop Mobile Learning Communities (MLC) learning tools. These learners were tested on their course knowledge by creating distributed applications to assist other undergraduate learners in other classes. MLC features included chat clients and peer-to-peer file sharing programs to enable learners to share trusted educational services by means of mobile handheld devices such as mobile phones, iPods etc. Learners made use of the Google Android development platform to develop distributed applications. The MLC did not only enable learners to receive their homework and subject problems, but also aimed at providing learners with a larger pool of resources by linking the MLC to existing social networking platforms (Iandola, 2010:Online).
- **Studio-1.00 (n.d.):** This research project investigated the in-class use of wireless notebooks by undergraduate learners, as well as attitude and learning gains in a Java computer programming subject. The study was conducted over a period of three semesters, and aimed to enhance active learning techniques, interactive programming, and the investigation and discovery of software development methods and concepts by means of mobile devices in an electronic classroom. Mobile technology enabled learners to access Java resources, and course notes, download significant volumes of Java code onto the wireless notebooks, as a part of their problem-solving assignments, as well as

to access the course website. This enabled the integration of lectures, hands-on exercise, and immediate feedback. Results confirm that the use of mobile technology had a positive effect on learner achievement, especially for the intermediate/low academic level learners or those who had no or limited prior knowledge of Java programming. Furthermore, learners indicated highly positive attitudes towards the use of wireless notebooks, and they expressed the opinion that the approach assisted them to better understand programming and encouraged interactions among themselves (Barak, Harward & Lerman, 2007:15). The authors are of the opinion that learners' learning gains would not have improved without the use of wireless notebooks in the classroom.

- **BlackBerry mobile devices in computer programming:** The BlackBerry Academic Program (BAP) was a Research In Motion (RIM) initiative that provided curriculum resources to assist academics worldwide to bring mobile innovation to teaching and learning. Several tertiary institutions across the globe made use, or are still making use of this initiative of which most aid learners in gaining a competitive edge in the job market. BlackBerry devices have been successfully incorporated into lower and upper division programming courses (Mahmoud & Dyer, 2007:500; 2008:107), advanced courses, and senior capstone projects (Mahmoud, 2008:S3E-17). Results proved that the level of learner excitement and satisfaction with the courses improved, and it also increased the employment opportunities of learners (n.a., 2008:4).
    - **Pace University (2008):** Learners from the Pace University in New York were exposed to the BlackBerry Academic Program and assisted in creating practical mobile applications that deal with real-world challenges. Over the past few years, learners from Pace university have been working with teams of learners from across the USA, India and Senegal, to focus their attention on possible avenues that mobile applications could befall to be valuable and effective tools worldwide. This project formed part of an undergraduate Engineering project (the “Capstone Project”) were learners work, often in small groups, to solve a real-world engineering problem (Scharff, 2011:Online).
    - **University of Guelph (n.d.):** BlackBerry mobile devices were incorporated into a computer programming subject at the University of Guelph in Canada, where learners experimented with the devices, and developed and deployed applications for these devices. They therefore moved away from the standard computing device and on to a smaller platform that could possibly point towards a future trend (Mahmoud & Dyer, 2007:495). Learners first learnt how to use the devices and how to download and deploy existing Java ME applications (MIDlets) onto the device. Thereafter, learners learnt how to develop and test their own applications and to convert it into a format that is suitable for BlackBerry devices. Learners then

deployed the applications onto the devices (Mahmoud & Dyer, 2007:497; 2008:106). The authors are of the opinion that by teaching computer programming in the context of simple wireless mobile applications provides a motivating framework for learners and motivate them to perform better, mainly due to the practical experience they acquire that in turn allows them to program their own mobile phones (Mahmoud & Dyer, 2007:500). In addition, Mahmoud (2011:334), reports that "the popularity of mobile devices among students is inspiring faculty to look for ways to teach students how to develop mobile applications, and the use of HTML and JavaScript present a powerful opportunity for teaching introductory programming for mobile devices".

- **Gordon College (2012):** Since 2012, the College of Computer Studies at the Gordon College in the Philippines, have incorporated the BlackBerry Academic Program to educate 4th year learners about the latest trends in mobile computing and application development using BlackBerry devices. The College aims to provide quality education relevant to time and technology by developing, updating and evaluating mobile programs. Since the commencement of the initiative learners are more enthusiastic to create applications as they can now view their output on a BlackBerry mobile device (Abarintos, 2012:Online).
- **Universidade Anhembi Morumbi (n.d.):** The Universidade Anhembi Morumbi (UAM) in Brazil, makes use of the BlackBerry Academic Program resources to assist learners in gaining a competitive edge in the job market. Learners have access to a wide range of superior quality resources to study and prepare for classes, and they are provided with the opportunity to test their applications on BlackBerry smartphones. Learners learn how to develop and deploy BlackBerry applications through a combination of theoretical concepts and practical application of the course topics (Freire, 2011:Online).
- **Universidade Federal de Alagoas (n.d.):** Senior learners at the Universidade Federal de Alagoas in Brazil design, plan and deliver workshops on BlackBerry development for first-year learners. These workshops enable learners to become skilled on program design and delivery. It further affords them the opportunity to share their learning experiences with their peers, and reinforce concepts they have learned (learners learning learners). In addition, learners are provided with tangible opportunities to put their learning to use by creating an application idea, and to develop and submit their applications to BlackBerry App World thus moving learners away from learning, to doing (De Sales, 2012:Online).
- **Silesian University of Technology (n.d.):** The Silesian University of Technology in Poland incorporated the BlackBerry Academic Program into their Mechanical Engineering curriculum to teach learners how to control and monitor other devices using the BlackBerry solution. They are mainly looking at the use of smartphones

and tablets as data interfaces and monitoring terminals for machinery and other devices. Learners were first introduced to mobile technologies en thereafter were taught the basics of programming in Java ME and how to develop basic projects (Cholewa, 2012:Online).

- **University of Alcalá (2004 - 2008):** The MobiGame initiative used mobile technologies (mobile phone or PDA) and mobile games at the University of Alcalá to improve the programming skills of its learners and to assist them in passing their programming-related courses in information engineering degrees. Upon investigation of learner results, it was concluded that there was an improvement in learner achievement and that they had acquired new skills and obtained excellent academic results (Barchino, Gutiérrez, De-Marcos, Martínez, Jiménez, Otón, Gutiérrez & Hilera, 2012:1167).
- **Abilene Christian University (2010 - 2012):** In a lab-intensive undergraduate introductory course on mobile computing at Abilene Christian University, learners were shown the basics on how to program for iPads/iOS. Learners developed applications for the iPhone, iPod touch or iPad during the course of their studies. Key findings include that learners were highly motivated to complete projects, and they were motivated to become self-directed learners (Burton, 2011:Online).

4.4.3 Programming on mobile devices

As elaborated upon in Paragraph 4.4, the majority of research studies only address "learning programming via mobile devices" and "programming for mobile devices", and there is very little academic literature evidence on "programming on mobile devices". According to Copas and Elder (2004:Online), programming on mobile devices with limited capabilities gives the impression that it is an extremely complex undertaking, even for a skilled and experienced programmer. Since the input method mechanism of mobile devices is one of the most pertinent challenges when programming on mobile devices, Copas and Elder (2004:Online), evaluated three input methods (i.e. external keyboard, internal keyboard, and stylus) in terms of the speed and accuracy with which a task can be performed, as well as user satisfaction. Results indicate that the internal keyboard proved to be the most accurate for data entry, and that most users prefer its use over that of a stylus. Other significant challenges of programming on mobile devices include small screen size, appropriate software for a mobile environment, and technical limitations, such as memory size and processing speed (Laine, 2007:23-24). Solutions however that facilitate programming with/on mobile devices has increased exponentially over the past few years, though it is extremely platform dependent and most do not fulfil the requirements of the FIS computer science programming subject at the CPUT.

- **Programming tool for VISCOS Mobile (2007):** At the University of Joensuu in Finland, novice JAVA programming learners were exposed to a m-learning application referred to as mobProg, a mobile-based application that provided learners with a mobile phone based platform for learning Java programming at any time and place. It enabled learners to write Java programs and execute them directly on their mobile devices (Hashim, 2007:2). The project supported learner learning and increased learner motivation (Hashim, 2007:47).
- **Australia University of Technology (2007 - n.d.):** Learners at this university were afforded the opportunity to learn C# by programming directly onto mobile devices, and perceived learning wireless programming techniques on a mobile device to be superior to learning on a simulator. They have also re-emphasised the necessity to be able to have access to PDAs outside the boundaries of the classroom to practice their coding. Using PDAs in computer science programming was considered as highly successful, especially in improving learner experience of learning wireless programming (Dyson *et al.*, 2009:260-261).

4.4.4 Mobile learning in a technology-based (computer science programming) subject at the CPUT

Historically, computer science programming subjects represent a problem for learners (Barchino *et al.*, 2012:1167). Learning computer science programming poses various challenges to learners who are new to programming in computing and technology education. According to Caspersen (2007:12), computer science programming has been identified as one of the great challenges in computing education. The challenge of programming has contributed to the relatively low registration numbers and retention rate in the computing related programs at tertiary institutions (Denning, 2004:15). According to Robins, Rountree and Rountree (2003:137), the demand for programmers and learner interest in programming has grown and introductory programming courses have become progressively more popular. Robins *et al.* (2003:137), further state that learning computer programming is difficult and often has, "the highest dropout rates", and that novice programmers experience several problems and limitations. Poursaeed *et al.* (2009:285), agree with this notion by stating that, "computer programming is one of the most challenging subjects in a computer science curriculum", and that several learners achieve poor results in this subject. With the extensive use of mobile phones, PDAs and iPods, innovation in the computing science curriculum has developed into an vital precedence to reflect today's reality (Mahmoud & Dyer, 2008:108; Mahmoud, 2008:S3E-17). According to Mahmoud (2008:S3E-17), mobile devices represent a useful tool for teaching essential computer science concepts, and therefore necessitate innovation in computer science courses.

The situation in South Africa is no different, however the ubiquity of mobile technology, particularly in a South African context, suggests that it could be meaningfully applied in an educational environment in order to provide equal access to information and potential collaboration, as well as to extend the availability of educators outside the boundaries of the classroom. The justification for exploring m-learning in a technology-based subject is based on the understanding that mobile technologies have the potential of broadening educational opportunities for disadvantaged and marginalised learners (Mafenya, n.d.:Online).

The computer science programming subject (Software Skills 1) at the CPUT needs to embody the current reality and incorporate mobile devices and mobile application development as part of the curriculum. Using mobile devices to assist in classroom-based instruction, and encouraging learners to use mobile devices to aid them in scheduling tasks among other uses, is valuable and represents an important step in the direction of mobile device integration into the curriculum. However, learners should not only be learning about mobile devices and its features, but rather learning with mobile devices as they learn new course content and concepts. This will not only assist in teaching and learning in the classroom and computer laboratory, but will also expand and improve learning objectives (Mahmoud, 2008:S3E-17). By integrating mobile devices into the subject could potentially enhance and assist learners to quickly learn and observe the results of their programming efforts on a more innovative and exciting medium.

The aim is therefore to utilise mobile devices in order to extend ways in which undergraduate computer science programming learners could be supported, and to bridge the existing learning gap to facilitate technology-based learning, and as a result increase throughput and success rates. This research study therefore focuses on the amalgamation of "programming for mobile devices", "programming on mobile devices", and IM both on and off-campus in a computer science programming subject. Mobile devices are most effective when combined with group activities and have the potential to improve education for the millions of under-privileged users in the developing world (Mafenya, n.d.:Online). Furthermore, a significant motivating factor that contributed to the incorporation of m-learning in a technology-based subject was to improve the quality of teaching and learning, to improve access to education in remote locations, as well as to promote critical thinking and creativity. The university's introductory computer science programming subject provides a comprehensive introduction to computer programming that emphasises problem solving, and basic algorithms. The subject is computer laboratory intensive and allows learners learning by doing. Work done in the computer laboratories reinforces the theory learners learn in the classroom.

This notion maps to the CPUT's strategic direction regarding teaching and learning, namely to continue to evolve and implement a teaching and learning framework founded on the principles of equity and learner success; cooperative, work-based learning; innovation; as well as the effective application of technology, with the aim of producing graduates who can make a significant contribution to society, in South Africa in particular. The CPUT took a major decision that all courses should have a minimum web presence on the university's Blackboard LMS.

The institution's teaching and learning objectives are therefore to:

- Develop and implement a teaching and learning strategy relevant to emerging regional and national needs and based on relevant current research.
- Develop learner-centred teaching methodologies.
- Improve assessment practices to meet external standards.
- Develop and implement strategies to use ICT as an enabler for teaching and learning.
- Improve throughputs, retention rates and pass rates.

4.5 Conclusion

This chapter provided a literature background to the utilisation of m-learning in developed and underdeveloped countries. It provided an overview of current academic evidence on the use of innovative mobile technology tools in an educational context focusing mainly on how educators integrate these tools within their pedagogy, especially in technology-based subjects. It furthermore considers the different m-learning impediments experienced within developed and underdeveloped countries.

In the next chapter data collected will be analysed and interpreted.

CHAPTER 5

DATA ANALYSIS AND INTERPRETATION OF RESULTS

SYNOPSIS

The content of Chapter 5, along with the relative positioning of the topics, is graphically depicted in Figure 5.

This chapter discusses descriptive and inferential statistics that aim to assist primarily tertiary educators to understand the implications of mobile technology utilisation in a technology-based (computer programming) subject.

The chapter highlights that the majority of learners would like to be able to use mobile technology at their home/residence as well as in the classroom as a tool to help them with their university work. They furthermore believe that it will make a difference to the quality of their university work. Furthermore, it is evident that most of the learners in the survey believed that off-campus access to the Visual Basic computer programming application is important to them. Nearly 75% found it difficult to access university computer laboratories outside computer programming class times, and less than a half have access to the programming application off-campus (all of which are illegal copies).

The chapter furthermore reveals that the use of mobile devices are: 1) Perceived as useful for teaching and learning purposes, 2) perceived to have mobility- and, 3) social interaction value, 4) perceived to have an enjoyment factor, 5) to be easy to use, 6) improve learner attitude, 7) have certain access barriers, 8) have output quality, and 9) the behavioural intention to use mobile devices are perceived to be positive.

In addition, results reflect that learners were able to skilfully use PDAs to perform a variety of tasks. Most of the learners use mobile devices on a daily basis or at least a few days a week for mostly more than 30 minutes at a time. Learners primarily made use of the PDA for formal subject-related activities (assignments etc.). The majority of learners indicated that the university is ready to implement m-learning, and should require learners to use mobile devices during the course of their studies, but that the university should pay for it. Learners furthermore indicated that to incur a broader common acceptance of mobile devices in education a larger display screen, improved processing power, and larger memory are important factors. Learners found it acceptable to learn computer programming with mobile device access only, and would prefer to use a mobile device during tests to assist them with coding programs. After being exposed to m-learning, the majority of learners felt more enthusiastic about the use of mobile devices; compared to the beginning of the semester when they were introduced to the use of mobile devices in a technology-based subject.

A further encouraging statistic emerging from the survey data is that the marks for the summative tests, as well as the formative assignments and class tests consistently decreased from 2007 to 2010 and then increased again for 2010 to 2012. With respect to 2011 when m-learning was introduced, there is an indication that the marks improved after the m-learning experience. More specific, there was an increase in the assignment marks from before to after m-learning was introduced and it is evident that learners from the 2012 m-learning group have improved assignment marks.

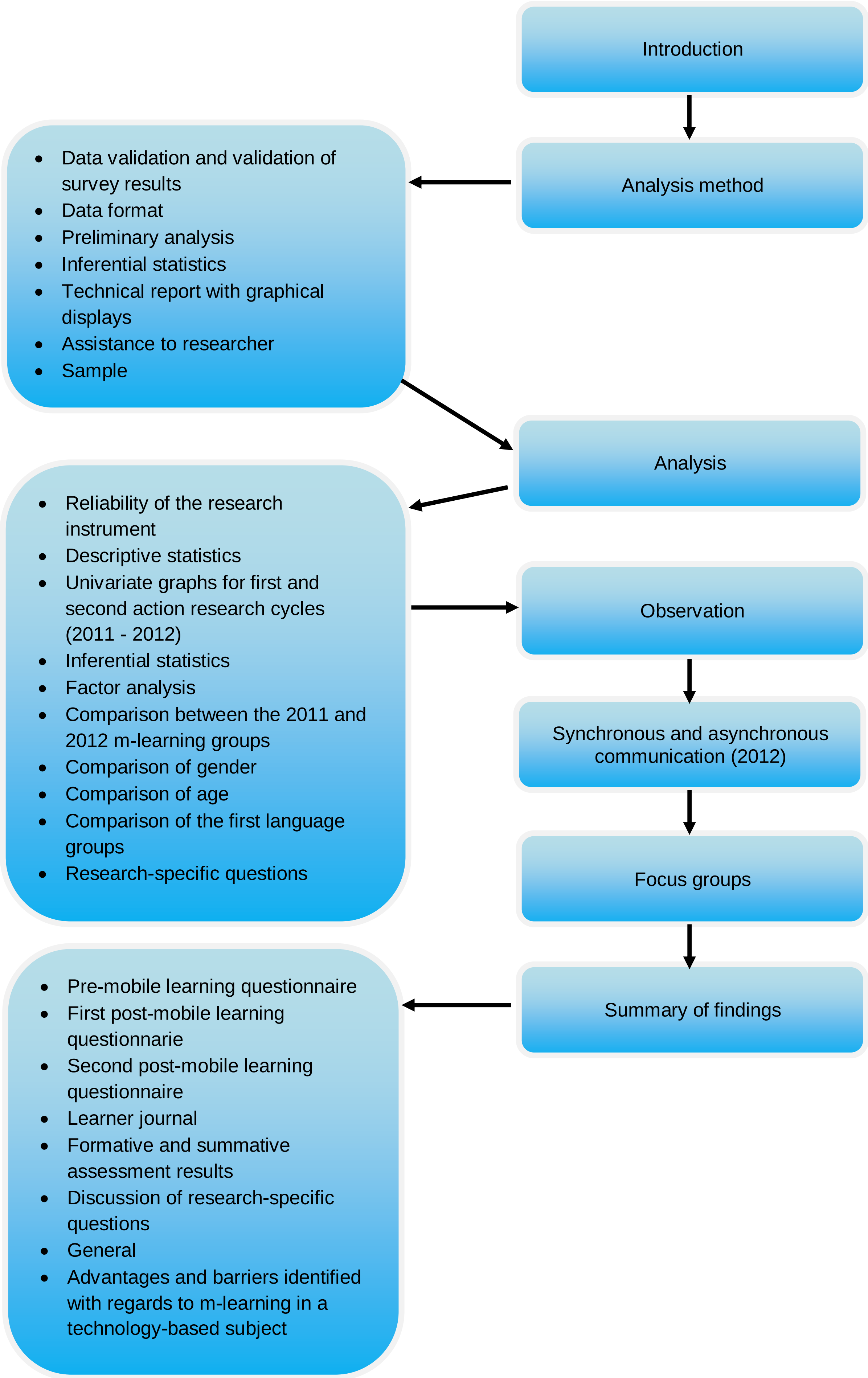

Figure 5: Detailed layout of Chapter 5 - Data analysis and interpretation of results

5. CHAPTER FIVE

DATA ANALYSIS AND INTERPRETATION OF RESULTS

5.1 Introduction

The analytical process followed thus far, is graphically depicted in Figure 5.1, which places the chapters in context with the overall thesis objectives, and furthermore indicates the relative positioning of this chapter.

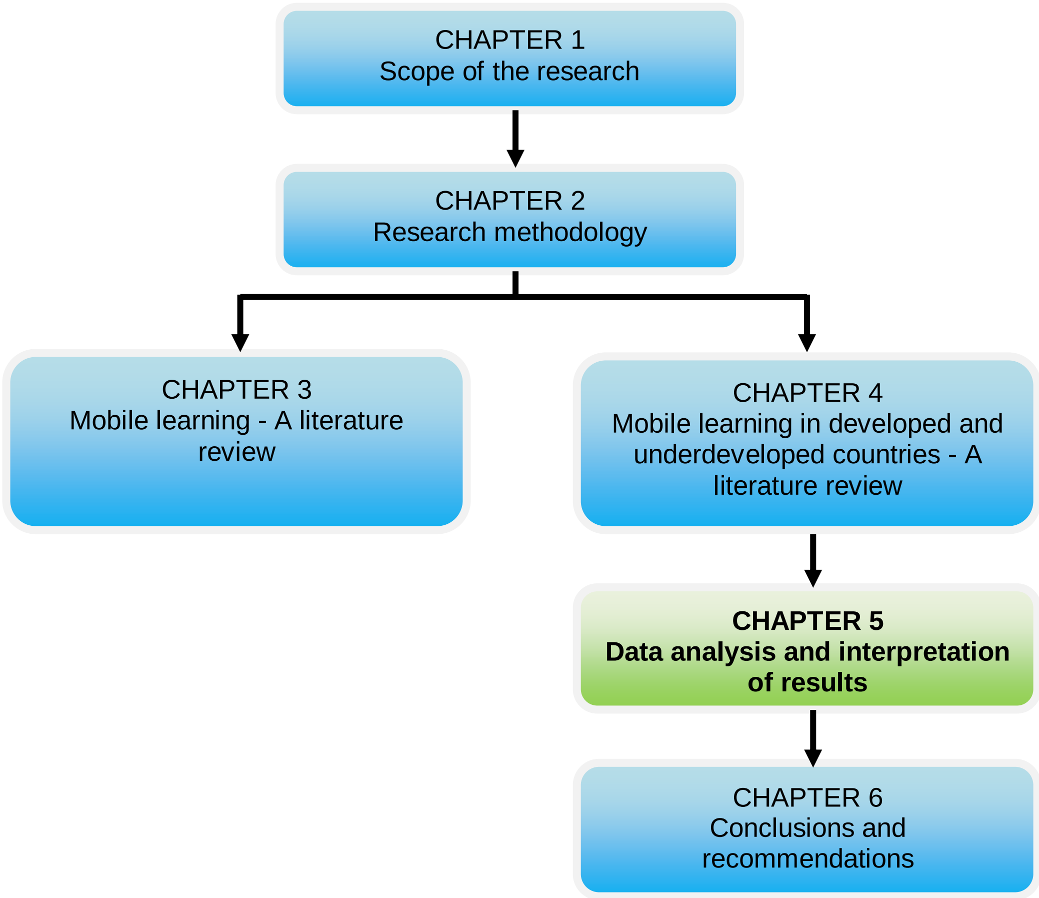

Figure 5.1: Chapter 5 - Data analysis and interpretation of results

This chapter discusses the results of the data analysis of the surveys conducted at the CPUT to investigate the potential of m-learning and whether it can bridge the existing learning gap to facilitate technology-based learning within tertiary education courses in developing countries. Data analysis can be defined as, "the process of bringing order, structure and meaning to the mass of collected data" (De Vos, 2002:339). The main objective of this study is to investigate the potential of m-learning and to determine whether it can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions in developing countries. The data obtained from the completed questionnaires will be presented and analysed by means of various analyses (univariate, bivariate and multivariate) as it comes applicable.

In most social research the analysis entails three major steps:

- Cleaning and organising the information that was collected (data preparation).
- Describe the information that was collected (descriptive statistics).
- Testing the assumptions made through hypothesis and modeling (inferential statistics).

The collected data has been analysed by using SAS software. The data has been cleaned, re-coded and organised and expanded upon in Paragraph 5.3.2 (see CD-ROM: Analysis of Data (Content of Paragraph 5.3, Chapter 5)). Descriptive statistics such as frequency tables are displayed in Paragraph 5.3.2 (see CD-ROM: Analysis of Data (Content of Paragraph 5.3, Chapter 5)), showing the distributions of the statement responses (descriptive statistics are used to summarise the data).

5.2 Analysis method

5.2.1 Data validation and validation of survey results

In determining, through the use of a structured questionnaire, whether m-learning can bridge the existing learning gap to facilitate technology-based learning in tertiary institutions in developing countries, the validity and reliability of the questionnaire is important. Validity is concerned with whether the actual measuring reflects the intended measure (Rose & Sullivan, 1996:19). For the purpose of this research study, only content and construct validity will be elaborated upon. 'Content validity' is concerned with the representativeness or sampling adequacy of the content (e.g. topic or items) of a measuring instrument (De Vos & Fouche, 2001:84), while 'construct validity' refers to the extent that a measuring instrument can be shown to measure a particular hypothetical construct.

A descriptive analysis of the survey results returned by the research questionnaire respondents are reflected in Appendix I. The responses to the questions obtained through the questionnaires are indicated in table format for ease of reference. Each variable is tested to fall within the set boundaries. Data validation is the process of ensuring that a program operates on 'clean', correct and useful data.

The construct validation however, can only be taken to the point where the questionnaire measures what it is supposed to measure. Construct validation as a rule is addressed in the planning phases of the survey and when the questionnaire is being developed. Reliability will be addressed in the analysis phase of the data (information).

5.2.2 Data format

The data was provided in Excel format, i.e. questionnaires were captured onto Excel spreadsheets. The actual responses were then imported into SAS, and recoding was done in order to provide quantitative information for analysis purposes. Coding was applied where Likert scales were used and can be found in Appendix G.

It is of importance to note that when the coding was applied, the aim was to code the data in such a way that if there were indications of for example days or some other type of measurement, that it is coded from the lesser to the bigger value, thus making data interpretation easier. The calculation of means for these ordinal variables will result in interpreting higher resulting means to indicate a bigger/higher/longer value.

5.2.3 Preliminary analysis

The reliability of the statements in the questionnaires posted to the respondents was tested by using Cronbach Alpha tests (see Paragraph 5.3.1, CD-ROM: Analysis of Data (Content of Paragraph 5.3, Chapter 5))). Descriptive statistics were performed on all variables, displaying means, standard deviations, frequencies, percentages, cumulative frequencies and cumulative percentages. These descriptive statistics are elaborated upon below.

5.2.4 Inferential statistics

The following inferential statistics were performed on the data:

- **Chi-square tests:** Chi-square tests were used for determining the association between biographical variables. Cross-tabulation and Chi-square-based measures of association, a technique for comparing two or more classification variables were used. These tables constructed for statistical testing, are referred to as contingency tables and determine whether the classification variables are dependent. Percentages are used for two purposes; firstly to simplify by reducing all numbers to a range of 0 to 100, and secondly to translate the data into standard form, with a base of 100, for relative comparisons. The Chi-square (two-sample) tests are probably the most widely used non-parametric test of significance that is useful for tests involving nominal data, but it can be used for higher scales, e.g. scenarios where persons, events or objects are grouped in two or more nominal categories such as ‘yes-no’ or cases A, B, C or D. The technique is used to test for significant differences between the observed distribution of data among categories, and the expected distribution based on the null hypothesis, and has to be calculated with actual counts rather than percentages (Cooper & Schindler, 2001:499).

- **McNemar’s test:** McNemar’s test is appropriate when you are analysing data from matched pairs of subjects with a dichotomous (yes-no) response.
- **Kruskal-Wallis**: Kruskal-Wallis test for interval data with more than two independent samples. The Kruskal-Wallis one-way analysis of variance by ranks is a non-parametric method for testing equality of population medians among groups. Intuitively, it is identical to a one-way analysis of variance with the data replaced by their ranks. It is an extension of the Mann-Whitney U test (Wilcoxon Two-Sample Test), which compares two groups to three or more groups. Since it is a non-parametric method, the Kruskal-Wallis test does not assume a normal population, unlike the analogous one-way analysis of variance. However, the test does assume an identically-shaped and scaled distribution for each group, except for any difference in medians.
- **Mann-Whitney U test or Wilcoxon rank-sum:** Mann-Whitney U test or Wilcoxon rank-sum test for ordinal data with two independent samples. The Mann-Whitney U test (also referred to as the Mann-Whitney-Wilcoxon (MWW), Wilcoxon rank-sum test, or Wilcoxon-Mann-Whitney test) is a non-parametric test for assessing whether two samples of observations come from the same distribution. The null hypothesis indicate that the two samples are drawn from a single population, and therefore that their probability distributions are equal. It requires the two samples to be independent, and the observations to be ordinal or continuous measurements, i.e. one can at least say, of any two observations, which is the greater. In a less general formulation, the Wilcoxon-Mann-Whitney two-sample test may be thought of as testing the null hypothesis, which indicate that the probability of an observation from one population exceed an observation from the second population by 0.05.
- **Factor analysis**: Factor analysis is a statistical approach that can be used to analyse interrelationships among a large number of variables and to explain these variables in terms of their common underlying dimensions (factors).
- **Cronbach Alpha test:** Cronbach’s Alpha is an index of reliability associated with the variation accounted for by the true score of the 'underlying construct' with 'construct' being the hypothetical variables that are being measured (Cooper & Schindler, 2001:216-217). More specific, Cronbach’s Alpha measures how well a set of items (or variables) measures a single uni-dimensional latent construct.

5.2.5 Technical report with graphical displays

A written report with explanations of all variables and their outcome were compiled. A cross-analysis of variables where necessary is performed and the statistical probabilities to indicate the magnitude of differences or associations are also attached. All inferential statistics are discussed in Paragraph 5.3.4 (see CD-ROM entitled Analysis of Data (Content of Paragraph 5.3, Chapter 5)).

5.2.6 Assistance to researcher

The conclusions made by the researcher, were validated by the statistical report. A professional statistician provided input to interpret the outcome of the data. Reciprocally, the final report written by the researcher was validated and checked by the statistician to exclude any misleading interpretations.

5.2.7 Sample

The target population is first-year undergraduate computer science programming learners at the CPUT in South Africa. The total population of first-year undergraduate computer science programming learners for 2011 and 2012 at the CPUT were sampled to participate in this survey.

5.3 Analysis

Data analysis (described in Paragraph 5.3) due to its voluminous nature, will for ease of reference be contained within the CD-ROM entitled Analysis of Data (Content of Paragraph 5.3, Chapter 5) of this research study. To aid the reader, an index of the headings and subheadings pertaining to Paragraph 5.3 are provided below.

5.3.3.1.3 Second post-mobile learning (post 2) questionnaire (2011 - 2012)

5.3.3.1.4 Learner journal (2012)

5.3.4 Inferential statistics

5.3.5 Factor analysis

5.3.6 Comparison between the 2011 and 2012 m-learning groups

5.3.6.1 Pre-mobile learning questionnaire

5.3.6.2 Second post-mobile learning (post 2) questionnaire

5.3.7 Comparison of gender

5.3.7.1 First post-mobile learning (post 1) questionnaire

5.3.7.2 Second post-mobile learning (post 2) questionnaire

5.3.8 Comparison of age

5.3.8.1 First post-mobile learning (post 1) questionnaire

5.3.8.2 Second post-mobile learning (post 2) questionnaire

5.3.9 Comparison of the first language groups

5.3.9.1 First post-mobile learning (post 1) questionnaire

5.3.10 Research-specific questions

5.3.10.1 Pre-mobile learning (2007 - 2010) and m-learning (2011 - 2012) formative and summative assessment comparison

5.3.10.2 Formative and summative assessments versus pre-mobile learning- and post-mobile learning questionnaires (2011 - 2012)

5.3.10.3 Pre-mobile learning questionnaire

5.3.10.4 First post-mobile learning (post 1) questionnaire

5.3.10.5 Pre-mobile learning- versus first post-mobile learning (post 1) questionnaire

5.3.10.6 Second post-mobile learning (post 2) questionnaire

5.3.10.7 Pre-mobile learning- versus second post-mobile learning (post 2) questionnaire

5.3.10.8 Second post-mobile learning (post 2) questionnaire versus learner journal

5.3.10.9 Learner journal (2012)

It is of importance for the reader to note that the numbering order of tables and figures within the CD-ROM entitled Analysis of Data (Content of Paragraph 5.3, Chapter 5) will be retained to ensure the logic flow of information as it pertains to Paragraph 5.3. Furthermore, the same logic would apply to Appendices referred to within the ambit of Paragraph 5.3. Underpinning data (which includes raw and processed data contained in Appendix K to Appendix U) is also, due to the voluminous nature thereof, contained within the ambit of a CD-ROM entitled Supporting Data.

5.4 Observation

Learners were observed on a daily basis while utilising mobile technology in a technology-based subject in a developing country. The purpose of the observation was to provide the researcher with the opportunity to: 1) Gather information about learners' learning activities in a formal educational context while utilising mobile technology as they occur, 2) observe aspects that learners might not openly discuss in a questionnaire or during a focus group session, and to, 3) triangulate learner self-reports that were collected by means of the questionnaires and focus groups, as variations could be found between what learners say they have done, or will do, and what they actually did, or will do (Robson, 2002[19] cited by Wali, 2008:80). This process therefore assisted the researcher in identifying and thinking critically about what was learned, and how this newfound knowledge could be applied to the benefit of the learners and the subject. It served as a reflective mechanism to identify the strengths and weaknesses of m-learning in a technology-based subject, and to evaluate the implications of m-learning in a technology-based subject, as well as to serve as a record for future use.

Both m-learning groups (2011 - 2012) were observed as well as all the activities and findings that emerged when learners attended class (theory classes and practical programming classes in computer laboratories) throughout a six month period for six hours per week. Detailed descriptions were gathered on learners and their utilisation of mobile devices in a technology-based subject, focusing on how they were used, and their attitude towards using it. The observational data was recorded by the researcher by means of photographs, video and taking notes. The researcher was generally conducting the class, or moving unobtrusively amongst learners while observing and taking notes about learner activities, learner interactions with peers while utilising the mobile devices, and learner attitudes toward mobile technology utilisation in a technology-based subject.

The observational data was analysed by referring to the concepts of Activity Theory. The Activity Theory framework assisted in the investigation of learners' learning practices that are mediated by the use of tools in a formal and informal educational context. In this research study the Activity Theory framework includes a first-year computer science programming learner (subject) that is engaged in completing a practical computer science programming assignment (object) by using a PDA (tool) in a computer laboratory (formal context). The community in the framework includes the learners and educator who are governed by a set of computer science programming constraints and protocols (i.e. university policies, course framework, class rules, learners must meet programming assignment deadlines) and

[19] Robson, C. 2002. *Real World Research*. Oxford: Blackwell.

communication (i.e. IM and uploading assignments). Synergy was attained on the following:

- **Enthusiasm:** Learners have shown a considerable amount of enthusiasm when the mobile devices were handed out for the first time, and during the course of their studies. Unlike studies that have fell victim to the 'novelty effect' (Kneebone & Brenton, 2005:113), also referred to as the 'generally positive effect', that results from the enthusiasm for using a new device or tool in learning, learners have never appeared to be bored or frustrated (despite several limitations or barriers) when the novelty of using these devices started wearing off over a period of six months (Figure 5.154). To these learners the benefits and use of mobile technology to assist them in a technology-based subject was clearly outweighing the limitations they faced. According to Mostert (n.d.:Online), there are several factors, such as the introduction of mobile technology and the functionality it provides in a technology-based subject, that could have contributed to this sudden change in attitude. Mostert (n.d.:Online), however warns that a decrease in interest and participation could be experienced, which is mainly attributed to the novelty of using mobile devices wearing off over time, however this was not the case with this research study. All learners immediately started utilising the mobile devices upon hand-out (i.e. changing the date/time, background colours and images, exploring the calendar, making notes, typing a Word document etc.). The majority of learners (84.6%) even went so far to explore the Basic4PPC application, despite the fact that they have never seen or used it before. Only one learner (2011 - 2012) were observed to lose interest after struggling to switch the device on, change the date/time, and use the stylus, and opted to rather continue with other work. The enthusiasm and excitement amongst learners were almost infectious as they smiled, discussed the devices, and even mentioned the word "cool" several times. Some learners even enquired about the availability of the devices and whether they would be able to buy it. The potential option of buying devices was an even bigger attraction when learners realised that they will be using these devices in their second and third year of computer programming studies. It was of interest to note that the French learners seemed to be more enthusiastic and at ease as they have shown more emotion, interest, and control while utilising the devices. This could however not be prescribed to the fact that they own and are more familiar with mobile devices, since there is no statistically significant correlation between learners' first language and the ownership of desktop and mobile technology. These learners later also proved to be more inquisitive, and were asking more subject-related questions than their counterparts.

Figure 5.154: Learners' excitement upon receiving the mobile devices

- **Introduction to PDAs:** Learners were briefed beforehand on their responsibility towards the devices and its fragile nature. This resulted in learners handling the device with great care. Though some learners were cautious to use the mobile device, others were more confident and gave devices their own personal feel (i.e. changing the start-up picture, colour scheme etc.). During the first week learners were introduced to the basic functions/capabilities of the PDA before using the Basic4PPC programming application. Learners were shown the different input methods by means of the stylus, however all of them preferred using the on screen keyboard even though they complained that it was too small. Learners were also 'shown the ropes' on how to synchronise their PDA with a computer via ActiveSync in addition to providing notes on Blackboard on how to perform the synchronisation process. Learners were required to synchronise their PDAs with a computer in order to: 1) Copy their programming assignments from the computer onto the device that would enable them to complete their programming assignments off-campus, and then again to, 2) copy their assignments and learner research journals from the device onto an Internet-enabled computer (synchronisation) that would allow them to upload their programming assignments and learner journals onto Blackboard. Several learners were intrigued by the new mobile technology and immediately started exploring other functions (i.e. Bluetooth, Wi-Fi and Internet connectivity). The prospect of being able to connect to the Internet from home/residence via their mobile phones (something none of them has done before), made learners even more enthusiastic to use these devices, however most learners (34.2%) experienced problems in pairing their mobile phone with the PDA. BlackBerry owners (20.2%) could not pair their phones with a PDA, since the

BlackBerry Internet service only allows unlimited Internet access on the mobile phone itself.

- **General PDA usage:** Learners became effective quickly in the design and development of their first programming applications. Four French male learners were the first to experiment with the new devices and immediately started with the design and development of an assignment. Learners were found to be less bored in class and became more active and engaged during the learning process. While it can be postulated that engagement does not necessarily translate in learning more, it indeed proved not to be the case in this research study, as learner marks (especially formative assessment marks) improved dramatically since the implementation of m-learning. Mobile devices (PDAs) are mainly used to accomplish subject-related tasks such as going online (74.7%), completing and submitting programming assignments (67.1%), accessing the university website (64.6%), accessing social networking sites (59.5%) to communicate with peers, viewing and downloading course material and assignments (59.5%), as well as taking notes in class (53.2%). This is mainly attributed to the structure of classes, which are based around learners utilising mobile devices to aid their classroom-based teaching and learning practices in formal educational settings. It is of interest to note that despite the small screen size and stylus input of a PDA, 35% of the learners unexpectedly opted to make use of the PDA even if they had access to a personal computer in a practical class (Figure 5.155). One French female learner has even gone so far to have never used a computer again since she received the mobile device. Upon probing learners why they prefer using this option, they indicated that they want to become more familiar with the device and the Basic4PPC software, and that they also enjoy using and exploring the new technology. It was also of interest to note that one learner from the 2012 m-learning group started to attend classes after the distribution of PDAs amongst learners. Mobile devices are also used for other teaching and learning purposes such as taking photos, instead of taking notes, of work covered on the whiteboard (Figure 5.156), recording lectures, downloading and listening to podcasts, assessing library services and communicating with the educator. Most learners gave PDAs their own personal 'look and feel' by adding background photos and their own choice of music. Some learners even bought an additional SD memory card for their devices, allowing them to have access to additional content (applications, documents, photos, music, podcasts, etc.) on the PDA.

Figure 5.155: PDA preference above computer utilisation in a practical computer programming class

Figure 5.156: Taking photos of work covered via mobile phone instead of taking notes

- **Formative assessment (programming assignments and class tests):** It was evident that learners make use of PDAs in a practical computer classroom more often when nearing assignment deadlines as well as before formative class tests.
- **Collaboration/communication:** Learners in general assisted one another when experiencing problems during the synchronisation process or on some occasions when struggling with certain aspects of a programming assignment (Figure 5.157). It was furthermore determined that learners predominantly do not use their mobile devices to communicate with peers and educators outside the classroom (i.e. IM, e-mail), but rather prefer face-to-face discussions on subject-related issues. Learners mainly use their mobile devices outside the classroom to communicate with family and friends.

Figure 5.157: Learner collaboration regarding subject-related issues

- **Context:** Despite the vast possibilities that mobile devices bring to an educational environment, it comes as no surprise that some learners still prefer to use conventional mechanisms (i.e. desktop computers, class hand-outs/subject material, paper-based notes) to accomplish their learning activities in formal learning settings. This can be attributed to the fact that learners prefer to rather write down notes instead of typing them, since it is a much slower process to type on a mobile device without a keyboard, and also to rather read printed hand-outs as opposed to electronic notes. It could therefore be argued that mobile devices are only used in certain contexts by some learners. On the contrary, it is also true that some learners prefer to use mobile technology as opposed to using computers and taking notes (Figure 5.155, Figure 5.156 & Figure 5.157), which proved to be mostly the case in a technology-based subject.

5.5 Synchronous and asynchronous communication (2012)

Learners were informed that they can make use of WhatsApp, an IM service, on a 24/7 basis to contact the educator (the author and researcher of this research study) regarding any subject-related queries (62.5% of learners indicated that they have used WhatsApp before). The majority of the learners prefer WhatsApp as a communication means due to the fact that the foreign learners are not familiar with South Africa's leading IM application, MXit. Learners were initially excited and very keen about the idea about using WhatsApp as part of the subject, however it was found that only a few (30.4%) made use of this unique opportunity. Learners used this service mainly to: 1) Ask subject content-related questions before formative class tests and summative tests, 2) ask for assistance with programming assignments, 3) be assisted with subject administrative queries, and 4) resolve technical difficulties experienced with mobile devices. Instant messages were received and answered any time during the day and night, with the earliest being at 05:59 am and the latest at 00:59 am. Some learners went online, but never chatted. Data gathered from the focus groups provided informative data on why most learners did not make use of this service (see Paragraph 5.6).

From an educator perspective, WhatsApp proved to be quite challenge to use when answering learner queries, since it is a relatively time-consuming process to answer queries using the different input mechanisms of a mobile phone or PDA. In this particular case, MXit, the South African developed IM application, would be more viable, as it allows users to either type messages directly from a mobile phone or by means of a computer. The software is provided free of cost despite the mobile operating system in use, which is not the case with an application such as WhatsApp which can cost up to US $0.99, depending on a user's mobile operating system.

5.6 Focus groups

Focus group discussions were included as a data collection method in this research study in order to gather information and provide further clarification on issues identified from the questionnaire data. This type of discussion can be described as a panel of people, typically made up of six to ten participants, led by a trained facilitator that uses group dynamic principles to focus or guide the group in an exchange of ideas, feelings, and experience on a specific topic (Cooper & Schindler, 2006:212-216). Focus groups are an extremely efficient technique to collect qualitative data, as the amount and range of data are increased by collecting from numerous individuals simultaneously (Robson, 2002:284). In this research study, each group consisted of three to five participants, as the 2012 m-learning group consisted of only 48 learners. Small groups permit the researcher to effectively control the discussion, as well as to provide all the participants with an equal opportunity to present their points of view.

A major advantage of focus group discussions, according to Dürrenberger, Behringer, Dahinden, Gerger, Kasemir, Querol, Schüle, Tabara, Toth, Van Asselt, Vassilarou, Willi and Jaeger (1997:15), is that the data gathered from focus groups is very rich. Focus groups can also be used to gather a vast number of data in a fairly short time period (Berkowitz, 2013:Online; Rabiee, 2004:656; Scheuren, 2004:Online), providing an expedient way to gather data from numerous participants at the same time, and as a result encourage participation from those who are unwilling to be interviewed individually, elicit contributions from those who feel they have nothing to contribute (Kitzinger, 1995:299), inspire participants to reveal actions and attitudes that they might not deliberately disclose in an one-on-one interview, as well as to allow the interviewer to explore related, but unanticipated topics as they arise in the discussion (Scheuren, 2004:Online).

All the focus group discussions were conducted in the researcher's office during the second semester of 2012 after the implementation of m-learning, with only the researcher and the interviewees present. All the discussions were recorded on a digital recording device for later referral. The protocol for the focus group process was consistent in every session, where the same questions were asked to all the participants. The purpose of the focus groups was to be a conversational open-ended discussion in order to understand the attitudes and opinions of the participants towards the utilisation of mobile technology in a technology-based subject. The focus group questions focused on specific issues identified by means of the feedback received from the questionnaires that qualitatively needed further exploration. The open-ended questions that captured these issues and provided the intended perspectives that were lacking in the questionnaire are provided in the ambit of Appendix F. After 18 focus group discussions, each being approximately 20 - 30 minutes in duration, learners mainly revealed similar viewpoints on the specified issues when compared to the data gathered from the questionnaires, however some additional information was also gathered.

Synergy was attained on the following for each of the eleven questions:

1. When learners were probed about their general experience during the completion and submission of programming assignments, 16 groups (89%) out of the total 18 focus groups, indicated that have found it extremely easy and fair to complete and submit programming assignments utilising mobile technology. Groups in particular mentioned the convenience of being able to complete and submit their programming assignments, anywhere, anytime without the need of a computer and the proper software. Two groups experienced it to be a challenging exercise due to the constant lack of wireless Internet access, the small screen size, and the time-consuming processes of synchronising the PDA with a campus computer in order to allow learners to submit their assignments (those who do not have access to a computer or the Internet off-campus), as well as data entry by means of the stylus. It was of interest to note that despite the mentioned barriers, learners were still using PDAs to complete and submit programming assignments on a continuous basis.

2. All 18 groups agreed that they would prefer to use mobile devices within other subjects as well, especially in the Financial Information Systems course for which they are enrolled for. Learners found the use of mobile technology to be extremely useful for the purposes of their studies. One group expressed that it would be of great assistance in especially subjects such as Commercial Law and Communication, were they have to frequently prepare presentations and present them in front of an audience. Another group also highlighted the usefulness of mobile devices that could be used anywhere on campus to complete course-related work, in contrast with the constant unavailability of overpopulated computer laboratories.

3. The majority of the groups viewed mobile devices as an educational investment and indicated that they would buy a mobile device if it could aid them in their studies, or if it would be a course requirement. Some learners however did point out that it will be subject to the cost of such as device. Only two learners (from different groups) indicated that they would not be able to afford such technology, and that they are entirely reliant on study loans in order to complete their studies.

4. Data gathered from the second post-m-learning questionnaire reflect that most learners indicated that they feel that the CPUT should have the responsibility of purchasing mobile devices for its learners. Three groups were of the opinion that learners should pay for mobile devices themselves, since they will then tend to look after the devices better. In addition, they were also of the opinion that learners would have less

"problems" if they had to lose or damage a mobile device or any of its equipment. This was mainly due to learners being held accountable for any lost/stolen or damaged devices and equipment. Most learners did not appreciate the extra responsibility of looking after these devices with great care. Conversely, some groups expressed financial concerns indicating that they feel that the CPUT should pay for mobile devices in order to allow learners from all dispensations, especially previously disadvantages learners that are still severely affected by the digital divide and who can mostly not afford such technology, to have a true anywhere, anytime teaching and learning experience, such as their counterparts. By assisting all learners, despite their financial background, to seamlessly complete and prepare course-related work, would show the institution's responsibility and interest towards its learners/clients, and furthermore it could potentially enable learners to achieve better academic results, and as a result afford them the opportunity to successfully complete their studies. Several groups were of the opinion that it could serve as an institutional asset being a worthwhile investment. One learner felt very strongly about the fact that if the institution wanted learners to do their work/assignments, they should provide and pay for the required technology.

5. Most learners (34.2%) indicated by means of the second post-m-learning questionnaire (P210) that they did not pair the PDA with their mobile phones. When learners were asked why, the majority responded by saying that they did try, but were unsuccessful mainly because their mobile phone would not allow pairing with the PDA. Nearly all of these learners attempted to pair the mobile devices more or less three times on different occasions, and in some instances learners also turned to their peers for assistance, but also to no avail. When these learners were probed on why they did not ask their educator (the researcher), they could provide no valid reason. Out of the entire 2012 m-learning group (n=48), only two learners asked for assistance with the pairing process. Some groups (10.1%) indicated that they were not aware that they could pair their mobile phone with the PDA, despite the fact that it has been announced and discussed in class on more than one occasion. Only 8.3% of the learners indicated that they did not bother to pair the PDA with their mobile phone, since they felt that it was unnecessary as they had either Wi-Fi access on campus, though limited, and at residence, or in one instance even at home.

6. As discussed in Paragraph 1.3 (Chapter 1), it is a harsh reality that theft and robbery in South Africa is a serious problem, especially for mobile devices that are carried on a person. Because of the danger of using mobile devices in South African public spaces, and even to transport them due to risk of theft/robbery (if its presence is noticed), most learners did not utilise the PDA while commuting. Most learners indicated that they are

too afraid (including male learners) and that it is simply too risky to use mobile technology while using public transport. Some learners were extra cautious since they were aware that they would be held responsible for lost/stolen devices. Another reason was that several learners were of the opinion that the screen size of the PDA is too small to use while travelling. None of the learners were bold enough to use the PDA in a taxi. Conversely, some learners however by far the minority, indicated that they did use the PDA while travelling by means of either the train, bus or university bus, but that it was dependent on the location, time of the day, and the travelling time. These learners would only use the PDA while travelling through specific locations, and they would not use it during the evening. If some instances where learners would use the PDA and feel threatened for whatever reason, they would immediately put it away. Some learners indicated that they would only use the PDA on a bus and in the morning, since it was safer than travelling by train. Those learners who indicated that they would not use the PDA during afternoons, was mainly because they feel that in the morning the "regulars" use the bus/train to go to work, but in the afternoon (before 16:00), different people (normally non-workers), use the train/bus with whom learners feel more precarious. Two learners used the PDA while walking (mainly to listen to music) to the university, of which one indicated that he was not scared at all, but actually felt "proud to show it off", whereas the other was "a bit scared, because you are nowhere safe". Another two learners used it while travelling by car, and one learner used the PDA while travelling by airplane, but was unfortunately also responsible for the only PDA being lost, since it was left behind on the airplane. One learner did not wish to bring the PDA to the university at all, since he was afraid that it might get stolen in class by peers.

7. In total, only 6.0% of the programming assignments (23 out of a possible 384) were not submitted by 11 (22.9%) of the learners. When learners were asked why they did not submit all of their assignments if they had 24/7 access to a PDA to assist them with the completion of their assignments anywhere, anytime, the following reasons were provided:

   - They arrived too late on campus, or tried too late to synchronise and upload/submit the assignments.
   - There was some confusion regarding the submission/due dates of the assignments.
   - They could not log into the CPUT network to upload assignments.
   - One learner missed two assignments due to illness.

8. It was of interest to note that more than 50% of the learners indicated that they prefer IM as a communication means, however only a few made use of IM during their studies. Since they had a 24/7 direct open channel to their lecturer, learners were asked why they did not make use of this unique opportunity. Learners responded by providing the following answers:

    - They are more familiar with sending/receiving e-mail.
    - They prefer to use Facebook as a means of communication instead of using IM applications.
    - They do not have access to the WhatsApp IM application on their mobile device or it does not run on certain mobile phones.
    - They will instead ask peers for assistance since they are either too "shy" or "scared" to ask the educator.
    - They feel that it is not their place (out of respect) to contact their educator via IM after hours, or that it was too much of a personal communication method that could make them feel uncomfortable.
    - They (the majority of the learners) prefer face-to-face communication in a classroom.
    - Some learners have no experience in using IM.
    - They feel they understand the work well enough and do not require additional assistance.
    - They would prefer to use IM during class, as most learners are shy, aware of language barriers, group pressure, and rejection.

    Learners also indicated that they would prefer to use IM in a classroom to for example, ask subject-related questions, since they mostly feel uncomfortable and pressured to express themselves in a classroom situation due to language barriers (English is a second or third language to almost all the learners) or the fact that peers might “laugh at their mistakes” or their “lack of knowledge”.

9. Learners were probed on why some of them (63.3%) found it acceptable to exclusively use mobile devices in a technology-based subject (P223). Learners’ main reason for the sole exception of mobile technology instead of using PCs, was the fact that practical computer classes on campus are always full during the day and the evening when part-time classes are offered, thus not providing learners with sufficient time to prepare for classes, practices their work, and complete programming assignments. To make matters worse, learners on some occasions did find an available computer, but just after they have started with work, or in some cases even during an online test, an educator will arrive at the venue to start a lecture, thus requiring the learners to leave the venue.

Learners lose focus and have to commence whatever they were busy with at a different location and time. Providing learners with 24/7 access to a mobile device would eliminate such problematic instances. In addition, learners referred to the fact that mobile devices are extremely portable, which would allow them to complete subject-related work anytime, anywhere, and also affording them the opportunity to improve their knowledge and skills. One learner indicated that even though she did not always feel in control while using technology, she would prefer to use a mobile device instead of a PC, since it was less demanding on her. Furthermore, one group specified that they would only use mobile technology if they could still have access to PCs as a "backup" alternative.

Conversely, learners who did not wish to exclusively utilise mobile technology, indicated that it was mainly due to the following reasons:

- PCs are more powerful, offered more storage space, and were easier to use, because of its input mechanisms (keyboard and mouse) that enabled learners to complete work faster and are thus less time-consuming.
- Some learners (however by far the minority), are scared that the mobile device might not work (i.e. drained battery, technical problems) and that they then would panic and feel frustrated. In addition, this would also entail that they will be responsible for the repair, which is currently not the case with campus computers.

10. Most learners (93.6%) indicated in the first post-m-learning questionnaire that they would prefer mobile devices to be incorporated into the classroom in the future (P133). Learners were probed on how they believed mobile devices could be used in a classroom situation. Learners expressed the following opinions:

    - The main aspect raised by learners was that they would like to receive "just-in-time" notes or PowerPoint slides from their educator while covering the work in class. This would allow learners to add their own information/notes while the lecture is in progress. Currently learners either have to make their own notes during the lecture, or print the material before or after a lecture. In addition, learners could also record lectures that could be listened to at a time and place that suits the learner. Though one could argue that most learners with smartphones can record lectures from their phones, it is the affordances of mobile technology (PDAs and tablets), such as receiving/downloading and storing notes, hosting course-related e-books, submitting/uploading assignments, and recording lectures that makes it such a popular device since it serves as an all-in-one device for teaching and learning purposes.

- They would prefer Blackboard Mobile instead of Blackboard for desktop computers that would allow them to submit assignments and access course material anytime, anywhere via a mobile device.
- They would favour the use of tablets in especially theory-related classes as it will allow them to instantaneously communicate with the educator. This was viewed as a significant asset by shy learners who did not have the confidence to ask questions in class. Learners also indicated that they would be more likely to use IM if they could do so by means of a tablet, that would provide a bigger screen and an easier means of entering information (especially if a mobile keyboard is available) when compared with a mobile phone and PDA.
- During 2011 and 2012 learners were introduced to Netop School, a classroom management software solution provided by the CPUT, to teach computer science programming by taking the Basic4PPC and Basic4Desktop software running on either the PDA or desktop computer, and then share it on the learners' computers in real time, therefore making the use of technology in the classroom slicker, easier and more proficient. Learners preferred to replicate this scenario in future classes, when for example utilising mobile technology such as tablets.

11. Learners were availed of the opportunity to indicate whether they would buy a tablet or desktop/laptop if they had the choice. Most groups indicated that they would purchase a tablet, because of its small, portable size (mobility), lighter weight when compared to computers/laptops, provides more applications that can be downloaded for educational and personal use, it is more exciting to use, and that it was safer to carry around, since it is not as easily noticed as laptops. It was however in some cases mentioned that it is price dependant. Conversely, some learners indicated that they would rather buy a laptop, since they do not prefer the "touch" aspect of tablets and rather prefer the old-fashioned way of using a keyboard/mouse (it is faster), it has more hard disk drive space, it provides more capabilities, has a bigger screen, it can be upgraded more easily, and that they were mostly unfamiliar with mobile technology.

5.7 Summary of findings

5.7.1 Pre-mobile learning questionnaire

As for the results obtained through this survey with respect to the pre-questionnaire, the following analogies can be drawn from this research:

- The genders were equally distributed.
- The survey group was made up of learners who were mostly born between 1989 and 1992; thus the ages of the learners at the time of the study were between 19 and 22.
- The learners spoke mostly isiXhosa, followed by French and then English as their first language.
- English and then Afrikaans were mostly indicated as being the learners' second language.
- This study consists mainly out of Black learners, followed by Coloured, then Indian, Asian and White learners.
- The learners who participated in this survey were mainly living at home or in a university residence.
- Public transport and the university bus was the most common means used by learners to travel to the university.
- Learner mobile phones were mostly not stolen previously, however should it be stolen, it would predominantly be stolen outside the boundaries of the university.
- Learners would like to be able to use mobile technology at their home/residence as well as in the classroom as a tool to help them with their university work. They furthermore believe that it will make a difference to the quality of their university work.
- The desktop computer, laptop computer and mobile phone were the technologies mostly used by the majority of the learners.
- Nearly all the learners in this survey own a mobile phone and nearly 60% owns a laptop computer.
- Most of the learners have off-campus access to a mobile phone, followed by a laptop computer.
- It is evident that most of the learners in the survey believed that off-campus access to the Visual Basic computer programming application is important to them. Nearly 75% found it difficult to access university computer laboratories outside computer programming class times, and less than a half have access to the programming application off-campus (all of which are illegal copies).
- The majority of the learners in this survey uses the Internet / goes online several times a day, and the technologies mainly used to go online are desktop computers/laptop computers, and then mobile phones.
- Computers are mainly used at the university.
- Nearly all the learners had their own mobile phone and SIM card, which they have mostly purchased themselves.
- The most popular mobile phone brands learners use are firstly Nokia, followed by BlackBerry, and then Samsung.
- The majority of learners from the 2012 m-learning group have a smart phone.

- The mobile provider of preference is MTN followed by Vodacom.
- Learners mainly utilise prepaid mobile phone contracts.
- The preferred way of mobile communication is firstly phone calls, because it is more convenient, then IM, and then SMS (text messaging) since it is cheaper.
- The majority of the mobile phones owned by learners are able to perform all the functions required for m-learning.
- The IM application of preference for the 2012 m-learning group is WhatsApp.
- The majority of learners will use the Internet / go online, do IM and play music / videos when they have some free time.
- Just more than a third of the learners spend between R50-R100 per month, a fifth spend R100 - R200 per month, and just more than a fifth spend R200-R300 per month on airtime and mobile data usage.
- The majority of learners pay for their own airtime / data usage, however some have their Parents/Legal guardians pay the cost.
- The majority of learners have used a mobile phone for the first time more than three years ago, and are therefore very familiar with this mobile technology.
- The majority of learners have their current mobile phone for less than a year.
- The majority of learners are happy to very happy with their current mobile phone.
- The main activities performed most often on a mobile phone is first IM, then phone calls, accessing the Internet/going online, listening to music/radio, SMS and chat.
- The mobile phone mostly helps learners to keep in touch with friends and family, find important information, and share their ideas and creations with others.
- Learners use the 'missed call' and 'please call me' mobile phone functions frequently.
- The following aspects are the most important when buying a mobile phone:
  - Access to fast Internet / going online.
  - Ability to download/receive files from other mobile phones via Bluetooth or Infrared.
  - Ability to send/receive e-mail.
  - Screen size.
  - Ability to download music, ringtones, games, applications or videos.
  - Ability to play music/mp3 files.
  - That it is the latest model or newest technology.
  - Ability to send /receive IM.
- The computer is most often used by learners to do their assignments and to use the Internet / go online.
- The majority of learners send 0-5 SMS’s (text messages) daily.
- The learners are mostly financially well off, however they feel that they deserve to be comfortable or affluent.

5.7.2 First post-mobile learning questionnaire

The results gleaned from the survey of the first post-m-learning questionnaire, returned the following results:

- The use of mobile devices are perceived as useful when pertaining to:
  - The use of mobile devices for learning purposes would save learners considerable time.
  - The use of mobile devices for learning computer programming would be feasible.
  - The use of mobile devices would increase the quality of computer programming teaching and learning.
  - The use of mobile devices for learning purposes would enhance the effectiveness of the learners' learning.
  - The use of mobile devices for learning would be ubiquitous and useful.
  - The use of mobile devices would increase the productivity in course work.
  - The use of mobile devices would improve academic performance.
  - The use of mobile devices to access material anywhere, anytime would allow the learners to spend more time on class work.
  - The learners would buy a mobile device if it will be useful in their course.
- The use of mobile devices are perceived to have mobility value as:
  - Mobility enables learners to access real-time information anywhere, anytime.
  - Mobility enables learners to accomplish tasks more quickly.
- The use of mobile devices are perceived to have social interaction value as:
  - Learners would be more likely to interact with educators and fellow learners both inside and outside the classroom if they could use mobile devices.
  - Learners would be more likely to participate in class discussions if they could share/post their thoughts in real-time through mobile devices.
- The use of mobile devices are perceived to have an enjoyment factor as:
  - The use of mobile devices would stimulate learner curiosity.
  - The learners would feel more interested in learning by using mobile devices.
  - The learners would enjoy learning if they could use mobile devices.
- The use of mobile devices are perceived to be easy to use as:
  - It would be easier for learners to ask for help if they could communicate through mobile devices.
  - It would be easier to complete class work and assignments if learners could use mobile devices.
  - It would be easy to engage in discussions using IM on mobile devices.

    - It would be easy to use mobile devices for learning.
    - It would ease the learners' learning, since it allows them to learn anywhere, anytime.
    - It would not require a lot of effort to learn, because learners can skilfully use mobile devices.
- The use of mobile devices are perceived to improve learner attitude as:
    - Learners would like to be able to view course material on mobile devices.
    - They would be more encouraged to learn if they could access learning materials anywhere, anytime.
    - They would feel ready for m-learning if the university implements it now.
    - They would like to be able to use mobile devices as a method for learning, since it will allow them to learn in places they could normally not learn/study in.
    - They would feel positive towards, and in control when using mobile devices in teaching and learning.
- The use of mobile devices are perceived to have access barriers such as:
    - Learners are afraid that they would spend more money on mobile data usage, because of m-learning.
    - The affordability of mobile devices may be an issue for some of the learners.
- The behavioural intention to use mobile devices are perceived to be positive as:
    - The learners would like to use mobile devices in the future, because they believe that it will assist them in their learning.
- The use of mobile devices are perceived to have output quality when:
    - Compared with traditional learning, learners believe that m-learning is more portable/mobile and flexible enabling anywhere, anytime learning.
    - Compared with traditional learning, they believe that m-learning enhances daily teaching and learning.
    - Compared with traditional learning, they believe that m-learning improves communication between learners and their educator.
    - Compared with traditional learning, they believe that m-learning is more initiative and dynamic.
    - Compared with traditional learning, they believe that m-learning provides a better alternative for teaching and learning.
    - Compared with traditional learning, they believe that m-learning ensures learning effectiveness.
    - Compared with traditional learning, they believe that m-learning enables high engagement (Making them more involved and active learners).

5.7.3 Second post-mobile learning questionnaire

The results gleaned from the survey of the second post-m-learning questionnaire, returned the following results:

- The learners were able to skilfully use PDAs (hereafter referred to as mobile devices) to:
  - Access the Internet / go online.
  - Watch videos and listen to music.
  - Complete and submit programming assignments.
  - Send text messages, instant messages and e-mails.
  - View and download course material and assignments.
  - Access Blackboard.
  - Access social network sites.
  - Download and install applications.
- The learners indicated the following current uses of mobile devices for learning purposes:
  - Access the Internet / go online.
  - Effectively complete and submit programming assignments.
  - Access the university web site.
  - Use a social networking site.
  - View and download course materials and assignments.
  - Make notes during class.
- Learners use mobile devices on a daily basis or at least a few days a week.
- Mobile devices are mostly used in the afternoon.
- Time spent on mobile devices is mostly more than 30 minutes.
- The events for which mobile devices are mostly used include:
  - Formal subject-related activities (assignments etc.).
  - Homework.
  - Personal use.
- The people mostly involved when learners utilise mobile devices are:
  - Friends.
  - Educators.
- The majority of the learners made use of Bluetooth to share files.
- The majority of learners intend using mobile devices in future at:
  - Home.
  - Computer lab on campus.
  - Theory class on campus.

- The majority of learners indicated that the university should require the learners to use mobile devices during the course of their studies, but that the university should pay for it.
- Learners are of the opinion that the university is ready to implement m-learning.
- The changes that learners indicated to incur a broader common acceptance of mobile devices in education are mostly:
  - Larger display screens.
  - Improved processing power.
  - Larger memory.
- Learners found it acceptable to learn computer programming with mobile device access only.
- Learners would prefer to use a mobile device during tests to assist them with coding programs.
- The majority of learners feels more enthusiastic about the use of mobile devices after the m-learning experience; compared to the beginning of the semester when they were introduced to the use of mobile devices in a technology-based subject.

5.7.4 Learner journal

Learner journals returned the following results:

- The majority of learners made more than 10 entries in their learner journals.
- Most of the entries were made in October 2012.
- The majority of learners used mobile technology in the mornings and the afternoons.
- The majority of learners used mobile technology for 10 minutes to an hour per session.
- Mobile technology is mostly used on campus and at home.
- Mobile technology is mostly used for formal subject related activities.
- In the majority of the cases the learners are using the mobile technology by themselves without any assistance. In only a few cases, other people such as a friend, the educator or a peer were involved.

5.7.5 Formative and summative assessment results

Formative and summative assessments returned the following results:

- It is evident that the marks for the summative tests, as well as the formative assignments and class tests consistently decreased from 2007 to 2010 and then increased again for 2010 to 2012.

- With respect to 2011 when m-learning was introduced, there is an indication that the marks improved after the m-learning experience.
- More specific, there was an increase in the assignment marks from before to after m-learning was introduced and it is evident that learners from the 2012 m-learning group have improved assignment marks.

5.7.6 Discussion of research-specific questions

Research-specific questions returned the following results:

- The 13.2% gain of the average formative practical assignment mark from before m-learning to after m-learning for the 2011 m-learning group, is as statistically significant as the 7.7% average gain achieved for the formative class tests.
- There was not a statistical significant gain in marks from the first summative assessment (T1) to the second summative assessment (T2) of both the 2011 and 2012 m-learning groups.
- With respect to the 2007 to 2010 groups, whether learner marks increased or decreased from the first summative test to the second summative test, the results are as follow:
  - For 2007 there is a statistical significant decrease in marks.
  - For 2008 the marks stayed constant.
  - For 2009 as well as for 2010 the marks statistically significant decreased.
- There was no difference between the marks of the different tests between the 2011 and 2012 m-learning groups, however learners from the 2012 m-learning group show a statistical significant higher mark than the 2011 m-learning group with respect to their formative practical assignment marks.
- Although the average marks of the second summative test were higher for the 2011 and 2012 m-learning groups than the average marks of the 2007-2010 groups, it is not statistically significant higher.
- The average marks of the formative practical assignments of the 2007-2010 groups, and the average marks of the 2011 m-learning group for the practical assignments before m-learning, are statistically significant lower than the average marks of the practical assignments for the 2012 m-learning group.
- The average marks for the formative practical assignments of the 2007-2010 groups are lower than both the average marks for the practical assignments after m-learning of the 2011 m-learning group, and the average marks for the practical assignments of the 2012 m-learning group, however only the difference between the 2007-2010 and 2012 classes is statistically significant.

- When the classes of the different years are compared with each other with respect to the two summative tests, formative practical assignments and class tests; there were statistical differences between the years.
- More specific, the following facts culminated as a result:
  - For the first summative test there is a statistically significant decrease from 2007 to 2010 as well as a statistical significant increase from 2010 to 2012.
  - For the second summative test there is a statistically significant decrease from 2007 to 2010, as well as a statistical significant increase from 2010 to 2011 and from 2010 to 2012.
  - For the 2011 formative practical assignment marks before the implementation of m-learning, there is a statistically significant decrease from 2007 to 2010, as well as a statistical significant increase from 2010 to 2012.
  - For the 2011 formative practical assignment marks after the m-learning intervention, there is a statistically significant decrease from 2007 to 2010, as well as a statistical significant increase from 2010 to 2011 and from 2010 to 2012.
  - For the 2011 formative class test marks before m-learning, there is a statistically significant decrease from 2007 to 2010, as well as a statistical significant increase from 2010 to 2011 and from 2010 to 2012.
  - For the 2011 formative class test marks after m-learning, there is a statistically significant decrease from 2007 to 2010, as well as a statistical significant increase from 2010 to 2011 and from 2010 to 2012.
- There were no statistically significant differences between the gain on summative test marks, formative assignment- and class test marks between the genders, first language groups and different race groups.
- The only differences between the 2011 - 2012 m-learning groups with respect to the questionnaires are:
  - The two survey groups differed with respect to their first language distribution. There were more isiXhosa speaking learners in the 2011 group than in the 2012 group and more French speaking learners in the 2012 group than in the 2011 group.
  - More learners from the 2011 survey reside in a university residence during their studies than the 2012 survey, and the analogy can be drawn that more of the learners of the 2012 survey live with their families or friends.
  - Furthermore, more learners from the 2011 survey use the university bus to get to the university than the 2012 survey. It seems that more respondents of the 2012 survey make use of public transport / a taxi.
  - More learners from the 2011 survey do not know whether the use of mobile technology as a tool in the classroom would make a difference to the quality of their university work than the 2012 survey. It seems that more learners of the 2012 survey

believed that it would make a difference, which could be attributed to the fact that they were already using the mobile devices in the classroom.

- Proportionally, more learners from the 2011 survey have never used a laptop computer, or mobile phone when compared to the 2012 survey.
- Proportionally, more learners from the 2011 survey have used an iPad/Tablet before when compared to the 2012 survey.
- Proportionally, more learners from the 2012 survey own a desktop computer when compared to the 2011 survey.
- Proportionally, more learners from the 2012 survey own an iPad/Tablet and go on line with this device when compared to the 2011 survey group.
- The 2012 survey group own mostly BlackBerry and Nokia phones, whilst the 2011 survey group own mostly Nokia phones.
- More learners from the 2012 survey have been aided by using a mobile phone to do well at the university when compared to the 2011 survey group.
- More learners from the 2011 group have used MXit before on a mobile phone than the 2012 survey group.
- More learners from the 2012 survey found it very important to be able to send and receive instant messages when they buy a new mobile phone, than the 2011 survey.
- More learners from the 2012 survey had used a mobile phone the previous day to download music etc. than the 2011 survey.
- More learners from the 2012 survey had used a computer the previous day to play music / MP3 files than the 2011 survey.
- More learners from the 2012 survey had used a computer the day before to send and receive e-mail than the 2011 survey.
- More learners from the 2011 survey have never used a computer to send instant messages than the 2012 survey.
- More learners from the 2012 survey had used a computer the day before to research information for university work on the internet than the 2011 survey.

- Except for the points mentioned above, the 2011 and 2012 surveys are comparable with respect to the questions (knowledge levels) posed to them.
- Gender and race for this research study do not determine ownership of mobile devices.
- First language groups do not determine ownership of mobile phones, but it does determine ownership of desktops, laptops or tablets.
- Race, first language and gender do not determine the average amount of money spent on airtime/mobile data usage per month.
- Males seem to enjoy learning more than the females if they could use mobile devices.

- Learners who believed that the use of mobile technology as a tool in the classroom will make a difference to the quality of their university work, agreed more with the Attitude variable than the learners who did not know whether the use of mobile technology as a tool in the classroom will make a difference to the quality of their university work.
- The learners who believed that the use of mobile technology as a tool in the classroom will make a difference to the quality of their university work, agreed more with the Perceived Usefulness variable than the learners who did not believe so.
- The learners who believed that the use of mobile technology as a tool in the classroom will make a difference to the quality of their university work, agreed more with the Behavioural Intention to Use variable, than the learners who did not know whether the use of mobile technology as a tool in the classroom will make a difference to the quality of their university work.
- The learners who believed that the use of mobile technology as a tool in the classroom will make a difference to the quality of their university work, agreed more with the Perceived Output Quality variable than the respondents who did not know whether the use of mobile technology as a tool in the classroom will make a difference to the quality of their university work.
- Race, first language and gender do not determine whether a learner bought a SD memory card to extend the storage capacity of the mobile device.
- More learners used the mobile devices for formal subject-related activities than for entertainment.
- More learners who said 'Yes' for the use of PDAs in computer laboratories, and while commuting, said 'No' to the use of PDAs at these locations in the future.

5.7.7 General

The following general findings are of importance:

- In general, non-parametric tests were mostly used as doubt existed whether the data had a normal distribution.
- Due to the number of respondents in the survey, some of the tests became invalid as there were expected frequencies of less than 5 in the cells when cross tabulations were performed.
- The factor analysis was deemed to be invalid as the number of variables being entered in the analysis was more than the number of respondents in the survey, thus the data was only used for exploratory purposes.

5.7.8 Advantages and barriers identified with regard to m-learning in a technology-based subject

The following advantages were identified with regard to the implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country:

- All learners (regardless of their culture, social- and financial background) could design, develop, test and electronically submit their programming assignments from anywhere, and at any time without the necessity of a computer or being on campus.
- Learners had 24/7 access to their educator via IM to address any subject-related issues.
- Learners have rarely subverted formal education by engaging in activities that are not related to the lecture, such as going online for non-subject-related activities, sending/receiving personal instant messages, reading/writing e-mails, accessing social networks, playing games, listening to music, and watching videos. This proves that mobile devices can effectively be used to facilitate learning in formal and informal educational settings, without necessarily distracting the teaching and learning process.

Learners expressed and were confronted by the following barriers/limitations as a result of using mobile devices in a technology-based subject:

- **On campus access only (2011):** During the first action research cycle (Cycle 1), learners from the 2011 m-learning group were only allowed to utilise PDAs exclusively on campus, therefore not allowing them a true m-learning experience. These learners had restricted opportunities compared with other m-learning programmes in which learners usually have access to mobile devices 24/7.
- **Microsoft ActiveSync and Blackboard Mobile:** Learners were required to connect (synchronise) their mobile device by means of Microsoft ActiveSync with an Internet-enabled computer (via cables) in order to upload their programming assignments and learner research journals onto Blackboard. ActiveSync is used to synchronise mail, calendars, contacts and other data between computers and mobile devices such as PDAs and smartphones. A major disadvantage of the ActiveSync application proved to be the setup procedure of a device each time a learner had to synchronise the PDA with a computer. A mobile device could only be associated with a maximum of two computers, therefore forcing learners to remove one of the associations each time they performed synchronisation. Fortunately, this was not a very time-consuming process. In addition, some learners experienced problems with the synchronisation process due to faulty cables or USB ports. The latter deemed to be a common occurrence since its daily high volume use by learners (11 000 learners within the faculty) tend to damage the

ports forcing learners to toggle around with the cables until they ultimately connect. Though learners could access the university website by means of Wi-Fi on campus, it was of no use to learners since they were required to upload their assignments and learner journals exclusively via Blackboard. In order to afford learners the opportunity to upload assignments or any other material onto Blackboard through a mobile device, the Blackboard Mobile application is required. Blackboard Mobile is a platform for bringing the teaching, learning, and campus experience to the mobile device. Blackboard Mobile applications currently address two vital expectations of the institution's increasingly mobile campus community, namely taking teaching and learning mobile with the Blackboard Mobile™ Learn application, and bringing the campus experience to the mobile device with the Blackboard Mobile Central application. (Blackboard Mobile, 2013:Online). Unfortunately, the CPUT is not in possession of a Blackboard Mobile site license, which forced learners to synchronise and upload their programming assignments via Internet-enabled computers - again not allowing learners a true m-learning experience.

- **Limited or no Wi-Fi availability on campus or at university residences:** Several Wi-Fi related issues were experienced, which included extremely weak or even no Wi-Fi signals, and the limited availability of Wi-Fi hotspots on campus (i.e. learners only had Wi-Fi access directly in front of the cafeteria at a certain spot, as well as the library). Furthermore, learners could only access Intranet web pages (i.e. all CPUT related content), and where therefore not able to access the Internet/go online. To elevate the problem, classrooms which were scheduled to be equipped with Wi-Fi access during the second semester of 2012, never materialised. In addition, to aggravate the problem, it was discovered that wireless systems in one of the institution's largest residences were impacted upon due to the theft of 12 access points within the residence. This had a severe and critical impact on learners' ability to access the Internet, and as a result also to access course notes and assignments published on Blackboard (n.a., 2013:Online).
- **Technical issues (soft- and hard reset):** Some learners "lost" their PDA keyboards, not allowing them to continue with any programming/coding. A soft reset of the mobile device seemed to be the only solution to fix the problem. Fortunately, learners did not lose any work due to performing a soft reset. In addition, several learners opted to password protect their devices. Though none of them forgot their passwords (which would have required a hard reset that results in losing all the files and applications on the device), two learners from the 2011- and 2012 m-learning groups experienced screen calibration problems. This led to learners not being able to accurately enter the passwords and as a result also not access the content on their devices. A hard reset was performed on these devices restoring it to its original factory settings. This served as an urgent reminder that work has to be backed up on a regular basis. Not only did these

learners lose all their work, but all the subject-related applications also had to be re-installed.

- **Lost/stolen devices and components:** A major concern throughout the 2011 and 2012 m-learning period, was the constant anticipation for lost or stolen devices. This was the main and exclusive reason for not allowing learners to use mobile devices off-campus during the 2011 m-learning period. This proved to be very successful as all 33 learners returned their devices in working order. It was however a different situation with the 2012 m-learning group, who was allowed to also make use of the mobile devices off-campus, and as a result provided more opportunity to lose or even get the devices or some of its components stolen. This fear became a reality, because of the following scenarios:

    - One foreign female learner lost her PDA on an airplane after visiting her parents.
    - One male learner provided a police statement indicating that the PDA was stolen after a car break in.
    - Two male learners disappeared from all enrolled classes and as a result have never returned the devices. These learners also never paid their university fees.
    - One male learner left behind his PDA after a practical class. Fortunately one of his peers picked it up and handed it in at the researcher's office. It was within a few minutes reported as "stolen" by the learner. This was the only incident of its kind for both the 2011 and 2012-m-learning groups.
    - Several learners have either lost or broken their stylus. When one of these learners were confronted about this and were reminded that lost components should be replaced, he simply replied by saying: "I will just steal somebody else's!". Others responded by just saying: "I think it is at home somewhere", clearly an indication that it does not bother them to say the least. However, despite these shocking and troublesome comments, it has to be noted that the rest of the learners (by far the majority), handled and looked after the devices with great care. This might bring one back to the argument about device ownership and whether learners will actually look better after devices if they had to pay for it themselves. The researcher is of the opinion that even if mobile devices are entirely subsidised by the institution or other funding, learners still take full ownership and responsibility of the devices, and minimal damage or loss to equipment occurs.

Since the PDAs were obtained through joint funding from the National Research Foundation (NRF) of South Africa and the CPUT to research the implications of m-learning in a technology-based subject, learners were not required to replace the devices. Learners were however not informed about this in an attempt to reduce the possibility of lost/stolen devices.

- **Basic4PPC vs. Basic4Desktop:** Several learners experienced problems with their Basic4PPC programs after synchronising and running them from the Basic4Desktop application. It was found that the PDA version was less strict regarding certain programming rules. This entailed learners to re-test their programs after synchronisation before submission via Blackboard. Once the differences were determined, issues were quickly and effectively rectified. Again, not allowing learners a true m-learning experience.
- **Formative assessment (programming assignments and class tests):** Despite the fact that learners were required to have access to an Internet-enabled computer in order to upload their programming assignments onto Blackboard (due to the lack of Blackboard Mobile that would allow them to do so directly from a mobile device), several learners were also confronted with the fact that they could not access computer laboratories on campus, especially in the morning, when they wanted to synchronise and upload their programming assignments before the deadline. Missing deadlines resulted in a zero mark allocation. This once again proved that by not affording learners a true m-learning experience by enabling them to design, develop and electronically submit their programming assignments outside the boundaries of the classroom before the due date and time, it could potentially have a negative impact on their academic performance.

  The 2012 m-learning group was the first group to ever write a test on a mobile device (Figure 5.158). The researcher beforehand successfully tested the Wi-Fi availability as well as the ability to send e-mails via Wi-Fi in the scheduled test venue and the campus cafeteria area. During the first mobile class test, all the learners were required to design, developed and electronically submit the class test by means of a PDA. Since learners were not able to upload assignments via Blackboard, they were allowed to e-mail the class test to the educator (researcher), however this was (unexpectedly) not possible on the day. Since learners could not access the Wi-Fi within the venue where they have written the test (which was indicated as a Wi-Fi venue by the institution), they had to move to the cafeteria area in order to submit their tests - definitely not an ideal situation for any type of assessment where learners need to move from one venue to another during a test. To aggravate the submission problem learners could previously access their e-mail via the CPUT's website by means of Wi-Fi, but during 2012 it was switched to a Cloud e-mail service. This resulted in learners not being able to access their e-mail via Wi-Fi as previously possible. In addition, to aggravate the problem even further, the majority of learners could not pair their mobile phones with the PDA, thus still not allowing them to submit the test by e-mailing it from the PDA itself via a mobile phone connection. Furthermore, learners could also not print the programming code, as there are no Wi-Fi enabled printers available to learners on campus. Learners were therefore once again forced to use the old fashioned method of synchronising the PDA with an Internet-enabled computer in order to submit the test, which in this particular case was not practical. The first mobile test experience was a huge disappointment for both the learners and the educator, and has instead been converted to an assignment to be submitted the following day.

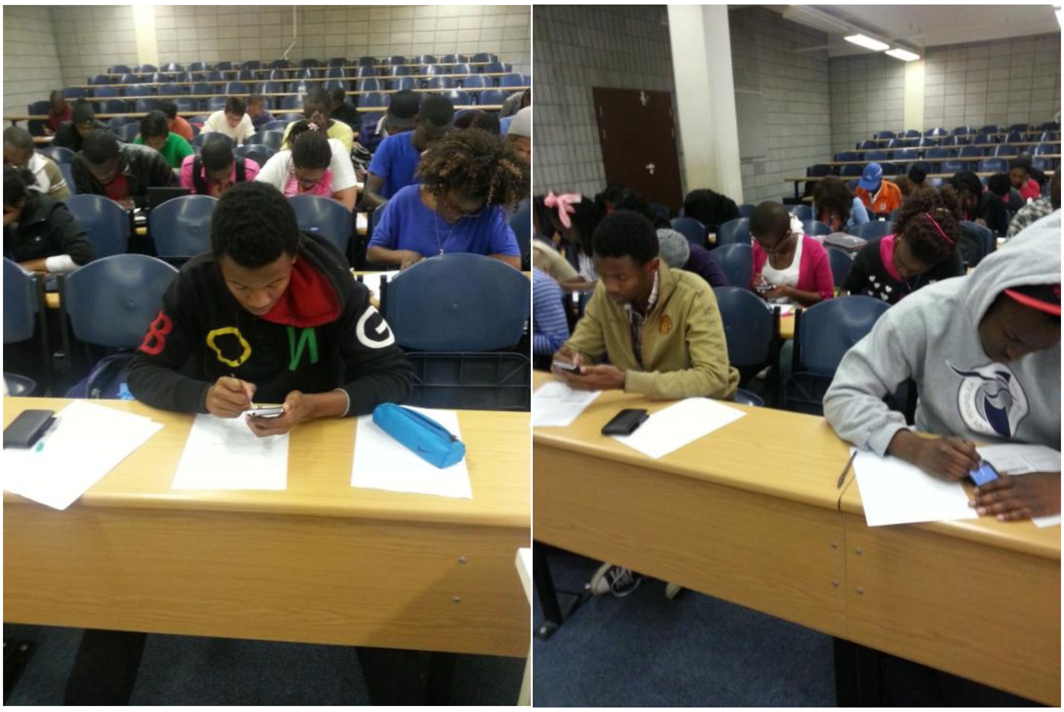

Figure 5.158: PDA utilisation during assessment

During the second class test, learners were given the choice to either complete the test on the PDA or on paper. Despite the multiple barriers experienced during the first class test, the majority of the learners (69%) still preferred to make use of the PDA. From an educator perspective it proved to be a nightmare, because since there was no Wi-Fi availability in classrooms, the educator had to collect all the PDAs a few days before the test, charge all the PDAs (since they were not all fully charged for the test), load the necessary test files onto the PDA, and mark each PDA with a learner's surname to ensure a quick hand back of devices in the test venue to the correct "owner". After the second assessment, PDAs were returned to the educator, test files downloaded to a computer, printed, and thereafter handed back to learners the following day.

From a learner perspective, it was evident that some of the learners found it to be a time-consuming process to design screens and enter code with a stylus during assessments.

These learners were afraid that they would not be able to complete a test in time when using a mobile device, and would therefore rather opt to not make use of a mobile device during an assessment. Conversely, learners pointed out that they would be more likely to use mobile devices if screen designs of computer programs were provided during assessments, they could submit their tests via Wi-Fi, and if mobile device screens were larger and input mechanisms more effective. Several learners also mentioned that they "stress", "panic" or feel extra "pressure" during a test if the program is not running on the PDA, and had the mentality of "at least it always runs on paper".

In conclusion it could therefore be argued that despite the many barriers learners have faced during the m-learning experience, m-learning can serve as a paradigmatic mechanism to bridge the existing learning gap to facilitate technology-based learning in a developing country since learner marks, especially formative assessment marks, have improved significantly after the implementation of m-learning in 2011 and 2012, and learners in general have indicated a positive attitude and perception towards m-learning.

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

SYNOPSIS

The content of Chapter 6, along with the relative positioning of the topics, is graphically depicted in Figure 6.

In this chapter a reflective perspective will be provided of the research undertaken to serve as a preamble to the conclusions and recommendations to follow. Of importance to the reader is a rendition of the consolidated research findings extrapolated from the literature study and data analysis juxtaposed and underpinned by the Activity theory culminating in the formulated conceptual model.

As a result, the focus of this chapter is the recommendations to mitigate the research problem which is the formulated conceptual model to serve as a means to effectively implement m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country.

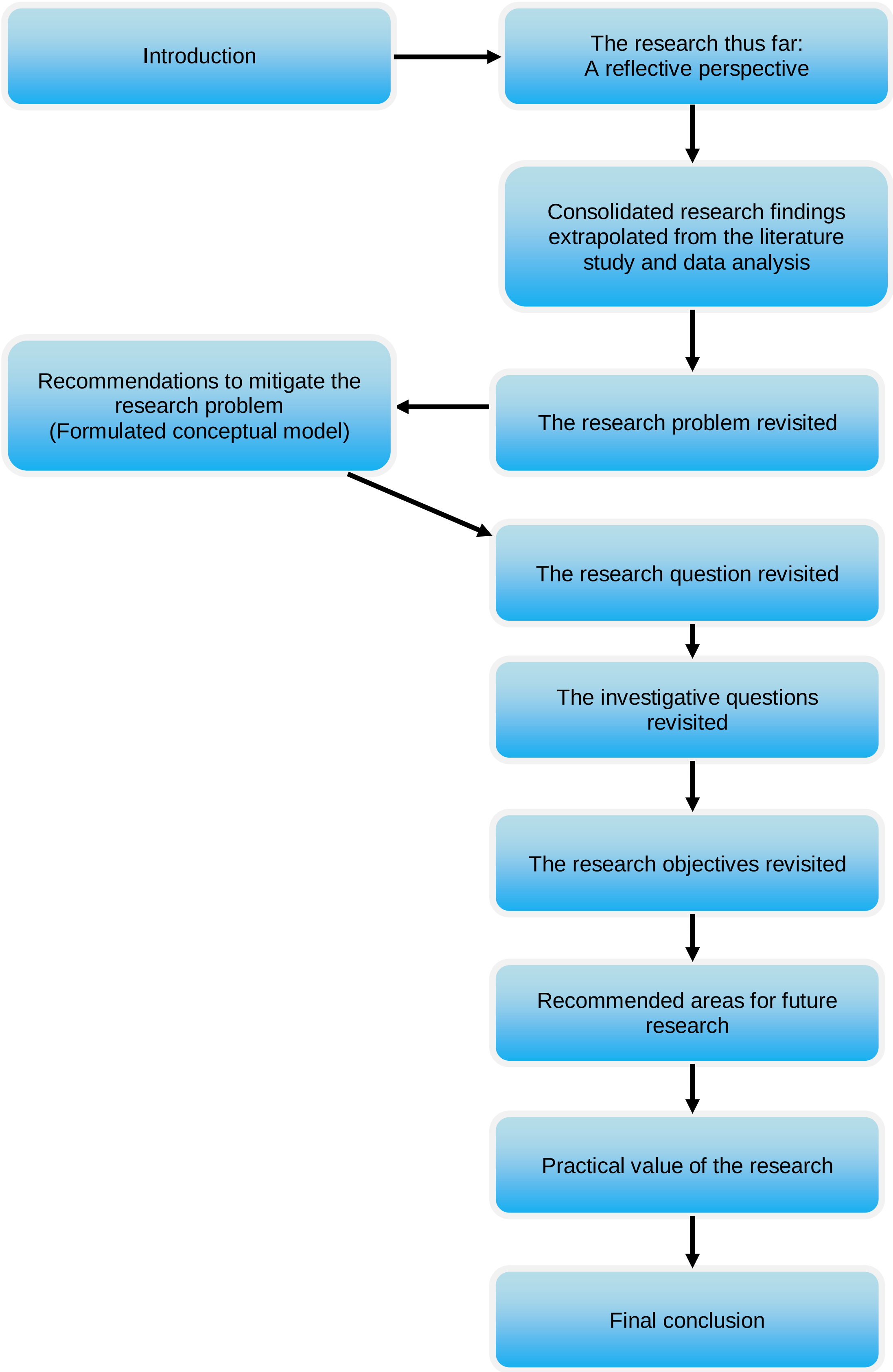

Figure 6: Detailed layout of Chapter 6 - Conclusions and recommendations

6. CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The analytical process followed thus far, is graphically depicted in Figure 6.1, which places the chapters in context with the overall thesis objectives, and furthermore indicates the relative positioning of this chapter.

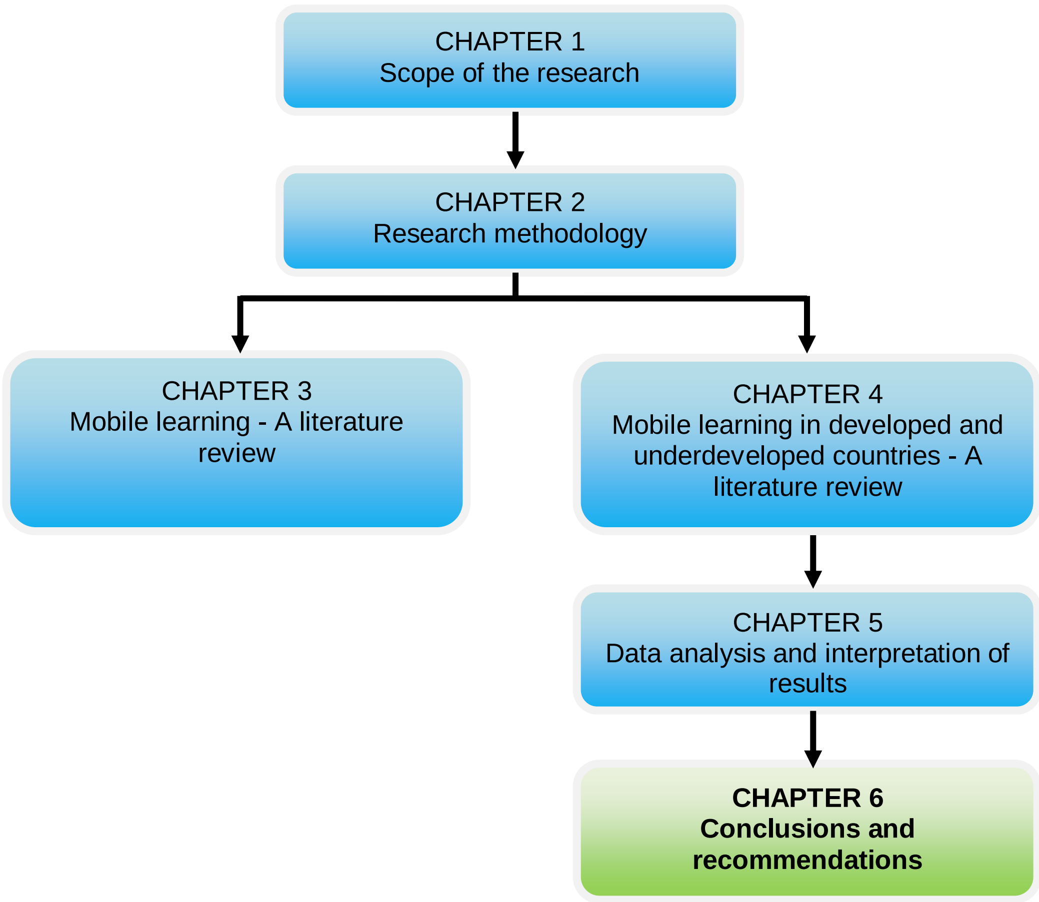

Figure 6.1: Chapter 6 - Conclusions and recommendations

Based on the literature review conducted in Chapters 3 and 4 and the various survey results analysed in Chapter 5, a conceptual model is proposed to assist with the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country.

6.2 The research thus far: A reflective perspective

In the research thus far, the extent of the research was elaborated upon in Chapter 1, while in Chapter 2, a holistic perspective on the research environment was provided. In Chapters 3 and 4, a literature review underpinning the primary theme of the thesis was conducted with specific focus on the following:

- Current status of the research area.
- Mobile learning in developed countries.
- Mobile learning in underdeveloped countries.
- Worldwide mobile learning projects in technology-based (computer science programming) subjects.

In Chapter 5, the research design and methodology, as well as the data analysis and interpretation of results were executed. In this final Chapter 6, the research will be concluded with recommendations being made to mitigate the research problem.

6.3 Consolidated research findings extrapolated from the literature study and data analysis

In this research study, a literature review on m-learning was conducted and the following analogies were drawn:

- Despite several m-learning barriers (i.e. small screen, limited storage capacity, fragility, batteries have to be charged regularly, technology failure, input medium, cost, complexity to set-up a m-learning environment), m-learning by far has more key advantages, which include the ability to allow learners to learn anytime, anywhere, and at their own pace. M-learning furthermore provides a learner with the ability to learn at his/her own pace, more rapid and convenient communication, quick 24/7 access to a variety of educational sources, portability, motivation, an increased understanding and depth of knowledge, reinforcement of existing material, as well as support.
- M-learning consists of three main elements, namely the mobility of technology, the mobility of learning and the mobility of the learner, which are mutually dependent and are equally significant in making mobile devices feasible tools for teaching and learning.

The literature review furthermore elaborated upon m-learning in developed and under-developed countries as the primary theme of the thesis, and provided an empirical underpinning to the research problem. It presented an overview of current academic evidence on the use of innovative mobile technology tools in an educational context focusing mainly on how educators integrate these tools within their pedagogy, especially in technology-based subjects. In addition, it considered the different m-learning impediments experienced within developed and underdeveloped countries.

Consolidated research findings extrapolated from the data analysis as elaborated upon in Chapter 5, Paragraph 5.7 include the following:

The chapter highlights that the majority of learners would like to be able to use mobile technology at their home/residence as well as in the classroom as a tool to aid them with their university work. They furthermore believe that it will make a difference to the quality of their university work. It is also evident that most of the learners in the survey believed that off-campus access to the Visual Basic computer programming application is important to them. Nearly 75% of the learners found it difficult to access university computer laboratories outside computer programming class times, and less than 50% of the respondents have access to the programming application off-campus (all of which are illegal copies).

The chapter furthermore returned that the use of mobile devices are: 1) Perceived as useful for teaching and learning purposes, 2) perceived to have mobility- and, 3) have social interaction value, 4) perceived to have an enjoyment factor, 5) to be easy to use, 6) improve learner attitudes, 7) have certain access barriers, 8) have output quality, and 9) the behavioural intention to use mobile devices are perceived to be positive.

In addition, results reflect that learners were able to skilfully use PDAs to perform a variety of tasks. Most of the learners use mobile devices on a daily basis or at least a few days a week for more than 30 minutes at a time. Learners primarily made use of the PDA for formal subject-related activities (assignments etc.). The majority of learners believed that the university is ready to implement m-learning, and should require learners to use mobile devices during the course of their studies, however the university should pay for it. Learners furthermore indicated that to incur a broader common acceptance of mobile devices in education, a larger display screen, improved processing power, and larger memory are important factors. Learners found it acceptable to learn computer programming with mobile device access only, and would prefer to use a mobile device during tests to assist them with coding programs. After being exposed to m-learning, the majority of learners felt more enthusiastic about the use of mobile devices, compared to the beginning of the semester when they were introduced to the use of mobile devices in a technology-based subject.

A further encouraging statistic emerging from the survey data is that the marks attained for the summative tests, as well as the formative assignments and class tests consistently decreased from 2007 to 2010 and then increased again for 2010 to 2012. With respect to 2011 when m-learning was introduced, there is clear evidence that the marks improved after the m-learning experience. More specific, there was an increase in the assignment marks from before to after m-learning was introduced and it is evident that learners from the 2012 m-learning group have improved practical assignment marks.

6.4 The research problem revisited

The research problem researched within the ambit of this thesis, read as follows: "*Current learning mechanisms to facilitate technology-based learning do not comply with the demands faced by tertiary institutions of developing countries*."

6.4.1 Recommendations to mitigate the research problem

The focus of this research study is the mitigation of the research problem. In order to solve the research problem, a conceptual model was developed, detail of which are elaborated upon below.

6.4.1.1 Background to conceptual model formulation

In this research study, a conceptual model is developed in an attempt to encapsulate a certain level of abstraction. The model aims to offer a m-learning solution in a technology-based subject (computer programming) to aid mainly previously disadvantaged learners in developing countries by providing educators with an improved understanding of the research findings, and to place these findings into context. A conceptual model involves the simplification and the abstraction of a real or proposed system (Robinson, 2006:792). Robinson (2004:65), furthermore defines a conceptual model as, "non-software specific description of the simulation model that is to be developed, describing the objectives, inputs, outputs, content, assumptions and simplifications of the model".

Wingkvist (2008:9-10), summarises conceptual modelling as follows: "In order to create a conceptual model, a certain level of simplification of reality is required. A conceptual model can be seen as a set of concepts that stand in relation to each other to explain a phenomenon in the real world. In comparison to a framework, conceptual modeling is done from a more practical rather than a philosophical stance, as distinguished by Aidemark (2007). This entails a presentation of the conceptual model, often consisting of an explanation interlinking text, figures, and tables, which all are descriptive and informative in character, to match the intended audience".

Based on a real world experience involving a m-learning initiative in a technology-based subject in a developing country, the factors that influenced the implementation, as well as the stages that occurred during the action research implementation process in this research study, were considered and categorised. This resulted in a conceptual model that serves to illustrate the effective implementation of m-learning as a paradigmatic mechanism to facilitate technology-based learning in a developing country.

While the defined conceptual model in this research study has yet to be proved to be applied to other m-learning initiatives, the model can serve to be of benefit to mainly tertiary educators, who wish to commence new m-learning initiatives in technology-based subjects (i.e. computer programming) in developing countries. The conceptual model furthermore aims to serve as a "thinking tool, as it is bringing together practice, theory, and research in an attempt to trigger understanding of the complexity involved" (Wingkvist, 2008:10).

Figure 6.2 depicts the conceptual model to serve as a means to effectively implement m-learning as a paradigmatic mechanism in a technology-based subject to mitigate the research problem. Keys depicting the various model elements are elaborated upon hereafter:

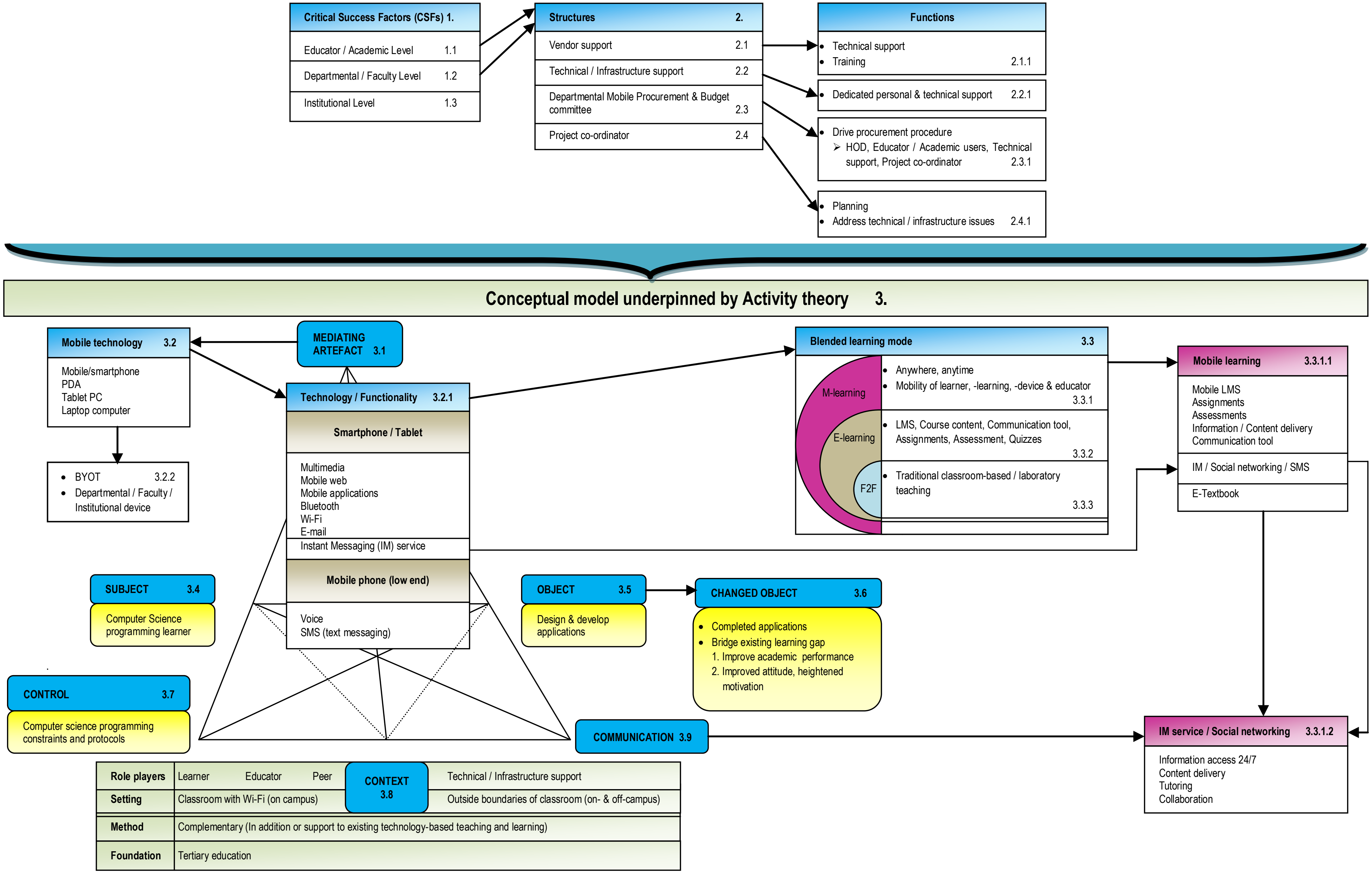

Figure 6.2: Conceptual model for the implementation of mobile learning in a technology-based subject in a developing country

Key 1: Critical Success Factors (CSFs)

Paramount to the success of the conceptual model is the absolute requirement to address the identified CSFs before the potential of m-learning in a technology-based subject can be harnessed. These include the adaptation of a m-learning activity theory conceptual model to satisfy the teaching and learning needs of learners, who will be utilising mobile technology in an attempt to bridge the existing learning gap to facilitate technology-based learning from a developing country perspective. The CSFs that have an impact on the success or failure of m-learning implementation and adoption in a technology-based subject will primarily depend on structural aspects such as the balancing of vendor support (Key 2.1), technical/infrastructure support (Key 2.2), effective m-learning procurement procedures (Key 2.3), and the successful management of the initiative by a project co-ordinator (Key 2.4).

The following Critical Success Factors (CSFs) have been identified for the implementation of m-learning in a technology-based subject in a developing country:

- **Learner, educator and departmental/faculty buy-in.** Learner, educator and departmental/faculty buy-in, is an essential element in the success of m-learning implementation and adoption. Not only should one familiarise oneself with the targeted end-users (their perceptions, preferences, attitudes, habits) and their contexts, but also obtain buy-in from learners, educators, departments/faculties and in certain instances, the institution as a whole, however it is not always an easy task. It is important to survey the target end-users and validate their readiness for accepting m-learning. One of the most common reasons may be resistance to change and the potential cost implications. It is therefore of importance to establish a persuasive business case for departmental/faculty m-learning implementation, and to address possible constraints by highlighting the benefits of m-learning in tertiary education for the learners, educators, and the faculty.
- **Selecting the right hardware and software**. In order to select appropriate hardware and software requires careful planning and management. One should familiarise oneself with the capabilities and limitations of the mobile technologies involved (i.e. mobile device reliability, performance, compatibility, connectivity, security). Before the mobile technology procurement process can start, the mobile devices containing the required software should be thoroughly tested and evaluated to ensure that learner and educator needs will be met.
    - **3G/4G-enabed mobile devices.** Devices should preferably have integrated 3G/4G capabilities allowing learners to bypass Wi-Fi networks and experience a true anytime, anywhere m-learning experience, that allows them to communicate and collaborate with peers and educators, access course content, and submit

programming assignments without the necessity of being on campus. The latter is however only possible if the institution makes use of a mobile LMS.

  - **Open-source software.** Open-source software is the most viable option for BYOT initiatives (see Key 3.3), since obtaining software licenses for privately owned devices could be a considerable stumbling block. In addition, open-software provides an added advantage of being cost fee – saving learners and the institution money.
  - **Mobile LMS.** In order to provide learners with a true m-learning experience a mobile LMS such as Mobile Blackboard (licensed software), Moodle or Sakai (open-source software) should be used in order to afford learners the opportunity to access course content, as well as download and submit programming assignments anywhere, anytime. By using a mobile LMS, learners are no longer required to synchronise mobile devices with campus computers to submit programming assignments.
  - **Device display screen and input mechanisms.** A larger mobile device screen (such as those provided by tablet computers) and mobile keyboards could address issues regarding small screens (such as that of PDAs and mobile phones) and stylus input mechanisms. By addressing these issues, it will assist learners in completing programming assignments quicker and in a more efficient manner.
  - **Prototype**. It is of utmost importance to first test the mobile devices and software, as prototyping assists in managing risk and cost. In addition, it can assist with learner-, educator- and departmental/faculty buy-in. Choosing the technology may seem to be a complex and daunting task since there are several aspects to consider. Mobile technology selection should be dependent on choice and user requirements.
- **Training.** Introduce learners to the new technology during the course extending a minimum two-week period. Without training and the proper support, mobile technology utilisation can result in disappointment. Furthermore, educator/academic training and development in adapting new mobile technologies and mobile teaching techniques for m-learning are also critical.
- **Motivation.** Learner motivation to use mobile devices is critical in order to gain acceptability, as persistence is vital for m-learning benefits to be properly realised.
- **Time.** To be successful, mobile devices should save time and not result in extra work. Learners normally only accept m-learning as part of the curriculum if it adds value to the subject, such as saving time, using free time more effectively to do subject-related work, and enables learners to have more fun when learning when compared to traditional teaching and learning methods.

- **Vendor support.** Vendor support should mainly be provided to departmental/institutional technical support staff in the form of new technology training, mobile device support, and device exchange, irrespective of whether devices are supplied by the department/faculty/institution or whether devices are part of a BYOT initiative (see Key 2.1).
- **Technical/infrastructure support.** Dedicated and personal technical/infrastructure support should be provided to learners, tutors and educators thereby ensuring exclusive technical support for m-learning. Support should be provided to all on an on-going basis (see Key 2.2).
    - **Technical-Educator-Learner support.** Educator involvement between technical/infrastructure support staff and learners is essential.
    - **Wi-Fi and network infrastructure.** A reliable Wi-Fi and network infrastructure should be provided by departmental/institutional technical support staff.
- **Departmental Mobile Procurement and Budget committee.** Cost can vary greatly depending on the m-learning approach. The Departmental Mobile Procurement and Budget Committee should determine which hardware and software are the most appropriate, cost effective, reliable and sustainable to purchase, and they should also carry out an investigation to develop an infrastructure and support services cost model that will address the on-going costs of technical/infrastructure support (see Key 2.3).
- **Project co-ordinator.** A project co-ordinator should be appointed to guide the planning, implementation and adoption of m-learning within a department/faculty (see Key 2.4)

Keys 1.1 – 1.3: Educator/Academic-, Departmental/Faculty- and Institutional level

In most instances, m-learning initiatives are restricted to researchers using individual subjects or courses as experiments outside mainstream methods offered by their tertiary institutions or to short-lived, short-funded pilot projects, in an attempt to address a specific teaching/learning need (educator/academic level). When planning to implement m-learning in a variety of courses within a faculty, it would be dealt with on a departmental/faculty level. In order to ensure the successful implementation calls for buy-in or acceptance from the department/faculty. Lastly, m-learning could also be implemented at an institutional level where m-learning will be offered in most courses and faculties throughout the institution, therefore requiring buy-in from the entire institution. However, the latter does not fall within the scope of this research study.

Key 2: Structures

The following structures with its associated functions have been identified to ensure the successful implementation and adoption of m-learning at departmental/faculty level in a technology-based subject in a developing country.

Key 2.1: Vendor support

It is vital that vendor support should be provided to departmental/institutional technical support staff in the form of new technology training, mobile device support, and device exchange, irrespective of whether devices are supplied by the department/institution or whether devices are part of a BYOT initiative.

Key 2.1.1: Technical support and training

Vendors should provide free technical support and mobile device training to educators and the technical support staff of a tertiary institution.

Key 2.2: Technical/Infrastructure support

From a practical perspective, adequate technical support would be critical when implementing m-learning, especially if the department/faculty/institution is providing mobile devices to learners. In addition, the management of equipment is also vital.

Key 2.2.1: Dedicated personal and technical support

Dedicated personal and technical support needs to be provided to all learners and educators on an on-going basis.

Key 2.3: Departmental Mobile Procurement and Budget committee

When a m-learning initiative is implemented at a departmental level, an investigation into the capital expenditure, on-going costs of technical and infrastructure support, as well as the costs of designing and implementing new concepts etc. of such an initiative, should be addressed. A Departmental Mobile Procurement and Budget Committee would be ideal in such a scenario, consisting of all the key role players, which should at least include the Head of Department (HOD), educator/ academic users, technical/infrastructure support, as well as a project co-ordinator.

Key 2.3.1: Drive procurement procedure

The main aim of the Departmental Mobile Procurement and Budget Committee should be to drive the procurement procedure and should at a minimum attend to the following processes:

- Evaluate and plan for the business and educational needs for m-learning within the department.
- Establish the m-learning objectives.
- Understand/know your learner by gathering background information about learner habits, perceptions, preferences, and attitudes toward mobile technology usage, especially for teaching and learning in a technology-based subject.
- Create requirements.
- Plan the effort.
- Define functional and technical requirements.

Key 2.4: Project co-ordinator

A project co-ordinator should be appointed to play a key role in the planning, implementation and adoption of m-learning at a departmental/faculty level, and should furthermore address any technical/infrastructure issues related to the initiative.

Key 2.4.1: Planning and addressing technical/infrastructure issues

In addition to the project co-ordinator's responsibility to plan and address any technical and infrastructure issues at a departmental level/faculty level, stakeholders should also be provided the opportunity to voice their concerns via formal and informal forums that the project co-ordinator should investigate and attend to.

Key 3: Conceptual model underpinned by Activity theory

Although the Activity Theory was elaborated upon in detail in Chapter 2, Paragraph 2.6, the detail due to the high relevance thereof to the conceptual model, is hereby repeated for ease of reference of the reader and also emphasise its relevant positioning and function within the context of the conceptual model.

Activity Theory was used as the underpinning theory to this action research study. Activity theory is proposed as a pedagogical underpinning to m-learning, where technology is perceived as a tool or artefact to mediate human activity. Activity theory in m-learning has been applied as an analytical lens to extricate the intricate relationships of subjects, tools, relationships, and other socio-technical infrastructure manifested through the utilisation of mobile devices. Since activity theory is mainly a descriptive tool, it focuses on practice and represents a qualitative approach that presents a different lens for analysing learning processes and learning outcome, making the activities people are engaged in the focal point. The lens of activity theory can provide insights into change in educators' practices or into how their teaching is "restructured", when a new technological tool becomes part of their teaching activity. From an activity theory perspective in analysing m-learning, mobile devices are perceived as tools that aid collaborative learning environments, however this can only happen when the technology is designed to fit with the context of its intended use, as well as support an extensive range of learner learning activities. In the education field, activity theory can therefore facilitate understanding of how technological advances influence change.

One of the main premises of activity theory is that activities are of a cultural-historical nature. Using activity theory to analyse learning as a cultural-historical system, two layers of tool-mediated activity are evident, namely the semiotic layer (socio-cultural perspective), and the technological layer (technology perspective). These layers can either be overlaid in order to scrutinise the holistic system of learning as interaction between people and technology as graphically depicted in Figure 2.12, Chapter 2 or be forced apart to provide either a semiotic framework to analyse the activity and discourse of m-learning, or a technological framework to suggest requirements for the design and evaluation of new m-learning systems The semiotic layer portrays learning as a semiotic system in which the object-oriented actions of a learner (i.e. actions to promote an objective) are mediated by cultural tools and signs. The technological layer on the other hand represents learning as an engagement with technology. Here tools (i.e. PDA, mobile phone) function as interactive agents in the process of coming to know, creating a human-technology system to communicate, to mediate agreements between learners and to aid recall and reflection.

The following aspects relating to the Activity Theory underpinning the conceptual model (Figure 6.2) are of importance:

Key 3.1: Mediating artefact

Mobile technology (i.e. PDA and tablet computer) act as an artefact and mediator of learning that has to meet all the goals and mediate all related actions. It is elaborated upon in more detail below.

Key 3.2: Mobile technology

M-learning facilitated through the use of mobile technology such as a mobile/smartphone, PDA, tablet PC and laptop computer, are considered as an extension of the more traditional e-learning framework to support interactive, self-directed, constructivist learning. M-learning could increase access to quality education for learners across all dispensations seeking anywhere, anytime and just-for-me teaching and learning solutions.

Each tertiary institution, especially in developing countries, is in a different phase in a journey towards embedding aspects of m-learning into practice. Despite the specific phase an institution has reached, it is of importance to ensure that the mobile technology is not driving the decision-making, but that it is instead utilised as part of a planned initiative to meet the subject/course/department/institution's aims and learning outcomes. Furthermore, it is of importance to note that not all types of learners or subject disciplines will benefit from the implementation and use of mobile technologies, however an investigation into the advantages and constraints thereof could potentially lead to identifying appropriate opportunities for its application.

It is of utmost importance to first test the mobile technology (hardware) and software within the environment of its intended use. Prototyping can provide the following key advantages:

- Assists in managing cost and risk.
- Assists in obtaining stakeholder buy-in and acceptance.
- Assist in managing the scope, budget and timeline of an m-learning initiative.
- The ability to simulate and refine some part of the learner experience before any major development and implementation effort has been completed.
- Ensure hardware compatibility on mobile device for the expected feature set. In the case of incompatibility, it is much easier to modify features and associated architecture during the prototype stage than later in the development cycle.
- Stakeholders have the opportunity to test some features of the mobile devices and accompanying software serving as confirmation of whether it meets their needs and requirements. As mentioned previously, it is easier and more affordable to make modifications during prototyping to conform to stakeholder expectations, than later in the development cycle.

Key 3.2.1: Technology/Functionality

Technology relates to the performance, compatibility, connectivity, security and reliability of a mobile device. In addition, the processing power, memory capacities, the ability to view and run a variety of software file formats, as well as compatibility and support for varied protocols and platforms are of significant importance. Connectivity limitations must be examined, and security remains a growing concern as mobile devices can be prone to loss or theft. Functionality relates to the features, functions and tools of a mobile device, such as the ability to access the Internet, running mobile applications, and providing multimedia, Bluetooth, and Wi-Fi capabilities. The device should support both synchronous and asynchronous modes of communication (IM and e-mail), as well as the ability to access, retrieve, process and display varied types of information.

Key 3.2.2: BYOT vs. Departmental/Faculty/Institutional device

M-learning integration into a technology-based subject such as computer science programming, has the ability of acting as an equaliser in tertiary education that bridges the existing learning gap learners are facing by providing all learners, especially those learners from previously disadvantaged backgrounds, with anywhere, anytime access to course content, 24/7 communication with educators and peers by means of online tools and resources, and most importantly the ability to complete and electronically submit their programming assignments outside the boundaries of the classroom. However, this will only be possible if learners have 24/7 access to a mobile device and broadband and/or Wi-Fi services both on and off-campus. It is of importance to note that approaches to m-learning aim to improve this inequality rather than aggravate it. Therefore, it is important to decide whether one will go the BYOT or Departmental/Faculty/Institutional device route.

- **BYOT (Bring Your Own Technology).** There is an increasing agreement that learners should bring their own technology/mobile devices (Bellis, 2012:Online), as it is believed that most learners already own some form of mobile technology (laptop computer, smartphone). Just as tertiary institutions do not provide learners with paper, pens and stationery items, but expect them to be used, the time is coming when mobile devices will be another expected part of a learner's toolkit. This view, commonly referred to as BYOT, is backed up with the following rationale:

  - Smartphones, tablets and other mobile devices are expensive.
  - Mobile devices become outdated and are perceived as 'obsolete' more quickly than other equipment used for learning. The continuous change in hardware or software technologies that causes other technologies to become obsolete can result in significant amounts of wasted individual and institutional resources.
  - Learners are increasingly likely to have a mobile device that contains functionality that can be used for learning.

  The BYOT approach however has its challenges. BYOT initiatives should employ a systemic approach by having a clear and comprehensive implementation plan, re-visiting and changing policies to support the BYOT initiative, managing the initiative, performing cost estimations, attending to possible equity issues, and evaluating the impact of the initiative. For BYOT initiatives, a department/faculty should cautiously consider the way it approaches the issue of learners who do not have access to mobile devices or Internet access at home, to ensure that the initiative is narrowing, rather than widening the digital divide. Some learners can simply not afford to buy a mobile device. To ensure equity, the department/faculty should permit learners to borrow mobile devices if they do not have their own. In an effort to narrow the digital divide it is important to focus on providing all learners with lower tariffs on mobile technology. It is for this reason why vendor support and commitment plays such a critical role in the implementation of m-learning. Vendors can provide devices at discounted rates (educational tariffs) allowing more learners to afford the technology. Some devices can be bought with an ISBN, which entails that learners who are studying by means of a study loan/bursary/sponsor (which make up the majority of tertiary learners in a developing country such as South Africa) could buy these devices without incurring additional costs since most study loans/bursaries/sponsors pay for prescribed textbooks. Conversely, mobile devices have the power to transform teaching and learning, so it is fundamental that tertiary institutions find avenues to integrate mobile devices into the classrooms, and provide learners with devices if they do not have one (on a loan basis) thereby keeping equity at the forefront of m-learning implementation by ensuring equal access to all. This would ensure that a learner is not being ridiculed or embarrassed about not owning his/her own mobile device. In addition, the costs associated with purchasing a device (and possibly a related mobile data plan) for each learner, and the accompanying maintenance costs, may be too high for some institutions, especially in light of other expenses and economic pressures.

- **Departmental/Faculty/Institutional devices.** Information technology has become inescapable in most individuals' daily lives (Lavin, Korte & Davies, 2010:2), and learners more and more need to learn in an environment that provides real life connections. This implies according to MacNeil and Delafield (1998:297), that if an educator would elect to utilise new technologies both in and out of the classroom, it would be expected from tertiary institutions to invest in the necessary hardware and software. However, in most instances the lack of planning and financial resources are the main inhibitors to implement technology in the classroom. By supplying mobile devices to learners not only increases educational equity, but the financial investment in devices also signals a strong commitment from the department/faculty/institution, which may lead to better and more sustained efforts to plan, implement and maintain m-learning initiatives.

Equity must be a fundamental element of any education initiative, and should include access to similar mobile devices and Internet services for all learners, regardless of demographics or income especially those who do not have mobile devices or broadband at home. However, the BYOT approach could also address the issue of "access to similar mobile devices", by prescribing a specific mobile device for a subject or course.

Whether following an approach where learners are supplied with mobile devices, or whereby learners need to buy their own technology (based on the assumption that learners will be required to purchase a specific prescribed device), integration into teaching and learning may be easier, because all learners are using the same type of mobile device, platform and software. Furthermore, the management and maintenance of mobile devices are more feasible for technical support staff, however there is a significant burden on the department/faculty to maintain and eventually replace the mobile devices. As new technology emerges and new versions of hardware and software are frequently released, it places significant financial pressure on departments/faculties when they own and provide the mobile devices.

In addition, by providing learners with mobile devices introduces the risk of learners losing or misappropriated the devices, which can be a costly exercise for the department/faculty to replace, and an extremely time-consuming process from a disciplinary perspective. The responsibility for replacement of lost or stolen devices can be problematic, therefore it is recommended that when a device is reported as stolen, that it will not be replaced, but instead learners will be expected to reimburse the department/faculty. This research study however confirms the findings of Gaskell and Mills (2009:9), reporting that when mobile devices are subsidised, learners take ownership of the devices and there is minimal damage or loss to equipment.

In order to provide a cost-effective and sustainable mobile solution to all learners, the researcher recommends a viable system that needs to be organised in such a way that it meets the demands of an ever-changing environment in order to survive. Projects that involve partnerships, and that makes use of private/public partnerships are more sustainable, however BYOT initiatives prove to be just as effective in certain instances.

Key 3.3: Blended learning model

This research study made use of a blended learning approach where first-year undergraduate learners have learned via a blend of three modes: 4 ½ hours of face-to-face classroom and laboratory-based instruction per week, e- learning via a LMS, as well as m-learning. With the incorporation of m-learning, a blended learning environment could be enhanced in that it provides learners with the opportunity to have 24/7 access to the required software to complete programming assignments both on and off-campus, assist and enable learners to design, develop and electronically submit programming assignments anytime and anywhere, provide immediate and timely subject-related content and feedback via an IM service, as well as increase learner motivation. The learners of today expect their learning environment to include mobile technology, because it forms an intrinsic part of their lives. Blended learning, which characteristically extends classroom instruction online, provides tertiary institutions with new approaches and strategies for addressing the challenges they face and for taking advantage of the exciting new learning opportunities that are now available (Blackboard K-12, 2009:Online)

Key 3.3.1: M-learning

Mobile learning is an integrated component and an enlargement of the learning strategy that allows anywhere, anytime collaboration and learning from a mobile device with an impact that extends beyond the classroom into the general learning environment. M-learning is about the mobility of the learner, -learning, -device and the educator. It is a mode of learning that uses mobile or wireless technology as a tool for supplementing learning, and offers an extensive variety of learning activities that support the learning process by means of motivation, control, ownership, fun and communication.

Key 3.3.1.1: Mobile learning

A mobile LMS provides access to learning resources (information/content delivery), assignments, assessments, and communication tools as and when the need arises and forms a vital part of any m-learning initiative. M-learning do not only extend class interaction beyond time, space and distance, but also enhances communication between learners and educators by means of IM/social networking/SMS, provides personal learning support for learners, introduces anonymous knowledge which in turn empowers shy learners, improve course management, and motivates learners to engage with their learning and encourages educators to develop innovative ways of using the devices to complement traditional teaching and learning methods. If available and appropriate, educators can also prescribe electronic textbooks (e-books) instead of, or in addition to, printed textbooks. This is not only a cost-effective way of replacing printed textbooks, but would also allow learners to carry the "textbook" with them without added weight and using additional space.

Key 3.3.1.2: IM service / Social networking

IM/Social networking services provide learners with 24/7 information access, course content delivery, and immediate feedback on any subject-related issues. When mobile devices are used as part of a blended learning program, it can be used to facilitate collaboration/interaction between learners, peers, tutors and educators.

Key 3.3.2: E-learning

This mode of learning is intended to reach learners who encounter difficulties in attending conventional learning. E-learning enables learners to not physically attend classes, and as a result they are not faced and restricted by time and geographical constraints. It is characteristically a web-based system carried out over the Internet (or the Intranet within the campus environment) supported by a virtual environment. This provides the flexibility and the capability of integrating course content, assignments, assessments, quizzes, communication tools, as well as text, picture, animation, audio and video to create multimedia instructional material. Frequently, e-learning incorporates a blended learning approach, which includes e-classroom and face-to-face meetings.

Key 3.3.3: Face-to-face (F2F) learning. F2F education entails traditional classroom-based/laboratory teaching where learners are usually restricted to a single location, and there is a fixed amount of time for interaction which could be limited due to large class sizes.

Key 3.4 – Key 3.6: Subject, Object and Changed object

The relationship between the subject (computer science programming learner) and the object (the goal of utilising m-learning in a technology-based subject, i.e. to complete and submit practical computer science programming assignments, accessing course material anywhere, anytime etc.) of the activity is not direct, but is rather mediated through the use of tools (PDAs, tablets). The subject is therefore perceived to be doing something other than merely 'using the technology'. The technology is simply the tool through which the subject achieves his/her objectives. The assessment of technology artefacts should therefore focus on the identification of usability issues, as well as the examination on how well the tool supports the subject's activities. The relationship between the subject and the learning context (formal context: computer laboratory and classroom, informal context: outside the classroom) is mediated by rules/controls, and the relationship between the object and the context is mediated by communication: How the activity is distributed among the role players within the context it occurs. Learning control can be viewed as learners' independence toward m-learning, the learning context as m-learning system functions and learner satisfaction toward these functions, as well as the communication of learning as interactive and communicative activities of m-learning. Learners are therefore viewed as active learners and not passive knowledge receivers as they gain new knowledge by means of sufficient learning technologies or tools that educators supply within essential learning activities to guide learners to master new knowledge. The conceptual framework can assist in the investigation of learners' learning practices that are mediated by the use of tools in both a formal and informal educational context. The role players/community within the context of the framework mainly includes the learners, educator and peers who are governed by a set of computer science programming constraints and protocols (i.e. university policies, course framework, class rules, learners must meet programming assignment deadlines) and communication (i.e. IM and uploading assignments).

Key 3.7: Control

The control of learning is generally focused on the educator, but may also be distributed among the learners. Control rules function in any context or community, referring to the explicit regulations, policies, and conventions that limit activity, as well as the implicit social standards, standards, and relationships among members of the community. Consequently, control may also pass between learners and technology.

- **Technological layer:** One of the most significant benefits of technology enhanced learning is to place learners in control of their learning. By placing learners in control of their learning can to some degree be perceived as a technological benefit, which originates from the approach in which learning is delivered, for example if learners are allowed to access learning materials at their own pace, revising and re-checking work at anytime, anywhere. In order to retain this benefit, it is important to ensure device or application usability, where the device or user interfaces must be effective and fit for purpose. In addition, system performance standards must be adhered to.

- **Semiotic layer:** The exploitation of technology also occurs within a social system of other learners. This entails that learners can be influenced without difficulty not only by what other users are essentially doing, but also their attitude towards it. Social rules (i.e. university policies, course framework, class rules etc.) preside over what is acceptable (i.e. learners must meet programming assignment deadlines). Learner attitudes toward the technology can be influenced by other people's opinions (i.e. do people mainly show a positive or negative attitude towards technology use?).

Key 3.8: Context

The context of learning can hold multiple communities of actors (both people and interactive technology), who intermingle around a joint objective, therefore making it an evolving and essential property of interaction. From the m-learning system perspective, the context of learning is based on the quality of system interactive functions, physical context, or learning content. It is a known and accepted fact that the higher the quality of the system's functions is, the more learner satisfaction there is.

- **Technological layer:** Context is facilitated by means of interaction between people, technology, objects and activities. It refers to either the characteristics of the learning environment (where learning occurs) or the social setting of learning activities, for example by utilising mobile devices, learners can learn and complete assignments in the classroom or elsewhere on campus, at home/residence, or even while travelling. As described earlier, there are two contextual aspects of importance, namely the physically embodied technological context, and the human semiotic context (i.e. the community) within which learning occurs. Furthermore, context refers to how social rules control what users are expected to do.
- **Semiotic layer:** The community may consist of various 'related' co-workers or co-learners who may or may not share the same current 'object' or objective, however to a larger degree form part and parcel of what a person may like to accomplish.

Key 3.9: Communication

If the system permits certain types of communication, learners can adjust their communication behaviours accordingly and from time to time, find alternative avenues to subvert the technology (e.g. finding new ways of connecting across networks). With the communication of learning, the technological system facilitates various forms of communication (i.e. IM), while learners embark on adapting their communication and learning activities accordingly. As the technology become more familiar to learners, they create novel ways of interacting through creating new rules and exclusive communities. This technology appropriation does not only lead to new ways of learning, but it also establishes trepidation with existing technologies and practices. On a broader scale, mobile technology supports interactions and communication (i.e. file and information retrieving and knowledge sharing).

Table 6.1 presents a summary of the three components based on activity theory and m-learning.

Table 6.1 The components based on activity theory and m-learning perspectives

Component	Activity theory perspectives	M-learning perspectives
The control of learning	• Learners directly access learning materials conveniently • Learners control the learning pace and style • Learners are independent and competent	• Systems provide self regularity or autonomous learning functions • Learners use systems personally and independently
The context of learning	• Context is an integral property of interaction • Context embraces the multiple communities of actors who interact around a shared objective	• Systems offer functions for learning activities, such as retrieval content or information sharing knowledge • Systems provide high quality functions to encourage and enhance learners' usage
The communication of learning	• Learners adapt their communication and learning activities • Learners invent new ways of interacting that creates new rules and exclusive communities	• Systems supply various interaction and communication to support diversely learning activities • Systems provide meaningful communication • Learners use systems individually or collaboratively

6.5 The research question revisited

The primary research question, which was researched in support of the mitigation of the research problem, reads as follows: *"Can mobile learning bridge the existing learning gap to facilitate technology-based learning in tertiary institutions in a developing country?"*

This question was answered by the formulated conceptual model as described in Paragraph 6.4.1.1 of this chapter.

6.6 The investigative questions revisited

In support of the primary research question, the following research sub-questions were researched:

- *What does current learning mechanisms used in tertiary institutions entail and what are their associated salient impediments?*

  This question was answered in terms of the elaboration of the issues as described in Chapter 3.
- *To what extent is m-learning deployed in developed countries to facilitate technology-based learning?*

  This question was answered in terms of the elaboration of the issues as described in Chapter 4.
- *To what extent is m-learning deployed in under-developed countries to facilitate technology-based learning?*

  This question was answered in terms of the elaboration of the issues as described in Chapter 4.
- *What are the typical potential usage patterns for m-learning learners in a technology-based subject?*

  This question was answered in terms of the elaboration of the issues as described in Chapter 5.
- *What specific challenges/problems are evident to implement m-learning in a technology-based subject in tertiary institutions of developing countries?*

  This question was answered in terms of the elaboration of the issues as described in Chapter 5.
- *To what extent (i.e. learning/performance, satisfaction, interest) does m-learning contribute in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries?*

  This question was answered in terms of the elaboration of the issues as described in Chapter 5.

6.7 The research objectives revisited

The key research objectives, as defined in Chapter 1, Paragraph 1.8, has been reached through the application of the conceptual model as described in Paragraph 6.4.1.1 of this chapter. The key research objectives were elaborated upon in Chapters 3, 4 and 5, and were defined as follow:

- To determine the extent of mobile technology utilisation within tertiary institutions and to identify their associated salient impediments.
- To determine the extent of m-learning deployment in developed countries to facilitate technology-based learning.

- To determine the extent of m-learning deployment in under-developed countries to facilitate technology-based learning.
- To identify the typical potential usage patterns for m-learning learners in a technology-based subject.
- To determine the specific challenges/problems that are evident to implement m-learning in a technology-based subject in tertiary institutions of developing countries.
- To determine the extent (i.e. learning/performance, satisfaction, interest) to which m-learning contributes in bridging the existing learning gap to facilitate technology-based learning in tertiary institutions of developing countries.

6.8 Recommended areas for future research

A recommended area for future research is to test the conceptual model developed in this research study to determine whether it can be used to map other m-learning initiatives in technology-based subjects (i.e. computer programming) in developing countries. In this process, the conceptual model should be provided to tertiary educators in order to allow them to utilise the model on their own and report on the results attained. This would test how helpful and useful the model would be from the perspective of an educator, who is working in the field of m-learning in a technology-based subject. In this thesis, a partial research study was conducted, and based on the findings from this study, a larger study that includes more learners and educators from different courses, departments, faculties, and tertiary institutions that utilise mobile technology such as tablet computers, could be of interest to the m-learning community. Due to the various infrastructure and synchronisation problems experienced in this research study, the Wi-Fi infrastructure needs to be improved upon, and an alternative to Blackboard needs to be considered in order to allow learners 24/7 access to course content from a mobile device. In addition, the use of PDAs will be abandoned in favour of Android tablet computers. The latter recommendation is based on the affordability of Android tablet computers by learners.

6.9 Practical value of the research

A direct consequence from the utilisation of the action research approach in this research study, as elaborated upon in Chapter 2, is culminating in the final results and the development of a conceptual model. The conceptual model illustrate the findings that resulted from this research study, and were then amalgamated in the form of a conceptual model that maps to CSFs to provide tertiary educators with a valuable mechanism and guide to implement m-learning in a technology-based subject in a developing country.

6.10 Final conclusion

The research presented in this thesis is concerned with investigating whether m-learning can serve as a paradigmatic mechanism to bridge the existing learning gap to facilitate technology-based learning in a developing country. This research study sought to identify by means of questionnaires, formative and summative assessments, learner research journals, focus groups, as well as synchronous and asynchronous communication, the rudimentary use, attitude and perceptions of learners related to m-learning in a technology-based subject. By gathering and disseminating the findings of this research study, the researcher anticipates that it will mainly provide tertiary education educators with a valuable tool who wish to commence new m-learning initiatives in technology-based subjects in developing countries.

In many respects, the findings of this research study juxtapose and strengthen what the literature in the field of m-learning already suggests. However, this research study has taken earlier notions one step further, by attempting to identify the advantages and limitations/barriers in the implementation of m-learning in technology-based subjects in especially developing countries such as South Africa.

Providing learners at the CPUT with access to remote resources while on the move, has increased their capability to physically shift/transfer their own learning environment as they move, thus enabling them the opportunity of taking the learning experience outside the boundaries of the classroom. Key findings from the research study indicate that mobile devices can be utilised as an acceptable additional technology in a technology-based subject. The results further indicate that learner reactions toward these devices are positive and may increase their enthusiasm and motivation to work and learn. Mobile programming can as a result bring new motivational dimensions to the learning experience of learners. However, despite the vast number of advantages that mobile technology brings to technology-based teaching and learning, it is important to recognise that mobile devices still cannot entirely replace traditional methods of instruction, especially in a developing country such as South Africa. Furthermore, CSFs as identified should serve as prerequisites for successful implementation. The researcher is of the opinion that a combination of m-learning and face-to-face education could serve as a step in the right direction for technology-based subject challenges. Conversely, there are significant challenges from a pragmatic real world perspective, which can not be ignored. It is important to ensure that mobile technology is used in a pragmatic way by focusing on the advantages of mobile devices, rather than to endevour and replicate the functionality of a computer, allowing traditional instruction and the utilisation of mobile technology to complement each other.

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APPENDIX A: Pre-mobile learning questionnaire[20]

Appendix A depicts the first pre-mobile learning survey questionnaire that was electronically distributed to first-year undergraduate computer science programming learners at the Cape Peninsula University of Technology in South Africa. This questionnaire is aimed at exploring learners' general daily use and perceptions of desktop computers and mobile technologies.

Student number: ______________

1. Gender?	☐	Male
	☐	Female
2. In which year where you born?		
3. What is your first (home) language?		
4. What is your second language?		
5. Race?	☐	Asian
	☐	Black
	☐	Coloured
	☐	Indian
	☐	White
	☐	Other
6. Where do you live during your studies?	☐	Family / Friends
	☐	Home
	☐	Residence
	☐	Other
7. How do you usually get to the university?	☐	Car
	☐	Public transport or taxi
	☐	University bus
	☐	Walk
8. Has your cell phone ever been stolen?	☐	Yes, at university
	☐	Yes, not at university
	☐	No
9. Would you like to be able to use mobile technology (e.g. cell phone, PDA, tablet etc.) **in the classroom** as a tool to help you with your university work?	☐	Yes
	☐	No
	☐	Don't know
10. Would you like to be able to use mobile technology (e.g. cell phone, PDA, tablet etc.) **at home/residence** as a tool to help you with your university work?	☐	Yes
	☐	No
	☐	Don't know
11. Do you think that the use of mobile technology (e.g. cell phone, PDA, tablet etc.) as a tool **in the classroom** will make a difference to the quality of your university work?	☐	Yes
	☐	No
	☐	Don't know
12. Do you think that the use of mobile technology (e.g. cell phone, PDA, tablet etc.) as a tool **at home/residence** will make a difference to the quality of your university work?	☐	Yes
	☐	No
	☐	Don't know

[20] Partially shaded questions appeared only in the 2011 survey, shaded questions only in the 2012 survey, and those questions that are not shaded appeared in both the 2011 and 2012 surveys.

13. Which ones have you **ever** used? (You can tick more than one box.)	☐	Desktop computer
	☐	Laptop computer
	☐	Pocket PC / PDA
	☐	iPad / Tablet
	☐	Cell phone
	☐	iPod or other MP3 player
	☐	Video game console / handheld gaming device
	☐	None of the above
14. Which ones did you use **yesterday**? (You can tick more than one box.)	☐	Desktop computer
	☐	Laptop computer
	☐	Pocket PC / PDA
	☐	iPad / Tablet
	☐	Cell phone
	☐	iPod or other MP3 player
	☐	Video game console / handheld gaming device
	☐	None of the above
15. Which ones do you **own** personally? (You can tick more than one box.)	☐	Desktop computer
	☐	Laptop computer
	☐	Pocket PC / PDA
	☐	iPad / Tablet
	☐	Cell phone
	☐	iPod or other MP3 player
	☐	Video game console / handheld gaming device
	☐	None of the above
16. Which ones do you have access to **off-campus**? (You can tick more than one box.)	☐	Desktop computer
	☐	Laptop computer
	☐	Pocket PC / PDA
	☐	iPad / Tablet
	☐	Cell phone
	☐	iPod or other MP3 player
	☐	Video game console / handheld gaming device
	☐	None of the above
17. Do you have access to the Visual Basic computer programming application off-campus?	☐	Yes
	☐	No
	☐	Don't know
18. Is off-campus access to the Visual Basic computer programming application important to you?	☐	Yes
	☐	No
	☐	Don't know
19. Is off-campus Internet access important to you?	☐	Yes
	☐	No
	☐	Don't know
20. Do you find it difficult to access university computer laboratories outside Visual Basic computer programming class times?	☐	Yes
	☐	No
	☐	Don't know
21. How often do you use the Internet / go online (incl. websites, e-mail, instant messages etc.)?	☐	Several times a day
	☐	About once a day
	☐	3 - 5 days a week
	☐	1 - 2 days a week
	☐	Every few weeks
	☐	Less often
	☐	Never
	☐	Don't know

22.	When you use the Internet / go online, do you use a(n) ... ? (You can tick more than one box.)	☐	Cell phone
		☐	Computer / Laptop
		☐	Pocket PC / PDA
		☐	iPad / Tablet
		☐	Other devices
23.	If you go online using a computer, where do you do this?	☐	At CPUT or the library
		☐	At home
		☐	At the residence
		☐	At an Internet Café
		☐	At someone else's place
		☐	Some other place
24.	How frequently do you use the Internet / go online **with a computer**?	☐	Daily
		☐	Weekly
		☐	Monthly
		☐	Never
25.	How frequently do you use the Internet / go online **with a cell phone**?	☐	Daily
		☐	Weekly
		☐	Monthly
		☐	Never
26.	Do you own or use a cell phone?	☐	I own a cell phone with a SIM card
		☐	I own a SIM card, but not a cell phone
		☐	I use a cell phone, but don't have my own phone or SIM card
		☐	I never use a cell phone
27.	How did you obtain your current cell phone?	☐	As a gift
		☐	Parent upgraded and you got their **new** phone
		☐	Parent upgraded and you got their **old** phone
		☐	Parents took out a contract for you
		☐	Purchased one yourself
		☐	Other
28.	What is the brand name of your cell phone (e.g. BlackBerry, Nokia, Samsung etc.)?		
29.	Is your cell phone a smart phone?	☐	Yes
		☐	No
		☐	Don't know
30.	Which mobile provider do you use? (You can tick more than one box if you use more than one phone.)	☐	Vodacom
		☐	MTN
		☐	Cell C
		☐	Virgin Mobile
		☐	8ta
		☐	Other
		☐	Don't know
31.	Is your cell phone using prepaid or contract?	☐	Prepaid
		☐	Contract
		☐	Don't know
32.	Do you prefer contacting someone via a(n)	☐	E-mail
		☐	Instant messaging
		☐	Phone call
		☐	SMS
33.	Why do you prefer the above selected method?	☐	Cheaper
		☐	More convenient
		☐	No specific reason
34.	With your cell phone, is it possible to **play music or MP3 files**?	☐	Yes
		☐	No
		☐	Don't know
35.	With your cell phone, is it possible to **send and receive e-mail**?	☐	Yes
		☐	No
		☐	Don't know

36.	With your cell phone, is it possible to **access the Internet / go online**?	☐	Yes
		☐	No
		☐	Don't know
37.	With your cell phone, is it possible **to use fast Internet**?	☐	Yes
		☐	No
		☐	Don't know
38.	With your cell phone, is it possible to **download / receive files from other cell phones via Bluetooth / Infrared**?	☐	Yes
		☐	No
		☐	Don't know
39.	With your cell phone, is it possible to **download music, ringtones, games, applications or videos**?	☐	Yes
		☐	No
		☐	Don't know
40.	With your cell phone, is it possible to **use MXit**?	☐	Yes
		☐	No
		☐	Don't know
41.	With your cell phone, is it possible to **use WhatsApp**?	☐	Yes
		☐	No
		☐	Don't know
42.	Which instant messaging application do you prefer to use with your cell phone?	☐	MXit
		☐	WhatsApp
		☐	Other
43.	What would you do on your cell phone if you had an hour or two?	☐	Play games
		☐	Use the Internet / go online
		☐	Chat via instant messaging
		☐	Send SMS's
		☐	Take photos / videos
		☐	Play music / videos
		☐	Download music, ringtones, games, applications or videos
		☐	Other
44.	On average, how much money do you spend on airtime and data usage per month?	☐	Less than R50
		☐	Between R50 and R100
		☐	Between R100 and R200
		☐	Between R200 and R 300
		☐	More than R300
45.	Who pays for your airtime and data usage or for your cell phone's contract? (You can tick more than one box.)	☐	My parents or legal guardians
		☐	My family members other than my parents
		☐	Myself
		☐	Boyfriend/girlfriend
		☐	Other
46.	How long ago was the first time you have used any cell phone?	☐	6 months or less
		☐	1 Year
		☐	2-3 Years
		☐	More than 3 years
		☐	Don't know
47.	How long have you had your current cell phone?	☐	6 months or less
		☐	1 Year
		☐	2-3 Years
		☐	More than 3 years
		☐	Don't know
48.	How happy or satisfied are you with your current cell phone?	☐	Very happy
		☐	Happy
		☐	Neither happy nor unhappy
		☐	Unhappy
		☐	Very unhappy
		☐	Don't know
49.	What are the three activities you do **most often** on a **cell phone**: Most often I, …..		
	Second		

	Third …..		
50.	How much, if at all, has your cell phone helped you to **keep in touch with your family**?	☐	A lot
		☐	Some
		☐	Only a little
		☐	Not at all
		☐	Don’t know
51.	How much, if at all, has your cell phone helped you to **keep in touch with your friends**?	☐	A lot
		☐	Some
		☐	Only a little
		☐	Not at all
		☐	Don’t know
52.	How much, if at all, has your cell phone helped you to **do well at university**?	☐	A lot
		☐	Some
		☐	Only a little
		☐	Not at all
		☐	Don’t know
53.	How much, if at all, has your cell phone helped you to **learn new things**?	☐	A lot
		☐	Some
		☐	Only a little
		☐	Not at all
		☐	Don’t know
54.	How much, if at all, has your cell phone helped you to **share your ideas and creations with others**?	☐	A lot
		☐	Some
		☐	Only a little
		☐	Not at all
		☐	Don’t know
55.	How much, if at all, has your cell phone helped you to **find important information**?	☐	A lot
		☐	Some
		☐	Only a little
		☐	Not at all
		☐	Don’t know
56.	How much, if at all, has your cell phone helped you to **work with others in your community or in groups you belong to**?	☐	A lot
		☐	Some
		☐	Only a little
		☐	Not at all
		☐	Don’t know
57.	How much, if at all, has your cell phone helped you to **follow your hobbies or interests**?	☐	A lot
		☐	Some
		☐	Only a little
		☐	Not at all
		☐	Don’t know
58.	Do you **ever** give a missed call to other people?	☐	Yes
		☐	No
		☐	Don’t know
59.	If yes, did you do this **yesterday**?	☐	Yes
		☐	No
60.	Do you **ever** use the feature “Please call me” on your cell phone?	☐	Yes
		☐	No
		☐	Don’t know
61.	If yes, did you do this **yesterday**?	☐	Yes
		☐	No
62.	Have you **ever** used MXit on a cell phone?	☐	Ever
		☐	Yesterday
		☐	Never

63. How much time did you spend on MXit **yesterday**?	☐	Did not use it
	☐	Less than 30 minutes
	☐	30 minutes – 1 hour
	☐	1-2 hours
	☐	2-4 hours
	☐	More than 4 hours
64. Have you **ever** used WhatsApp on a cell phone?	☐	Ever
	☐	Yesterday
	☐	Never
65. How much time did you spend on WhatsApp **yesterday**?	☐	Did not use it
	☐	Less than 30 minutes
	☐	30 minutes – 1 hour
	☐	1-2 hours
	☐	2-4 hours
	☐	More than 4 hours
66. If you had to buy a new cell phone today, how important is **great looks**?	☐	Very important
	☐	Somewhat important
	☐	Neither important nor unimportant
	☐	Not very important
	☐	Not important at all
	☐	Don't know
67. If you had to buy a new cell phone today, how important is the **screen size**?	☐	Very important
	☐	Somewhat important
	☐	Neither important nor unimportant
	☐	Not very important
	☐	Not important at all
	☐	Don't know
68. If you had to buy a new cell phone today, how important is the **size or weight**?	☐	Very important
	☐	Somewhat important
	☐	Neither important nor unimportant
	☐	Not very important
	☐	Not important at all
	☐	Don't know
69. If you had to buy a new cell phone today, how important is it that it is the **latest model or newest technology**?	☐	Very important
	☐	Somewhat important
	☐	Neither important nor unimportant
	☐	Not very important
	☐	Not important at all
	☐	Don't know
70. If you had to buy a new cell phone today, how important is the **brand name**?	☐	Very important
	☐	Somewhat important
	☐	Neither important nor unimportant
	☐	Not very important
	☐	Not important at all
	☐	Don't know
71. If you had to buy a new cell phone today, how important is it that it has a **low price**?	☐	Very important
	☐	Somewhat important
	☐	Neither important nor unimportant
	☐	Not very important
	☐	Not important at all
	☐	Don't know
72. If you had to buy a new cell phone today, how important is it to be able to play **music or MP3 files**?	☐	Very important
	☐	Somewhat important
	☐	Neither important nor unimportant
	☐	Not very important
	☐	Not important at all
	☐	Don't know

73.	If you had to buy a new cell phone today, how important is it to be able to **send and receive e-mails**?	☐	Very important
		☐	Somewhat important
		☐	Neither important nor unimportant
		☐	Not very important
		☐	Not important at all
		☐	Don't know
74.	If you had to buy a new cell phone today, how important is it to be able to **access the Internet / go online**?	☐	Very important
		☐	Somewhat important
		☐	Neither important nor unimportant
		☐	Not very important
		☐	Not important at all
		☐	Don't know
75.	If you had to buy a new cell phone today, how important is it to have **fast Internet (3G or HSDPA)**?	☐	Very important
		☐	Somewhat important
		☐	Neither important nor unimportant
		☐	Not very important
		☐	Not important at all
		☐	Don't know
76.	If you had to buy a new cell phone today, how important is it to be able to **download / receive files from other cell phones via Bluetooth or Infrared**?	☐	Very important
		☐	Somewhat important
		☐	Neither important nor unimportant
		☐	Not very important
		☐	Not important at all
		☐	Don't know
77.	If you had to buy a new cell phone today, how important is it to be able to **download music, ringtones, games, applications or videos**?	☐	Very important
		☐	Somewhat important
		☐	Neither important nor unimportant
		☐	Not very important
		☐	Not important at all
		☐	Don't know
78.	If you had to buy a new cell phone today, how important is it to be able to **send and receive instant messages**?	☐	Very important
		☐	Somewhat important
		☐	Neither important nor unimportant
		☐	Not very important
		☐	Not important at all
		☐	Don't know
79.	Have you **ever** used a cell phone to **play music or mp3 files**?	☐	Ever
		☐	Yesterday
		☐	Never
80.	Have you **ever** used a cell phone to **send and receive text messages or SMS**?	☐	Ever
		☐	Yesterday
		☐	Never
81.	Approximate number of SMS's sent daily?	☐	0 - 5
		☐	5 - 10
		☐	10 - 15
		☐	More than 15
82.	Have you **ever** used a cell phone to **send and receive e-mail**?	☐	Ever
		☐	Yesterday
		☐	Never
83.	Have you **ever** used a cell phone to **access the Internet / go online for no particular reason, just to browse for fun**?	☐	Ever
		☐	Yesterday
		☐	Never
84.	Have you **ever** used a cell phone to **download / receive files from other cell phones via Bluetooth or Infrared**?	☐	Ever
		☐	Yesterday
		☐	Never
85.	Have you **ever** used a cell phone to **download music, ringtones, games, applications or videos**?	☐	Ever
		☐	Yesterday
		☐	Never

86.	Have you **ever** used a cell phone to **research information for university work on the Internet**?	☐	Ever
		☐	Yesterday
		☐	Never
87.	What are the three activities you do **most often** on a **computer**? Most often I …..		
	Second …..		
	Third		
88.	Have you **ever** used a **computer** to **play music or MP3 files**?	☐	Ever
		☐	Yesterday
		☐	Never
89.	Have you **ever** used a **computer** to **send text messages or SMS**?	☐	Ever
		☐	Yesterday
		☐	Never
90.	Have you **ever** used a **computer** to **send and receive e-mail**?	☐	Ever
		☐	Yesterday
		☐	Never
91.	Have you **ever** used a **computer** to **access the Internet / go online for no particular reason, just to browse for fun**?	☐	Ever
		☐	Yesterday
		☐	Never
92.	Have you **ever** used a **computer** to **download music, ringtones, games, applications or videos**?	☐	Ever
		☐	Yesterday
		☐	Never
93.	Have you **ever** used a **computer** to **send instant messages to someone who was online at the same time**?	☐	Ever
		☐	Yesterday
		☐	Never
94.	Have you **ever** used a **computer** to **research information for university work on the Internet**?	☐	Ever
		☐	Yesterday
		☐	Never
95.	How are the students in your class doing financially?	☐	Affluent, plenty for all
		☐	Comfortable
		☐	Struggling, money is tight
		☐	Vary from lots to little
96.	How are you and your family doing financially?	☐	Affluent, plenty for all
		☐	Comfortable
		☐	Struggling, money is tight
		☐	Vary from lots to little
97.	What do you think you would deserve financially?	☐	Affluent, plenty for all
		☐	Comfortable
		☐	Struggling, money is tight
		☐	Vary from lots to little

APPENDIX B: First post-mobile learning questionnaire

Appendix B depicts the first post-mobile learning survey questionnaire that was electronically distributed to first-year undergraduate computer science programming learners at the Cape Peninsula University of Technology in South Africa. This questionnaire is aimed at exploring learners' perceptions and attitudes toward mobile learning as a learning tool in a technology-based subject.

1. Student number: ______________

PERCEIVED USEFULNESS (PU)					
2. To use mobile devices for learning purposes would save me a lot of time	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
3. To use mobile devices to access course material anywhere, anytime would allow me to spend more time on class work	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
4. To use mobile devices for learning purposes would enhance the effectiveness of my learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
5. To use mobile devices for learning would be ubiquitous and useful	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
6. To use mobile devices would improve my academic performance	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
7. To use mobile devices would increase my productivity in my course work	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
8. To use mobile devices would increase the quality of computer programming teaching and learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
9. To use mobile devices for learning computer programming would be feasible	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
10. I would buy a mobile device if it will be useful in my course	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
PERCEIVED MOBILITY VALUE (PMV)					
11. Mobility enables me to accomplish tasks more quickly	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
12. Mobility enables me to access real-time information anywhere, anytime	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
PERCEIVED SOCIAL INTERACTION VALUE (PSIV)					
13. I would be more likely to interact with lecturers and fellow students both inside and outside the classroom if I could use mobile devices	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
14. I would be more likely to participate in class discussions if I could share/post my thoughts in real-time through mobile devices	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

PERCEIVED ENJOYMENT (PE)					
15. I would feel more interested in learning by using mobile devices	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
16. I would enjoy learning if I could use mobile devices	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
17. To use mobile devices would stimulate my curiosity	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
PERCEIVED EASE OF USE (PEOU)					
18. It would not require a lot of effort to learn, because I can skilfully use mobile devices	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
19. It would ease my learning, since it allows me to learn anywhere, anytime	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
20. It would be easy to use mobile devices for learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
21. It would be easier to complete class work and assignments if I could use mobile devices	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
22. It would be easy to engage in discussions using instant messaging on mobile devices	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
23. It would be easier for me to ask for help if I could communicate through mobile devices	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
ATTITUDE (ATT)					
24. I would be more encouraged to learn if I could access learning materials anywhere, anytime	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
25. I would like to be able to use mobile devices as a method for learning, since it will allow me to learn in places I could normally not learn/study in	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
26. I would like to be able to view course material on mobile devices	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
27. I would feel in control when using mobile devices in teaching and learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
28. I would feel positive towards using mobile devices in teaching and learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
29. I would feel ready for mobile learning if the university implements it now	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
30. I would find it acceptable to study computer programming with mobile device access only	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
PERCEIVED ACCESS BARRIERS (PAB)					
31. I would not be able to afford mobile devices for educational use	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
32. I am afraid that I would spend more money on data usage, because of mobile learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
BEHAVIOURAL INTENTION TO USE (BI)					
33. I would like to use mobile devices in the future, because it will assist in my learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

PERCEIVED OUTPUT QUALITY (POQ)					
34. Compared with traditional learning, I believe that mobile learning is more initiative and dynamic	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
35. Compared with traditional learning, I believe that mobile learning is more portable/mobile and flexible enabling anywhere, anytime learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
36. Compared with traditional learning, I believe that mobile learning enhances daily teaching and learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
37. Compared with traditional learning, I believe that mobile learning enables high engagement	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
38. Compared with traditional learning, I believe that mobile learning ensures learning effectiveness	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
39. Compared with traditional learning, I believe that mobile learning provides a better alternative for teaching and learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
40. Compared with traditional learning, I believe that mobile learning improves communication between students and their lecturer	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree

APPENDIX C: Second post-mobile learning questionnaire[21]

Appendix C depicts the second post-mobile learning survey questionnaire that was electronically distributed to first-year undergraduate computer science programming learners at the Cape Peninsula University of Technology in South Africa. This questionnaire is aimed at exploring learners' use, perceptions and attitudes toward mobile learning (specifically focusing on PDAs) as a learning tool in a technology-based subject after being exposed to mobile learning.

1. Student number: ______________

USE		
2. I am able to skilfully use mobile devices to: (You can tick more than one box.)	☐	Access the Internet / go online
	☐	Download and install applications
	☐	Download podcasts
	☐	Watch videos and listen to music
	☐	Send SMS's, instant messages and e-mails
	☐	Access social networking sites (i.e. Facebook)
	☐	View and download course material and assignments
	☐	Complete and submit programming assignments
	☐	Access Blackboard
3. Current uses regarding mobile devices for learning purposes: (You can tick more than one box.)	☐	I have used it for library services
	☐	I have accessed the university website
	☐	I have viewed and downloaded course materials and assignments
	☐	I have accessed the Internet / went online for learning purposes
	☐	I have used a social networking site (i.e. Facebook)
	☐	I have interacted and communicated with my lecturer (i.e text messages (SMS), instant messages, e-mail)
	☐	I have interacted and communicated with fellow students (i.e text messages (SMS), instant messages, e-mail)
	☐	I have downloaded and listened to podcasts
	☐	I have recorded information during class (voice recording or taking photos)
	☐	I have made notes during class
	☐	I have effectively completed and submitted programming assignments

[21] Partially shaded questions appeared only in the 2011 survey, shaded questions only in the 2012 survey, and those questions that are not shaded appeared in both the 2011 and 2012 surveys.

4. Where did you use the mobile device? (You can tick more than one box.)	☐	Home
	☐	CPUT Residence
	☐	Computer laboratory on campus
	☐	Theory class on campus
	☐	Elsewhere on campus outside the classroom
	☐	While commuting
	☐	Family / Friends
	☐	Elsewhere off-campus
5. How frequently did you use the mobile device?	☐	Less than once a week
	☐	Once a week
	☐	A few days a week
	☐	Everyday
	☐	Never
6. I have used the mobile device mostly during the:	☐	Morning (6am - 12 pm)
	☐	Afternoon (12pm - 6pm)
	☐	Evening (6pm - 12am)
	☐	Night (12am - 6am)
7. How much did you spend on average during the week using the mobile device?	☐	Did not use it
	☐	Less than 30 minutes
	☐	30 minutes - 1 hour
	☐	1 - 2 hours
	☐	More than 4 hours
8. For which events did you mainly use the mobile device for? (You can tick more than one box.)	☐	Personal use
	☐	Information search
	☐	Homework
	☐	Formal subject-related activities
	☐	Hobbies / Interests
	☐	Communication / Collaboration
	☐	Provide help
	☐	Receive help
	☐	Entertainment
	☐	Other
9. Who were involved when you have used the mobile device during the course of your studies? (You can tick more than one box.)	☐	Lecturer
	☐	Peer
	☐	Mentor / Advisor
	☐	Technical Support
	☐	Friend
	☐	Partner
	☐	Family
	☐	None (except myself)
	☐	Other
10. Did you pair the mobile device with your cell phone in order to go online / access the Internet?	☐	Yes
	☐	Yes, but the devices did not want to pair
	☐	No, I did not know how to pair the devices
	☐	No, I did not want to
11. Did you make use of Bluetooth to share files?	☐	Yes
	☐	No
12. Did you buy or use a SD memory card to extend the storage capacity of the mobile device?	☐	Yes
	☐	No
13. Where do you think you will use mobile devices in future? (You can tick more than one box.)	☐	Home
	☐	CPUT residence
	☐	Computer laboratory on campus
	☐	Theory class on campus
	☐	Elsewhere on campus outside the classroom
	☐	While commuting
	☐	Family / Friends
	☐	Elsewhere off-campus

PERCEPTION					
14. Should the university require students to use mobile devices during the course of their computer programming studies?		☐	Yes, even if students have to pay for them		
		☐	Yes, but CPUT should pay for them		
		☐	I'm not sure		
		☐	No		
15. The university is ready to implement mobile learning	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
16. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? (You can tick more than one box.)		☐	Larger display screens		
		☐	Lower data cost tariffs		
		☐	Lower mobile device costs		
		☐	Better processing power		
		☐	Larger memory capacities		
		☐	Technology unification / consolidation		
		☐	Better proliferation (spreading at a rapid rate)		
		☐	Other		
ATTITUDE					
17. I do not want to use mobile devices, because they are too heavy to carry around	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
18. I do not want to use mobile devices, because they are too fragile and easily broken	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
19. I do not want to use mobile devices, because I find it difficult to read text on a mobile device screen	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
20. I do not want to use mobile devices, because it is hard to enter data using the stylus/pen/touch on a mobile device	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
21. What did you like about using a mobile device (PDA)? (Please specify at least one thing.)					
22. What did you dislike about using a mobile device (PDA)? (Please specify at least one thing.)					
23. I would find it acceptable to learn computer programming with mobile device access only	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
24. I would prefer to use a mobile device during tests to assist me with coding programs	Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly Disagree
25. Compared to the beginning of this semester, how do you feel about the use of mobile devices now?		☐	More enthusiastic		
		☐	About the same		
		☐	Less enthusiastic		

APPENDIX D: Learner assessment marks (2007-2012)

2007 Pre-mobile learning group

T1	T2	Gain	A1	A2	A3	A4	A5	A6	AVG	CT1	CT2	CT3	CT4	CT5	CT6	AVG
92	74	-18	9	9	10	10	7	10	**92**	100	80	47	80	87	72	**78**
76	53	-23	5	4	10	9	8	10	**77**	18	60	67	50	93	50	**56**
77	76	-1	8	10	10	10	0	10	**80**	35	70	87	80	87	80	**73**
87	52	-35	0	0	0	10	0	10	**33**	93	50	0	0	87	0	**38**
77	78	1	7	10	10	10	8	10	**92**	100	43	83	70	80	92	**78**
67	76	9	5	4	5	10	4	2	**50**	30	47	23	70	70	58	**50**
57	61	4	5	9	10	8	8	10	**83**	0	13	57	80	80	48	**46**
75	69	-6	6	10	9	10	6	6	**78**	25	50	33	90	73	48	**53**
95	87	-8	8	10	10	10	8	10	**93**	85	87	80	90	83	76	**84**
81	84	3	8	10	8	10	0	10	**77**	85	87	**A**	80	67	88	**81**
59	55	-4	0	10	7	9	4	0	**50**	0	67	30	0	87	72	**43**
88	92	4	5	10	9	10	7	10	**85**	93	67	80	90	97	92	**87**
83	56	-27	5		10	9	0	0	**48**	65	**A**	60	0	93	76	**59**
71	58	-13	5	9	8	9	8	7	**77**	30	70	87	40	93	88	**68**
99	85	-14	9	10	10	9	8	10	**93**	100	80	97	100	100	100	**96**
80	66	-14	8	9	9	9	8	7	**83**	0	7	80	40	90	78	**49**
91	88	-3	8	10	10	10	8	3	**82**	58	77	97	100	100	88	**87**
69	89	20	10	9	9	10	0	6	**73**	0	60	73	90	97	92	**69**
80	69	-11	8	9	10	10	4	10	**85**	85	77	97	70	97	84	**85**
85	86	1	7	10	10	10	8	9	**90**	30	40	87	100	87	76	**70**
80	59	-21	7	10	8	10	7	10	**87**	15	67	80	70	97	16	**58**
67	59	-8	0	4	6	8	8	7	**55**	15	23	33	60	60	28	**37**
88	80	-8	6	10	10	10	8	10	**90**	95	30	80	60	70	92	**71**
89	71	-18	7	10	10	10	8	10	**92**	100	47	90	60	87	84	**78**
91	82	-9	9	4	10	10	8	10	**85**	95	67	80	90	97	72	**84**
71	61	-10	5	10	8	9	5	10	**78**	38	**A**	87	70	73	38	**61**
85	82	-3	5	10	10	9	7	10	**85**	88	77	90	70	97	84	**84**
92	72	-20	8	9	10	0	8	10	**75**	93	67	50	50	97	92	**75**
91	82	-9	8	10	10	10	8	10	**93**	58	67	93	90	100	72	**80**
83	69	-14	9	9	7	9	7	10	**85**	70	23	77	70	97	84	**70**
64	58	-6	8	8	10	10	7	6	**82**	30	0	37	100	83	40	**48**
69	66	-3	5	9	7	9	8	7	**75**	33	17	47	60	83	64	**51**
92	93	1	5	10	10	9	8	10	**87**	65	90	93	100	100	100	**91**
79	86	7	8	10	10	10	8	10	**93**	70	73	70	70	97	88	**78**
76	86	10	0	4	0	10	0	0	**23**	0	60	100	0	97	84	**57**
93	82	-11	0	8	0	10	7	0	**42**	13	80	83	100	97	46	**70**
85	79	-6	9	10	10	10	8	10	**95**	45	23	0	80	90	48	**48**
71	46	-25	5	9	7	9	7	10	**78**	35	40	37	0	97	52	**44**

2007 Pre-mobile learning group (continued)

T1	T2	Gain	A1	A2	A3	A4	A5	A6	AVG	CT1	CT2	CT3	CT4	CT5	CT6	AVG
79	78	-1	9	9	10	10	8	7	**88**	93	7	57	50	87	80	**62**
84	72	-12	6	9	10	10	8	10	**88**	25	40	70	80	97	72	**64**
87	81	-6	9	10	10	10	8	10	**95**	35	70	97	50	90	92	**72**
80	64	-16	7	9	8	9	7	10	**83**	0	**A**	87	60	97	66	**62**
87	78	-9	5	8	10	10	8	10	**85**	0	**A**	93	80	97	52	**64**
85	81	-4	8	10	10	9	7	10	**90**	93	37	93	90	90	100	**84**
69	61	-8	6	9	10	10	8	10	**88**	85	70	83	80	97	72	**81**
89	80	-9	8	10	10	10	7	10	**92**	50	67	100	70	93	80	**77**
69	44	-25	8	0	0	9	8	10	**58**	45	50	0	0	77	42	**36**
92	82	-10	9	10	10	10	8	10	**95**	93	77	90	60	93	80	**82**
89	67	-22	5	9	8	9	8	10	**82**	58	27	97	60	100	72	**69**
71	61	-10	0	4	8	10	0	10	**53**	60	**A**	93	80	0	38	**54**
79	81	2	6	9	10	9	8	10	**87**	70	**A**	53	90	87	50	**70**
0	80	80	0	0	5	5	0	0	**17**	65	**A**	83	70	0	0	**44**

	T1	T2	Gain	A	CT
MEAN/AVG	79.13	72.63	-6.50	77.37	66.42
STDEV	14.79139767	12.35747	16.00919	18.80657879	15.65398163
MEDIAN	80.50	76.00	-8.00	84.17	69.42
MODE	92	82	-6	85	78

2008 Pre-mobile learning group

T1	T2	Gain	A1	A2	A3	A4	A5	AVG	CT1	CT2	CT3	CT4	CT5	AVG
21	3	-18	10	0	0	0	0	**20**	0	0	0	0	0	**0**
86	77	-9	10	10	10	9	10	**98**	95	80	97	51	88	**82**
81	71	-10	10	10	10	9	10	**98**	65	84	83	68	70	**74**
81	89	8	10	6	8	8	6	**76**	65	92	83	68	98	**81**
78	84	6	10	10	10	2	9	**82**	65	80	91	78	67	**76**
54	39	-15	8	9	6	8	0	**62**	35	60	71	34	31	**46**
64	50	-14	10	0	10	9	7	**72**	15	44	49	64	59	**46**
71	71	0	10	10	10	8	10	**96**	75	72	91	75	59	**74**
85	88	3	10	10	10	10	10	**100**	60	80	100	89	77	**81**
70	75	5	4	8	0	10	9	**62**	45	48	77	51	39	**52**
23	45	22	0	0	0	0	0	**0**	0	36	0	0	0	**7**
88	95	7	10	10	10	9	10	**98**	50	52	100	98	81	**76**
52	64	12	0	9	6	8	8	**62**	25	52	46	40	62	**45**
54	50	-4	10	10	0	10	6	**72**	40	84	**A**	75	59	**65**
76	88	12	9	10	10	9	9	**94**	45	50	80	75	81	**66**
66	69	3	9	0	10	4	10	**66**	50	40	66	70	70	**59**
77	79	2	10	10	8	0	10	**76**	70	72	80	41	83	**69**
78	79	1	10	10	8	8	10	**92**	50	80	80	81	89	**76**
15	45	30	0	0	0	0	0	**0**	0	76	60	0	0	**27**
51	40	-11	0	7	0	0	0	**14**	0	32	0	26	0	**12**
69	82	13	10	9	10	10	8	**94**	75	84	91	64	82	**79**
54	67	13	10	10	0	0	0	**40**	50	**A**	74	33	0	**39**
76	86	10	9	10	10	10	10	**98**	25	68	94	94	96	**75**
71	54	-17	10	9	8	9	6	**84**	45	68	89	64	79	**69**
78	72	-6	10	7	10	10	10	**94**	50	44	89	83	74	**68**
41	44	3	10	8	0	10	6	**68**	65	84	54	70	59	**66**
71	67	-4	10	6	9	10	0	**70**	45	28	80	75	75	**61**
69	59	-10	10	10	6	9	8	**86**	0	32	66	85	60	**49**
75	90	15	10	10	10	10	9	**98**	50	72	100	98	77	**79**
51	83	32	0	0	10	0	0	**20**	10	44	63	54	81	**50**
60	63	3	0	0	6	0	0	**12**	50	44	86	55	54	**58**
73	76	3	0	9	7	9	7	**64**	50	72	94	80	68	**73**
83	83	0	10	10	9	10	10	**98**	65	80	66	75	79	**73**
82	74	-8	10	10	9	10	10	**98**	5	46	89	81	94	**63**
81	86	5	10	10	6	6	9	**82**	75	76	97	90	87	**85**
81	75	-6	10	9	0	9	7	**70**	40	68	80	39	78	**61**
78	59	-19	0	10	10	9	9	**76**	45	54	71	38	68	**55**
59	64	5	10	10	10	9	10	**98**	30	16	86	63	75	**54**
63	61	-2	4	9	8	9	9	**78**	25	60	83	54	54	**55**

2008 Pre-mobile learning group (continued)

86	79	-7	8	9	10	9	10	**92**	35	64	91	73	85	**70**
88	86	-2	0	10	10	10	10	**80**	40	56	89	90	94	**74**
82	79	-3	10	10	10	10	9	**98**	75	60	100	90	87	**82**
69	77	8	10	10	10	8	7	**90**	30	36	83	85	72	**61**
61	81	20	10	0	9	9	7	**70**	35	52	77	65	62	**58**
80	74	-6	9	9	10	9	9	**92**	45	72	94	79	86	**75**
74	81	7	9	10	10	10	10	**98**	60	64	94	85	70	**75**
64	75	11	10	10	10	9	7	**92**	40	76	86	76	71	**70**
73	76	3	10	10	5	9	10	**88**	35	48	83	66	76	**62**
64	73	9	0	9	10	9	9	**74**	40	52	66	55	66	**56**
59	55	-4	9	7	7	10	9	**84**	10	22	43	25	71	**34**
73	72	-1	10	10	10	9	10	**98**	70	84	71	55	80	**72**
62	48	-14	9	9	0	9	0	**54**	40	32	74	78	61	**57**
83	66	-17	10	6	8	9	8	**82**	70	36	89	86	72	**71**
83	71	-12	8	9	9	10	9	**90**	10	52	83	83	76	**61**
76	84	8	0	0	10	9	9	**56**	20	52	87	78	69	**61**
71	59	-12	10	10	10	9	7	**92**	90	76	97	58	58	**76**
70	71	1	0	0	0	0	0	**0**	50	64	91	56	72	**67**
71	71	0	10	8	8	8	8	**84**	20	60	71	60	88	**60**
86	87	1	10	10	10	9	9	**96**	45	76	94	94	82	**78**
79	72	-7	0	9	10	9	0	**56**	65	84	91	83	81	**81**
T1	**T2**	**Gain**	**A1**	**A2**	**A3**	**A4**	**A5**	**AVG**	**CT1**	**CT2**	**CT3**	**CT4**	**CT5**	**AVG**

MEAN/AVG	69.00	69.72	0.72	73.90	62.14
STDEV	15.66600552	16.19279	11.122	27.55684418	18.00992686
MEDIAN	72.00	72.50	1.00	82.00	66.30
MODE	71	71	3	98	81
	T1	**T2**	**Gain**	**A**	**CT**

2009 Pre-mobile learning group

77	79	2	10	10	5	8	10	**86**	77	58	**68**
64	84	20	10	10	7	9	10	**92**	67	48	**58**
84	79	-5	9	10	6	7	10	**84**	71	88	**80**
7	23	16	5	6	5	5.5	5	**53**	34	4	**19**
88	88	0	10	10	6	7	10	**86**	87	88	**88**
85	82	-3	7	9	6	7	8	**74**	86	56	**71**
48	66	18	10	10	9	8.5	8	**91**	40	8	**24**
71	60	-11	10	10	10	0	10	**80**	54	76	**65**
86	81	-5	10	10	10	10	10	**100**	94	76	**85**
84	81	-3	10	10	10	10	9	**98**	76	96	**86**
73	54	-19	10	8	5	10	0	**66**	0	0	**0**
59	57	-2	10	5	5	10	10	**80**	54	36	**45**
60	50	-10	8	6.5	6	7	6	**67**	69	44	**57**
81	73	-8	1	5	10	10	9	**70**	23	80	**52**
66	51	-15	10	*5*	8	8	*8*	**78**	64	52	**58**
67	87	20	10	10	10	9	10	**98**	100	84	**92**
77	37	-40	10	5	10	9	*5*	**78**	0	84	**42**
87	78	-9	10	10	9	7	9	**90**	63	88	**76**
69	41	-28	9	0	0	8	0	**34**	77	0	**39**
76	80	4	9.5	10	8	9	10	**93**	69	64	**67**
92	96	4	10	10	10	10	10	**100**	97	98	**98**
92	91	-1	10	10	4	10	7	**82**	80	80	**80**
80	78	-2	9	9	10	10	9	**94**	43	84	**64**
87	76	-11	10	10	9	9.5	10	**97**	80	68	**74**
58	44	-14	5	5.5	5	5	6	**53**	54	46	**50**
42	50	8	9	7	8	7	7	**76**	66	12	**39**
73	62	-11	10	10	10	8	10	**96**	40	44	**42**
40	84	44	8	8	7	7	7	**74**	51	48	**50**
67	57	-10	5	0	0	5	0	**20**	60	82	**71**
78	84	6	6	5	5.5	6	6	**57**	74	80	**77**
81	36	-45	2.5	0	0	0	0	**5**	74	48	**61**
58	84	26	0	0	0	0	0	**0**	66	84	**75**
63	43	-20	6	5	5	5.5	5	**53**	9	20	**15**
76	78	2	0	0	0	0	0	**0**	66	40	**53**
83	61	-22	8	6	5	5	5	**58**	54	36	**45**
59	59	0	6	6	5	5	5	**54**	57	72	**65**
10	3	-7	0	0	0	0	0	**0**	11	4	**8**
61	56	-5	9.5	9	8	8	10	**89**	49	60	**55**
27	39	12	8	8	7	8	7	**76**	44	64	**54**
T1	**T2**	**Gain**	**A1**	**A2**	**A3**	**A4**	**A5**	**AVG**	**CT1**	**CT2**	**AVG**

2009 Pre-mobile learning group (continued)

T1	T2	Gain	A1	A2	A3	A4	A5	AVG	CT1	CT2	AVG
46	21	-25	0	5	0	6	10	**42**	54	48	**51**
76	61	-15	10	10	6	8	10	**88**	63	56	**60**
90	77	-13	10	10	10	8	10	**96**	83	88	**86**
47	44	-3	0	4	0	5	0	**18**	69	28	**49**
82	78	-4	8	10	10	10	10	**96**	51	70	**61**
59	54	-5	10	9	5	8	10	**84**	80	60	**70**
76	54	-22	8	8	5.5	7	6	**69**	46	36	**41**
52	55	3	8.5	7	5	6	7	**67**	71	20	**46**
81	64	-17	10	8	5	0	10	**66**	66	52	**59**
52	35	-17	9.5	8	8	8	9	**85**	56	64	**60**
79	46	-33	10	0	4	0	0	**28**	60	36	**48**
52	34	-18	10	8	8.5	9	10	**91**	46	52	**49**
67	57	-10	5	0	0	5	0	**20**	60	82	**71**
71	69	-2	10	9	8	9	9.5	**91**	77	52	**65**
53	51	-2	7	6	6	6	6.5	**63**	31	20	**26**
76	78	2	0	0	0	0	0	**0**	66	40	**53**
74	58	-16	10	8	10	10	10	**96**	0	92	**46**
T1	**T2**	**Gain**	**A1**	**A2**	**A3**	**A4**	**A5**	**AVG**	**CT1**	**CT2**	**AVG**

MEAN/AVG	67.30	61.57	-5.73	67.54	56.74
STDEV	18.52950438	19.90145	15.54523	29.86999972	20.54927361
MEDIAN	72.00	60.50	-5.00	77.00	57.75
MODE	76	78	-5	96	71
	T1	**T2**	**Gain**	**A**	**CT**

2010 Pre-mobile learning group

67	73	6	0	8	0	0	0	**16**	37	75	70	40	**56**
75	74	-1	10	0	0	0	0	**20**	30	75	73	23	**50**
58	47	-11	0	0	0	0	0	**0**	10	30	43	60	**36**
65	59	-6	0	0	0	0	0	**0**	37	50	80	73	**60**
54	49	-5	0	0	0	0	0	**0**	7	5	50	35	**24**
14	6	-8	0	5	0	0	0	**10**	3	20	23	6	**13**
58	69	11	10	0	10	0	0	**40**	32	68	50	43	**48**
15	0	-15	0	4	5	10	0	**38**	18	35	0	0	**13**
83	50	-33	10	9	5	10	4	**76**	50	93	73	64	**70**
40	20	-20	0	0	0	0	4	**8**	22	30	30	16	**25**
64	50	-14	10	7	10	10	4	**82**	43	83	63	71	**65**
36	23	-13	10	4	9	10	0	**66**	3	65	38	33	**35**
30	22	-8	10	8	0	5	4	**54**	20	43	27	6	**24**
45	50	5	0	0	0	0	0	**0**	27	55	27	20	**32**
46	39	-7	10	5	9	8	0	**64**	13	43	30	39	**31**
55	46	-9	0	0	10	0	0	**20**	27	73	35	53	**47**
44	28	-16	0	0	0	0	0	**0**	27	45	37	25	**34**
69	58	-11	10	8	10	10	10	**96**	28	88	61	44	**55**
0	32	32	0	0	0	0	0	**0**	43	45	53	14	**39**
67	67	0	10	5	0	0	4	**38**	50	50	68	34	**51**
59	57	-2	10	5	0	0	0	**30**	20	83	70	39	**53**
41	33	-8	10	8	0	0	0	**36**	38	88	32	44	**51**
33	42	9	10	7	9	10	9	**90**	13	50	40	18	**30**
69	36	-33	9	8	4	10	0	**62**	12	55	50	44	**40**
65	49	-16	10	5	0	10	0	**50**	25	60	53	46	**46**
85	80	-5	9	9	10	10	10	**96**	58	88	73	75	**74**
67	56	-11	10	0	0	10	10	**60**	40	70	58	31	**50**
67	46	-21	10	4	5	10	4	**66**	13	60	53	50	**44**
56	41	-15	10	9	10	10	10	**98**	10	68	47	75	**50**
57	49	-8	9	0	0	10	4	**46**	22	50	43	31	**37**
54	57	3	9	6	10	10	8	**86**	40	45	55	44	**46**
60	50	-10	9	6	5	4	4	**56**	30	53	40	36	**40**
88	91	3	10	8	10	10	0	**76**	52	73	92	88	**76**
55	39	-16	10	8	10	9	0	**74**	23	70	78	24	**49**
51	46	-5	10	6	5	10	0	**62**	28	45	30	18	**30**
46	30	-16	9	0	0	10	10	**58**	17	30	33	34	**29**
57	47	-10	9	0	10	9	10	**76**	38	60	30	50	**45**
49	41	-8	8	9	0	9	8	**68**	37	75	A	14	**42**
50	39	-11	9	5	10	7	5	**72**	10	0	58	36	**26**
59	34	-25	10	0	5	10	0	**50**	40	55	30	38	**41**
74	70	-4	0	0	0	10	0	**20**	12	55	70	78	**54**
T1	**T2**	**Gain**	**A1**	**A2**	**A3**	**A4**	**A5**	**AVG**	**CT1**	**CT2**	**CT3**	**CT4**	**AVG**

2010 Pre-mobile learning group (continued)

44	26	-18	9	6	0	0	0	**30**	7	60	38	23	**32**
73	59	-14	9	0	10	0	8	**54**	100	93	80	84	**89**
90	50	-40	10	10	10	10	*10*	**100**	50	83	93	75	**75**
61	66	5	0	5	5	0	5	**30**	37	63	0	74	**44**
81	46	-35	10	8	10	10	8	**92**	27	85	92	69	**68**
31	33	2	0	0	0	0	4	**8**	7	78	55	35	**44**
42	31	-11	0	0	0	0	0	**0**	3	55	43	50	**38**
T1	**T2**	**Gain**	**A1**	**A2**	**A3**	**A4**	**A5**	**AVG**	**CT1**	**CT2**	**CT3**	**CT4**	**AVG**

MEAN/AVG	55.19	45.96	-9.23	47.38	44.73
STDEV	18.82241336	18.0224	12.59895	31.72798282	16.27749992
MEDIAN	57.00	46.50	-9.50	52.00	43.88
MODE	67	50	-11	0	51
	T1	**T2**	**Gain**	**A**	**CT**

2011 Mobile learning group
(Action research Cycle 1 - On campus only)

	T1	T2	Gain	A1	A2	A3	AVG	A4	A5	A6	A7	AVG	Gain	CT1	CT2	AVG	CT3	CT4	CT5	AVG	Gain
1	77	83	6	0	8	6	**47**	0	10	0	9	**48**	1	75	72	**74**	75	79	90	**81**	8
2	71	73	2	7	7	6	**67**	10	0	9	10	**73**	6	60	58	**59**	67	49	80	**65**	6
3	93	97	4	7	8.5	9	**82**	9	10	9	8	**90**	8	59	67	**63**	54	77	97	**76**	13
4	82	95	13	8	7	8	**77**	9	10	9	5	**83**	6	66	72	**69**	94	62	80	**79**	10
5	69	66	-3	8	5.5	8	**72**	9	10	9	0	**70**	-2	67	73	**70**	95	63	90	**83**	13
6	52	62	10	5	6.5	6	**58**	10	10	0	6	**65**	7	53	55	**54**	12	90	85	**62**	8
7	80	82	2	8	6.5	7	**72**	9	8	5	7	**73**	1	62	66	**64**	89	64	77	**77**	13
8	55	65	10	6	0	5	**37**	0	9	0	9	**45**	8	68	66	**67**	84	60	68	**71**	4
9	35	32	-3	6	5.5	6	**58**	6	10	5	9	**75**	17	47	29	**38**	64	0	30	**31**	-7
10	38	30	-8	7	6.5	6.5	**67**	6	10	9	7	**80**	13	46	44	**45**	42	39	48	**43**	-2
11	93	93	0	10	9	7	**87**	9	9	10	9	**93**	6	77	79	**78**	99	75	92	**89**	11
12	58	75	17	9	6.5	8.5	**80**	9	10	9	9	**93**	13	74	75	**75**	94	69	85	**83**	8
13	68	77	9	10	9.5	0	**65**	8	9	9	10	**90**	25	61	64	**63**	81	50	83	**71**	9
14	41	31	-10	5	6	6	**57**	6	10	5	7	**70**	13	0	15	**8**	12	31	0	**14**	7
15	66	67	1	9	7	7	**77**	10	10	9	10	**98**	21	65	71	**68**	85	67	85	**79**	11
16	79	85	6	10	9	0	**63**	7	10	7	10	**85**	22	77	79	**78**	85	82	83	**83**	5
17	76	81	5	9	6	7	**73**	4	9	8	9	**75**	2	82	83	**83**	98	80	93	**90**	8
18	9	3	-6	0	0	4	**13**	0	0	4	10	**35**	22	0	0	**0**	20	0	0	**7**	7
19	77	75	-2	9	0	10	**63**	8	10	9	10	**93**	29	78	80	**79**	96	73	93	**87**	8
20	85	85	0	9	8	9	**87**	9	10	9	10	**95**	8	79	76	**78**	85	88	85	**86**	9
21	19	15	-4	0	0	0	**0**	0	0	0	9	**23**	23	65	55	**60**	41	59	83	**61**	1
22	79	88	9	9	9	7	**82**	8	10	10	8	**90**	8	71	67	**69**	90	60	88	**79**	10
23	84	84	0	9	9	7	**83**	8	10	9	9	**90**	7	85	87	**86**	99	96	93	**96**	10

2011 Mobile learning group (continued)
(Action research Cycle 1 - On campus only) - continued

	T1	T2	Gain	A1	A2	A3	AVG	A4	A5	A6	A7	AVG	Gain	CT1	CT2	AVG	CT3	CT4	CT5	AVG	Gain
24	79	79	0	9	8	8.5	**85**	9	10	9	10	**95**	10	73	78	**76**	92	76	87	**85**	10
25	76	76	0	9	7.5	8	**82**	8	10	8	10	**90**	8	0	45	**23**	12	0	80	**31**	8
26	61	67	6	7	6	8.5	**72**	8	9	7	10	**85**	13	54	52	**53**	54	68	75	**66**	13
27	34	22	-12	0	0	0	**0**	2	0	7	10	**48**	48	0	21	**11**	34	22	27	**28**	17
28	59	66	7	9	6.5	6	**72**	7	10	7	9	**83**	11	72	65	**69**	80	50	90	**73**	5
29	85	88	3	10	9	8	**90**	9	10	9	10	**95**	5	81	80	**81**	92	82	88	**87**	7
30	56	58	2	8	6	7	**70**	6	10	9	8	**83**	13	47	53	**50**	46	39	58	**48**	-2
31	0	42	42	0	0	0	**0**	9	10	0	2	**53**	53	0	50	**25**	54	0	30	**28**	3
32	38	33	-5	0	5	0	**17**	0	6	4	0	**25**	8	0	31	**16**	48	0	37	**28**	13
33	83	87	4	9.5	8	9	**88**	10	10	7	10	**93**	4	67	67	**67**	72	73	90	**78**	11
	T1	**T2**	**Gain**	**A1**	**A2**	**A3**	**AVG**	**A4**	**A5**	**A6**	**A7**	**AVG**	**Gain**	**CT1**	**CT2**	**AVG**	**CT3**	**CT4**	**CT5**	**AVG**	**Gain**

MEAN/AVG	62.33	65.52	3.18	61.82	75.00	13.18	57.36	65.03	7.67
STDEV	23.93698324	25.17454222	9.50807	26.8689064	21.20399432	12.0302	23.82333176	24.74289511	4.92478
MEDIAN	69.00	75.00	2.00	71.67	82.50	8.33	67.00	76.00	8.33
MODE	79	66	0	72	90	8	69	83	13
	T1	**T2**	**Gain**	**A1**	**A2**	**Gain**	**CT1**	**CT2**	**Gain**

2012 Mobile learning group
(Action research Cycle 2 - On and off-campus)

	T1	T2	Gain	A1	A2	A3	A4	A5	A6	A7	A8	AVG	CT1	CT2	CT3	CT4	AVG
1	88	93	5	10	10	10	10	10	9	9	9.5	97	76	76	82	0	58
2	75	34	-41	10	9.5	10	10	10	10	10	10	99	54	66	51	93	66
3	88	95	7	9.5	10	0	8	10	10	0	7	68	82	82	98	80	86
4	80	89	9	8.5	9.5	10	10	10	9	10	9.5	96	76	93	78	93	85
5	50	17	-33	9	9.5	9.5	10	10	9	5	9	89	73	26	35	23	39
6	83	91	8	9.5	9.5	10	10	10	10	9	9.5	97	66	65	69	93	73
7	65	63	-2	9.5	9.5	0	10	10	10	10	8	84	59	37	82	70	62
8	88	94	6	10	10	9.5	10	10	10	9.5	10	99	22	83	75	73	63
9	47	77	30	9.5	7	0	8.5	10	10	9	7.5	77	47	28	63	80	54
10	66	85	19	9.5	10	10	10	10	10	10	10	99	57	84	58	57	64
11	16	45	29	9.5	0	9.5	9.5	9.5	0	0	5	54	29	0	0	57	21
12	95	97	2	10	10	10	10	10	10	9	10	99	93	98	89	95	94
13	55	77	22	9.5	10	9	9.5	8.5	8.5	10	9	93	43	58	61	53	54
14	89	95	6	10	0	10	10	10	10	10	8.5	86	82	94	78	72	82
15	74	94	20	10	10	10	9.5	10	0	10	8.5	85	78	60	69	90	74
16	85	86	1	10	10	0	6.5	10	10	10	8	81	81	78	85	97	85
17	23	33	10	9	10	9.5	0	9	10	10	8	82	44	50	55	60	52
18	91	77	-14	10	10	10	10	10	8.5	9.5	9.5	97	64	100	92	93	87
19	89	92	3	10	10	10	10	10	10	5	9	93	86	84	97	72	85
20	91	88	-3	10	9	9.5	9.5	10	10	10	9.5	97	69	74	56	97	74
21	61	58	-3	9.5	9	9.5	9	10	10	9	9.5	94	36	6	63	77	45
22	83	81	-2	7.5	9	9	10	0	9	9	7	76	76	60	82	85	76
23	64	82	18	0	9.5	10	10	10	9	10	8.5	84	60	89	58	60	67
	T1	T2	Gain	A1	A2	A3	A4	A5	A6	A7	A8	AVG	CT1	CT2	CT3	CT4	AVG

2012 Mobile learning group (continued)
(Action research Cycle 2 - On and off-campus) - continued

	T1	T2	Gain	A1	A2	A3	A4	A5	A6	A7	A8	AVG	CT1	CT2	CT3	CT4	AVG
24	58	81	23	9.5	9.5	10	10	10	10	9	9.5	**97**	73	60	71	78	**71**
25	52	53	1	8.5	8.5	9	7.5	9.5	9.5	9	8.5	**88**	52	31	46	75	**51**
26	62	89	27	10	10	9.5	10	10	10	10	10	**99**	62	81	63	85	**73**
27	70	59	-11	9.5	10	10	9.5	9	10	10	9.5	**97**	50	76	80	85	**73**
28	66	84	18	9.5	9	9.5	9.5	10	10	0	8	**82**	40	36	84	82	**61**
29	82	70	-12	10	10	10	9.5	10	**9**	**5**	**9**	**91**	91	81	63	0	**59**
30	88	92	4	10	9.5	10	10	10	10	10	10	**99**	56	82	95	92	**81**
31	75	70	-5	9.5	5.5	9.5	0	10	10	10	7.5	**78**	49	80	68	90	**72**
32	45	27	-18	9.5	9.5	9.5	0	0	9	9	6	**66**	51	26	43	23	**36**
33	15	1	-14	9.5	0	0	9	0	0	0	2.5	**26**	0	28	0	33	**15**
34	80			0	0	10	9.5	10	9	9.5	7.5	**69**	0	0	0	67	**17**
35	56	54	-2	9.5	9	9.5	9.5	9	0	9	8	**79**	50	46	49	53	**50**
36	62	82	20	9.5	9.5	10	9	10	10	9	9.5	**96**	34	32	74	82	**56**
37	20	33	13	9.5	0	9.5	9	0	0	0	4	**40**	0	0	0	60	**15**
38	74	81	7	10	10	10	10	10	9	9.5	10	**98**	56	96	66	78	**74**
39	66	69	3	10	10	9.5	10	10	9	9	9.5	**96**	61	88	68	58	**69**
40	65	87	22	7	0	10	10	10	10	10	8	**81**	64	72	82	87	**76**
41	70	81	11	9.5	9.5	9.5	9.5	10	10	10	9.5	**97**	33	56	29	93	**53**
42	46	45	-1	10	10	0	9	8	**A**	**A**	7.5	**74**	39	0	A	0	**13**
43	68	53	-15	10	10	9	6	8	10	10	9	**90**	34	56	48	68	**52**
44	79	92	13	10	10	10	10	0	8.5	0	7	**69**	60	62	82	87	**73**
	T1	**T2**	**Gain**	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**AVG**	**CT1**	**CT2**	**CT3**	**CT4**	**AVG**

2012 Mobile learning group (continued)
(Action research Cycle 2 - On and off-campus)

	T1	T2	Gain	A1	A2	A3	A4	A5	A6	A7	A8	AVG	CT1	CT2	CT3	CT4	AVG
45	75	51	-24	10	10	10	10	8.5	9	9	9.5	**95**	44	66	75	75	**65**
46	65	86	21	9.5	9.5	8	9	9	9	8	9.5	**89**	44	38	63	75	**55**
47	65	59	-6	10	0	8.5	10	10	**9**	5	7.5	**75**	38	50	57	0	**36**
48	56	70	14	9.5	9	10	9.5	10	9.5	9	9.5	**95**	30	29	67	87	**53**

	T1	T2	Gain	A	CT
MEAN/AVG	66.79	70.47	3.96	85.19	60.28
STDEV	19.77959225	23.34230258	15.64547	15.5249357	20.35355324
MEDIAN	67.00	81.00	5.00	89.69	63.61
MODE	88	81	-2	97	73

APPENDIX E: Learner journal

Appendix D depicts the learner journal that was electronically distributed to first-year undergraduate computer science programming learners at the Cape Peninsula University of Technology in South Africa. This learner journal is aimed at exploring learners' use and attitudes toward mobile learning (specifically focusing on PDAs) as a learning tool in a technology-based subject while being exposed to mobile learning.

Student Number: ___________ **Date (dd-mm-yyyy):** ___________

Time span:

☐	Morning (6am - 12 pm)	☐	Afternoon (12 pm - 6 pm)	☐	Evening (6 pm - 12 am)	☐	Night (12 am - 6 am)

Duration:

☐	< 10 min	☐	< 10 min	☐	< 10 min	☐	< 10 min
☐	10 - 30 min	☐	10 - 30 min	☐	10 - 30 min	☐	10 - 30 min
☐	30 - 60 min	☐	30 - 60 min	☐	30 - 60 min	☐	30 - 60 min
☐	1 - 2 hours	☐	1 - 2 hours	☐	1 - 2 hours	☐	1 - 2 hours
☐	> 2 hours	☐	> 2 hours	☐	> 2 hours	☐	> 2 hours

Location:

☐	Campus	☐	Campus	☐	Campus	☐	Campus
☐	Home	☐	Home	☐	Home	☐	Home
☐	CPUT Residence	☐	CPUT Residence	☐	CPUT Residence	☐	CPUT Residence
☐	Family / Friends	☐	Family / Friends	☐	Family / Friends	☐	Family / Friends
☐	Public transport	☐	Public transport	☐	Public transport	☐	Public transport
☐	Place of leisure	☐	Place of leisure	☐	Place of leisure	☐	Place of leisure
☐	Outdoors	☐	Outdoors	☐	Outdoors	☐	Outdoors
☐	Other	☐	Other	☐	Other	☐	Other

Event:

☐	Personal use	☐	Personal use	☐	Personal use	☐	Personal use
☐	Information search	☐	Information search	☐	Information search	☐	Information search
☐	Homework (any subject)	☐	Homework (any subject)	☐	Homework (any subject)	☐	Homework (any subject)
☐	Formal subject-related activities (assignments etc.)	☐	Formal subject-related activities (assignments etc.)	☐	Formal subject-related activities (assignments etc.)	☐	Formal subject-related activities (assignments etc.)
☐	Hobbies / Interests	☐	Hobbies / Interests	☐	Hobbies / Interests	☐	Hobbies / Interests
☐	Communication/Collaboration	☐	Communication/Collaboration	☐	Communication/Collaboration	☐	Communication/Collaboration
☐	Provide help	☐	Provide help	☐	Provide help	☐	Provide help
☐	Receive help	☐	Receive help	☐	Receive help	☐	Receive help
☐	Entertainment	☐	Entertainment	☐	Entertainment	☐	Entertainment
☐	Other	☐	Other	☐	Other	☐	Other

People involved:

☐	Lecturer	☐	Lecturer	☐	Lecturer	☐	Lecturer
☐	Peer	☐	Peer	☐	Peer	☐	Peer
☐	Mentor / Advisor	☐	Mentor / Advisor	☐	Mentor / Advisor	☐	Mentor / Advisor
☐	Friend	☐	Friend	☐	Friend	☐	Friend
☐	Partner	☐	Partner	☐	Partner	☐	Partner
☐	Family	☐	Family	☐	Family	☐	Family
☐	Stranger	☐	Stranger	☐	Stranger	☐	Stranger
☐	None (except myself)	☐	None (except myself)	☐	None (except myself)	☐	None (except myself)
☐	Other	☐	Other	☐	Other	☐	Other

YOUR THOUGHTS (Comments / Issues (i.e. High or low points - Why?)):

High point: ____

Low point: ____

APPENDIX F: Focus group questions

Appendix F depicts the focus group questions that were asked to first-year undergraduate computer science programming learners at the Cape Peninsula University of Technology in South Africa, after completion of the pre- and post-mobile learning questionnaires and being exposed to mobile learning in a technology-based subject.

1. How did you experience the process of completing/submitting practical assignments?
2. Are you of the opinion that m-learning should be implemented and used in other subjects as well?
3. Would you be more likely to purchase a mobile device if it was to be used for other subjects as well?
4. The majority of the learners indicated that CPUT should pay for mobile devices. Why?
5. Most learners did not pair the PDA with a mobile phone. Why?
   If you did not want to, what was the main reason?
   Some learners say they did not know how. Why did you not ask for assistance?
6. Why did most learners not use the PDA while commuting?
7. Why did some learners not submit ALL the practical assignments if they had 24/7 access to a PDA?
8. More than 50% of the learners indicated that they prefer instant messaging as a communication means. Why did you not make use of instant messaging during your studies while you had a 24/7 communication channel to your lecturer?
9. Why do some learners find it acceptable to exclusively use mobile devices in a technology-based subject?
10. How would you like to see mobile devices be incorporated into class in the future?
11. Would you buy a tablet or desktop computer/laptop computer if you had to buy one today? Why?

APPENDIX G: Coding used with Likert scales

5.2.2.1 Scale 1

- “Don’t know” is coded as 1
- “Not at all” is coded as 2
- “Only a little” is coded as 3
- “Some” is coded as 4
- “A lot” is coded as 5
- No response is indicated as Unknown and is not used in the inferential analysis.

5.2.2.2 Scale 2

- “Very important” is coded as 1
- “Somewhat important” is coded as 2
- “Neither important nor unimportant” is coded as 3
- “Not very important” is coded as 4
- “Not important at all” is coded as 5
- “Don’t know” is coded as 6
- No response is indicated as Unknown and is not used in the inferential analysis.

5.2.2.3 Scale 3

- “Strongly agree” is coded as 1
- “Agree” is coded as 2
- “Neither agree nor disagree” is coded as 3
- “Disagree” is coded as 4
- “Strongly disagree” is coded as 5
- No response is indicated as Unknown and is not used in the inferential analysis.

5.2.2.4 Scale 4

- “Very happy” is coded as 1
- “Happy” is coded as 2
- “Neither happy nor unhappy” is coded as 3
- “Unhappy” is coded as 4
- “Very unhappy” is coded as 5
- “Don’t know” is coded as 6
- No response is indicated as Unknown and is not used in the inferential analysis.

Other scales used were coded as follow:

5.2.2.5 Scale 5

- “Yes” is coded as 1
- “No” is coded as 2
- “Don’t know” is coded as 3

5.2.2.6 Scale 6

- “Don’t’ know” is coded as 1
- “Never” is coded as 2
- “Less often” is coded as 3
- “Every few weeks” is coded as 4
- “1-2 days a week” is coded as 5.
- “3-5 days a week” is coded as 6
- “About once a day” is coded as 7
- “Several times a day” is coded as 8

5.2.2.7 Scale 7

- “Less than R50” is coded as 1
- “Between R50 and R100” is coded as 2
- “Between R100 and R200” is coded as 3
- “Between R200 and R300” is coded as 4
- “More than R300” is coded as 5

5.2.2.8 Scale 8

- “6 months or less” is coded as 1
- “1 Year” is coded as 2
- “2-3 Years” is coded as 3
- “More than 3 years” is coded as 4
- “Don’t know” is coded as 5

5.2.2.9 Scale 9

- “Ever” is coded as 1
- “Yesterday” is coded as 2
- “Never” is coded as 3

5.2.2.10 Scale 10

- "Did not use it" is coded as 1
- "Less than 30 minutes" is coded as 2
- "30 minutes - 1 hour" is coded as 3
- "1 - 2 hours" is coded as 4
- "2 - 4 hours" is coded as 5
- "More than 4 hours" is coded as 6

5.2.2.11 Scale 11

- "0 - 5" is coded as 1
- "5 - 10" is coded as 2
- "10 - 15" is coded as 3
- "More than 15" is coded as 4

5.2.2.12 Scale 12

- "Affluent, plenty for all" is coded as 1
- "Comfortable" is coded as 2
- "Struggling, money is tight" is coded as 3
- "Vary from lots to little" is coded as 4

5.2.2.13 Scale 13

- "Never" is coded as 1
- "Less than once a week" is coded as 2
- "Once a week" is coded as 3
- "A few days a week" is coded as 4
- "Every day" is coded as 5

5.2.2.14 Scale 14

- "Morning (6am-12pm)" is coded as 1
- "Afternoon (12pm-6pm)" is coded as 2
- "Evening (6pm-12am)" is coded as 3
- "Night (12am-6am)" is coded as 4

5.2.2.15 Scale 15

- "More enthusiastic" is coded as 1
- "About the same" is coded as 2
- "Less enthusiastic" is coded as 3

5.2.2.16 Scale 16

- “Daily” is coded as 1
- “Weekly” is coded as 2
- “Monthly” is coded as 3
- "Never" is coded as 4

APPENDIX H: Cronbach's Alpha coefficients

Table 5.1: Cronbach's Alpha coefficients for survey measuring instrument of the pre-mobile learning questionnaire (2011 and 2012)

Statements	Variable nr.	Correlation with total	Cronbach's Alpha Coefficient
Measuring instrument			
9. Would you like to be able to use mobile technology in the classroom as a tool to help you with your university work?	A09	0.0877	0.6874
11. Do you think that the use of mobile technology as a tool in the classroom will make a difference to the quality of your university work?	A11	-0.0489	0.6929
12. Do you think that the use of mobile technology as a tool at home/residence will make a difference to the quality of your university work?	A12	0.1701	0.6849
13a. Which ones have you ever used? Desktop computer	A13a	0.2944	0.6834
13b. Which ones have you ever used? Laptop computer	A13b	0.2704	0.6836
13d. Which ones have you ever used? iPad / Tablet	A13d	-0.2445	0.6954
13e. Which ones have you ever used? Cell phone	A13e	0.2488	0.6840
13f. Which ones have you ever used? iPod or other MP3 player	A13f	0.3242	0.6809
13g. Which ones have you ever used? Video game console / handheld gaming device	A13g	0.3668	0.6796
13h. Which ones have you ever used? None of the above	A13h	-0.1722	0.6909
14a. Which ones did you use yesterday? Desktop computer	A14a	0.0146	0.6894
14b. Which ones did you use yesterday? Laptop computer	A14b	0.0154	0.6893
14d. Which ones did you use yesterday? iPad / Tablet	A14d	-0.0331	0.6894
14e. Which ones did you use yesterday? Cell phone	A14e	0.3432	0.6819
14f. Which ones did you use yesterday? iPod or other MP3 player	A14f	0.0849	0.6875
14g. Which ones did you use yesterday? Video game console / handheld gaming device	A14g	0.0554	0.6881
14h. Which ones did you use yesterday? None of the above	A14h	-0.3264	0.6928
15a. Which ones do you own personally? Desktop computer	A15a	0.0731	0.6878
15b. Which ones do you own personally? Laptop computer	A15b	-0.0828	0.6920
15d. Which ones do you own personally? iPad / Tablet	A15d	0.0448	0.6883
15e. Which ones do you own personally? Cell phone	A15e	0.3517	0.6837
15f. Which ones do you own personally? iPod or other MP3 player	A15f	0.1514	0.6859

Statements	Variable nr.	Correlation with total	Cronbach's Alpha Coefficient
15g. Which ones do you own personally? Video game console / handheld gaming device	A15g	-0.0554	0.6907
15h. Which ones do you own personally? None of the above	A15h	0.1209	0.6876
21. How often do you use the Internet / go online?	A21	-0.3210	0.7123
22a. When you use the Internet / go online, do you use a cell phone?	A22a	0.3003	0.6824
22b. When you use the Internet / go online, do you use a computer / laptop?	A22b	0.0233	0.6886
22d. When you use the Internet / go online, do you use a(n) iPad / Tablet?	A22d	0.0209	0.6886
26. Do you own or use a cell phone?	A26	0.0868	0.6874
30a. Which mobile provider do you use? Vodacom	A30a	-0.0487	0.6909
30b. Which mobile provider do you use? MTN	A30b	0.0730	0.6878
30c. Which mobile provider do you use? Cell C	A30c	0.0715	0.6879
30e. Which mobile provider do you use? 8ta	A30e	0.0227	0.6885
30f. Which mobile provider do you use? Other	A30f	-0.1561	0.6896
34. With your cell phone, is it possible to play music or MP3 files?	A34	0.3735	0.6821
35. With your cell phone, is it possible to send and receive e-mail?	A35	0.1141	0.6867
36. With your cell phone, is it possible to access the Internet / go online?	A36	0.2727	0.6844
37. With your cell phone, is it possible to use fast Internet?	A37	0.0407	0.6894
38. With your cell phone, is it possible to download / receive files from other cell phones via Bluetooth / Infrared?	A38	0.4260	0.6789
39. With your cell phone, is it possible to download music, ringtones, games, applications or videos?	A39	0.3466	0.6817
40. With your cell phone, is it possible to use MXit?	A40	0.0478	0.6887
44. On average, how much money do you spend on airtime and data usage per month?	A44	-0.1512	0.7060
45a. Who pays for your airtime and data usage or for your cell phone's contract? My parents or legal guardians	A45a	0.1187	0.6865
45b. Who pays for your airtime and data usage or for your cell phone's contract? My family members other than my parents	A45b	0.0939	0.6874
45c. Who pays for your airtime and data usage or for your cell phone's contract? Myself	A45c	-0.0182	0.6899
45d. Who pays for your airtime and data usage or for your cell phone's contract? Boyfriend/girlfriend	A45d	-0.0497	0.6904
45e. Who pays for your airtime and data usage or for your cell phone's contract? Other	A45e	0.2567	0.6860

Statements	Variable nr.	Correlation with total	Cronbach's Alpha Coefficient
46. How long ago was the first time you have used any cell phone?	A46	-0.1202	0.6983
47. How long have you had your current cell phone?	A47	0.0965	0.6892
48 How happy or satisfied are you with your current cell phone?	A48	-0.0597	0.7001
50. How much, if at all, has your cell phone helped you to keep in touch with your family?	A50	0.0710	0.6878
51. How much, if at all, has your cell phone helped you to keep in touch with your friends?	A51	-0.0675	0.6902
52. How much, if at all, has your cell phone helped you to do well at university?	A52	-0.0221	0.6970
53. How much, if at all, has your cell phone helped you to learn new things?	A53	-0.1606	0.7003
54. How much, if at all, has your cell phone helped you to share your ideas and creations with others?	A54	0.1388	0.6857
55. How much, if at all, has your cell phone helped you to find important information?	A55	-0.0092	0.6934
56. How much, if at all, has your cell phone helped you to work with others in your community or in groups you belong to?	A56	0.0632	0.6915
57. How much, if at all, has your cell phone helped you to follow your hobbies or interests?	A57	0.0119	0.6943
58. Do you ever give a missed call to other people?	A58	0.0491	0.6882
59. If yes, did you do this yesterday?	A59	0.0859	0.6874
60. Do you ever use the feature "Please call me" on your cell phone?	A60	0.3412	0.6815
61. If yes, did you do this yesterday?	A61	0.0323	0.6889
62. Have you ever used MXit on a cell phone?	A62	0.4007	0.6729
63. How much time did you spend on MXit yesterday?	A63	-0.0872	0.6989
66. If you had to buy a new cell phone today, how important is great looks?	A66	0.4164	0.6662
67. If you had to buy a new cell phone today, how important is the screen size?	A67	0.2240	0.6824
68. If you had to buy a new cell phone today, how important is the size or weight?	A68	0.1410	0.6856
69. If you had to buy a new cell phone today, how important is it that it is the latest model or newest technology?	A69	0.2877	0.6778
71. If you had to buy a new cell phone today, how important is it that it has a low price?	A71	0.2710	0.6775
72. If you had to buy a new cell phone today, how important is it to be able to play music or MP3 files?	A72	0.5352	0.6626
73. If you had to buy a new cell phone today, how important is it to be able to send and receive e-mails?	A73	0.1759	0.6841
74. If you had to buy a new cell phone today, how important is it to be able to access the Internet / go online?	A74	0.4468	0.6741
75. If you had to buy a new cell phone today, how important is it to have fast Internet (3G or HSDPA)?	A75	0.0249	0.6901

Statements	Variable nr.	Correlation with total	Cronbach's Alpha Coefficient
76. If you had to buy a new cell phone today, how important is it to be able to download / receive files from other cell phones via Bluetooth or Infrared?	A76	0.1986	0.6830
77. If you had to buy a new cell phone today, how important is it to be able to download music, ringtones, games, applications or videos?	A77	0.3153	0.6769
78. If you had to buy a new cell phone today, how important is it to be able to send and receive instant messages?	A78	0.2815	0.6775
79. Have you ever used a cell phone to play music or mp3 files?	A79	0.4070	0.6761
80. Have you ever used a cell phone to send and receive text messages or SMS?	A80	0.3173	0.6804
81. Approximate number of SMS's sent daily?	A81	0.0312	0.6917
82. Have you ever used a cell phone to send and receive e-mail?	A82	0.1930	0.6831
83. Have you ever used a cell phone to access the Internet / go online for no particular reason, just to browse for fun?	A83	0.3382	0.6786
84. Have you ever used a cell phone to download / receive files from other cell phones via Bluetooth or Infrared?	A84	0.6141	0.6657
85. Have you ever used a cell phone to download music, ringtones, games, applications or videos?	A85	0.3052	0.6786
86. Have you ever used a cell phone to research information for university work on the Internet?	A86	0.2555	0.6806
88. Have you ever used a computer to play music or MP3 files?	A88	0.3654	0.6786
89. Have you ever used a computer to send text messages or SMS?	A89	0.1516	0.6851
90. Have you ever used a computer to send and receive e-mail?	A90	0.0849	0.6875
91. Have you ever used a computer to access the Internet / go online for no particular reason, just to browse for fun?	A91	0.3538	0.6792
92. Have you ever used a computer to download music, ringtones, games, applications or videos?	A92	0.3355	0.6772
93. Have you ever used a computer to send instant messages to someone who was online at the same time?	A93	0.2464	0.6805
94. Have you ever used a computer to research information for university work on the Internet?	A94	0.1047	0.6870
95. How are the students in your class doing financially?	A95	0.0607	0.6894
96. How are you and your family doing financially?	A96	0.1455	0.6855
97. What do you think you would deserve financially?	A97	0.3435	0.6766
Cronbach's Coefficient Alpha for standardized variable			**0.7361**
Cronbach's Coefficient Alpha for raw variables			**0.6885**

Table 5.2: Cronbach's Alpha Coefficients for survey measuring instrument of the first post-mobile learning (post 1) questionnaire (2011 and 2012)

Statements	Variable nr.	Correlation with total	Cronbach's Alpha Coefficient
Measuring instrument			
PERCEIVED USEFULNESS (PU)			
2. To use mobile devices for learning purposes would save me a lot of time	P102	0.6358	0.9308
3. To use mobile devices to access course material anywhere, anytime would allow me to spend more time on class work	P103	0.3170	0.9332
4. To use mobile devices for learning purposes would enhance the effectiveness of my learning	P104	0.5756	0.9312
5. To use mobile devices for learning would be ubiquitous and useful	P105	0.4433	0.9320
6. To use mobile devices would improve my academic performance	P106	0.4441	0.9320
7. To use mobile devices would increase my productivity in my course work	P107	0.4269	0.9321
8. To use mobile devices would increase the quality of computer programming teaching and learning	P108	0.5309	0.9315
9. To use mobile devices for learning computer programming would be feasible	P109	0.3775	0.9325
10. I would buy a mobile device if it will be useful in my course	P110	0.1661	0.9347
PERCEIVED MOBILITY VALUE (PMV)			
11. Mobility enables me to accomplish tasks more quickly	P111	0.4159	0.9322
12. Mobility enables me to access real-time information anywhere, anytime	P112	0.5046	0.9317
PERCEIVED SOCIAL INTERACTION VALUE (PSIV)			
13. I would be more likely to interact with lecturers and fellow students both inside and outside the classroom if I could use mobile devices	P113	0.4156	0.9322
14. I would be more likely to participate in class discussions if I could share/post my thoughts in real-time through mobile devices	P114	0.4414	0.9320
PERCEIVED ENJOYMENT (PE)			
15. I would feel more interested in learning by using mobile devices	P115	0.5004	0.9315
16. I would enjoy learning if I could use mobile devices	P116	0.6950	0.9297
17. To use mobile devices would stimulate my curiosity	P117	0.5103	0.9314
PERCEIVED EASE OF USE (PEOU)			
18. It would not require a lot of effort to learn, because I can skilfully use mobile devices	P118	0.4830	0.9324
19. It would ease my learning, since it allows me to learn anywhere, anytime	P119	0.6316	0.9304
20. It would be easy to use mobile devices for learning	P120	0.7650	0.9294
21. It would be easier to complete class work and assignments if I could use mobile devices	P121	0.6374	0.9302

Statements	Variable nr.	Correlation with total	Cronbach's Alpha Coefficient
22. It would be easy to engage in discussions using instant messaging on mobile devices	P122	0.4988	0.9315
23. It would be easier for me to ask for help if I could communicate through mobile devices	P123	0.6361	0.9303
ATTITUDE (ATT)			
24. I would be more encouraged to learn if I could access learning materials anywhere, anytime	P124	0.6905	0.9302
25. I would like to be able to use mobile devices as a method for learning, since it will allow me to learn in places I could normally not learn/study in	P125	0.4142	0.9323
26. I would like to be able to view course material on mobile devices	P126	0.5698	0.9314
27. I would feel in control when using mobile devices in teaching and learning	P127	0.5618	0.9308
28. I would feel positive towards using mobile devices in teaching and learning	P128	0.5557	0.9311
29. I would feel ready for mobile learning if the university implements it now	P129	0.5283	0.9313
30. I would find it acceptable to study computer programming with mobile device access only	P130	0.5562	0.9313
PERCEIVED ACCESS BARRIERS (PAB)			
31. I would not be able to afford mobile devices for educational use	P131	0.25811	0.9360
32. I am afraid that I would spend more money on data usage, because of mobile learning	P132	0.3188	0.9343
BEHAVIOURAL INTENTION TO USE (BI)			
33. I would like to use mobile devices in the future, because it will assist in my learning	P133	0.6315	0.9305
PERCEIVED OUTPUT QUALITY (POQ)			
34. Compared with traditional learning, I believe that mobile learning is more initiative and dynamic	P134	0.5921	0.9305
35. Compared with traditional learning, I believe that mobile learning is more portable/mobile and flexible enabling anywhere, anytime learning	P135	0.5214	0.9316
36. Compared with traditional learning, I believe that mobile learning enhances daily teaching and learning	P136	0.6050	0.9307
37. Compared with traditional learning, I believe that mobile learning enables high engagement	P137	0.7322	0.9289
38. Compared with traditional learning, I believe that mobile learning ensures learning effectiveness	P138	0.7046	0.9298
39. Compared with traditional learning, I believe that mobile learning provides a better alternative for teaching and learning	P139	0.7356	0.9293
40. Compared with traditional learning, I believe that mobile learning improves communication between students and their lecturer	P140	0.3488	0.9332
Cronbach's Coefficient Alpha for standardized variable			**0.9418**
Cronbach's Coefficient Alpha for raw variables			**0.9331**

Table 5.4: Cronbach's Alpha coefficients for survey measuring instrument of the second post-mobile learning (post 2) questionnaire (2011 and 2012)

Statements	**Variable nr.**	**Correlation with total**	**Cronbach's Alpha Coefficient**
MEASURING INSTRUMENT			
USE			
2a. I am able to skilfully use mobile devices to: Access the Internet / go online	P202a	0.0950	0.8451
2b. I am able to skilfully use mobile devices to: Download and install applications	P202b	0.4728	0.8403
2c. I am able to skilfully use mobile devices to: Download podcasts	P202c	0.5336	0.8390
2d. I am able to skilfully use mobile devices to: Watch videos and listen to music	P202d	0.3554	0.8425
2e. I am able to skilfully use mobile devices to: Send SMS's, instant messages and e-mails	P202e	0.4978	0.8410
2f. I am able to skilfully use mobile devices to: Access social networking sites	P202f	0.2676	0.8434
2g. I am able to skilfully use mobile devices to: View and download course material and assignments	P202g	0.3616	0.8424
2h. I am able to skilfully use mobile devices to: Complete and submit programming assignments	P202h	0.0319	05459
2i. I am able to skilfully use mobile devices to: Access Blackboard	P202i	0.1584	0.8446
3a. Current uses regarding mobile devices for learning purposes: I have used it for library services	P203a	0.2980	0.8427
3b. Current uses regarding mobile devices for learning purposes: I have accessed the university website	P203b	0.2986	0.08427
3c. Current uses regarding mobile devices for learning purposes: I have viewed and downloaded course materials and assignments	P203c	0.1483	0.8448
3d. Current uses regarding mobile devices for learning purposes: I have accessed the Internet / went online for learning purposes	P203d	0.2793	0.8431
3e. Current uses regarding mobile devices for learning purposes: I have used a social networking site	P203e	0.4653	0.8402
3f. Current uses regarding mobile devices for learning purposes: I have interacted and communicated with my lecturer	P203f	0.3231	0.8423
3g. Current uses regarding mobile devices for learning purposes: I have interacted and communicated with fellow students	P203g	0.3773	0.8414
3h. Current uses regarding mobile devices for learning purposes: I have downloaded and listened to podcasts	P203h	0.4069	0.8411
3i. Current uses regarding mobile devices for learning purposes: I have recorded information during class	P203i	0.4394	0.8407
3j. Current uses regarding mobile devices for learning purposes: I have made notes during class	P203j	0.3142	0.8424

Statements		Variable nr.	Correlation with total	Cronbach's Alpha Coefficient
3k.	Current uses regarding mobile devices for learning purposes: I have effectively completed and submitted programming assignments	P203k	0.2683	0.8431
4a.	Where did you use the mobile device: Home?	P204a	0.3630	0.8437
4b.	Where did you use the mobile device: CPUT Residence?	P204b	0.2870	0.8428
4c.	Where did you use the mobile device: Computer laboratory on campus?	P204c	0.2203	0.8439
4d.	Where did you use the mobile device: Theory class on campus?	P204d	0.1836	0.8443
4e.	Where did you use the mobile device: Elsewhere on campus outside the classroom?	P204e	0.4337	0.8406
4f.	Where did you use the mobile device: While commuting?	P204f	0.4512	0.8413
4g.	Where did you use the mobile device: Family / Friends?	P204g	0.6131	0.8382
4h.	Where did you use the mobile device: Elsewhere off-campus?	P204h	0.3035	0.8426
5.	How frequently did you use the mobile device?	P205	-0.3139	0.8558
6.	I have used the mobile device mostly during the:	P206	-0.2356	0.8544
7.	How much did you spend on average during the week using the mobile device?	P207	0.1518	0.8503
8a.	For which events did you mainly use the mobile device for? Personal use	P208a	0.2060	0.8440
8b.	For which events did you mainly use the mobile device for? Information search	P208b	0.3724	0.8416
8c.	For which events did you mainly use the mobile device for? Homework	P208c	0.2252	0.8437
8d.	For which events did you mainly use the mobile device for? Formal subject-related activities	P208d	0.0763	0.8457
8e.	For which events did you mainly use the mobile device for? Hobbies / Interests	P208e	0.3264	0.8422
8f.	For which events did you mainly use the mobile device for? Communication / Collaboration	P208f	0.2926	0.8428
8g.	For which events did you mainly use the mobile device for? Provide help	P208g	0.4582	0.8416
8h.	For which events did you mainly use the mobile device for? Receive help	P208h	0.3131	0.8428
8i.	For which events did you mainly use the mobile device for? Entertainment	P208i	0.4459	0.8404
8j.	For which events did you mainly use the mobile device for? Other	P208j	-0.0255	0.8466
9a.	Who were involved when you have used the mobile device during the course of your studies? Lecturer	P209a	0.2404	0.8435
9b.	Who were involved when you have used the mobile device during the course of your studies? Peer	P209b	-0.0951	0.8480
9c.	Who were involved when you have used the mobile device during the course of your studies? Mentor / Advisor	P209c	0.4558	0.8428

Statements	Variable nr.	Correlation with total	Cronbach's Alpha Coefficient
9d. Who were involved when you have used the mobile device during the course of your studies? Technical Support	P209d	0.2750	0.8440
9e. Who were involved when you have used the mobile device during the course of your studies? Friend	P209e	0.1285	0.8452
9f. Who were involved when you have used the mobile device during the course of your studies? Partner	P209f	0.2150	0.8443
9g. Who were involved when you have used the mobile device during the course of your studies? Family	P209g	0.3501	0.8426
9h. Who were involved when you have used the mobile device during the course of your studies? None (except myself)	P209h	-0.1011	0.8483
9i. Who were involved when you have used the mobile device during the course of your studies? Other	P209i	0.3585	0.8439
10. Did you pair the mobile device with your cell phone in order to go online / access the Internet?	P210	0.0916	0.8500
11. Did you make use of Bluetooth to share files?	P211	0.2057	0.8440
12. Did you buy or use a SD memory card to extend the storage capacity of the mobile device?	P212	0.2433	0.8434
13a. Where do you think you will use mobile devices in future? Home	P213a	0.3924	0.8421
13b. Where do you think you will use mobile devices in future? CPUT residence	P213b	0.5094	0.8395
13c. Where do you think you will use mobile devices in future? Computer laboratory on campus	P213c	0.4925	0.8400
13d. Where do you think you will use mobile devices in future? Theory class on campus	P213d	0.3181	0.8423
13e. Where do you think you will use mobile devices in future? Elsewhere on campus outside the classroom	P213e	0.5283	0.8391
13f. Where do you think you will use mobile devices in future? While commuting	P213f	0.3221	0.8423
13g. Where do you think you will use mobile devices in future? Family / Friends	P213g	0.5482	0.8388
13h. Where do you think you will use mobile devices in future? Elsewhere off-campus	P213h	0.3818	0.8414
PERCEPTION			
14. Should the university require students to use mobile devices during the course of their computer programming studies?	P214	-0.0104	0.8473
15. The university is ready to implement mobile learning	P215	0.2013	0.8441
16a. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Larger display screens	P216a	0.1898	0.8442
16b. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Lower data cost tariffs	P216b	0.1197	0.8453

Statements	Variable nr.	Correlation with total	Cronbach's Alpha Coefficient
16c. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Lower mobile device costs	P216c	0.0796	0.8459
16d. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Better processing power	P216d	0.3151	0.8425
16e. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Larger memory capacities	P216e	0.3706	0.8416
16f. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Technology unification / consolidation	P216f	0.4115	0.8410
16g. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Better proliferation	P216g	0.3405	0.8420
16h. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Other	P216h	0.3070	0.8430
ATTITUDE			
17. I do not want to use mobile devices, because they are too heavy to carry around	P217	0.2030	0.8451
18. I do not want to use mobile devices, because they are too fragile and easily broken	P218	0.2600	0.8435
19. I do not want to use mobile devices, because I find it difficult to read text on a mobile device screen	P219	0.3308	0.8418
20. I do not want to use mobile devices, because it is hard to enter data using the stylus/pen/touch on a mobile device	P220	0.2078	0.8450
23. I would find it acceptable to learn computer programming with mobile device access only	P223	0.1070	0.8488
24. I would prefer to use a mobile device during tests to assist me with coding programs	P224	0.2480	0.8440
25. Compared to the beginning of this semester, how do you feel about the use of mobile devices now?	P225	-0.0072	0.8468
Cronbach's Coefficient Alpha for standardized variable			**0.8796**
Cronbach's Coefficient Alpha for raw variables			**0.8453**

APPENDIX I: Descriptive statistics for all categorical variables

Table 5.6: Descriptive statistics for all the categorical variables for the pre-, post 1- and post 2 mobile learning questionnaires (2011 and 2012)

Variables	Categories	Frequency	Percentage out of total
PRE-MOBILE LEARNING QUESTIONNAIRE Biographic information of respondents			
1. Gender?	Male	41	51.9%
	Female	38	48.1%
2. In which year where you born?	1982	1	1.3%
	1986	3	3.8%
	1988	7	8.9%
	1989	14	17.7%
	1990	15	19.0%
	1991	16	20.2%
	1992	16	20.2%
	1993	6	7.6%
	1994	1	1.3%
2a. Estimated age when survey was taken	18	1	1.3%
	19	13	16.5%
	20	15	19.0%
	21	18	22.8%
	22	14	17.7%
	23	9	11.4%
	24	5	6.3%
	25	3	3.8%
	30	1	1.3%
3. What is your first (home) language?	Afrikaans	4	5.1%
	Chinese	1	1.3%
	English	15	19.0%
	French	18	22.8%
	Igbo	1	1.3%
	Kimbundo	1	1.3%
	Lingala	1	1.3%
	Portuguese	2	2.5%
	Sesotho	2	2.5%
	Zulu	2	2.5%
	isiXhosa	32	40.5%
4. What is your second language?	Afrikaans	12	15.2%
	English	54	68.4%
	Fang	1	1.3%
	French	3	3.8%
	Kikongo	1	1.3%
	Kimbundo	1	1.3%
	Lingala	1	1.3%
	Portuguese	1	1.3%
	Swahili	3	3.8%
	Venda	1	1.3%
	Zulu	1	1.3%
5. Race?	Asian	1	1.3%
	Black	61	77.2%
	Coloured	10	12.7%
	Indian	4	5.1%
	White	1	1.3%
	Other	2	2.5%

Variables	Categories	Frequency	Percentage out of total
6. Where do you live during your studies?	Family/Friends	17	21.5%
	Home	34	43.0%
	Residence	25	31.6%
	Other	3	3.8%
7. How do you usually get to the university?	Car	6	7.6%
	Public transport or taxi	44	55.7%
	University bus	19	24.0%
	Walk	10	12.7%
Background information regarding mobile usage			
8. Has your cell phone ever been stolen?	Yes, at university	3	3.8%
	Yes, not at university	29	36.7%
	No	47	59.5%
9. Would you like to be able to use mobile technology in the classroom as a tool to help you with your university work?	Yes	68	86.1%
	No	8	10.1%
	Don’t know	3	3.8%
10. Would you like to be able to use mobile technology at home/residence as a tool to help you with your university work?	Yes	79	100.0%
	No	0	0.0%
	Don’t know	0	0.0%
11. Do you think that the use of mobile technology as a tool in the classroom will make a difference to the quality of your university work?	Yes	62	78.5%
	No	7	8.9%
	Don’t know	10	12.7%
12. Do you think that the use of mobile technology as a tool at home/residence will make a difference to the quality of your university work?	Yes	69	87.3%
	No	4	5.1%
	Don’t know	6	7.6%
13a. Which ones have you ever used? Desktop computer	Yes	68	86.1%
	No	11	13.9%
13b. Which ones have you ever used? Laptop computer	Yes	66	83.5%
	No	13	16.5%
13c. Which ones have you ever used? Pocket PC / PDA	Yes	0	0.0%
	No	79	100.0%
13d. Which ones have you ever used? iPad / Tablet	Yes	22	27.8%
	No	57	72.2%
13e. Which ones have you ever used? Cell phone	Yes	65	82.3%
	No	14	17.7%
13f. Which ones have you ever used? iPod or other MP3 player	Yes	44	55.7%
	No	35	44.3%
13g. Which ones have you ever used? Video game console / handheld gaming device	Yes	41	51.9%
	No	38	48.1%
13h. Which ones have you ever used? None of the above	Yes	4	5.1%
	No	75	94.9%
14a. Which ones did you use yesterday? Desktop computer	Yes	35	44.3%
	No	44	55.7%
14b. Which ones did you use yesterday? Laptop computer	Yes	52	65.8%
	No	27	34.2%
14c. Which ones did you use yesterday? Pocket PC / PDA	Yes	0	0.0%
	No	79	100.0%
14d. Which ones did you use yesterday? iPad / Tablet	Yes	6	7.6%
	No	73	92.4%
14e. Which ones did you use yesterday? Cell phone	Yes	64	81.0%
	No	15	19.0%
14f. Which ones did you use yesterday? iPod or other MP3 player	Yes	13	16.5%
	No	66	83.5%
14g. Which ones did you use yesterday? Video game console / handheld gaming device	Yes	12	15.2%
	No	67	84.8%

Variables	Categories	Frequency	Percentage out of total
14h. Which ones did you use yesterday? None of the above	Yes	4	5.1%
	No	75	94.9%
15a. Which ones do you own personally? Desktop computer	Yes	26	32.9%
	No	53	67.1%
15b. Which ones do you own personally? Laptop computer	Yes	45	57.0%
	No	34	43.0%
15c. Which ones do you own personally? Pocket PC / PDA	Yes	0	0.0%
	No	79	100.0%
15d. Which ones do you own personally? iPad / Tablet	Yes	10	12.7%
	No	69	87.3%
15e. Which ones do you own personally? Cell phone	Yes	73	92.4%
	No	6	7.6%
15f. Which ones do you own personally? iPod or other MP3 player	Yes	21	26.6%
	No	58	73.4%
15g. Which ones do you own personally? Video game console / handheld gaming device	Yes	18	22.8%
	No	61	77.2%
15h. Which ones do you own personally? None of the above	Yes	2	2.5%
	No	77	97.5%
16a. Which ones do you have access to off-campus? Desktop computer	Yes	19	41.3%
	No	27	58.7%
16b. Which ones do you have access to off-campus? Laptop computer	Yes	33	71.7%
	No	13	28.3%
16c. Which ones do you have access to off-campus? Pocket PC / PDA	Yes	0	0.0%
	No	46	100.0%
16d. Which ones do you have access to off-campus? iPad / Tablet	Yes	11	23.9%
	No	35	761%
16e. Which ones do you have access to off-campus? Cell phone	Yes	42	91.3%
	No	4	8.7%
16f. Which ones do you have access to off-campus? iPod or other MP3 player	Yes	13	28.3%
	No	33	71.7%
16g. Which ones do you have access to off-campus? Video game console / handheld gaming device	Yes	13	28.3%
	No	33	71.7%
16h. Which ones do you have access to off-campus? None of the above	Yes	0	0.0%
	No	46	100.0%
17. Do you have access to the Visual Basic computer programming application off-campus?	Yes	21	45.6%
	No	25	54.4%
18. Is off-campus access to the Visual Basic computer programming application important to you?	Yes	43	93.5%
	No	3	6.5%
19. Is off-campus Internet access important to you?	Yes	41	89.1%
	No	5	10.9%
20. Do you find it difficult to access university computer laboratories outside Visual Basic computer programming class times?	Yes	34	73.9%
	No	12	26.1%
21. How often do you use the Internet / go online?	Several times a day	60	76.0%
	About once a day	8	10.1%
	3-5 days a week	8	10.1%
	1-2 days a week	0	0.0%
	Every few weeks	1	1.3%
	Less often	0	0.0%
	Never	0	0.0%
	Don't know	2	2.5%
22a. When you use the Internet / go online, do you use a cell phone?	Yes	61	77.2%
	No	18	22.8%

Variables	Categories	Frequency	Percentage out of total
22b. When you use the Internet / go online, do you use a computer / laptop?	Yes	72	91.1%
	No	7	8.9%
22c. When you use the Internet / go online, do you use a Pocket PC / PDA?	Yes	0	0.0%
	No	79	100.0%
22d. When you use the Internet / go online, do you use an iPad / Tablet?	Yes	7	8.9%
	No	72	91.1%
22e. When you use the Internet / go online, do you use other devices?	Yes	0	0.0%
	No	79	100.0%
23a. If you go online using a computer, where do you do this? At CPUT or the library	Yes	31	93.9%
	No	2	6.1%
23b. If you go online using a computer, where do you do this? At home	Yes	10	30.3%
	No	23	69.7%
23c. If you go online using a computer, where do you do this? At the residence	Yes	11	33.3%
	No	22	66.7%
23d. If you go online using a computer, where do you do this? At an Internet Café	Yes	14	42.4%
	No	19	57.6%
23e. If you go online using a computer, where do you do this? At someone else's place	Yes	6	18.2%
	No	27	81.8%
23f. If you go online using a computer, where do you do this? Some other place	Yes	2	6.1%
	No	31	93.9%
24. How frequently do you use the Internet / go online with a computer?	Daily	39	84.8%
	Weekly	5	10.9%
	Monthly	1	2.2%
	Never	1	2.2%
25. How frequently do you use the Internet / go online with a cell phone?	Daily	38	82.6%
	Weekly	2	4.4%
	Monthly	2	4.4%
	Never	4	8.7%
26. Do you own or use a cell phone?	I own a cell phone with a SIM card	74	93.7%
	I own a SIM card, but not a cell phone	2	22.5%
	I use a cell phone, but don't have my own phone or SIM card	3	3.8%
	I never use a cell phone	0	0.0%
27. How did you obtain your current cell phone?	As a gift	10	21.7%
	Parent upgraded and you got their new phone	2	4.4%
	Parent upgraded and you got their old phone	5	10.8%
	Parents took out a contract for you	7	15.2%
	Purchased one yourself	20	43.5%
	Other	2	4.4%
28. What is the brand name of your cell phone?	BlackBerry	16	20.2%
	HTC	3	3.8%
	LG	4	5.1%
	Nokia	34	43.0%
	Samsung	12	15.2%
	Sony Ericsson	6	7.6%
	Techno	1	1.3%
	Windows Mobile Mova	1	1.3%
	ZTE	1	1.3%
	Don't know	1	1.3%

Variables	Categories	Frequency	Percentage out of total
29. Is your cell phone a smart phone?	Yes	35	76.1%
	No	10	21.7%
	Don't know	1	2.2%
30a. Which mobile provider do you use? Vodacom	Yes	27	34.2%
	No	52	65.8%
30b. Which mobile provider do you use? MTN	Yes	58	73.4%
	No	21	26.6%
30c. Which mobile provider do you use? Cell C	Yes	5	6.3%
	No	74	93.7%
30d. Which mobile provider do you use? Virgin Mobile	Yes	0	0.0%
	No	79	100.0%
30e. Which mobile provider do you use? 8ta	Yes	2	2.5%
	No	77	97.5%
30f. Which mobile provider do you use? Other	Yes	1	1.3%
	No	78	98.7%
30g. Which mobile provider do you use? Don't know	Yes	0	0.0%
	No	79	100.0%
31. Is your cell phone using prepaid or contract?	Prepaid	64	81.0%
	Contract	9	11.4%
	Don't know	6	7.6%
32. Do you prefer contacting someone via a(n)	E-mail	1	1.3%
	Instant messaging	23	29.1%
	Phone call	36	45.6%
	SMS	19	24.0%
33. Why do you prefer the above selected method?	Cheaper	35	44.3%
	More convenient	37	46.8%
	No specific reason	7	8.9%
34. With your cell phone, is it possible to play music or MP3 files?	Yes	69	87.3%
	No	10	12.7%
35. With your cell phone, is it possible to send and receive e-mail?	Yes	60	76.0%
	No	17	21.5%
	Don't know	2	2.5%
36. With your cell phone, is it possible to access the Internet / go online?	Yes	71	89.9%
	No	8	10.1%
37. With your cell phone, is it possible to use fast Internet?	Yes	38	48.1%
	No	31	39.2%
	Don't know	10	12.7%
38. With your cell phone, is it possible to download / receive files from other cell phones via Bluetooth / Infrared?	Yes	67	84.8%
	No	10	12.7%
	Don't know	2	2.5%
39. With your cell phone, is it possible to download music, ringtones, games, applications or videos?	Yes	64	81.0%
	No	15	19.0%
40. With your cell phone, is it possible to use MXit?	Yes	65	82.3%
	No	9	11.4%
	Don't know	5	6.3%
41. With your cell phone, is it possible to use WhatsApp?	Yes	34	73.9%
	No	11	23.9%
	Don't know	1	2.2%
42. Which instant messaging application do you prefer to use with your cell phone?	MXit	7	15.2%
	Other	10	21.7%
	WhatsApp	29	63.0%
43a. What would you do on your cell phone if you had an hour or two? Play games	Yes	17	37.0%
	No	29	63.0%
43b. What would you do on your cell phone if you had an hour or two? Use the Internet / go online	Yes	36	78.3%
	No	10	21.7%

Variables	Categories	Frequency	Percentage out of total
43c. What would you do on your cell phone if you had an hour or two? Chat via instant messaging	Yes	35	76.1%
	No	11	23.9%
43d. What would you do on your cell phone if you had an hour or two? Send SMS's	Yes	20	43.5%
	No	26	56.5%
43e. What would you do on your cell phone if you had an hour or two? Take photos / videos	Yes	18	39.1%
	No	28	60.9%
43f. What would you do on your cell phone if you had an hour or two? Play music / videos	Yes	34	73.9%
	No	12	26.1%
43g. What would you do on your cell phone if you had an hour or two? Download music, ringtones, games, applications or videos	Yes	14	30.4%
	No	32	69.6%
43h. What would you do on your cell phone if you had an hour or two? Other	Yes	4	8.7%
	No	42	91.3%
44. On average, how much money do you spend on airtime and data usage per month?	Less than R50	10	12.7%
	Between R50 and R100	27	34.2%
	Between R100 and R200	16	20.2%
	Between R200 and R 300	18	22.8%
	More than R300	8	10.1%
45a. Who pays for your airtime and data usage or for your cell phone's contract? My parents or legal guardians	Yes	40	50.6%
	No	39	49.4%
45b. Who pays for your airtime and data usage or for your cell phone's contract? My family members other than my parents	Yes	11	13.9%
	No	68	86.1%
45c. Who pays for your airtime and data usage or for your cell phone's contract? Myself	Yes	60	76.0%
	No	19	24.0%
45d. Who pays for your airtime and data usage or for your cell phone's contract? Boyfriend/girlfriend	Yes	15	19.0%
	No	64	81.0%
45e. Who pays for your airtime and data usage or for your cell phone's contract? Other	Yes	3	3.8%
	No	76	96.2%
46. How long ago was the first time you have used any cell phone?	6 months or less	5	6.3%
	1 Year	2	2.5%
	2-3 Years	1	1.3%
	More than 3 years	62	78.5%
	Don't know	9	11.4%
47. How long have you had your current cell phone?	6 months or less	29	36.7%
	1 Year	31	39.2%
	2-3 Years	5	6.3%
	More than 3 years	11	13.9%
	Don't know	3	3.8%
48. How happy or satisfied are you with your current cell phone?	Very happy	19	24.0%
	Happy	30	38.0%
	Neither happy nor unhappy	16	20.2%
	Unhappy	9	11.4%
	Very unhappy	3	3.8%
	Don't know	2	2.5%

Variables	Categories	Frequency	Percentage out of total
49a. What are the three activities you do most often on a cell phone: Most often I …..	Chat	9	11.4%
	Communicate	1	1.3%
	Don't do anything	1	1.3%
	Instant messaging	15	19.0%
	Internet / online	11	13.9%
	Listen to music / radio	11	13.9%
	Phone call	14	17.7%
	Phone call & SMS	1	1.3%
	Play games	2	2.5%
	SMS	11	13.9%
	Social networks	2	2.5%
	Survey	1	1.3%
49b. What are the three activities you do most often on a cell phone: Second	Chat	2	2.5%
	Don't do anything	1	1.3%
	Download music	2	2.5%
	E-mail	2	2.5%
	Instant messaging	8	10.1%
	Internet / online	13	16.5%
	Listen to music / radio	13	16.5%
	Phone call	15	19.0%
	Photos	2	2.5%
	Play games	4	5.1%
	SMS	9	11.4%
	Set reminders	2	2.5%
	Social networks	5	6.3%
	Listen to music / radio & Movies	1	1.3%
49c. What are the three activities you do most often on a cell phone: Third …..	Chat	2	2.5%
	Don't do anything	1	1.3%
	Download music	1	1.3%
	Downloads	1	1.3%
	E-mail	4	5.1%
	Horoscope	1	1.3%
	Internet / online	13	16.5%
	Internet / online & Instant messaging	1	1.3%
	Listen to music / radio	10	12.7%
	Listen to music / radio & Movies	1	1.3%
	Phone call	11	13.9%
	Photos	5	6.3%
	Play games	7	8.9%
	Play games & listen to music / radio	1	1.3%
	SMS	10	12.7%
	Set alarm	2	2.5%
	Social networks	5	6.3%
	Social networks & Instant messaging	1	1.3%
	WAP	2	2.5%
50. How much, if at all, has your cell phone helped you to keep in touch with your family?	A lot	72	91.1%
	Some	5	6.3%
	Only a little	1	1.3%
	Not at all	1	1.3%
	Don't know	0	0.0%

Variables	Categories	Frequency	Percentage out of total
51. How much, if at all, has your cell phone helped you to keep in touch with your friends?	A lot	74	93.7%
	Some	4	5.1%
	Only a little	1	1.3%
	Not at all	0	0.0%
	Don't know	0	0.0%
52. How much, if at all, has your cell phone helped you to do well at university?	A lot	30	38.0%
	Some	22	27.8%
	Only a little	13	16.5%
	Not at all	12	15.2%
	Don't know	2	2.5%
53. How much, if at all, has your cell phone helped you to learn new things?	A lot	39	49.4%
	Some	24	30.4%
	Only a little	12	15.2%
	Not at all	4	5.1%
	Don't know	0	0.0%
54. How much, if at all, has your cell phone helped you to share your ideas and creations with others?	A lot	40	%
	Some	23	29.1%
	Only a little	13	16.5%
	Not at all	3	3.8%
	Don't know	0	0.0%
55. How much, if at all, has your cell phone helped you to find important information?	A lot	46	58.2%
	Some	18	22.8%
	Only a little	10	12.7%
	Not at all	5	6.3%
	Don't know	0	0.0%
56. How much, if at all, has your cell phone helped you to work with others in your community or in groups you belong to?	A lot	32	40.5%
	Some	22	27.8%
	Only a little	11	13.9%
	Not at all	12	15.2%
	Don't know	2	2.5%
57. How much, if at all, has your cell phone helped you to follow your hobbies or interests?	A lot	37	46.8%
	Some	20	25.3%
	Only a little	10	12.7%
	Not at all	11	13.9%
	Don't know	1	1.3%
58. Do you ever give a missed call to other people?	Yes	70	88.6%
	No	8	10.1%
	Don't know	1	1.3%
59. If yes, did you do this yesterday?	Yes	31	39.2%
	No	48	60.8%
60. Do you ever use the feature "Please call me" on your cell phone?	Yes	65	82.3%
	No	12	15.2%
	Don't know	2	2.5%
61. If yes, did you do this yesterday?	Yes	36	46.2%
	No	42	53.8%
62. Have you ever used MXit on a cell phone?	Ever	40	50.6%
	Yesterday	16	20.2%
	Never	23	29.1%
63. How much time did you spend on MXit yesterday?	Did not use it	50	64.9%
	Less than 30 minutes	11	14.3%
	30 minutes – 1 hour	9	11.7%
	1-2 hours	6	7.8%
	2-4 hours	1	1.3%
	More than 4 hours	0	0.0%
64. Have you ever used WhatsApp on a cell phone?	Ever	12	26.1%
	Yesterday	19	41.3%
	Never	15	32.6%

Variables	Categories	Frequency	Percentage out of total
65. How much time did you spend on WhatsApp yesterday?	Did not use it	15	37.5%
	Less than 30 minutes	7	17.5%
	30 minutes – 1 hour	7	17.5%
	1-2 hours	7	17.5%
	2-4 hours	4	10.0%
	More than 4 hours	0	0.0%
66. If you had to buy a new cell phone today, how important is great looks?	Very important	44	55.7%
	Somewhat important	19	24.0%
	Neither important nor unimportant	5	6.3%
	Not very important	6	7.6%
	Not important at all	2	2.5%
	Don't know	3	3.8%
67. If you had to buy a new cell phone today, how important is the screen size?	Very important	60	76.0%
	Somewhat important	16	20.2%
	Neither important nor unimportant	1	1.3%
	Not very important	1	1.3%
	Not important at all	1	1.3%
	Don't know	0	0.0%
68. If you had to buy a new cell phone today, how important is the size or weight?	Very important	42	53.2%
	Somewhat important	28	35.4%
	Neither important nor unimportant	4	5.1%
	Not very important	4	5.1%
	Not important at all	1	1.3%
	Don't know	0	0.0%
69. If you had to buy a new cell phone today, how important is it that it is the latest model or newest technology?	Very important	60	76.0%
	Somewhat important	14	17.7%
	Neither important nor unimportant	1	1.3%
	Not very important	1	1.3%
	Not important at all	2	2.5%
	Don't know	1	1.3%
70. If you had to buy a new cell phone today, how important is the brand name?	Very important	32	69.6%
	Somewhat important	9	19.6%
	Neither important nor unimportant	1	2.2%
	Not very important	3	6.5%
	Not important at all	0	0.0%
	Don't know	1	2.2%
71. If you had to buy a new cell phone today, how important is it that it has a low price?	Very important	28	35.4%
	Somewhat important	22	27.8%
	Neither important nor unimportant	12	15.2%
	Not very important	11	13.9%
	Not important at all	4	5.1%
	Don't know	2	2.5%
72. If you had to buy a new cell phone today, how important is it to be able to play music or MP3 files?	Very important	65	82.3%
	Somewhat important	8	10.1%
	Neither important nor unimportant	0	0.0%
	Not very important	3	3.8%
	Not important at all	2	2.5%
	Don't know	1	1.3%

Variables	Categories	Frequency	Percentage out of total
73. If you had to buy a new cell phone today, how important is it to be able to send and receive e-mails?	Very important	64	81.0%
	Somewhat important	10	12.7%
	Neither important nor unimportant	3	3.8%
	Not very important	1	1.3%
	Not important at all	0	0.0%
	Don't know	1	1.3%
74. If you had to buy a new cell phone today, how important is it to be able to access the Internet / go online?	Very important	76	96.2%
	Somewhat important	1	1.3%
	Neither important nor unimportant	0	0.0%
	Not very important	1	1.3%
	Not important at all	0	0.0%
	Don't know	1	1.3%
75. If you had to buy a new cell phone today, how important is it to have fast Internet (3G or HSDPA)?	Very important	67	84.8%
	Somewhat important	9	11.4%
	Neither important nor unimportant	2	2.5%
	Not very important	0	0.0%
	Not important at all	0	0.0%
	Don't know	1	1.3%
76. If you had to buy a new cell phone today, how important is it to be able to download / receive files from other cell phones via Bluetooth or Infrared?	Very important	69	87.3%
	Somewhat important	5	6.3%
	Neither important nor unimportant	2	2.5%
	Not very important	2	2.5%
	Not important at all	0	0.0%
	Don't know	1	1.3%
77. If you had to buy a new cell phone today, how important is it to be able to download music, ringtones, games, applications or videos?	Very important	61	77.2%
	Somewhat important	12	15.2%
	Neither important nor unimportant	2	2.5%
	Not very important	2	2.5%
	Not important at all	1	1.3%
	Don't know	1	1.3%
78. If you had to buy a new cell phone today, how important is it to be able to send and receive instant messages?	Very important	58	73.4%
	Somewhat important	9	11.4%
	Neither important nor unimportant	7	8.9%
	Not very important	2	2.5%
	Not important at all	2	2.5%
	Don't know	1	1.3%
79. Have you ever used a cell phone to play music or mp3 files?	Ever	46	58.2%
	Yesterday	27	34.2%
	Never	6	7.6%
80. Have you ever used a cell phone to send and receive text messages or SMS?	Ever	45	57.0%
	Yesterday	32	40.5%
	Never	2	2.5%
81. Approximate number of SMS's sent daily?	0-5	50	63.3%
	5-10	16	20.2%
	10-15	6	7.6%
	More than 15	7	8.9%
82. Have you ever used a cell phone to send and receive e-mail?	Ever	36	45.6%
	Yesterday	15	19.0%
	Never	28	35.4%
83. Have you ever used a cell phone to access the Internet / go online for no particular reason, just to browse for fun?	Ever	52	65.8%
	Yesterday	21	26.6%
	Never	6	7.6%

Variables	Categories	Frequency	Percentage out of total
84. Have you ever used a cell phone to download / receive files from other cell phones via Bluetooth or Infrared?	Ever	50	63.3%
	Yesterday	18	22.8%
	Never	11	13.9%
85. Have you ever used a cell phone to download music, ringtones, games, applications or videos?	Ever	51	64.6%
	Yesterday	16	20.2%
	Never	12	15.2%
86. Have you ever used a cell phone to research information for university work on the Internet?	Ever	56	70.9%
	Yesterday	9	11.4%
	Never	14	17.7%
87a. What are the three activities you do most often on a computer? Most often I …..	Assignments	28	35.4%
	Chat	2	2.5%
	Downloads	2	2.5%
	E-mail	5	6.3%
	Internet / Online	27	34.2%
	Listen to music / radio	1	1.3%
	Movies	2	2.5%
	Play games	2	2.5%
	Social network	4	5.1%
	Studying	1	1.3%
	Word Document	5	6.3%
87b. What are the three activities you do most often on a computer? Second …..	Assignments	20	25.3%
	Chat	2	2.5%
	Downloads	2	2.5%
	E-mail	6	7.6%
	Internet / Online	16	20.2%
	Listen to music / radio	11	13.9%
	Movies	7	8.9%
	Photos	1	1.3%
	Play games	4	5.1%
	Reply	1	1.3%
	Share files	1	1.3%
	Social network	4	5.1%
	Use application software	1	1.3%
	Word Document	3	3.8%
87c. What are the three activities you do most often on a computer? Third	Assignments	9	11.4%
	Chat	1	1.3%
	E-mail	5	6.3%
	Horoscope	1	1.3%
	Instant messaging & Social network	1	1.3%
	Instant messaging	1	1.3%
	Internet / Online	8	10.1%
	Listen to music / radio	13	16.5%
	Listen to music / radio & Movies	2	2.5%
	Movies	12	15.2%
	Online Assessment	1	1.3%
	Photos	3	3.8%
	Play games	12	15.2%
	Skype	2	2.5%
	Social network	6	7.6%
	Study	1	1.3%
	Word Document	1	1.3%
88. Have you ever used a computer to play music or MP3 files?	Ever	49	62.0%
	Yesterday	27	34.2%
	Never	3	3.8%

Variables	Categories	Frequency	Percentage out of total
89. Have you ever used a computer to send text messages or SMS?	Ever	29	36.7%
	Yesterday	9	11.4%
	Never	41	51.9%
90. Have you ever used a computer to send and receive e-mail?	Ever	59	74.7%
	Yesterday	18	22.8%
	Never	2	2.5%
91. Have you ever used a computer to access the Internet / go online for no particular reason, just to browse for fun?	Ever	54	68.4%
	Yesterday	22	27.8%
	Never	3	3.8%
92. Have you ever used a computer to download music, ringtones, games, applications or videos?	Ever	49	62.0%
	Yesterday	17	21.5%
	Never	13	16.5%
93. Have you ever used a computer to send instant messages to someone who was online at the same time?	Ever	41	51.9%
	Yesterday	16	20.2%
	Never	22	27.8%
94. Have you ever used a computer to research information for university work on the Internet?	Ever	59	74.7%
	Yesterday	19	24.0%
	Never	1	1.3%
95. How are the students in your class doing financially?	Affluent, plenty for all	6	7.6%
	Comfortable	43	54.4%
	Struggling, money is tight	16	20.2%
	Vary from lots to little	14	17.7%
96. How are you and your family doing financially?	Affluent, plenty for all	3	3.8%
	Comfortable	43	54.4%
	Struggling, money is tight	29	36.7%
	Vary from lots to little	4	5.1%
97. What do you think you would deserve financially?	Affluent, plenty for all	27	34.2%
	Comfortable	41	51.9%
	Struggling, money is tight	7	8.9%
	Vary from lots to little	4	5.1%
FIRST POST-MOBILE LEARNING QUESTIONNAIRE (POST 1)			
PERCEIVED USEFULNESS (PU)			
102. To use mobile devices for learning purposes would save me a lot of time	Strongly agree	53	68.0%
	Agree	24	30.8%
	Neither agree or disagree	1	1.3%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
103. To use mobile devices to access course material anywhere, anytime would allow me to spend more time on class work	Strongly agree	42	53.8%
	Agree	29	37.2%
	Neither agree or disagree	4	5.1%
	Disagree	3	3.8%
	Strongly disagree	0	0.0%
104. To use mobile devices for learning purposes would enhance the effectiveness of my learning	Strongly agree	38	48.7%
	Agree	40	51.3%
	Neither agree or disagree	0	0.0%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%

Variables	Categories	Frequency	Percentage out of total
105. To use mobile devices for learning would be ubiquitous and useful	Strongly agree	44	56.4%
	Agree	27	34.6%
	Neither agree or disagree	7	9.0%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
106. To use mobile devices would improve my academic performance	Strongly agree	39	50.0%
	Agree	36	46.2%
	Neither agree or disagree	3	3.8%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
107. To use mobile devices would increase my productivity in my course work	Strongly agree	39	50.0%
	Agree	36	46.2%
	Neither agree or disagree	3	3.8%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
108. To use mobile devices would increase the quality of computer programming teaching and learning	Strongly agree	42	53.8%
	Agree	36	46.2%
	Neither agree or disagree	0	0.0%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
109. To use mobile devices for learning computer programming would be feasible	Strongly agree	42	53.8%
	Agree	36	46.2%
	Neither agree or disagree	0	0.0%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
110. I would buy a mobile device if it will be useful in my course	Strongly agree	27	34.6%
	Agree	37	47.4%
	Neither agree or disagree	12	15.4%
	Disagree	2	2.6%
	Strongly disagree	0	0.0%
PERCEIVED MOBILITY VALUE (PMV)			
111. Mobility enables me to accomplish tasks more quickly	Strongly agree	44	56.4%
	Agree	27	34.6%
	Neither agree or disagree	5	6.4%
	Disagree	2	2.6%
	Strongly disagree	0	0.0%
112. Mobility enables me to access real-time information anywhere, anytime	Strongly agree	50	64.1%
	Agree	28	35.9%
	Neither agree or disagree	0	0.0%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
PERCEIVED SOCIAL INTERACTION VALUE (PSIV)			
113. I would be more likely to interact with lecturers and fellow students both inside and outside the classroom if I could use mobile devices	Strongly agree	48	61.5%
	Agree	25	32.0%
	Neither agree or disagree	4	5.1%
	Disagree	1	1.3%
	Strongly disagree	0	0.0%

Variables	Categories	Frequency	Percentage out of total
114. I would be more likely to participate in class discussions if I could share/post my thoughts in real-time through mobile devices	Strongly agree	46	59.0%
	Agree	27	34.6%
	Neither agree or disagree	3	3.8%
	Disagree	2	2.6%
	Strongly disagree	0	0.0%
PERCEIVED ENJOYMENT (PE)			
115. I would feel more interested in learning by using mobile devices	Strongly agree	39	50.0%
	Agree	28	35.9%
	Neither agree or disagree	10	12.8%
	Disagree	1	1.3%
	Strongly disagree	0	0.0%
116. I would enjoy learning if I could use mobile devices	Strongly agree	32	41.0%
	Agree	35	44.9%
	Neither agree or disagree	11	14.1%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
117. To use mobile devices would stimulate my curiosity	Strongly agree	43	55.1%
	Agree	29	37.2%
	Neither agree or disagree	4	5.1%
	Disagree	1	1.3%
	Strongly disagree	1	1.3%
PERCEIVED EASE OF USE (PEOU)			
118. It would not require a lot of effort to learn, because I can skilfully use mobile devices	Strongly agree	21	26.9%
	Agree	35	44.9%
	Neither agree or disagree	10	12.8%
	Disagree	8	10.3%
	Strongly disagree	4	5.1%
119. It would ease my learning, since it allows me to learn anywhere, anytime	Strongly agree	41	52.6%
	Agree	30	38.5%
	Neither agree or disagree	7	9.0%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
120. It would be easy to use mobile devices for learning	Strongly agree	40	51.3%
	Agree	33	42.3%
	Neither agree or disagree	5	6.4%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
121. It would be easier to complete class work and assignments if I could use mobile devices	Strongly agree	49	62.8%
	Agree	24	30.8%
	Neither agree or disagree	3	3.8%
	Disagree	2	2.6%
	Strongly disagree	0	0.0%
122. It would be easy to engage in discussions using instant messaging on mobile devices	Strongly agree	45	57.7%
	Agree	27	34.6%
	Neither agree or disagree	5	6.4%
	Disagree	1	1.3%
	Strongly disagree	0	0.0%

Variables	Categories	Frequency	Percentage out of total
123. It would be easier for me to ask for help if I could communicate through mobile devices	Strongly agree	51	65.4%
	Agree	22	28.2%
	Neither agree or disagree	4	5.1%
	Disagree	1	1.3%
	Strongly disagree	0	0.0%
ATTITUDE (ATT)			
124. I would be more encouraged to learn if I could access learning materials anywhere, anytime	Strongly agree	54	69.2%
	Agree	21	26.9%
	Neither agree or disagree	3	3.8%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
125. I would like to be able to use mobile devices as a method for learning, since it will allow me to learn in places I could normally not learn/study in	Strongly agree	39	50.0%
	Agree	31	39.7%
	Neither agree or disagree	6	7.7%
	Disagree	2	2.6%
	Strongly disagree	0	0.0%
126. I would like to be able to view course material on mobile devices	Strongly agree	54	69.2%
	Agree	24	30.8%
	Neither agree or disagree	0	0.0%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
127. I would feel in control when using mobile devices in teaching and learning	Strongly agree	36	46.2%
	Agree	28	35.9%
	Neither agree or disagree	12	15.4%
	Disagree	2	2.6%
	Strongly disagree	0	0.0%
128. I would feel positive towards using mobile devices in teaching and learning	Strongly agree	31	39.7%
	Agree	42	53.%
	Neither agree or disagree	5	6.4%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
129. I would feel ready for mobile learning if the university implements it now	Strongly agree	42	53.8%
	Agree	30	38.5%
	Neither agree or disagree	6	7.7%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
130. I would find it acceptable to study computer programming with mobile device access only	Strongly agree	17	21.8%
	Agree	24	30.8%
	Neither agree or disagree	21	26.9%
	Disagree	15	19.2%
	Strongly disagree	1	1.3%
PERCEIVED ACCESS BARRIERS (PAB)			
131. I would not be able to afford mobile devices for educational use	Strongly agree	16	20.5%
	Agree	31	39.7%
	Neither agree or disagree	14	18.0%
	Disagree	12	15.4%
	Strongly disagree	5	6.4%

Variables	Categories	Frequency	Percentage out of total
132. I am afraid that I would spend more money on data usage, because of mobile learning	Strongly agree	11	14.1%
	Agree	29	37.2%
	Neither agree or disagree	16	20.5%
	Disagree	22	28.2%
	Strongly disagree	0	0.0%
BEHAVIOURAL INTENTION TO USE (BI)			
133. I would like to use mobile devices in the future, because it will assist in my learning	Strongly agree	41	%
	Agree	32	%
	Neither agree or disagree	5	%
	Disagree	0	%
	Strongly disagree	0	%
PERCEIVED OUTPUT QUALITY (POQ)			
134. Compared with traditional learning, I believe that mobile learning is more initiative and dynamic	Strongly agree	41	52.6%
	Agree	25	32.0%
	Neither agree or disagree	9	11.5%
	Disagree	2	2.6%
	Strongly disagree	1	1.3%
135. Compared with traditional learning, I believe that mobile learning is more portable/mobile and flexible enabling anywhere, anytime learning	Strongly agree	52	66.7%
	Agree	26	33.3%
	Neither agree or disagree	0	0.0%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
136. Compared with traditional learning, I believe that mobile enhances daily teaching and learning	Strongly agree	39	50.0%
	Agree	34	43.6%
	Neither agree or disagree	5	6.4%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
137. Compared with traditional learning, I believe that mobile learning enables high engagement	Strongly agree	34	43.6%
	Agree	30	38.5%
	Neither agree or disagree	10	12.8%
	Disagree	3	3.8%
	Strongly disagree	1	1.3%
138. Compared with traditional learning, I believe that mobile learning ensures learning effectiveness	Strongly agree	28	35.9%
	Agree	42	53.8%
	Neither agree or disagree	8	10.3%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
139. Compared with traditional learning, I believe that mobile learning provides a better alternative for teaching and learning	Strongly agree	32	41.0%
	Agree	36	46.2%
	Neither agree or disagree	9	11.5%
	Disagree	1	1.3%
	Strongly disagree	0	0.0%
140. Compared with traditional learning, I believe that mobile learning improves communication between students and their lecturer	Strongly agree	37	47.4%
	Agree	31	39.7%
	Neither agree or disagree	8	10.3%
	Disagree	0	0.0%
	Strongly disagree	2	2.6%

Variables	Categories	Frequency	Percentage out of total
SECOND POST-MOBILE LEARNING QUESTIONNAIRE (POST 2)			
USE			
202a. I am able to skilfully use mobile devices to: Access the Internet / go online	Yes	74	93.7%
	No	5	6.3%
202b. I am able to skilfully use mobile devices to: Download and install applications	Yes	58	73.4%
	No	21	26.6%
202c. I am able to skilfully use mobile devices to: Download podcasts	Yes	36	45.6%
	No	43	54.4%
202d. I am able to skilfully use mobile devices to: Watch videos and listen to music	Yes	69	87.3%
	No	10	12.7%
202e. I am able to skilfully use mobile devices to: Send SMS's, instant messages and e-mails	Yes	68	86.1%
	No	11	13.9%
202f. I am able to skilfully use mobile devices to: Access social networking sites	Yes	64	81.0%
	No	15	19.0%
202g. I am able to skilfully use mobile devices to: View and download course material and assignments	Yes	65	82.3%
	No	14	17.7%
202h. I am able to skilfully use mobile devices to: Complete and submit programming assignments	Yes	68	86.1%
	No	11	13.9%
202i. I am able to skilfully use mobile devices to: Access Blackboard	Yes	64	81.0%
	No	15	19.0%
203a. Current uses regarding mobile devices for learning purposes: I have used it for library services	Yes	27	34.2%
	No	52	65.8%
203b. Current uses regarding mobile devices for learning purposes: I have accessed the university website	Yes	51	64.6%
	No	28	35.4%
203c. Current uses regarding mobile devices for learning purposes: I have viewed and downloaded course materials and assignments	Yes	47	59.5%
	No	32	40.5%
203d. Current uses regarding mobile devices for learning purposes: I have accessed the Internet / went online for learning purposes	Yes	59	74.7%
	No	20	25.3%
203e. Current uses regarding mobile devices for learning purposes: I have used a social networking site	Yes	47	59.5%
	No	32	40.5%
203f. Current uses regarding mobile devices for learning purposes: I have interacted and communicated with my lecturer	Yes	31	39.2%
	No	48	60.8%
203g. Current uses regarding mobile devices for learning purposes: I have interacted and communicated with fellow students	Yes	36	45.6%
	No	43	54.4%
203h. Current uses regarding mobile devices for learning purposes: I have downloaded and listened to podcasts	Yes	23	29.1%
	No	56	70.9%
203i. Current uses regarding mobile devices for learning purposes: I have recorded information during class	Yes	31	39.2%
	No	48	60.8%
203j. Current uses regarding mobile devices for learning purposes: I have made notes during class	Yes	42	53.2%
	No	37	46.8%
203k. Current uses regarding mobile devices for learning purposes: I have effectively completed and submitted programming assignments	Yes	53	67.1%
	No	26	32.9%

Variables		Categories	Frequency	Percentage out of total
204a.	Where did you use the mobile device? Home	Yes	41	89.1%
		No	5	10.9%
204b.	Where did you use the mobile device? CPUT Residence	Yes	33	41.8%
		No	46	58.2%
204c.	Where did you use the mobile device? Computer laboratory on campus	Yes	72	91.1%
		No	7	8.9%
204d.	Where did you use the mobile device? Theory class on campus	Yes	54	68.4%
		No	25	31.6%
204e.	Where did you use the mobile device? Elsewhere on campus outside the classroom	Yes	48	60.8%
		No	31	39.2%
204f.	Where did you use the mobile device? While commuting	Yes	8	17.4%
		No	38	82.6%
204g.	Where did you use the mobile device? Family/friends	Yes	16	34.8%
		No	30	65.2%
204h.	Where did you use the mobile device? Elsewhere off-campus	Yes	28	60.9%
		No	18	39.1%
205.	How frequently did you use the mobile device?	Less than once a week	5	6.3%
		Once a week	2	2.5%
		A few days a week	38	48.1%
		Everyday	34	43.0%
		Never	0	0.0%
206.	I have used the mobile device mostly during the:	Morning	23	29.1%
		Afternoon	31	39.2%
		Evening	22	27.8%
		Night	3	3.8%
207.	How much did you spend on average during the week using the mobile device?	Did not use it	0	0.0%
		Less than 30 minutes	2	2.5%
		30 minutes – 1 hour	20	25.3%
		1-2 hours	18	22.8%
		2-4 hours	24	30.4%
		More than 4 hours	15	19.0%
208a.	For which events did you mainly use the mobile device for? Personal use	Yes	47	59.5%
		No	32	40.5%
208b.	For which events did you mainly use the mobile device for? Information search	Yes	29	36.7%
		No	50	63.3%
208c.	For which events did you mainly use the mobile device for? Homework	Yes	57	72.2%
		No	22	27.8%
208d.	For which events did you mainly use the mobile device for? Formal subject-related activities	Yes	61	77.2%
		No	18	22.8%
208e.	For which events did you mainly use the mobile device for? Hobbies / Interests	Yes	32	40.5%
		No	47	59.5%
208f.	For which events did you mainly use the mobile device for? Communication / Collaboration	Yes	13	28.3%
		No	33	71.7%
208g.	For which events did you mainly use the mobile device for? Provide help	Yes	12	15.2%
		No	67	84.8%
208h.	For which events did you mainly use the mobile device for? Receive help	Yes	16	20.2%
		No	63	79.8%
208i.	For which events did you mainly use the mobile device for? Entertainment	Yes	37	46.8%
		No	42	53.2%
208j.	For which events did you mainly use the mobile device for? Other	Yes	12	15.2%
		No	67	84.8%
209a.	Who were involved when you have used the mobile device during the course of your studies? Lecturer	Yes	38	48.1%
		No	41	51.9%

Variables		Categories	Frequency	Percentage out of total
209b.	Who were involved when you have used the mobile device during the course of your studies? Peer	Yes	25	31.6%
		No	54	68.4%
209c.	Who were involved when you have used the mobile device during the course of your studies? Mentor / Advisor	Yes	3	3.8%
		No	76	96.2%
209d.	Who were involved when you have used the mobile device during the course of your studies? Technical Support	Yes	4	5.1%
		No	75	94.9%
209e.	Who were involved when you have used the mobile device during the course of your studies? Friend	Yes	46	58.2%
		No	33	41.8%
209f.	Who were involved when you have used the mobile device during the course of your studies? Partner	Yes	3	6.5%
		No	43	93.5%
209g.	Who were involved when you have used the mobile device during the course of your studies? Family	Yes	8	17.4%
		No	38	82.6%
209h.	Who were involved when you have used the mobile device during the course of your studies? None (except myself)	Yes	27	34.2%
		No	52	65.8%
209i.	Who were involved when you have used the mobile device during the course of your studies? Other	Yes	1	1.3%
		No	78	98.7%
210.	Did you pair the mobile device with your cell phone in order to go online / access the Internet?	Yes	18	22.8%
		Yes, but the devices did not want to pair	27	34.2%
		No, I did not know how to pair the devices	19	24.0%
		No, I did not want to	15	19.0%
211.	Did you make use of Bluetooth to share files?	Yes	58	73.4%
		No	21	26.6%
212.	Did you buy or use a SD memory card to extend the storage capacity of the mobile device?	Yes	32	40.5%
		No	47	59.5%
213a.	Where do you think you will use mobile devices in future? Home	Yes	67	84.8%
		No	12	15.2%
213b.	Where do you think you will use mobile devices in future? CPUT residence	Yes	36	45.6%
		No	43	54.4%
213c.	Where do you think you will use mobile devices in future? Computer laboratory on campus	Yes	51	64.6%
		No	28	35.4%
213d.	Where do you think you will use mobile devices in future? Theory class on campus	Yes	48	60.8%
		No	31	39.2%
213e.	Where do you think you will use mobile devices in future? Elsewhere on campus outside the classroom	Yes	45	57.0%
		No	34	43.0%
213f.	Where do you think you will use mobile devices in future? While commuting	Yes	31	39.2%
		No	48	60.8%
213g.	Where do you think you will use mobile devices in future? Family / Friends	Yes	34	43.0%
		No	45	57.0%
213h.	Where do you think you will use mobile devices in future? Elsewhere off-campus	Yes	46	58.2%
		No	33	41.8%

Variables	Categories	Frequency	Percentage out of total
PERCEPTION			
214. Should the university require students to use mobile devices during the course of their computer programming studies?	Yes, even if students have to pay for them	18	22.8%
	Yes, but CPUT should pay for them	52	65.8%
	I'm not sure	7	8.9%
	No	2	2.5%
215. The university is ready to implement mobile learning	Strongly agree	42	56.8%
	Agree	32	43.2%
	Neither agree nor disagree	0	0.0%
	Disagree	0	0.0%
	Strongly disagree	0	0.0%
216a. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Larger display screens	Yes	66	83.5%
	No	13	16.5%
216b. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Lower data cost tariffs	Yes	33	41.8%
	No	46	58.2%
216c. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Lower mobile device costs	Yes	36	45.6%
	No	43	54.4%
216d. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Better processing power	Yes	55	69.6%
	No	24	30.4%
216e. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Larger memory capacities	Yes	49	62.8%
	No	29	37.2%
216f. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Technology unification / consolidation	Yes	28	35.4%
	No	51	64.6%
216g. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Better proliferation	Yes	36	45.6%
	No	43	54.4%
216h. What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance? Other	Yes	13	16.5%
	No	66	83.5%
ATTITUDE			
217. I do not want to use mobile devices, because they are too heavy to carry around	Strongly agree	2	2.5%
	Agree	1	1.3%
	Neither agree nor disagree	2	2.5%
	Disagree	35	44.3%
	Strongly disagree	39	49.4%

Variables	Categories	Frequency	Percentage out of total
218. I do not want to use mobile devices, because they are too fragile and easily broken	Strongly agree	0	0.0%
	Agree	3	3.8%
	Neither agree nor disagree	14	17.7%
	Disagree	42	53.2%
	Strongly disagree	20	25.3%
219. I do not want to use mobile devices, because I find it difficult to read text on a mobile device screen	Strongly agree	0	0.0%
	Agree	2	2.5%
	Neither agree nor disagree	13	16.5%
	Disagree	47	59.5%
	Strongly disagree	17	21.5%
220. I do not want to use mobile devices, because it is hard to enter data using the stylus/pen/touch on a mobile device	Strongly agree	0	0.0%
	Agree	7	8.9%
	Neither agree nor disagree	8	10.1%
	Disagree	47	59.5%
	Strongly disagree	17	21.5%
223. I would find it acceptable to learn computer programming with mobile device access only	Strongly agree	14	17.7%
	Agree	36	45.6%
	Neither agree nor disagree	20	25.3%
	Disagree	8	10.1%
	Strongly disagree	1	1.3%
224. I would prefer to use a mobile device during tests to assist me with coding programs	Strongly agree	25	31.6%
	Agree	41	51.9%
	Neither agree nor disagree	10	12.7%
	Disagree	2	2.5%
	Strongly disagree	1	1.3%
225. Compared to the beginning of this semester, how do you feel about the use of mobile devices now?	More enthusiastic	59	74.7%
	About the same	20	25.3%
	Less enthusiastic	0	0.0%

Table 5.7: Descriptive statistics for entries made in the learner journals (2012)

Variables	Categories	Frequency	Percentage out of total
1. Number of entries made	1-5 entries	9	18.0%
	>5-10 entries	10	20.0%
	>10-15 entries	12	24.0%
	>15-20 entries	11	22.0%
	> 20 entries	8	16.0%
2. Number of entries made per month	August 2012	179	26.3%
	September 2012	196	28.8%
	October 2012	205	44.8%
3. Mobile technology was used:	Morning (6am-12pm)	238	35.0%
	Afternoon (12pm-6pm)	229	33.7%
	Evening (6pm-12am)	174	25.6%
	Night (12am-6am)	39	5.7%
4. Duration:	<10 minutes	87	12.8%
	10-30 minutes	231	34.0%
	30-60 minutes	258	37.9%
	1-2 hours	79	11.6%
	>2 hours	25	3.7%
5.1 Location: Campus	Yes	289	42.4%
	No	391	57.6%
5.2 Location: Home	Yes	287	42.2%
	No	393	57.8%
5.3 Location: CPUT residence	Yes	65	9.6%
	No	615	90.4%
5.4 Location: Family/Friends	Yes	7	1.0%
	No	673	99.0%
5.5 Location: Public transport	Yes	26	3.8%
	No	654	96.2%
5.6 Location: Place of leisure	Yes	2	0.3%
	No	678	99.7%
5.7 Location: Outdoors	Yes	1	0.2%
	No	679	99.8%
5.8 Location: Other	Yes	4	0.6%
	No	676	99.4%
6.1 Event: Personal use	Yes	179	26.3%
	No	501	73.7%
6.2 Event: Information search	Yes	39	5.7%
	No	641	94.3%
6.3 Event: Homework (any subject)	Yes	198	29.1%
	No	482	70.9%
6.4 Event: Formal subject-related activities	Yes	301	44.3%
	No	379	55.7%
6.5 Event: Hobbies / Interests	Yes	38	5.6%
	No	642	94.4%
6.6 Event: Communication / Collaboration	Yes	0	0.0%
	No	680	100.0%
6.7 Event: Provide help	Yes	15	2.2%
	No	665	97.8%
6.8 Event: Receive help	Yes	18	2.6%
	No	662	97.4%
6.9 Event: Entertainment	Yes	98	14.4%
	No	582	85.6%
6.10 Event: Other	Yes	0	0.0%
	No	680	100.0%
7.1 People involved: Lecturer	Yes	70	10.3%
	No	610	89.7%

Variables	Categories	Frequency	Percentage out of total
7.2 People involved: Peer	Yes	36	5.3%
	No	644	94.7%
7.3 People involved: Mentor / Advisor	Yes	4	0.6%
	No	676	99.4%
7.4 People involved: Friend	Yes	104	15.3%
	No	576	84.7%
7.5 People involved: Partner	Yes	4	0.6%
	No	676	99.4%
7.6 People involved: Family	Yes	9	1.3%
	No	671	98.7%
7.7 People involved: Stranger	Yes	1	0.2%
	No	679	99.8%
7.8 People involved: None	Yes	477	70.2%
	No	203	29.8%
7.9 People involved: Other	Yes	1	0.2%
	No	679	99.8%

Table 5.8: Descriptive statistics (number of responses, mean, standard deviation median and range) of surveys

Variable	N	Mean	Std Dev	Median	Range
PRE-MOBILE LEARNING QUESTIONNAIRE					
2a. Age at time of study	79	21.3	1.9372	21.0	12.0
21. How often do you use the Internet / go online?	79	7.5	1.2993	8.0	7.0
24. How frequently do you use the Internet / go online with a computer?	46	1.2	0.5930	1.0	3.0
25. How frequently do you use the Internet / go online with a cell phone?	46	1.4	0.9304	1.0	3.0
44. On average, how much money do you spend on airtime and data usage per month?	79	2.8	1.2135	3.0	4.0
46. How long ago was the first time you have used any cell phone?	79	3.9	0.8877	4.0	4.0
47. For how long have you had your current cell phone?	79	2.1	1.1568	2.0	4.0
48. How happy or satisfied are you with your current cell phone?	79	2.4	1.2249	2.0	5.0
50. How much, if at all, has your cell phone helped you to keep in touch with your family?	79	4.9	0.4632	5.0	3.0
51. How much, if at all, has your cell phone helped you to keep in touch with friends?	79	4.9	0.3110	5.0	2.0
52. How much, if at all, has your cell phone helped you do well at university?	79	3.8	1.1705	4.0	4.0
53. How much, if at all, has your cell phone helped you to learn new things?	79	4.2	0.8946	4.0	3.0
54. How much, if at all, has your cell phone helped you to share your ideas and creations with others?	79	4.3	0.8728	5.0	3.0
55. How much, if at all, has your cell phone helped you to find important information?	79	4.3	0.9299	5.0	3.0
56. How much, if at all, has your cell phone helped you to work with others in your community or in groups you belong to?	79	3.9	1.1766	4.0	4.0
57. How much, if at all, has your cell phone helped you to follow your hobbies or interests?	79	4.0	1.1320	4.0	4.0
63. How much time did you spend on MXit yesterday?	77	1.6	1.0463	1.0	4.0
65. How much time did you spend on WhatsApp yesterday?	40	2.45	1.4133	2.0	4.0
66. If you had to buy a new cell phone today, how important is great looks?	79	1.9	1.3300	1.0	5.0
67. If you had to buy a new cell phone today, how important is the screen size?	79	1.3	0.6896	1.0	4.0
68. If you had to buy a new cell phone today, how important is the size or weight?	79	1.7	0.8899	1.0	4.0
69. If you had to buy a new cell phone today, how important is it that it is the latest model or newest technology?	79	1.4	0.9543	1.0	5.0
70. If you had to buy a new cell phone today, how important is the brand name?	46	1.5	1.0689	1.0	5.0
71. If you had to buy a new cell phone today, how important is it that it has a low price?	79	2.3	1.3561	2.0	5.0
72. If you had to buy a new cell phone today, how important is it to be able to play music or MP3 files?	79	1.4	1.0166	1.0	5.0
73. If you had to buy a new cell phone today, how important is it to be able to send and receive e-mails?	79	1.3	0.7902	1.0	5.0

Variable	N	Mean	Std Dev	Median	Range
74. If you had to buy a new cell phone today, how important is it to be able to access the Internet / go online?	79	1.1	0.6600	1.0	5.0
75. If you had to buy a new cell phone today, how important is it to have fast Internet (3G or HSDPA)?	79	1.2	0.6970	1.0	5.0
76. If you had to buy a new cell phone today, how important is it to be able to download / receive files from other cell phones via Bluetooth or Infrared?	79	1.2	0.8081	1.0	5.0
77. If you had to buy a new cell phone today, how important is it to be able to download music, ringtones, games, applications or videos?	79	1.4	0.9257	1.0	5.0
78. If you had to buy a new cell phone today, how important is it to be able to send and receive instant messages?	79	1.5	1.0722	1.0	5.0
81. Approximate number of SMS's sent daily?	79	1.6	0.9648	1.0	3.0
POST 1-MOBILE LEARNING QUESTIONNAIRE					
PERCEIVED USEFULNESS (PU)					
102. To use mobile devices for learning purposes would save me a lot of time	78	1.3	0.5011	1.0	2.0
103. To use mobile devices to access course material anywhere, anytime would allow me to spend more time on class work	78	1.6	0.7634	1.0	3.0
104. To use mobile devices for learning purposes would enhance the effectiveness of my learning	78	1.5	0.5031	2.0	1.0
105. To use mobile devices for learning would be ubiquitous and useful	78	1.5	0.6591	1.0	2.0
106. To use mobile devices would improve my academic performance	78	1.5	0.5742	1.5	2.0
107. To use mobile devices would increase my productivity in my course work	78	1.5	0.5742	1.5	2.0
108. To use mobile devices would increase the quality of computer programming teaching and learning	78	1.5	0.5017	1.0	1.0
109. To use mobile devices for learning computer programming would be feasible	78	1.5	0.5017	1.0	1.0
110. I would buy a mobile device if it will be useful in my course	78	1.9	0.7683	2.0	3.0
PERCEIVED MOBILITY VALUE (PMV)					
111. Mobility enables me to accomplish tasks more quickly	78	1.6	0.7323	1.0	3.0
112. Mobility enables me to access real-time information anywhere, anytime	78	1.4	0.4828	1.0	1.0
PERCEIVED SOCIAL INTERACTION VALUE (PSIV)					
113. I would be more likely to interact with lecturers and fellow students both inside and outside the classroom if I could use mobile devices	78	1.5	0.6585	1.0	3.0
114. I would be more likely to participate in class discussions if I could share/post my thoughts in real-time through mobile devices	78	1.5	0.6979	1.0	3.0
PERCEIVED ENJOYMENT (PE)					
115. I would feel more interested in learning by using mobile devices	78	1.6	0.7529	1.5	3.0
116. I would enjoy learning if I could use mobile devices	78	1.7	0.6964	2.0	2.0
117. To use mobile devices would stimulate my curiosity	78	1.6	0.7660	1.0	4.0

Variable	N	Mean	Std Dev	Median	Range
PERCEIVED EASE OF USE (PEOU)					
118. It would not require a lot of effort to learn, because I can skilfully use mobile devices	78	2.2	1.1125	2.0	4.0
119. It would ease my learning, since it allows me to learn anywhere, anytime	78	1.6	0.6564	1.0	2.0
120. It would be easy to use mobile devices for learning	78	1.6	0.6168	1.0	2.0
121. It would be easier to complete class work and assignments if I could use mobile devices	78	1.5	0.6968	1.0	3.0
122. It would be easy to engage in discussions using instant messaging on mobile devices	78	1.5	0.6789	1.0	3.0
123. It would be easier for me to ask for help if I could communicate through mobile devices	78	1.4	0.6550	1.0	3.0
ATTITUDE (ATT)					
124. I would be more encouraged to learn if I could access learning materials anywhere, anytime	78	1.3	0.5542	1.0	2.0
125. I would like to be able to use mobile devices as a method for learning, since it will allow me to learn in places I could normally not learn/study in	78	1.6	0.7405	1.5	3.0
126. I would like to be able to view course material on mobile devices	78	1.3	0.4645	1.0	1.0
127. I would feel in control when using mobile devices in teaching and learning	78	1.7	0.8128	2.0	3.0
128. I would feel positive towards using mobile devices in teaching and learning	78	1.7	0.5958	2.0	2.0
129. I would feel ready for mobile learning if the university implements it now	78	1.5	0.6384	1.0	2.0
130. I would find it acceptable to study computer programming with mobile device access only	78	2.5	1.0778	2.0	4.0
PERCEIVED ACCESS BARRIERS (PAB)					
131. I would not be able to afford mobile devices for educational use	78	2.5	1.1702	2.0	4.0
132. I am afraid that I would spend more money on data usage, because of mobile learning	78	2.6	1.0458	2.0	3.0
BEHAVIOURAL INTENTION TO USE (BI)					
133. I would like to use mobile devices in the future, because it will assist in my learning	78	1.5	0.6178	1.0	2.0
PERCEIVED OUTPUT QUALITY (POQ)					
134. Compared with traditional learning, I believe that mobile learning is more initiative and dynamic	78	1.7	0.8752	1.0	4.0
135. Compared with traditional learning, I believe that mobile learning is more portable/mobile and flexible enabling anywhere, anytime learning	78	1.3	0.4745	1.0	1.0
136. Compared with traditional learning, I believe that mobile learning enhances daily teaching and learning	78	1.6	0.6156	1.5	2.0
137. Compared with traditional learning, I believe that mobile learning enables high engagement	78	1.8	0.8982	2.0	4.0
138. Compared with traditional learning, I believe that mobile learning ensures learning effectiveness	78	1.7	0.6332	2.0	2.0
139. Compared with traditional learning, I believe that mobile learning provides a better alternative for teaching and learning	78	1.7	0.7148	2.0	3.0
140. Compared with traditional learning, I believe that mobile learning improves communication between students and their lecturer	78	1.7	0.8545	2.0	4.0

Variable	N	Mean	Std Dev	Median	Range
POST 2-MOBILE LEARNING QUESTIONNAIRE					
USE					
205. How frequently did you use the mobile device?	79	4.3	0.7996	4.0	3.0
207. How much did you spend on average during the week using the mobile device?	79	4.4	1.1357	4.0	4.0
PERCEPTION					
215. The university is ready to implement mobile learning	74	1.4	0.4988	1.0	1.0
ATTITUDE					
217. I do not want to use mobile devices, because they are too heavy to carry around	79	4.4	0.8193	4.0	4.0
218. I do not want to use mobile devices, because they are too fragile and easily broken	79	4.0	0.7679	4.0	3.0
219. I do not want to use mobile devices, because I find it difficult to read text on a mobile device screen	79	4.0	0.6980	4.0	3.0
220. I do not want to use mobile devices, because it is hard to enter data using the stylus/pen/touch on a mobile device	79	3.9	0.8218	4.0	3.0
223. I would find it acceptable to learn computer programming with mobile device access only	79	2.3	0.9274	2.0	4.0
224. I would prefer to use a mobile device during tests to assist me with coding programs	79	1.9	0.8101	2.0	4.0
225. Compared to the beginning of this semester, how do you feel about the use of mobile devices now?	79	1.2	0.4376	1.0	1.0
FORMATIVE AND SUMMATIVE ASSESSMENT MARKS					
1. T1 2007-2010	216	67.9	18.7500	71.0	99.0
2. T2 2007-2010	216	63.0	19.5169	66.0	96.0
3. Gain_T 2007-2010	216	-4.9	14.3194	6.0	125.0
4. Average Assignment before M-learning 2007-2010	216	67.2	29.4259	76.7	100.0
5. T1 2011	33	62.3	23.9370	69.0	93.0
6. T2 2011	33	65.5	25.1745	75.0	94.0
7. Gain_T 2011	33	3.2	9.5081	2.0	54.0
8. Average Assignment before M-learning 2011	33	61.8	26.8689	71.7	90.0
9. Average Assignment after M-learning 2011	33	75.0	21.2040	82.5	75.0
10. Gain_A 2011	33	13.2	12.0302	8.3	54.2
11. Average Class Tests before M-learning 2011	33	57.4	23.8233	67.0	86.0
12. Average Class Tests after M-learning 2011	33	65.0	24.7429	76.0	89.3
13. Gain_CT 2011	33	7.7	4.9248	8.3	23.8
14. T1 2012	48	66.8	19.7796	67.0	80.0
15. T2 2012	47	70.5	23.3423	81.0	96.0
16. Gain_T 2012	47	4.0	15.6455	5.0	71.0
17. Average Assignment after M-learning 2012	48	85.2	15.5249	89.7	73.1
18. Average Class Tests after M-learning 2012	48	60.3	20.3536	63.6	80.9

APPENDIX J: Variable names for questionnaires and learner journal as per SAS

Pre-mobile learning questionnaire	
SAS name	**Question**
ID	Student number
A01	Gender
A02	In which year were you born?
A02a	Derived age
A03	What is your first (home) language?
A04	What is your second language?
A05	Race
A06	Where do you live during your studies?
A07	How do you usually get to the university?
A08	Has your cell phone ever been stolen?
A09	Would you like to be able to use mobile technology **in the classroom** as a tool to help you with your university work?
A10	Would you like to be able to use mobile technology **at home/residence** as a tool to help you with your university work?
A11	Do you think that the use of mobile technology as a tool **in the classroom** will make any difference to the quality of your university work?
A12	Do you think that the use of mobile technology as a tool **at home/residence** will make any difference to the quality of your university work?
A13	**Which ones have you ever used?:**
A13a	Desktop computer
A13b	Laptop computer
A13c	Pocket PC / Personal Digital Assistant (PDA)
A13d	iPad / Tablet
A13e	Cell phone
A13f	iPod or other MP3 player
A13g	Video game console or handheld gaming device
A13h	None of the above
A14	**Which ones did you use yesterday?:**
A14a	Desktop computer
A14b	Laptop computer
A14c	Pocket PC / Personal Digital Assistant (PDA)
A14d	iPad / Tablet
A14e	Cell phone
A14f	iPod or other MP3 player
A14g	Video game console or handheld gaming device
A14h	None of the above

Pre-mobile learning questionnaire	
SAS name	**Question**
A15	**Which ones do you own personally?:**
A15a	Desktop computer
A15b	Laptop computer
A15c	Pocket PC / Personal Digital Assistant (PDA)
A15d	iPad / Tablet
A15e	Cell phone
A15f	iPod or other MP3 player
A15g	Video game console or handheld gaming device
A15h	None of the above
A16	**Which ones do you have access to off-campus?:**
A16a	Desktop computer
A16b	Laptop computer
A16c	Pocket PC / Personal Digital Assistant (PDA)
A16d	iPad / Tablet
A16e	Cell phone
A16f	iPod or other MP3 player
A16g	Video game console or handheld gaming device
A16h	None of the above
A17	Do you have access to the Visual Basic computer programming application **off-campus**?
A18	Is **off-campus** access to the Visual Basic computer programming application important to you?
A19	Is off-campus Internet access important to you?
A20	Do you find it difficult to access university computer laboratories outside Visual Basic computer programming class times?
A21	How often do you use the Internet / go online?
A22	**When you use the Internet / go online do you …**
A22a	Use a cell phone
A22b	Use a computer / laptop
A22c	Use a Pocket PC / PDA
A22d	Use an iPad / Tablet
A22e	Other
A23	**If you go online using a computer, where do you do this?**
A23a	At CPUT or the library
A23b	At home
A23c	At the residence
A23d	At an Internet café
A23e	At someone else's house
A23f	Some other place
A24	How frequently do you use the internet / go online **with a computer**?
A25	How frequently do you use the internet / go online **with a cell phone**?
A26	Do you own or use a cell phone?
A27	How did you obtain your current cell phone?

Pre-mobile learning questionnaire	
SAS name	**Question**
A28	What is the brand name of your cell phone?
A29	Is your cell phone a smart phone?
A30	**Which mobile provider do you use?**
A30a	Vodacom
A30b	MTN
A30c	Cell C
A30d	Virgin Mobile
A30e	8ta
A30f	Other
A30g	Don't know
A31	Is your cell phone using prepaid or contract?
A32	Do you prefer contacting someone via a(n) ….?
A33	Why do you prefer the above selected method?
A34	With your cell phone, is it possible to **play music or MP3 files**?
A35	With your cell phone, is it possible to **send and receive e-mail**?
A36	With your cell phone, is it possible to **access the Internet / go online?**
A37	With your cell phone, is it possible to **use fast Internet?**
A38	With your cell phone, is it possible to **download / receive files from other cell phones via Bluetooth or Infrared?**
A39	With your cell phone, is it possible to **download music, ringtones, games, applications or videos?**
A40	With your cell phone, is it possible to **use MXit?**
A41	With your cell phone, is it possible to **use WhatsApp?**
A42	Which instant messaging application do you prefer to use with your cell phone?
A43	**What would you do on your cell phone if you had an hour or two?**
A43a	Play games
A43b	Use the Internet / Go online
A43c	Chat via Instant messaging
A43d	Send SMS's
A43e	Take photos / videos
A43f	Play music / videos
A43g	Download music, ringtones, games, applications or videos
A43h	Other
A44	On average, how much money do you spend on airtime and data usage **per month**?
A45	**Who pays for your airtime and data usage or for your cell phone's contract?**
A45a	My parents or legal guardians
A45b	My family members other than my parents
A45c	Myself
A45d	Boyfriend / Girlfriend
A45e	Other

Pre-mobile learning questionnaire	
SAS name	**Question**
A46	How long ago was the **first time** you have used **any cell phone**?
A47	For how long have you had your **current cell phone**?
A48	How happy or satisfied are you with your **current cell phone**?
A49a	What are the three activities you do **most often** on a cell phone: Most often I….
A49b	What are the three activities you do **most often** on a cell phone: Second….
A49c	What are the three activities you do **most often** on a cell phone: Third….
A50	How much, if at all, has your cell phone helped you to **keep in touch with your family?**
A51	How much, if at all, has your cell phone helped you to **keep in touch with friends?**
A52	How much, if at all, has your cell phone helped you to **do well at university?**
A53	How much, if at all, has your cell phone helped you to **learn new things?**
A54	How much, if at all, has your cell phone helped you to **share your ideas and creations with others?**
A55	How much, if at all, has your cell phone helped you to **find important information?**
A56	How much, if at all, has your cell phone helped you to **work with others in your community or in groups you belong to?**
A57	How much, if at all, has your cell phone helped you to **follow your hobbies or interests?**
A58	Do you **ever** give a missed call to other people?
A59	If yes, did you do this **yesterday?**
A60	Do you **ever** use the feature "Please call me" on your cell phone?
A61	If yes, did you use it **yesterday?**
A62	Have you **ever** used **MXit** on a cell phone?
A63	How much time did you spend on **MXit yesterday?**
A64	Have you **ever** used **WhatsApp** on a cell phone?
A65	How much time did you spend on **WhatsApp yesterday?**
A66	If you had to buy a new cell phone today, how important is **great looks**?
A67	If you had to buy a new cell phone today, how important is **screen size**?
A68	If you had to buy a new cell phone today, how important is s**ize or weight**?
A69	If you had to buy a new cell phone today, how important is **it that it is the latest model or newest technology**?
A70	If you had to buy a new cell phone today, how important is the **brand name**?
A71	If you had to buy a new cell phone today, how important is it **that it has a low price**?
A72	If you had to buy a new cell phone today, how important is **it to be able to play music or mp3 files**?
A73	If you had to buy a new cell phone today, how important is **it to be able to send and receive e-mail**?

Pre-mobile learning questionnaire	
SAS name	**Question**
A74	If you had to buy a new cell phone today, how important is **it to be able to access the Internet / go online**?
A75	If you had to buy a new cell phone today, how important is **it to have fast Internet (3G or HSDPA)**?
A76	If you had to buy a new cell phone today, how important is **it to be able to download/receive files from other cell phones via Bluetooth or Infrared**?
A77	If you had to buy a new cell phone today, how important is **it to be able to download music, ringtones, games, applications or videos**?
A78	If you had to buy a new cell phone today, how important is **it to be able to send and receive instant messages (i.e. MXit, WhatsApp, others)**?
A79	Have you **ever** used a cell phone to **play music or mp3 files**?
A80	Have you **ever** used your cell phone to **send and receive text messages or SMS?**
A81	Approximate number of SMS's sent daily?
A82	Have you **ever** used a cell phone to **send and receive e-mail**?
A83	Have you **ever** used a cell phone to **access the Internet / go online for no particular reason, just to browse for fun**?
A84	Have you **ever** used a cell phone to **download / receive files from other cell phones via Bluetooth or Infrared**?
A85	Have you **ever** used a cell phone to **download music, ringtones, games, applications or videos**?
A86	Have you **ever** used a cell phone to **research information for university work on the Internet**?
A87a	What are the three activities you do **most often** on a **computer**? Most often I ….
A87b	What are the three activities you do **most often** on a **computer**? Second….
A87c	What are the three activities you do **most often** on a **computer**? Third….
A88	Have you **ever** used a **computer** to **play music or mp3 files**?
A89	Have you **ever** used a **computer** to **send text messages or SMS**?
A90	Have you **ever** used a **computer** to **send and receive e-mail**?
A91	Have you **ever** used a **computer** to **access the Internet / go online for no particular reason, just to browse for fun**?
A92	Have you **ever** used a **computer** to **download music, ringtones, games, applications or videos**?
A93	Have you **ever** used a **computer** to **send instant messages to someone who was online at the same time (i.e. MXit or others)**?
A94	Have you **ever** used a **computer** to **research information for university work on the Internet**?
A95	How are the students in your class doing financially?
A96	How are you and your family doing financially?
A97	What do you think you would deserve financially?

First post-mobile learning (post 1) questionnaire	
SAS name	**Question**
ID	Student number
PERCEIVED USEFULNESS (PU)	
P102	To use mobile devices for learning purposes would save me a lot of time
P103	To use mobile devices to access material anywhere, anytime would allow me to spend more time on class work
P104	To use mobile devices for learning purposes would enhance the effectiveness of my learning
P105	To use mobile devices for learning would be ubiquitous and useful
P106	To use mobile devices would improve my academic performance
P107	To use mobile devices would increase my productivity in my course work
P108	To use mobile devices would increase the quality of computer programming teaching and learning
P109	To use mobile devices for learning computer programming would be feasible
P110	I would buy a mobile device if it will be useful in my course
PERCEIVED MOBILITY VALUES (PMV)	
P111	Mobility enables me to accomplish tasks more quickly
P112	Mobility enables me to access real-time information anywhere, anytime
PERCEIVED SOCIAL INTERACTION VALUE (PSIV)	
P113	I would be more likely to interact with lecturers and fellow students both inside and outside the classroom if I could use mobile devices
P114	I would be more likely to participate in class discussions if I could share/post my thoughts in real-time through mobile devices
PERCEIVED ENJOYMENT (PE)	
P115	I would feel more interested in learning by using mobile devices
P116	I would enjoy learning if I could use mobile devices
P117	To use mobile devices would stimulate my curiosity
PERCEIVED EASE OF USE (PEOU)	
P118	It would not require a lot of effort to learn, because I can skilfully use mobile devices
P119	It would ease my learning, since it allows me to learn anywhere, anytime.
P120	It would be easy to use mobile devices for learning
P121	It would be easier to complete class work and assignments if I could use mobile devices
P122	It would be easy to engage in discussions using instant messaging on mobile devices (i.e. MXit, WhatsApp)
P123	It would be easier for me to ask for help if I could communicate through mobile devices

First post-mobile learning (post 1) questionnaire	
SAS name	**Question**
ATTITUDE (ATT)	
P124	I would be more encouraged to learn if I could access learning materials anywhere, anytime.
P125	I would like to be able to use mobile devices as a method for learning, since it will allow me to learn in places I could normally not learn/study in
P126	I would like to be able to view course material (subject guide, class notes, assignments) on mobile devices
P127	I would feel in control when using mobile devices in teaching and learning
P128	I would feel positive towards using mobile devices in teaching and learning
P129	I would feel ready for mobile learning if the university implements it now
P130	I would find it acceptable to study computer programming with mobile device access only
PERCEIVED ACCESS BARRIERS (PAB)	
P131	I would be able to afford mobile devices for educational use
P132	I am afraid that I would spend more money on data usage, because of mobile learning
BEHAVIOURAL INTENTION TO USE (BI)	
P133	I would like to use mobile devices in the future, because it will assist in my learning
PERCEIVED OUTPUT QUALITY (POQ)	
P134	Compared with traditional learning, I believe that mobile learning is more initiative and dynamic
P135	Compared with traditional learning, I believe that mobile learning is more portable/mobile and flexible enabling anywhere, anytime learning
P136	Compared with traditional learning, I believe that mobile learning enhances daily teaching and learning
P137	Compared with traditional learning, I believe that mobile learning enables high engagement (making me a more involved and active learner)
P138	Compared with traditional learning, I believe that mobile learning ensures learning effectiveness
P139	Compared with traditional learning, I believe that mobile learning provides a better alternative for teaching and learning
P140	Compared with traditional learning, I believe that mobile learning improves communication between students and their lecturer

Second post-mobile learning (post 2) questionnaire	
SAS name	**Question**
ID	Student number
USE	
P202	**I am able to skilfully use mobile devices to:**
P202a	Access the Internet / Go online
P202b	Download and install applications
P202c	Download podcasts
P202d	Watch videos and listen to music
P202e	Send text messages (SMS), instant messages and e-mails
P202f	Access social networking sites (i.e. Facebook)
P202g	View and download course material and assignments
P202h	Complete and submit programming assignments
P202i	Access Blackboard
P203	**Current uses regarding mobile devices for learning purposes: I have …**
P203a	Used mobile devices for library services
P203b	Accessed the university website
P203c	Viewed and downloaded course materials and assignments
P203d	Accessed the Internet / went online for learning purposes
P203e	Used a social networking site (i.e. Facebook) for discussion
P203f	Interacted and communicated with my lecturer
P203g	Interacted and communicated with fellow students
P203h	Downloaded and listened to podcasts
P203i	Recorded information during class (voice recording or taking photos)
P203j	Made notes during class
P203k	Effectively completed and submitted programming assignments
P204	**Where did you use the mobile device?**
P204a	Home
P204b	CPUT Residence
P204c	Computer laboratory on campus
P204d	Theory class on campus
P204e	Elsewhere on campus outside the classroom
P204f	While commuting
P204g	Family / Friends
P204h	Elsewhere off-campus
P205	How frequently did you use the mobile device?
P206	I have used the mobile device mostly during the:
P207	How much time did you spend on average during the week using the mobile device?
P208	**For which events did you mainly use the mobile device for?**
P208a	Personal use
P208b	Information Search
P208c	Homework (any subject)
P208d	Formal subject-related activities (assignment etc.)
P208e	Hobbies / Interests

Second post-mobile learning (post 2) questionnaire	
SAS name	**Question**
P208f	Communication / Collaboration
P208g	Provide help
P208h	Receive help
P208i	Entertainment
P208j	Other
P209	**Who were involved when you have used the mobile device during the course of your studies?**
P209a	Lecturer
P209b	Peer
P209c	Mentor / Advisor
P209d	Technical support
P209e	Friend
P209f	Partner
P209g	Family
P209h	None (except myself)
P209i	Other
P210	Did you pair the mobile device with your cell phone in order to go online / access the Internet?
P211	Did you make use of Bluetooth to share files?
P212	Did you buy a SD memory card to extend the storage capacity of the mobile device?
P213	**Where do you think will you use mobile devices in future?**
P213a	Home
P213b	CPUT Residence
P213c	Computer laboratory on campus
P213d	Theory class on campus
P213e	Elsewhere on campus outside the classroom
P213f	While commuting
P213g	Family / Friends
P213h	Elsewhere off-campus
PERCEPTION	
P214	Should the university require students to use mobile devices during the course of their computer programming studies?
P215	The university is ready to implement mobile learning
P216	**What do you think would need to be changed so that educational offerings on mobile devices can incur a broader common acceptance?**
P216a	Larger display screens
P216b	Lower data cost tariffs
P216c	Lower mobile device costs
P216d	Better processing power
P216e	Larger memory capacities
P216f	Technology unification / consolidation
P216g	Better proliferation (spreading at a rapid rate)
P216h	Other

Second post-mobile learning (post 2) questionnaire	
SAS name	**Question**
ATTITUDE	
P217	I do not want to use mobile devices (i.e. PDA or tablet), because they are too heavy to carry around
P218	I do not want to use mobile devices (i.e. PDA or tablet), because they are too fragile and are easily broken
P219	I do not want to use mobile devices (i.e. PDA or tablet), because I find it difficult to read text on a mobile device screen
P220	I do not want to use mobile devices (i.e. PDA or tablet), because it is hard to enter data using the stylus/pen/touch on a mobile device
P221	What did you like about using a mobile device (PDA)?
P222	What did you dislike about using a mobile device (PDA)?
P223	I would find it acceptable to learn computer programming with mobile device access only
P224	I would prefer to use a mobile device during tests to assist me with coding programs
P225	Compare to the beginning of this semester, how do you feel about the use of mobile devices now?

Learner journal	
SAS name	**Question**
ID	Student number
Date	Date
Time_span	Time span
Duration	Duration
Location	Location
LOC1	Campus
LOC2	Home
LOC3	CPUT Residence
LOC4	Family / Friends
LOC5	Public transport
LOC6	Place of leisure
LOC7	Outdoors
LOC8	Other
Event	Event
EV01	Personal use
EV02	Information search
EV03	Homework (any subject)
EV04	Formal subject-related activities (assignments etc.)
EV05	Hobbies / Interests
EV06	Communication / Collaboration
EV07	Provide help
EV08	Receive help
EV09	Entertainment
EV10	Other
People_involved	People involved
PE1	Lecturer
PE2	Peer
PE3	Mentor / Advisor
PE4	Friend
PE5	Partner
PE6	Family
PE7	Stranger
PE8	None (except myself)
PE9	Other
High_point	Your thoughts (comments / issues i.e. High point - Why)
Low_point	Your thoughts (comments / issues i.e. Low point - Why)