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UNIVERSITI TEKNOLOGI PETRONAS

DEVELOPMENT AND USABILITY EVALUATION OF PLATFORM INDEPENDENT MOBILE LEARNING APPLICATION (M-LA)

by

SAHILU WENDESON SAHILU

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DEVELOPMENT AND USABILITY EVALUATION OF PLATFORM INDEPENDENT MOBILE LEARNING APPLICATION (M-LA)

by

SAHILU WENDESON SAHILU

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DECLARATION OF THESIS

Title of thesis | DEVELOPMENT AND USABILITY EVALUATION OF PLATFORM INDEPENDENT MOBILE LEARNING APPLICATION (M-LA)

I SAHILU WENDESON SAHILU

hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTP or other institutions.

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Date: _____

DEDICATION

Dedicated to my beloved:

- ✓ **Father**

Wendeson Sahilu

- ✓ **Grandmother**

Alemayehu Belaynehe

- ✓ **Mother**

Almaz Manahile

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Last but not least, I would like to express my gratitude to all my family.

ABSTRACT

In today's digital age, wireless technology and widespread use of handheld devices are going under a continuous advancement to provide information anywhere and at anytime. Furthermore, these technologies are being utilized in the field of education and called mobile learning (M-Learning). Hence, M-learning means using of mobile devices and wireless computing as a learning instrument and communication technology respectively. The limitations of M-learning include either hardware or software of mobile devices, content creation, and no standards for mobile learning system (M-LS), wireless technology, and security. The main objectives of this research are to study and design model for M-learning approach; to develop platform independent M-learning application (M-LA) for Fundamentals of Programming course; to design M-LS platform classification, and to evaluate the effectiveness and usability of the application. In addition, under the development of this application the following aspects are considered: learning theories, M-learning development principles, and some of the aforementioned M-learning limitations. To achieve the above mentioned objectives, ADDIE (Analysis, Design, Development, Implementation, and Evaluation) life cycle is adapted which is one type of instructional design model (IDM). The application has been developed using Java 2 Micro Edition (J2ME), and Extensible Markup Language (XML). It contains several sections, but the main modules are Lecture Materials, and Quiz. Quasi Experiment Design and usability attributes was used to evaluate the effectiveness and usability of the application respectively using Universiti Teknologi PETRONAS foundation students. Finally, the data was analyzed using quantitative and qualitative method. The quantitative data was analyzed using coefficient variance and independent t-Test, and Cronbach alpha used to measure the internal reliability of the data. Overall results show that M-LA is efficient to improve learners' performance, makes learning enjoyable, support continuous learning and learning time is reduced, and fulfilled the usability needs.

ABSTRAK

Dalam era digital hari ini, teknologi tanpa wayar dan penggunaan meluas peranti mudah alih akan terus dimajukan untuk menyampaikan maklumat di mana-mana dan pada bila-bila masa. Sementara itu, teknologi ini juga digunakan dalam bidang pendidikan dan dikenali sebagai pembelajaran mudah alih (*M-Learning*). Oleh itu, *M-learning* merujuk kepada penggunaan peranti mudah alih dan pengkomputeran tanpa wayar sebagai alat pembelajaran dan teknologi komunikasi. Antara kelemahan *M-learning* termasuk isu-isu peranti mudah alih sama ada perkakasan atau perisian, pembinaan kandungan, dan tidak mempunyai standard untuk sistem pembelajaran mudah alih (M-LS), serta lain-lain isu luar. Objektif utama kajian ini adalah untuk mengkaji dan merekabentuk model pendekatan *M-learning*; membangunkan platform bebas bagi aplikasi *M-learning* (M-LA) untuk kursus Pengaturcaraan Berstruktur; untuk mereka-bentuk platform klasifikasi M-LS, dan untuk menilai keberkesanan dan kebolehgunaan aplikasi yang dibina. Dalam pembangunan aplikasi ini, aspek-aspek berikut diambil kira: teori pembelajaran, prinsip-prinsip pembangunan *M-learning*, dan beberapa kelemahan *M-learning* yang dinyatakan di atas. Untuk mencapai objektif-objektif yang dinyatakan di atas, ADDIE (Analisis, Reka Bentuk, Pembangunan, Pelaksanaan dan Penilaian) diterapkan dalam kitaran hidup M-LA yang merupakan salah satu jenis model reka-bentuk pengajaran (IDM). Aplikasi ini telah dibangunkan dengan menggunakan *Java 2 Micro Edition* (J2ME), dan *Extensible Markup Language* (XML). Aplikasi ini mengandungi beberapa bahagian, tetapi modul utama adalah Bahan Kuliah, dan Kuiz. Reka Bentuk Eksperimen Quasi dan elemen-elemen kebolehgunaan telah digunakan untuk menilai keberkesanan dan kebolehgunaan aplikasi terhadap pelajar pegajian asas dari Universiti Teknologi PETRONAS. Akhirnya, data telah dianalisis dengan menggunakan kaedah kuantitatif dan kualitatif. Data kuantitatif telah dianalisis dengan menggunakan pekali varians dan t-*Test* bebas, dan *Cronbach alpha* digunakan untuk mengukur kebolehpercayaan dalaman data. Keputusan kesuluruhan menunjukkan M-LA berkesan untuk

meningkatkan pencapaian pelajar, membuatkan pembelajaran lebih menarik, menyokong pembelajaran berterusan dan mengurangkan masa pembelajaran, dan memenuhi keperluan-keperluan kebolehgunaan.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

R	Random learning
F	Formal Education
INF	Informal Education
NF	Non-formal Education
PDA	Personal Digital Assistant
W/H	Wireless Handheld
SMS	Simple Messaging Service
MMS	Multimedia Messaging Service
BBC	Britain Broadcasting Corporation
GPS	Global Positioning Service
M-Learning	Mobile Learning
E-Learning	Electronic Learning
E-Commerce	Electronic Commerce
M-Commerce	Mobile Commerce
ICT	Information Communication Technology
E-mail	Electronic Mail
M-LA	Mobile Learning Application
ISO	International Standard Organization
ADDIE	Analysis, Design, Development, Implementation, Evaluation
ISD	Instruction System Design
GUI	Graphical User Interface
ID	Instruction Model
IDM	Instruction Design Model
M-LS	Mobile Learning System
XML	Extensible Markup Language
XSLT	Extensible Stylesheet Language Transfer
KXML	K-Extensible Markup Language
IDE	Integrated Development Environment
PNG	Portable Network Graphics
J2SE	Java 2 Standard Edition
WMA	Windows Media Audio

J2EE	Java 2 Enterprise Edition
J2ME	Java 2 Micro Edition
SQL	Structured Query Language
IIS	Internet Information Server
SSL	Secure Socket Layer
MLI	Mobile Lecture Interaction
PHP	Hypertext Preprocessor
HTML	Hypertext Markup Language
DBMS	Database Management System
DOM	Document Object Model
SAX	Simple API for XML
JSR	Java Specification Request
CLDC	Connected Limited Device Configuration
CDC	Connected Device Configuration
ASSURE	Analyze, State, Select, Utilize, Require, and Evaluate
KVM	K-Virtual Machine
CVM	Conventional Virtual Machine
JVM	Java Virtual Machine
C_o	Control Group
E_x	Experiment Group
ChE	Chemical Engineering
ME	Mechanical Engineering
PE	Petroleum Engineering
CE	Civil Engineering
SPSS	Statistical Package for Social Sciences
UL	User Layer
2L	Logical Layer
AL	Application Layer
SL	Storage Layer
OS	Operating System
HTTP	Hypertext Transfer Protocol
IrDA	InfraRed Data Association
GPRS	General Packet Radio Service
GSM	Global System for Mobile communication
IEEE 802.11	Standard for Wireless Local Networks

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Education is the process of teaching and learning to transmit accumulated knowledge that has a formative effect on the mind, character, or physical ability of an individual (Escotet 1994). Today, there are four broad categories of learning activities as shown in Figure 1.1: Random learning (R); Formal education (F); Informal education (INF); and Non-Formal education (NF) (European Commission 2006). Random learning is not intentional learning but, which can happen in any activities whose main purpose is not learning. Formal education is the education that takes place in school and it involves teachers and students face to face using a given curriculum and continuous ladder of the system like conventional learning. Informal education is intentional way of learning, but it is less organized and structured that goes on in daily life which can be received from daily experience, such as from family, friends, peer groups, and other influences in person's environment (European Commission 2006). Finally, Non-Formal is defined as any organized and sustained educational activities with no particular class time which takes place both inside and outside educational institution. Hence, either printed or electronic media used to communicate both learners and educators which is called distance education. The main objective of distance education has always been on the individualization of teaching, learning and for communication between students. Generally, Non-Formal education is used to make learning materials easily accessible.

The next development of distance education was electronic learning (E-learning). E-learning is defined as the provision of education and training electronically, on the Internet and Web by removing the boundaries of the classes, saves costs of education and makes it available at every time and for the right person (Keegan 2005).

E-learning is essentially the computer and network that helps learners and educators to customize and personalize learning content targeted toward enhanced performance and enabled the transfer of skills and knowledge.

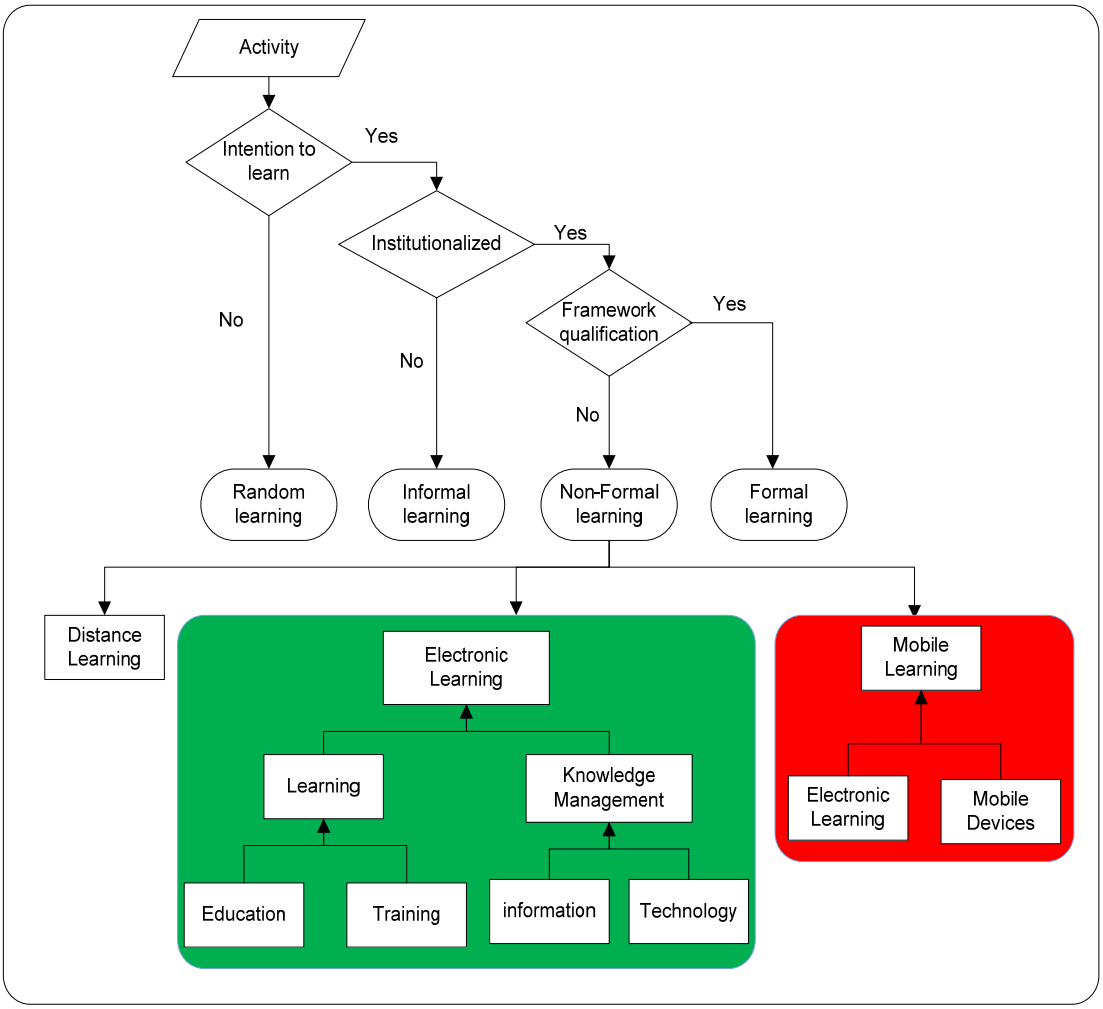

Figure 1.1: Types of Learning System (European Commission 2006)

Recently, wireless and mobile technologies are under the great advancement which leads to mobile period. With the new paradigm "anytime and anywhere computing" a shift from Electronic to Mobile services has begun (Lehner and Nösekabel 2002). Currently, electronic commerce (E-commerce) is extended to mobile commerce (M-commerce), and E-learning to mobile learning (M-learning). By July 2010, Britain Broadcasting Corporation (BBC) reported that more than a billion mobile phone connections have been added to the global tally in just 18 months and makes more than 5 billion mobile phone connections worldwide, according to

wireless intelligence (BBC July 2009). This shows that the number of mobile users is growing faster, and also due to its mobility nature it is used for different application. The term mobile device includes every portable devices like cell phones, smart phones, Personal Digital Assistant (PDA), tablet personal computers, and similar to wireless and handheld (W/H) devices. Due to mobility, size, and weight of mobile phones, they are very comfortable to use. In addition, mobile devices support different types of capabilities such as Simple Messaging Service (SMS) for text messaging, Multimedia Messaging Service (MMS) for multimedia messaging, audio, video, electronic mail (E-mail), Global Positioning Services (GPS), and camera to take pictures.

M-Learning is becoming the third form of education and training. M-learning has been defined as E-learning through mobile and handheld devices using wireless computing technology as a communication media (Lehner and Nösekabel 2002). In other word, M-learning means utilizing of mobile devices as a learning instrument. The use of Information and Communication Technology (ICT) has improved learning from specific to everyplace. In addition, since wireless handheld devices are being highly individualized, the collaborative communication tools are giving a flexible facilities by complementing and extending the current ways of learning (Motiwalla 2007) as well as makes ubiquitous. On the other hand, a wide varieties of mobile devices and also their constraints are affected the development of mobile learning systems (M-LS) which are presented in the entire thesis.

For the advantages offered by the M-learning approach, it could have a potential to add-value on the existing learning system if it is leveraged properly. In addition, learning of Fundamentals of Programming course can be made more exciting and learners are able to learn enjoyably and also effectively. This is anticipated to enhance their interest and performance.

Universiti Teknologi PETRONAS (UTP) is a higher institution that requires students to take Fundamentals of Programming classes which is compulsory for all students in the foundation program and new concept almost for all students. Moreover, it is mainly emphasized on concepts and not too much wordy. However, this course requires hands-on exercises and practices, and direct guidance from the

lecturer like traditional learning. But, it does not support online execution of programming exercises which is taken as a future work. Hence, the main aim of this research is complement the current learning system. The course is mainly focused on basic principles of C++ programming and addresses the following main concepts: Introduction, Selection Statements, Loop, Array, Function, and basics on File.

1.2 Problem Statements

The problems that have been identified in this research will be discussed as the following:

1.2.1 Problems of Conventional Learning

As discussed in the previous section, conventional learning is a type of formal education which takes place in school using face to face approach between students and lecturers using a given curriculum. Nevertheless, students' level of understanding towards the subject matter is different which affect the relation of learners and lectures during the class. On the contrary, it has a good socialization among students and allows them to learn from one another which cannot be obtained from any kind of learning system. Conversely, it cannot facilitate learning anytime and anywhere continuously (Devinder and Zaitun 2006). In other word, it does not support ubiquitous and personalize learning which is helpful for all students to improve their performance (Jacobijn Sandberg, Marinus Maris et al. 2011).

Prior to conducting this research, a preliminary survey on the M-learning approach, which involving 90 students in the foundation program was carried out to ascertain the problems faced in conventional learning, experience towards using mobile devices for different applications including learning, types of mobile devices they own, limitations of mobile devices, and their demographic data (the survey set is as in Appendix A) (Shu-Sheng Liaw , Marek Hatala et al. 2010). From the survey, two main areas of difficulties have been identified and are discussed in the following section. In addition, about 80% of students agreed to have M-learning facility as assistance (Wendeson et al. 2010). These and other factors motivated the researcher to

develop platform independent Mobile Learning Application (M-LA) to enhance conventional learning for Fundamentals of Programming course which is new concept almost for all foundation students. Hence, M-LA helps them to revise and realize the concept by giving assistance and guidance throughout the learning of the course beyond the laboratory. On the other hand, conventional learning has irreplaceable advantages such as good socialization among students and lecturers, to enquire questions about their class, to get guidance directly and on time, and remain motivated in the teaching and learning process. Due to these reasons, M-learning does not have a potential to replace conventional learning. However, it has a capability to assist students.

1.2.2 Issues with Mobile Phones

Problems of mobile phones can be considered from two aspects; diversity of mobile devices and their constraints. At present, there are various types of mobile device brands with different specification. In addition, they have different types of capabilities and constraints. The broad categories of mobile device constraints are both hardware and software. The main hardware limitations are memory, processing speed, storage capacity, battery life time, and screen size. On the other hand, software limitations are such as operating system (platform) and web browser. For these reasons, writing application for each kind of mobile devices is very tedious, tough and requires a lot of efforts. Moreover, maintenance of the application is challenging and costly. Hence, there should be a strategy to design contents once and develop platform independent application which can be reused for various target devices.

1.23 Issues of Common Instructional Design

Instructional Design (ID) is the entire process of analyzing the learning needs and goals to translate general principles of learning and instructions into plans for instructional materials and activities to meet those needs either by designing a new material or restructuring the existing one (Wilson and Ryder 1998). To design instructions there are different factors to consider which are learners' need, and other

external factors. Specifically, as discussed in the above sections, in M-learning approach the main factors include hardware and software limitations. These factors can affect the content creation and instructional design. Contents can be represented in different kinds of multimedia formats like, video, audio, picture, and texts (Jacobijn Sandberg, Marinus Maris et al. 2011)
. As discussed in Section 2.5.3, video and audio formats need more memory space than pictures and texts. In addition, due to diversification and limitations of mobile device; creating contents and design instructions which can be device independent is a big challenge. Furthermore, it is difficult and time consuming to create contents and designing instructions for each kind of mobile devices. Hence, there should be strategies to select the type of displaying format, and designing instruction which can be fit into the selected mobile devices.

1.2.4 No Standard for Mobile Learning System

Standard is used as a reference to define the technology selection and examine different systems (Evgeniya et al. 2005). As discussed in the above sections, there are many different types of mobile devices either by brand or capabilities or constraints. Due to these factors, that is difficult to have one rigid standard for M-LS implementation. Therefore, in this research platform classification of M-LS is designed by using previous studies and also other external factors which are affecting implementation of mobile applications. The basic advantage of having this classification is to scrutinize the application and select technology as well.

1.2.5 Issues of Learning Theory

Learning theory is used to deal about how to learn and maximize their performance from the field of educational psychology. However, it is affected by the type of learning system and also other external factors like, the nature of the course, the learners, and environmental issues. In M-LS, the nature of mobile devices, their diversification, and other external factors have affected the implementation of

learning theory in the system. Currently, there are different types of learning theories based on their treatment.

1.3 Objectives

Based on the identified problems from the preliminary survey which are discussed in Section 1.1 and 1.2, this study aims to develop a platform independent M-LA prototype using M-learning approach. In addition, the prototype will evaluate its effectiveness and usability. The major benefit of the application is to assist students in learning basic concepts of Fundamentals of Programming course. The following four specific objectives to be achieved after the completion of this study:

- To design instructional model for the whole M-LA using Fundamentals of Programming as a case study.
- To propose the design of mobile learning system (m-LS) platform classification using different parameters to evaluate and identify system requirements.
- To develop platform independent M-learning prototype for Fundamentals of Programming course by incorporating educational theories, and multimedia elements such as text and pictures.
- To evaluate the effectiveness and usability of the application.

1.4 Research Questions

As discussed in Section 1.1, in this study Fundamentals of Programming is used as a case study. Hence, M-learning approach is proposed to develop M-LA for the aforementioned course to assist students. To accomplish the research objectives, the following research questions are summarized as follow:

i. How can a simple model of platform independent M-LA be designed and implemented?

In order to design and develop the model of M-learning approach, a study is needed in order to understand different kinds of approaches from the previous studies and to be used as a reference. A review of different M-learning approaches is presented in Chapter 2, Section 2.3; while in Chapter 3, Section 3.2 the design for the suitability of this M-learning approach and development process are discussed. Finally, under Section 4.2 the technical details, operating scenario, and the process flow of each module are discussed.

ii. What are the main factors that are affecting the development of M-LS? and how platform classification of M-LS is designed?

There are different factors which are affecting the development of mobile application for learning. These factors are presented in Chapter 2, Section 2.5. Moreover, they are used to design platform classification which is presented in Section 3.2.5.

iii. How can IDM generated for M-learning approach?

In order to design IDM for M-LA, ADDIE (Analysis, Design, Development, Implementation, and Evaluation) is used. Briefly, it is presented in Section 3.2.

iv. How can learning theories be applied in M-LS

Though there are different types of learning theories some of them are used in this research and presented in Section 2.4. In which, these theories are applied in this application and summarized under Section 4.2.6.

v. How can the usability of M-LA be evaluated?

The usability of the application will be measured using the following attributes such as, Learnability, Memorability, Simplicity, and Satisfaction which are adopted from the previous studies and International Standard Organization (ISO 9241-11) (ISO; Han Joon Kim et al. 2008). The needs

of usability studies are to answer the following questions that are stated below:

- Do the students agree with the usability elements of M-LA?
- Does the application is interactive, and easy to use?
- Do the contents of M-LA help students to realize the course well?

vi. How can the effectiveness of M-LA approach for Fundamentals of Programming course be evaluated?

The effectiveness of the M-LA will also be measured and should answer the following sub-research question as follow:

- Does M-LA able to improve learners' comprehension of the Fundamentals of Programming course, and enhance conventional learning?
- Does using of mobile devices as a learning instrument been effective to students in teaching and learning?

1.5 Scope of the Study

The scope of the study is outlined as follows:

- The scope of the study is focused on the Fundamentals of Programming course, specifically Selection Statements, Loop, and Function topics in the domain of UTP.
- The design and development of the application is mainly emphasis learners' side and considered some of the limitations which are discussed under Section 2.5.
- The proposed application is mainly focused on educational materials and has two main modules, lecture materials and quizzes. Finally, its effectiveness and usability is evaluated.

1.6 Conceptual Framework

The general overview of this research work is about the full description for the development of platform independent M-LA and its evaluation. This research mainly contains the elementary components of Instruction Design Method (IDM), development design, and evaluation. Figure 1.2 depicts that the overview of research works of the M-learning application development and its evaluation. ADDIE (Analysis, Design, Development, Implementation, and Evaluation) has been adapted into M-LA life cycle as the IDM, and designing platform classification to examine the M-LS. The evaluation is included to measure the effectiveness and usability of the system.

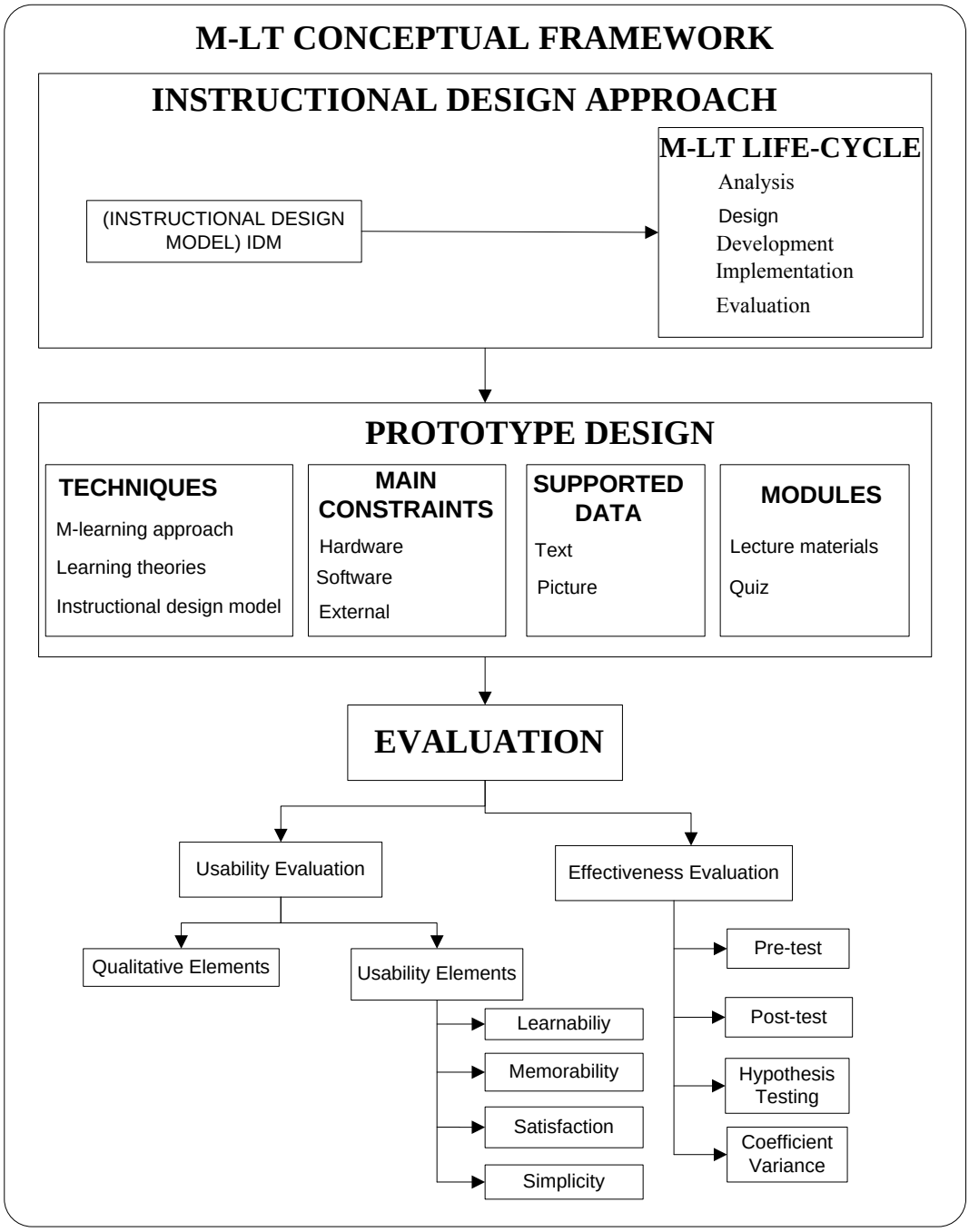

Figure 1.2: Conceptual Framework

1.7 Thesis Organization

This section provides the chapter outline of the thesis

Chapter 1 (Introduction):- discuss the background of the study under Section 1.1. Section 1.2 presents the context in which the research problem is studied. The objectives of the study are described in Section 1.3. Furthermore, the other main subchapters are scope, conceptual framework, and contribution of the thesis describe under the reaming sections of the chapter.

Chapter 2 (Literature Review):- presents a review of the literature pertinent to the topic under study. Section 2.1 describes the overall overview of the chapter. It examines various definitions of learning systems, and also limitations of mobile devices which are given under Section 2.2 and 2.3. Section 2.4 contains a brief description, advantages, and previous doings about learning concepts, styles, and theories. Section 2.5 presents the problems of M-LS development from different dimensions in detail. In addition, it also examines various literatures. Finally, Section 2.6 dictates the trends of this research followed by chapter review as a conclusion.

Chapter 3 (Methodology):- describes the research methodology adopted for the thesis. Introduction of the research methodology is given in Section 3.1. M-LA life cycle using ADDIE discussed in Section 3.2. Section 3.3 contains brief description about the software and tools used for development. Section 3.4 provides detailed explanation on methodology of usability study, and Section 3.5 describes chapter conclusion.

Chapter 4 (Result and Discussion):- presents the development of the prototype such as technical details, operating scenario, and the process flow of modules. The remaining sections deal with analysis of both the effectiveness, and usability evaluation data by using quantitative and qualitative methods.

Chapter 5 (Conclusion):- contains research objectives, limitations, future work, and conclusion of the thesis. Mainly, it is used to summarize the results of the research and its contributions.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to discuss basic definitions of terms relevant to this study and summarize different sets of related works using different parameters. This chapter is organized as follows: Section 2.2 discusses the transition of electronic learning (E-learning) to mobile learning (M-learning); Section 2.3 presents about mobile learning system (M-LS) and different parameters which are used to evaluate the previous related works: Section 2.4 describes about learning concepts and theory to address how learners learn and improve their performance. Section 2.5 explains about the problems of M-LS that most researchers are faced to develop M-LS. The last but not the least, the trained of M-LS will present followed by chapter summary as a conclusion.

Learning system is derived from two words learning and system (Diane and Kent 1996). Learning means a process of grasping, digging, or assimilating information or knowledge in day to day life. System means how this information does flow between the learner and educator. Therefore, learning system means the process of knowledge or information flow between the two ends. There are different types of learning systems to make teaching and learning process, and improve the learners' performance.

As discussed in Section 1.1, through the advancement of computer devices and Internet, distance learning which has been changed to E-learning, was evolved. Finally, M-learning became in existence which is the next generation of learning systems. The use of mobile devices for educational purposes is formerly explored by (Broadbent 1997), but the term M-learning became familiar in recent years of literatures. Thus, in the sequel, the transition of E-learning to M-learning is presented.

2.2 Transition from E-Learning to M-Learning

Currently, most researchers are writing about M-learning approach which is used to enable anywhere, anytime, and personalized learning using portable devices. It will facilitate communication and collaboration among participants in authentic and appropriate contexts of use. As discussed in the above section, M-learning is the next generation of E-learning to achieve aforementioned benefits. Figure 2.1 and 2.2 show that the transition from E-learning (using wired) to M-learning (using wireless) in a simple diagrammatic fashion (Landers 2002).

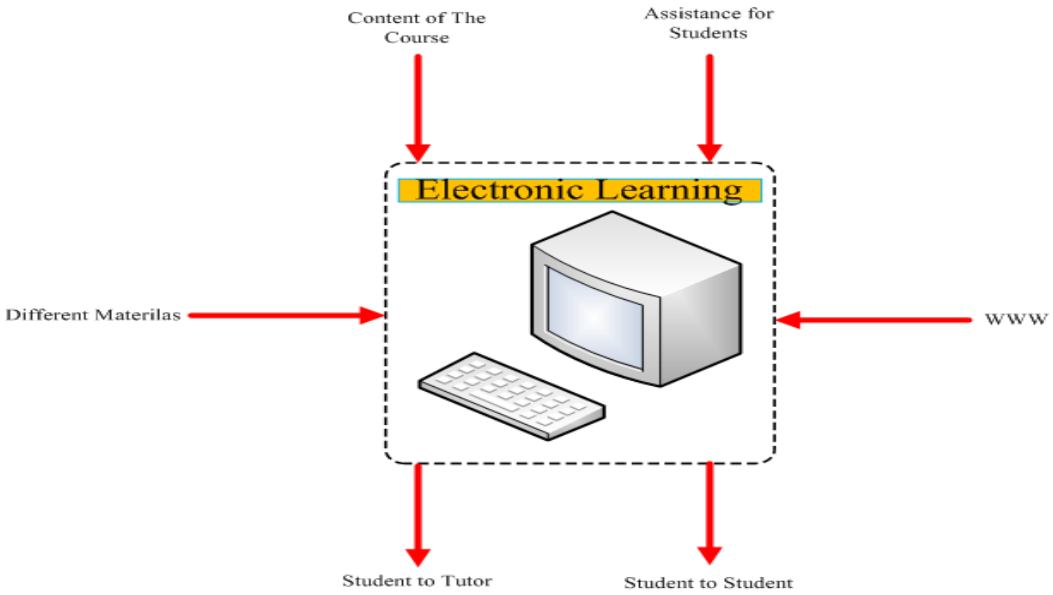

Figure 2.1: Wired Virtual Learning Environment of Today (Landers 2002)

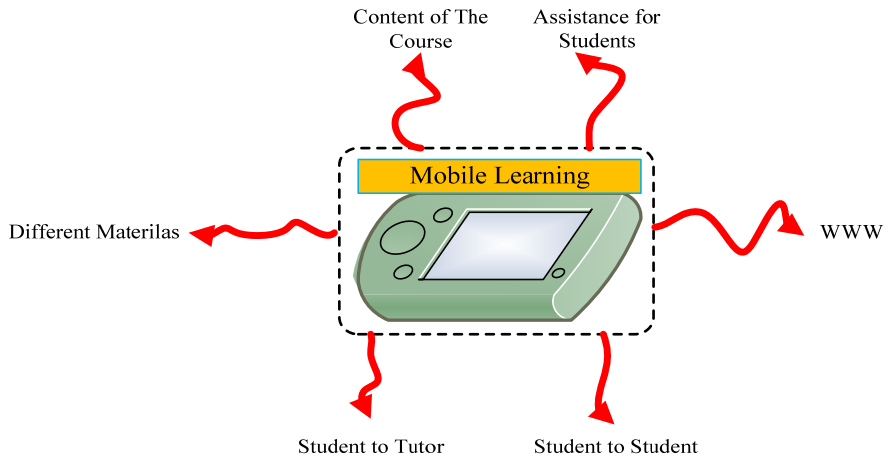

Figure 2.2: Wirelesses Virtual Learning Environment of Tomorrow (Landers 2002)

The M-learning transition from E-learning has been marked by many researchers (Nyiri 2002; Sharma and Kitchens 2004; Evgeniya et al. 2005; Laouris and Eteokleous 2005; Nyiri 2005) to make learning ubiquitous. According to Sharma and Kitchens (2004), this transition from E-learning to M-learning has been accompanied by changing the terminology as shown in Table 2.1:

Table 2.1: Terminologies to Compare E-learning and M-learning

E-learning	**M-learning**
Computer	Mobile
Bandwidth	GPRS, G3, Bluetooth
Multimedia	Objects
Interactive	Spontaneous
Hyperlinked	Connected
Collaborative	Networked
Media-rich	Lightweight
Distance learning	Situated learning
More formal	Informal
Simulated situation	Realistic situation
Hyper-learning	Constructivism, Situationism, Collaborative

Valentine (2004) observed by Mellow (2005) drew three conclusions about M-learning and its perceived relation to E-learning ;

- M-Learning is a sub-set of E-Learning
- M-Learning is a means to enhance the broader learning experience, not a primary method for delivering courses/distance learning;
- M-Learning is a powerful method for engaging learners on their own terms especially for those who are classified as non-traditional learners.

The appropriate practices of M-Learning have many benefits: Some of them are (Attewell 2005),

- To improve their literacy and numeracy skills and to recognize their existing abilities;
- To encourage both independent and collaborative learning experiences;
- To identify areas where they need assistance and support;
- To combat resistance to the use of ICT and can help bridge the gap between mobile phone literacy and ICT literacy;
- To remove some of the formality from the learning experience and engages reluctant learners;
- To remain more focused for longer periods;
- To raise self-esteem and self-confidence.

As discussed above, M-learning is originated from the E-learning using mobile devices as a learning instrument and wireless computing as a communication technology. In the following section, previous studies on M-learning approach will be reviewed by using different parameters.

2.3 M-learning Approach

The term M-learning approach is given to the delivery of learning materials by means of mobile devices that can be accessed anywhere and anytime by developing M-LS. Currently, some of the higher institutions are using M-LS as a complementary to get the aforementioned advantages. Due to the varieties and limitations of mobile devices, there is no rigid conventional standard or specification to develop M-LS. Thus, there are various types of M-LS using different specification depends on the case study. Nevertheless, evaluation has been made according to their capabilities and services they support using some of the indicators which are specified in (Dye and Torstein 2008; Attewell 2005; Evgeniya et al. 2005; Naismith et al. 2005). These are: types of supported mobile devices; availability of content; supported types of data and tools

used; and types of information. In addition, Instruction Design Model (IDM) is used in this thesis as an indicator.

2.3.1 Types of Supported Mobile Devices

The term mobile device includes not only mobile phones, smart phones and PDA, but also every portable device for instance, tablet PCs and laptop. However, there are thousands of different brands of mobile devices with different constraints that are discussed in Section 2.5.1. Therefore, these heterogeneity and limitations make development of platform and device independent M-LS very challenging. Additionally, currently there is no one rigid standard for M-LS development. Due to the above reasons, most researchers select devices based on the type of end users' mobile devices and content structure rather than considering all types of mobile devices. Most researchers used either less constrained devices or conducting preliminary survey to know their end-users' types of mobile devices in order to select supported devices. Through the aforementioned constraints different types of M-LSs are developed which are companionable to different types of mobile devices and also environments. In consideration of the above factor, different M-LS studies are summarized below.

The name M-learning was becoming familiar in the mid 1990's. However, in 2002 and 2003, a number of M-LS studies were undergoing. Some of them are reviewed here. WELCOME (Wireless E−Learning and Communication Environment) is a M-learning approach at the University of Regensburg which supports both PDA and Pocket PCs as a selected mobile devices based their capabilities and less constrained features (Lehner and Nösekabel 2002). Sharples, et al. (2002) developed HandLeR (Handheld Learning Resource) at university of Birmingham to provide learning resources and assist for all ages of learners in their personal learning using handheld devices which have fulfilled the requirements mentioned in (Sharples et al. 2000). Farooq, et al. (2002) have contributed an existing desktop-based online access virtual environment, MOOsburg, to W/H devices to allow students participation in educational trip to learn about ecology and to assess environmental water qualities,

MOOsburg++. Due to the features of the application, PDA, cellular phones and pagers are used in this application. Moreover, these devices have high memory size and less constrained. MobilP (Mobile learning platform) is a web based learning system which supports both mobile and non-mobile computing devices (Yuen-Yan et al. 2003). It aims at providing educational contents and communication services to teachers and students, anytime and anywhere.

Since 2004, there are different M-LS studies and some of them are reviewed here. Mobile Learning Engine (M-LE) (Meisenberger and Nischelwitzer 2004) is a computer-aided and multimedia learning application which enables students to use mobile as a medium of learning. It supports only smart phones (a mixture between a mobile phone and a personal digital assistance) as a device of choice by considering the type of learners' mobile devices they own. However, it does not support a broad range of mobile devices. Mobile Eldit (m-Eldit) (Trifonova and Marco 2004) means a Mobile Electronic Learner's Dictionary of German and Italian at Trento University, Italy which supports both PDA and Pocket PCs. MOBILE (Tan-Hsu Tan and Tsung-Yu Liu 2004) is a MObile-Based Interactive Learning Environment which aids elementary school English learning using PDA to send and receive learning materials form the M-LS. Devinder and Zaitun (2006) have developed M-learning application for Wireless Classrooms at University of Malaya which aims to facilitate the educational opportunities of teaching in a real time wireless classroom using Pocket PC, notebook and mobile phone as a learning instruments on windows platform. Moreover, Anang et al. (2006) have developed M-learning management tool in campus-wide environment by using Microsoft.Net infrastructure which is windows platform. The system is deployed using multiple devices including Nokia 6210, Pocket PC with Microsoft Internet Explorer v.4.5., and Sony Ericsson R380 (Anang et al. 2006). WAP-supported devices from a wapsite and website using WML based applications was used in (Motiwalla 2007; Li He et al. 2009). On the other hand, WML applications have the following drawbacks: limited types of objects, cannot integrate programming logic, increased number of requests to the server, and limited memory of WAP browser.

As discussed above the supported devices in M-LS are selected either by the purpose of the system, or types of end users' mobile devices or other environmental factors. Hence, in this research both the natures of the content and preliminary survey were used to choose the type of supported mobile devices. The preliminary survey (the survey is as in Appendix A) was used to know learners need and also type of mobile devices they own. Finally, smart phones, PDA, and laptop are selected as a supported device of the system.

2.3.2 Availability of Content

At present, depending on the communication between M-LS and users there are three types of access methods (Evgeniya et al. 2005). The first type of access method requires permanent communication between the system and users' mobile device which is called on-line M-learning (Mobile and Quest; Lehner and Nösekabel 2002). Hence, the mobile devices should have more processing speed, memory capacity and battery consumption. Moreover, according to Niazi and Mahmoud (2008), there are two types of technologies which are supported online access method of the contents which are, browser based and native technology. In browser-based, applications are developed using markup languages such as HTML, WML, and others (Ivanov and Momchedjikov 2010; Tan-Hsu Tan and Tsung-Yu Liu 2004). However, native technology is used by developing simple software which can be run in runtime environment by using XML as a backend to store the contents (Niazi and Mahmoud 2008). The next one is offline M-learning which means using communication temporarily to download the materials and used later whether there is communication or not (Trifonova and Marco 2004; Anang et al. 2006). However, it needs mobile devices with high processing speed, much memory space, and high battery life. The last type of system is which can ensure both on-line and off-line M-learning by comprising the advantages and disadvantages of both types of access methods (Lehner and Nösekabel 2002; Niazi and Mahmoud 2008).

As mentioned above, the second type of accessing method is offline which download the material and used anywhere and anytime. M-LA supports offline access

method and has a potential to support native technology due to the supported data format which is XML (Niazi and Mahmoud 2008). In this research, the application is developed and deployed in the device while using either Bluetooth or IrDA to share each other. Additionally, it is also possible to get access using either from laptop or PC through USB cable.

2.3.3 Types of Supported Data

The content of the system is a fundamental part of M-LS. Hence, they are represented in multimedia format which can be audio, video, image or texts. The first two, audio and video files (O'Connell and Smith 2007) need much memory and high processing speed of mobile devices. In addition, screen size and battery consumption are the other factors. On the other hand, they have advantage to make the learning interactive. Image or pictorial representation of concepts also needs much space, but lesser than audio and video. Due to the above reasons, most of the researchers are using pictures (Tan-Hsu Tan and Tsung-Yu Liu 2004) including in this research specifically Portable Network Graphics (PNG) file extension format. The last one is text which is the most familiar type of representation due to memory scarce and other mobile device limitations. Some of the previous M-LS supported data types are HTML (Cruz et al. 2008), XHTML (Niazi and Mahmoud 2008), WML (Motiwalla 2007; Li He et al. 2009), XML (Meisenberger and Nischelwitzer 2004; Trifonova and Marco 2004; Devinder and Zaitun 2006), and Flash (Lehner and Nösekabel 2002). In this research both J2ME midlets, and XML text file formats are used.

2.3.4 Types of Information

Currently, mobile devices are used for different applications such as education, commerce, etc. Depending on the access to learning materials and/or administrative services the existing M-LS (Evgeniya et al. 2005) may support either of one or both of them. When an M-LS support accessing of educational materials like test, dictionaries, test, lecture materials, etc means system is intended for educational services only (Sharples et al. 2002; Yuen-Yan et al. 2003; Meisenberger and

Nischelwitzer 2004). On the other hand, there are systems which are supported only administrative services (Mobile and Quest) of the educations like changed in timetable, exams and others. The third one is that the system which can have a potential to support both of the above services accessing of educational as well as administrative materials (Ivanov and Momchedjikov; Lehner and Nösekabel 2002; Anang et al. 2006). This study is intended for educational purpose.

2.3.5 Instruction Design Model

As shown from the title, Instructional Design (ID) is derived from two words Instruction and Design. Instructional means a set of events that facilitate learning. Design means a creative pattern or a rational, logical sequential process intended to solve problems. Therefore, Instructional Design Model (IDM) means the systematic process of translating general principles of learning and instructions into plans for instructional materials and activities in a consistent and reliable sequential fashion (Reiser and Dempsey 2007). Systematic usage of instructional design enables the developer to: identify a performance problem; determine the goals and objectives; define learners and their needs also; develop strategies to meet their needs; assessing learning outcomes; and evaluate if goals, objectives, and needs are met (Jemal Harun).

Based on the area of implementation, IDM is divided in to three broad categories, these are: classroom, product, and system (Gustafson and Maribe 2002). Classroom model are designed by teachers in classroom using the basic principles through considering the teaching and learning environments using the existing materials rather than designing new. However, these models have less rigorous formative evaluation and revision than product or system models. Product-oriented models are prescriptive in nature, and primarily focused on creating instructional products without any contact between users and developers. Hence, product models are not used to create comprehensive systems as system models are. Systems-oriented models are used to develop large amounts of instructions which can be courses or curricula and may include the development of new materials or restructuring of the existing materials.

According to the aforementioned areas of IDM definitions and nature of M-LS implementation, system-oriented model is used for M-learning application.

To design ID for the above specified areas and develop learning system application, there are numerous IDMs (Jemal Harun): Analysis, Design, Development, Implementation, and Evaluation (ADDIE); Analyze, State, Select, Utilize, Require, and Evaluate (ASSURE); Hannafin and Peck; Waterfall (Devinder and Zaitun 2006), Rapid Prototyping; Hypermedia Design; and multimedia models. ADDIE is used in this research to develop M-LA.

Due to lack of M-LS standard or specification, different researchers are used different types of learning framework, tools and learning resources file types which affect learner performance. Moreover, this can be improved if the right contents are covered in the system considering the limitations of mobile devices and shows how the learning practices has been applied among students. Therefore, due to mobile devices limitations and other factors, system-oriented IDM is very essential to make the general principles of learning in consistent, reliable, and concise fashion.

2.4 Learning Concepts, and Theories

Learning is a continuous process and mobile in terms of space, i.e. it happens at the workplace, at home, and at a place of leisure (Giasemi et al. 2004). It has a potential to change learners' behavior or understanding (Smith 1999). In addition, it is also used to get knowledge, skill, improve their performance either in formal class or not.

There are different types of learning theories, which are used to address how people learn and accelerate their performance from the field of educational psychology. Adherence to test practice pedagogical principles should lie at the heart of any M-learning projects. Learning theories are important to relate the techniques of learning and teaching among students. In order to implement the learning theories an individual's natural, habitual, and preferred ways of absorbing, processing, and retaining new information and skill should be considered (Sapiyan et al.). In addition, the nature of the topics and types of learning system should be considered to choose

suitable learning theories. In this research learning theories are adopted to accelerate learners' performance.

Different types of learning theories are presented in (Giasemi et al. 2004; Naismith et al. 2005; Siemens 2006). According to the characteristics of M-learning approach, the following learning theories are adapted in this research, these are: Behaviorism, Cognitivism, and Constructivism. The implementations of these learning theories are presented under Section 4.2.6.

2.4.1 Behaviourism Learning Theory

Behaviorism learning theory is activities that promote learning as a change in learners' observable actions. This paradigm draws on Skinners work on operant conditioning and behaviorism (Skinner 1968) based on Pavlov's work on classical conditioning (Naismith et al. 2005). In this theory, learning is facilitated through the reinforcement of an association between a stimulus and response which also known as drill and feedback. The source of knowledge is experience. The implementation of this learning theory in M-learning can be described as follows.

The use of mobile devices to present the learning materials and also specific question; obtain responses from the learners by answering the questions; and finally the system provide appropriate answer to the learners. In the meantime, presentations of questions are called Stimulus; the contribution from the part of the learner to the solution is response; and comments from the system replies the whether the answer is correct or not are called reinforcement (Naismith et al. 2005). As discussed in Section 4.2, quiz is the main module in M-LA. The evaluation system for students at the end of every chapter illustrates stimulus implications. In which, students replied for each questions as a response. Finally, the system evaluates the response and display the correct answer. These activities are used to promote learners performance through changing their observable actions.

2.4.2 Cognitivism Learning Theory

Cognitivism learning theory is the advancement of behaviorism theory by incorporating brain based learning. As stated in the *thinkquest* website, cognitivism is a learning through watching, touching, reading, or experiencing, then processing and memorizing the information (Thinkquest and Website). This theory is more effective than behaviorism theory since the behaviorism theory only suggests the try and error process and focuses on observable behavior.

According to Gagné, (1974, as cited in Monsakul & Ed.D, 2008), stated that learning started from the simple to the tough level. The higher learning level is dependent and related to the level before (Monsakul and Ed.D. 2008). Hence, the sequences of situations should be arranged accordingly since it can help to process the interior and critical cognitive information during the teaching course. Nine situations were mentioned, which are: get attention; present the learning objective; remember the past lessons; present the course contents; give the guidance/ assisted learning tools; get to know students' behavior via asking question; get the right response; examine the performance; and pertain the memory and transfer the learning. Therefore, to keep the flow of contents smoothly from simple to tough, ADDIE is used to design the instruction considering the aforementioned nine conditions. Mainly, this kind of flow makes the learning easy and builds learners' performance.

According to Siemens George (2006), cognitivism learning theory is used to interpret the realities which exists and mediated through symbol and signs. This kind of learning system is more of better than textual formats to transfer the main ideas of the content and does not consume more space. Therefore, due to limitations of mobile devices, figurative representation is used to present the basic concepts of the content including a bit textual explanation.

2.4.3 Constructivism Learning Theory

Constructivism is the most advanced theory compared to the two types of learning theories discussed earlier. Many educators have agreed that constructivism approach

is the most effective approach for learning activities. Constructivism learning theory as defined by Schneider (2006) is all about the ability of learners to construct new concepts or their previous experience into their own understanding (Schneider 2006). The activities in which learners actively construct new ideas based on both the current and previous knowledge is called Constructivist (Naismith et al. 2005). According to Jonassen also, constructivism is more of dependent on the mind of apprehend to construct a reality and interprets it based on his or her apperceptions (Jonassen 1991). It is a very personal endeavor, whereby internalized concepts, rules, and general principles may consequently be applied in a practical real-world context and promotes active learning. The main issue in constructivism learning is the practice of explaining the 'why' question. For that, based on the information that has been processed in the brain, the learners are able to relate the knowledge to their daily lives.

According to the social constructivist approach, instructors have the role of facilitators and not teachers (Cobb and Bauersfeld 1995). Whereas a teacher gives a didactic lecture that covers the subject matter, a facilitator helps the learner to get to his or her own understanding of the content. In the first scenario the learners play a passive role while in the latter situation they play an active role in the process of learning. The emphasis thus turns away from the instructor, and towards the content and learner (Gamoran, Secada et al. 2006). Hence, due to the nature of M-learning, this learning theory is suitable to implement M-LA.

As discussed above, one of the main features of constructivism learning theory is personal endeavor and M-learning is also personal learning. On the other direction, due to the constraints of mobile devices that is challenging to cover the entire contents rather than putting the main concepts by considering the learners' level of understanding. Hence, this learning theory is applied to make learners to be active by applying their previous knowledge to construct knowledge.

2.5 Problems in Mobile Learning Systems

As discussed in chapter 1, M-learning can offer opportunities to facilitate and enhance learning experiences. But, there are several challenges and obstacles which are

affected the implementation of M-LS. In order to identify these factors, methodical approach (Nasiri and Deng 2009) is used to identify these issues. As shown in Figure 2.3, in this research, these factors are categorized either in external or internal aspects of M-learning environment, and explained in the following subsections. It can be seen from the Figure 2.3 that there are four (4) major components of M-LS. These are mobile devices, contents, communication technology, and user.

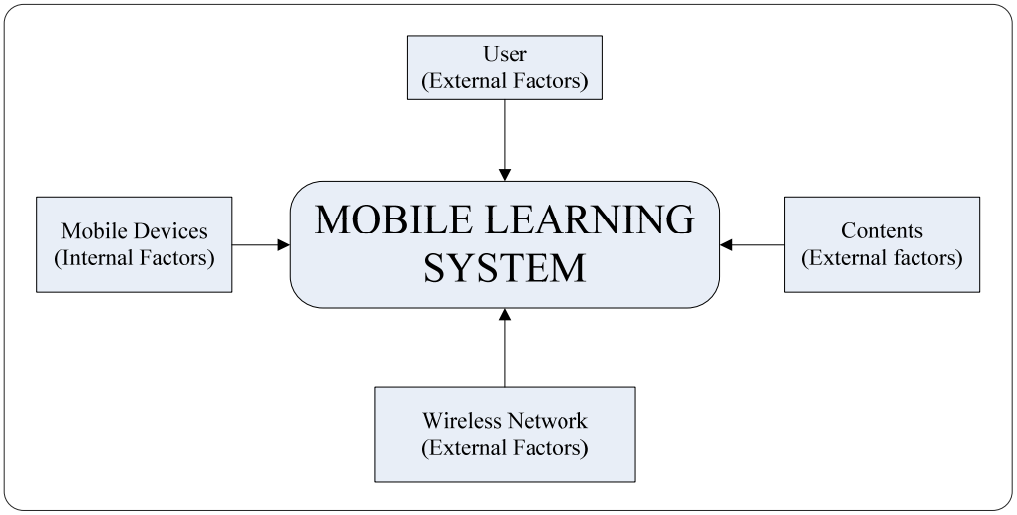

Figure 2.3: Components of Mobile Learning System

Across the aforementioned major objects of M-LS, there are issues which are affected the implementation of M-LS. According to Nasiri Alireza and Deng Guishi, the major factors of which are affected the developments of M-learning business model are: technology, standard, and market. Technology acts as a mediator between input and outputs which create new products or services (Tushman and Anderson 1986) and emerging new technologies is great driver in technology based business and also changes in centre of capabilities as well like M-learning. Under the reference of technological aspect, mobile devices, content and wireless technologies are the most important drivers forward the change in M-LS models (Sanz-Velasco 2007). Standards tend to define the technology selection and examine the system. It can be seen from the Figure 2.3 that in M-LS standard should consider issues, like mobile device, communication technology, types of content and other external factors. M-learning standard seeks to guide the decision-making process easier for developers by providing information addressing the nature of mobile devices and the baseline standards optimize their use (O'Connell and Smith 2007).

Hence, in this study the above two notions are used to mention the major issues of M-LS problems (or difficulties). Thus, the following major problems are identified under each of the aforementioned objects. These are: issues in mobile phones, issues in content creation, issues of wireless technology, absence of standard, and security.

2.5.1 Issues in Mobile Phones

From Figure 2.3, it can be seen that mobile device is one of the fundamental elements of M-LS. However, there are problems which can be considered from their diversity, and constraints. Nowadays, there are a number of mobile device brands in the market with different capacity and constraints. Mobile device constraints are either hardware or software. List of hardware limitations are memory, processing speed, battery consumption, screen size and resolution. On the other hand, there are two software limitations which are operating system and web browser (Chi-Hong and Yuen-Yan 2003). Even though, the current mobile devices are becoming hi-tech and improved in memory and processing speed, they have still limitations in some other aspects, such as battery consumption and screen size. Due to the above reasons, writing applications for each kind of mobile devices can be a solution. But, that is very tedious, tough, and requires a lot of efforts. In addition, maintenance cost is high and very challenging. Hence, two ways of strategies have been discussed under Section 2.3.1 to choose the supported mobile devices for the given system.

2.5.2 Issues in Wireless Technology

Networking becomes more advanced which is used to communicate independent end users over a shared network medium. There are two broad categories of network technologies which are wired and wireless technologies. Wired technology is used cable to transmit electronic signals. On the other hand, wireless technology allows communication between end users using radio waves through air.

Due to portability and mobility of mobile devices, wireless network is used to implement M-learning approach. It can be seen from the Figure 2.4 that there are

different types of wireless technologies such as Wi-Fi (IEEE 802.11), cellular technology, Bluetooth, IrDA, and so on (Cleveland and Xanthus Consulting International 2007). In addition, the Figure 2.4 shows that the data rate versus power consumption of aforementioned technologies. These technologies are used to communicate and share resources in M-LS.

Wi-Fi (Wireless Fidelity) is commonly called wireless Local Area Network (LAN) and the most popular wireless standard (Lehner and Nösekabel 2002; Sharples et al. 2002; Tan-Hsu Tan and Tsung-Yu Liu 2004; Danco et al. 2007; Devinder and Zaitun 2006). As seen in the Figure 2.4, it enables high speed transmission or data rate from 10Mbps up to 100Mbps and covers about 100 to 150 feet of distance. However, it needs high memory and processing speed, and high battery consumption of mobile devices.

Bluetooth is the other type of wireless technology that is used to transmit data from one device to another device within very short ranges about 33 feet only (Yonghong et al. 2005; Yanhui et al. 2007; Zhang et al. 2007). In addition, the data rate is relatively low 1.5Mbps. In other word, it is designed for low-power network devices like handhelds, cell phone, PDAs, and small mobile devices. Therefore, it does not need high processing power and memory, and battery consumption relative to other wireless technologies. In addition, both Bluetooth and IrDA do not have any cost. Therefore, most researchers are using it.

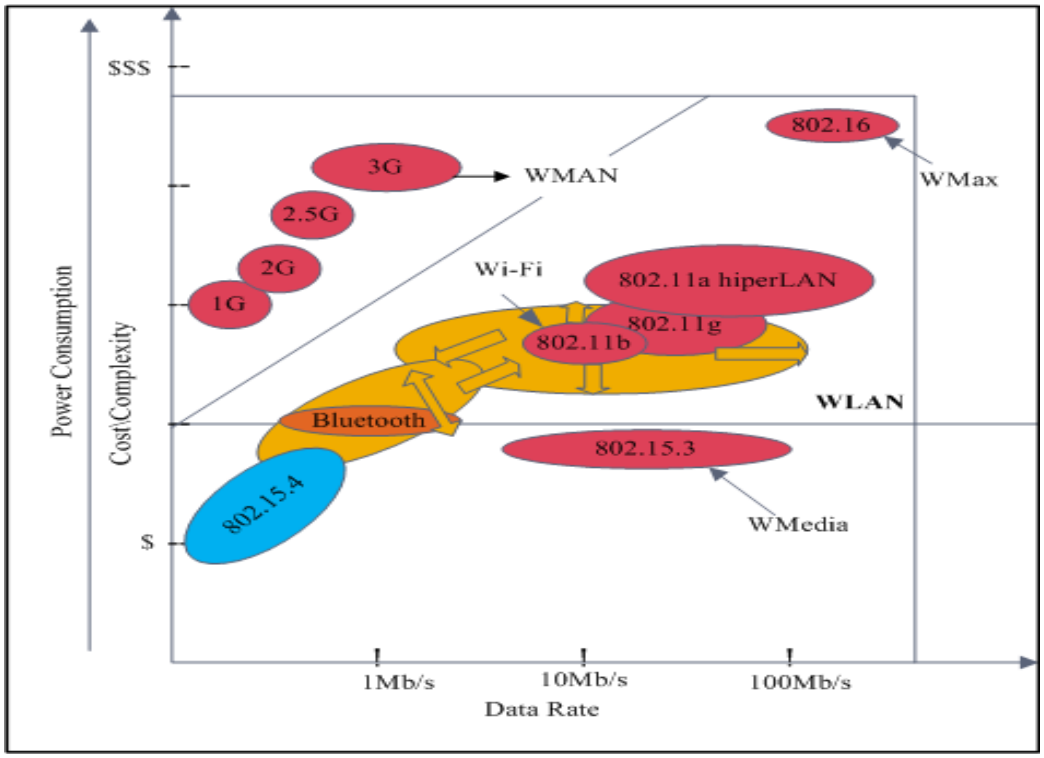

Figure 2.4: Comparisons of Different Wireless Technologies (Cleveland and Xanthus Consulting International 2007)

2.5.3 Issues in Content Creation

"Content is the king" has become a famous expression to show the rising importance of content creation as an important part of M-LS (Santally Mohammad Issack, et al. 2006) and also one of the fundamental elements of M-LS as shown from Figure 2.3. As discussed in Section 2.5.1, there are various types of mobile device brands and constraints. Due to these assortments and nature of the content, technically that is challenging to create contents which can be rendered in all types of mobile devices. In addition, designing of contents for each type of mobile devices is tedious and requires a lot of effort, and maintenance cost is high. Hence, both the type of mobile devices and nature of the content should be considered.

Every kind of multimedia format has their own details for instance audio has MP3 and Windows Media Audio (WMA). O'Connell and Smith (2007) outlined potential M-learning activity and resource developments, and categorizes different features of

mobile devices under their recommend types of learning resources format by considering the nature of the devices (O'Connell and Smith 2007). In which, it helps for developers to select appropriate types of content formats.

2.5.4 Absence of Standard for M-LS

Standard is used as a reference to define the technology selection and evaluate systems. But, due to thousands of mobile device brands and varieties of capabilities that is difficult to have one concrete standard. In other word, the problems in developing of platform and device independent M-LS is lack of specification and standards (Evgeniya et al. 2005). There is no standard framework which can help developers to develop M-LS, create educational materials appropriate for mobile devices, and evaluate different systems. The main factors are; diversity of mobile devices, and their constraints. Hence, there are studies (Chi-Hong and Yuen-Yan 2003; Yuen-Yan et al. 2003; Horstmanshof 2004; Attewell 2005; Evgeniya et al. 2005; Cobcroft et al. 2006) about the classification of M-LS using different types of indicators for instance supported mobile devices, usage of wireless communication technologies, access methods, and so on which are used to measure capabilities and for technology selection.

Based on the previous studies about the general classification M-LS, in this research some parameters are selected and added extra indicators to design platform classification for M-LS which is presented in Section 3.2.2.

2.5.5 Security

In general, security issue is one of the major problems in mobile phones, specifically in M-learning application. For the reason that mobile phones are defined as a private and personal space needed to keep secret. Due to limited resources in mobile devices, security in mobile devices is a big challenge. Since, the process of encryption and decryption of secured data on mobile devices demand more processing power which can impact the mobile devices performance and battery life. Lehner and Nösekabel

(2002) used adequate security which is used to insure by encrypting all data with Secure Socket Layer (SSL3) at 128 bits. Technically more processing power requires more battery and large amount of memory.

2.6 Related Works on M-learning Trends

Currently, adoption of M-learning in every society context will be influenced by organizational, socio-cultural, and intra-related and interrelated factors explicitly. These make that the implementation of M-LS is growing faster. However, none of them are fully functional due to different factors which are presented under Section 2.5 rather than solving the obstacles partly. To show the trend of M-learning, some of the previous studies are reviewed below.

Wireless E-learning and Communication Environment (WELCOME) is a project at the University of Regensburg which is intended to support both students and teachers by providing services that facilitate teaching, learning and educational-related administrative tasks (Lehner and Nösekabel 2002). This system has been built based on existing experiences in the field of E-learning from Virtual University Regensburg (VUR). However, it does not support E-learning specifications and standards. The selected features of this system such as news, distribution of learning materials and personalization are available for mobile devices. PDAs are selected as a device of choice and possible to have both online and offline access to Audios and Videos on the device. The supported information types are PDFs, Audio, Video, Flash animations and WML.

Mobile Learning Engine (M-LE) enables students to use smart phones as a medium for learning and used client-server architecture (Meisenberger and Nischelwitzer 2004). Mobile Learning Platform (MLP) is used as a central internet which hosted all learning objects which are in XML data format. It supports both online and offline access of learning materials, and developed using J2ME to make it platform independent.

ELDIT means Electronic Learner's Dictionary of German and Italian. Mobile ELDIT is a system is developed at the University of Trento, Italy. It is a mobile version that can be accessed from mobile devices like PDA, and Pocket PCs. Technically, data ELDIT (Trifonova and Marco 2004) means Electronic Learner's Dictionary of German and Italian. Mobile ELDIT (M-ELDIT) is a system under development at the University of Trento, Italy. It is a mobile version that can be accessed from mobile devices like PDAs and Pocket PCs. Technically, data are in XML file format of educational materials and the Web server transforms it into HTML and java script which can browses by clicking on hyperlink. It supports online access and used Hoarding technique when the data is bigger than the device available memory. Hoarding is a technique for automatic selection and caching of the data that the user will need during offline periods. The system only supports HTML and java script which are not supported by all mobile devices. The downside is that changing of XML to HTML and Java Script, which is very complicated and needs much memory space.

Devinder and Zaitun (2006) have developed M-learning application for wireless classrooms at University of Malaya. Initially, preliminary survey has been done from two hundred undergraduate students on the problems faced in conventional classrooms and their experience towards M-learning. Based on the survey results, M-learning application was developed for both students and instructors sides to enhance the conventional classroom learning approach in wireless classroom setting. The supported mobile devices are wireless notebook and Pocket PCs over wireless LAN using browser-based technology. Internet Information Server (IIS) is used as the web server running on Windows XP. The system used simple client-server architecture, and ASP.NET mobile web page has been used to develop the web page and displayed on a Compaq iPAQ. Structured Query Language (SQL) database is used to store the learning objects, and in attempt to remain platform independent, the supported information type is XML. But the system is only implemented for specific devices like Pocket PCs and wireless notebook. The other drawbacks are that, the system is implemented only for Windows mobile platform, and restricted inside classroom.

Mobile learning platform (MobilP) is a web based learning system which supports both mobile and non-mobile computing devices (Yuen-Yan et al. 2003). It aims at providing educational contents and communication services to teachers and students anytime, anywhere. The system supports online access using browser-based technology JSP to retrieve the XML and HTML data format. The system is developed for both mobile and non-mobile, but both devices have different features that should be considered to implement it, and it does not support offline access.

MObile-Based Interactive Learning Environment (MOBILE) used elementary school English learning which consists of M-learning modules and support in or outdoor learning activities (Tan-Hsu Tan and Tsung-Yu Liu 2004). It supports mobile devices including PDAs and notebooks to access HTML-based educational materials through online and offline method. Finally, they used post—tests and questionnaire to test the effectiveness and usability of the system. In fact, MOBILE does not support a wide variety of mobile devices, and the supported file format (HTML) needs much memory space.

Besides, another study by Anang et al. (2006) focuses on the development of M-learning management tool in campus-wide environment. Microsoft.Net infrastructure, ASP.NET for mobile web forms, and used Microsoft Mobile Internet Toolkit (MMIT) as a simulator are used to develop this application which is built on Microsoft ASP .NET Web Forms. The system used standard system development phases: planning, analysis, design, and implementation. This system is tested with multiple devices including Nokia 6210, Pocket PC with Microsoft Internet Explorer v.4.5., and Sony Ericsson R380. The main core modules of the system have been included: My Courses, My Schedule, My Grade, and My Assignment. Finally, the authors conducted survey on responses of user acceptance, user friendliness, didactic efficiency, and feasibility of the system. The downside of this system is that it is not platfrom independent, used only for Windows mobile platform.

Mobile Lecture Interaction (MLI) is an application which used to enhance the lecture interaction between a teacher and students, because the detrimental effect this lack of interaction has on student's learning motivation (Cruz et al. 2008). MLI is implemented using traditional client-server architecture and developed two different

systems for both ends. The client or student application was implemented by Java MIDlet J2ME MIDP, and the supported device is smart mobile phones. The server or teacher application was implemented by using Hypertext Preprocessor (PHP), and the application is running on PC. MySQL is used as a database; stores course information, question presented by students, and votes cast by the students. Finally, the system is evaluated empirically on real lectures, and the authors concluded that the students enjoyed and made the lectures more interesting. The drawback of the system is that it supports specific devices like smart phones. In addition, MLI does not provide online educational materials access.

As discussed under Section 2.3, to implement M-learning application most of the previous researchers were giving more emphasis on the following basic parameters; types of supported mobile device, availability of content, types of supported data, and information. However, none of them have not addressed about learning theories and IDM in their M-LS implementation which are included in this research and discussed under Section 4.2 and 3.2.2. Moreover, as mentioned above, due to various reasons different researchers were using different technologies to implement M-LS. To develop platform independent M-LA and accomplish the objective, researcher used both J2ME and XML. Finally, its effectiveness and usability are tested.

2.7 Chapter Summary

As discussed earlier, the current M-LS are examined their capabilities or services using different indicators. The second view point was how to apply learning theories in M-LS which is discussed under Section 2.4. Finally, problems of M-LS are presented from different view point and how the previous researchers treat the identified problems which are discussed under Section 2.5. Based on the above standpoints, the author has reached the following conclusions.

Due to limitations and varieties of mobile device, even though the number of M-LSs is growing fast, none of those are fully functional for all types of mobile devices. For instance WELCOME have only implemented for specific devices like PDA or Pocket PCs, MOBILE have supported for devices either PDA or notebooks, and so

on. Many systems are like MLE and MobiLP are used XML to avoid both platform and device dependency of data format. In this research, the supported devices are; smart phones, PDA and laptop. In addition, XML is used to gain the above benefits and also J2ME midlet data format is used. Finally, survey conducted to test the effectiveness and usability of the system which is presented in Section 4.3 and 4.4.

The aim of this chapter has been to describe the basic definition of learning system, and to present the transition of E-learning to M-learning. Moreover, it is used to evaluate previous related works using different indicators. Finally, learning theories and problems in M-LS are discussed. Herein, the key objectives of this chapter are summarized as follows:

- To present definitions of key terminologies which are used in this research
- The revise previous related works and evaluate using indicators like supported devices, availability of contents, and types of supported data and information.
- Discuss types of learning concepts and theories which are suitable for M-learning approaches.
- Finally, the problems of M-LSs are explained and also reviewed related works in accordance with the types of problems they tried to address.

In conclusion, these are the main key points which are addressed in this research through achieving the main objectives within the specified scope in Chapter 1. Furthermore, this chapter is input for the next to design and develop M-LA, and also to evaluate its effectiveness and usability.

CHAPTER 3

METHODOLOGY

3.1 Introduction

The problem statements and objectives of this research reported in this thesis were outlined in Chapter 1. The state of the art and researches in the area of mobile learning system (M-LS) by using different indicators were reviewed in Chapter 2 together with some of the learning theories which are adopted in this research. In this chapter, the methodology used to design the common platform classification specification, develop platform independent M-LS, and evaluate the effectiveness and usability of the system, are presented.

The following steps were used in developing and implementing the Mobile Learning Application (M-LA):

i. *Problem analysis and information collection.* An extensive literature survey was done to analyze the current development of M-LS. The results were used as preliminary findings for the next step.

ii. *Data collection (Conducting survey).* This includes collecting necessary domain knowledge about the M-learning approach from handbooks, patents, existing products, and experts. Moreover, the survey has been conducted from 90 UTP foundation students. These inputs are used for selecting programming language tool to development the application.

iii. *Programming language selection.* Based on the above input, the necessary programming languages are selected to develop the system.

iv. *Design platform classification.* Gather the indicators to build the platforms classification in order to examine the system and also for technology selection.

v. *Development of the system.* After analyzing the previous studies, conducting survey, and selecting the programming language, the platform independent application is implemented into a computer program using mobile emulator by adapting the learning theories.

vi. *Effectiveness and usability evaluation.* This is to confirm that the effectiveness and usability of the system. Pre-test and post-test were used to test the efficiency of the application. Moreover, usability attributes used to measure the extent to which the application can be used by specified users to achieve the goals and Cronbach's alpha was used to test reliability.

All of the above steps are discussed in this chapter except the fifth and sith steps which are discussed about application development and its evaluation respectively. Mainly, this chapter is presented about the methods which are used to implement this research and the results are discussed in the next result and discussion chapter.

3.2 ML-T life cycle

The development of M-LA platform will be interpreted according to the M-LA life cycle. Currently, there are different types of instructional design model (IDM) methods. Even though, ADDIE is not iterative, but due to its flexibility and effectiveness to build instructional product, it is used in this study. ADDIE consists five phases: Analysis, Design, Development, Implementation, and Evaluation.

3.2.1 Analysis

Analysis is a process of gathering requirements for the system (Software Development 2010) and making detailed study to understand a topic. In this phase, the previous related works, the conducted survey, and also the nature of the course are analyzed before proceeding to the next phase. As discussed in Chapter 1, Fundamentals of Programming course is used as a case study. Figure 3.1 depicts the analysis phase of M-LA.

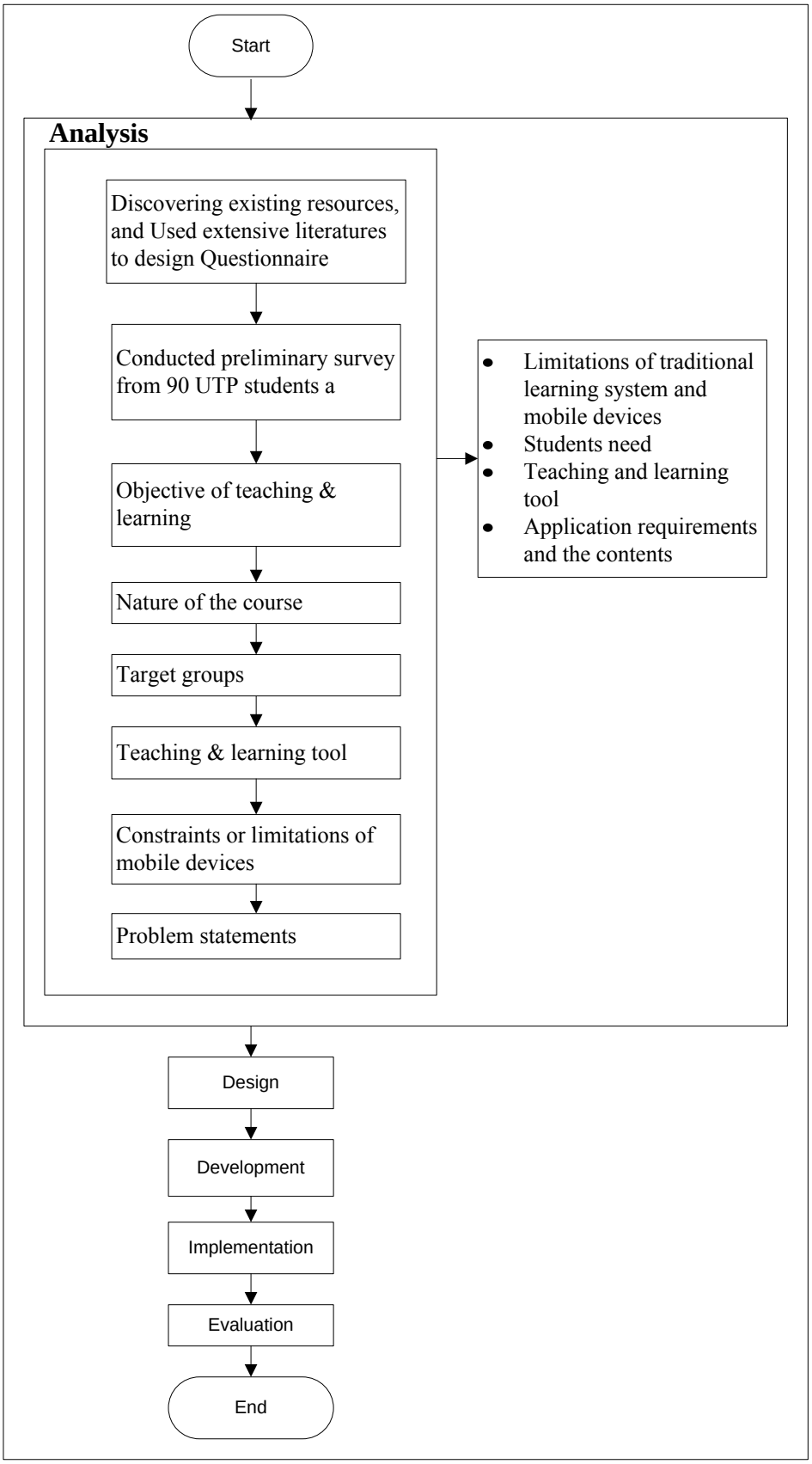

Figure 3.1: Analysis phase in M-LA Life Cycle

As discussed in the earlier section, during the analysis phase, a pilot study was conducted as preliminary survey (the survey set is as in Appendix A) from 90 foundation UTP students to get information (Wendeson et al. 2010). The survey was to gather the following:

- Weakness of conventional learning
- Identifying contents of Fundamentals of Programming course
- Identifying the types of contents that the system should comprises
- Their experience and willingness of using of mobile devices as a learning instrument
- Types of mobile device they own, and constraints or limitations and also capabilities of mobile devices while using as a learning instrument
- Advantage of M-learning
- Suggestion for more effective ways to teach this course

Before going to the design phase, the collected data should be analyzed, and contents of the course must be studied, understood, and arranged (Davis et al. 1988). In addition to the data obtained from the survey, the nature of the selected course contents and previous related studies of M-LS are analyzed and used as an input for the next phase. As discussed in Section 2.5.4, even though there is no conventional standard to develop M-LS, but the following factors should be considered: constraints of mobile devices, nature of the contents, and other external factors. The nature of the course content is preliminary inputs for the analysis phase. Therefore, before making any design structure it should be studied and understood by the developer.

From this phase about six types of data were identified as an input: objectives of teaching and learning, teaching and learning tool, nature of the course, problem statements, constraints or limitations of mobile devices, and target group. All of the above mentioned data were analyzed and the outputs are: the content of the course, teaching and learning tool, students' need, and constraints of mobile devices were used for the next phase, design phase.

3.2.2 Design

The design phase is the second phase according to ADDIE methodology. Based on the above section, the analysis phase facilitates the following inputs to the design phase: content, interface, and prototype design. Figure 3.2 shows the flowchart for the design phase.

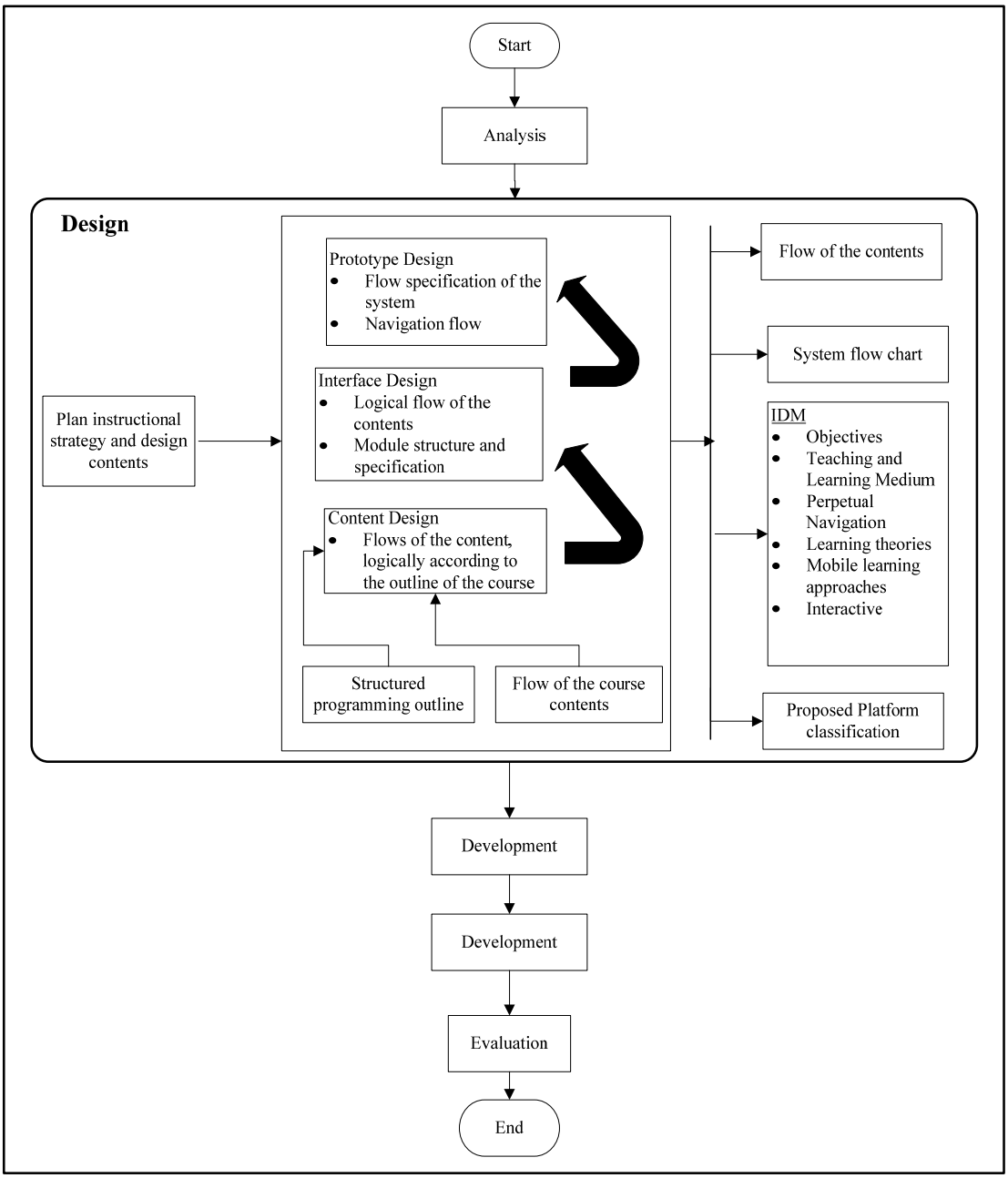

Figure 3.2: Design Phase in M-LA Life Cycle

i) Input to the tool design

From the above Figure 3.2, there are three designs which have been constructed during the design phase, as follows:

a) Content design

Content design is a process of designing logical flow of the course module based on the outline of the contents by considering different types of factors. As discussed in Section 2.5.3, it is challenging to create contents which are platform and device independent. In this study, the supported mobile devices are PDA, smart phones, and laptops. The output of content design is input for both interface and prototype design. As discussed in the Chapter 1, Fundamentals of Programming is a case study. In addition, as it can be seen from Figure 3.3 that Selection Statements, Loop, and Function concepts of the course are addressed in this tool. For the reasons that these topics are pillar to the course, and also the nature of the content is suitable for mobile devices. Hence, Figure 3.3 shows the content design of the course which is used in this study.

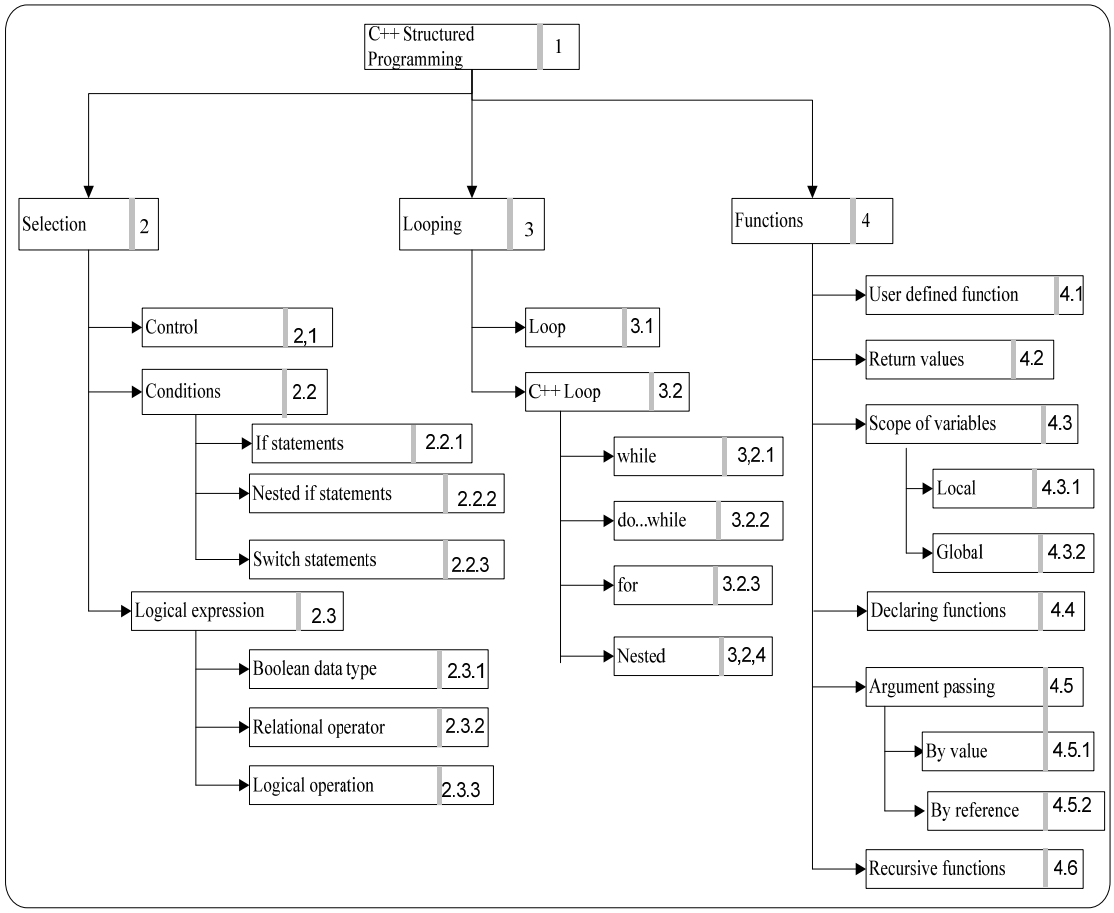

Figure 3.3: Content Design (course modules)

b) Interface design

One of the fundamental facts about application development is that the user interface. Therefore, it should meet users' needs, and easy to use, attractive appearance, reliability, adaptability, interoperability, and great mobility (Hobart 1995). In the design phase, it is one of the major process and used content design as input to design the system interface for each modules of the content. In M-LS development one of the main limitations is screen size that makes very difficult to design platform and device independent user interface. In addition, there are other limitations such as processing speed, battery life, memory and etc.

There are established opinions by Larry and Lucy (1999) to make the interface more attractive and user friendly. These principles of good graphical user interface (Nasiri and Deng 2009) should include the following attributes:

- *Consistency*: - the most important thing is that to ensure the user interface works consistently. Buttons should be in consistent places on all windows, use the same wording labels and messages, and use a consistent color scheme throughout. Because, Consistency in user interface enables users to build an accurate mental model of the way it works, and accurate mental models lead to lower training and support costs.
- *Be prepared to hold the line*: - when software developers are developing the user interface for the given system they discover that their stakeholders often have some unusual ideas as to how the user interface should be developed. Therefore, developers should definitely consider these ideas. Moreover, developers have to aware their stakeholders about GUI standard and system too.
- *Navigation*: - is important part and have to give more emphasis. Because, if it is difficult to get from one screen to another, then users will quickly become frustrated and give up. Therefore, the flow between screens should match the flow of the work.
- *Word of messages and labels*: - screen size is one of the mobile devices limitations. Therefore, it is better to use common abbreviations, and the displayed texts should not be too much and poorly worded.
- *Use colour appropriately*: - due to, the problem of some users may be colour blind that is better to use colour sparingly in the applications or better to use as a secondary indicator.
- *Mistakes*: - users may do mistakes. Therefore, the developer should design an interface to recover or a way to display message box before taking action by one click.
- *Interface should be intuitable*: - In other words, if users do not know how to use the system, they should be able to determine how to use it by making educated guesses. Even when the guesses are wrong, the system should provide reasonable results from which users can readily understand and ideally learn.

- *Don't create busy user interfaces*: - mobile devices are small screen size. Therefore, crowded screens are difficult to understand and use. However, the interface must have attractive look and not too much wordy.
- *Look at other applications with a grain of salt*: - developers should look others interface design to get ideas and verify the developed interface. Moreover, it uses to distinguish good and bad interface design.

All of the above basic principles of good GUI characteristics are adopted in this research, to improve the quality of user interface design.

c) Prototype design

The prototype design is the last and the most basic parts of design phase. It used interface design as input. Its output is the overall output of design phase. In this process, the flow structure of the system is designed including its navigation for the selected modules from the contents of the course. Through all this design, all the above mentioned principles have been adapted into this system. However, the prototype of the tool has been designed according to the flow specification, and navigation flow. Finally, it will make ready and used as an input for the next phase which is called development.

- Flow Specification

Currently, there are different types of interface design from simple to very complicated, based on the type of applications, considering the logical flow of the content, limitations of the learning instrument (mobile), and other external factors. The flow must be simple, specific, and intuitive to make sure users are aware of their positions during navigation.

- Navigation Flow

It is the most basic and important part for every application. Navigation has a potential to influence users and affect their satisfaction. Therefore, it should be:

simple, consistent, intuitive, and expressive. In addition, it should not make the interface crowded, specifically for mobile devices due to screen size limitation.

ii) Output from the design phase

It is one of the main output from design phase including module flowchart, is considered the logical flow of the contents (from the content of Fundamentals of Programming course), system flow (from the design process), and the Conceptual Framework as the IDM. The fundamental principle of IDM is used to maximize the efficiency and effectiveness of instruction in both the curricular and extracurricular settings (Thompson 2001). The basic elements of instruction are learners, objectives, methods, and evaluation (E-learning and Instructional Design Principles 2002). IDM is discussed in details in the following subsection while the system flowchart is presented in Section 4.2, specifically in Section 4.2.4.

The IDM consists of 6 elements that provide the reference for the next phase, development. The elements in IDM are: objectives, teaching and learning medium, perpetual navigation, characteristics of M-learning objects, M-learning approach, and interactivity. The IDM for M-LA can be seen in Figure 3.4.

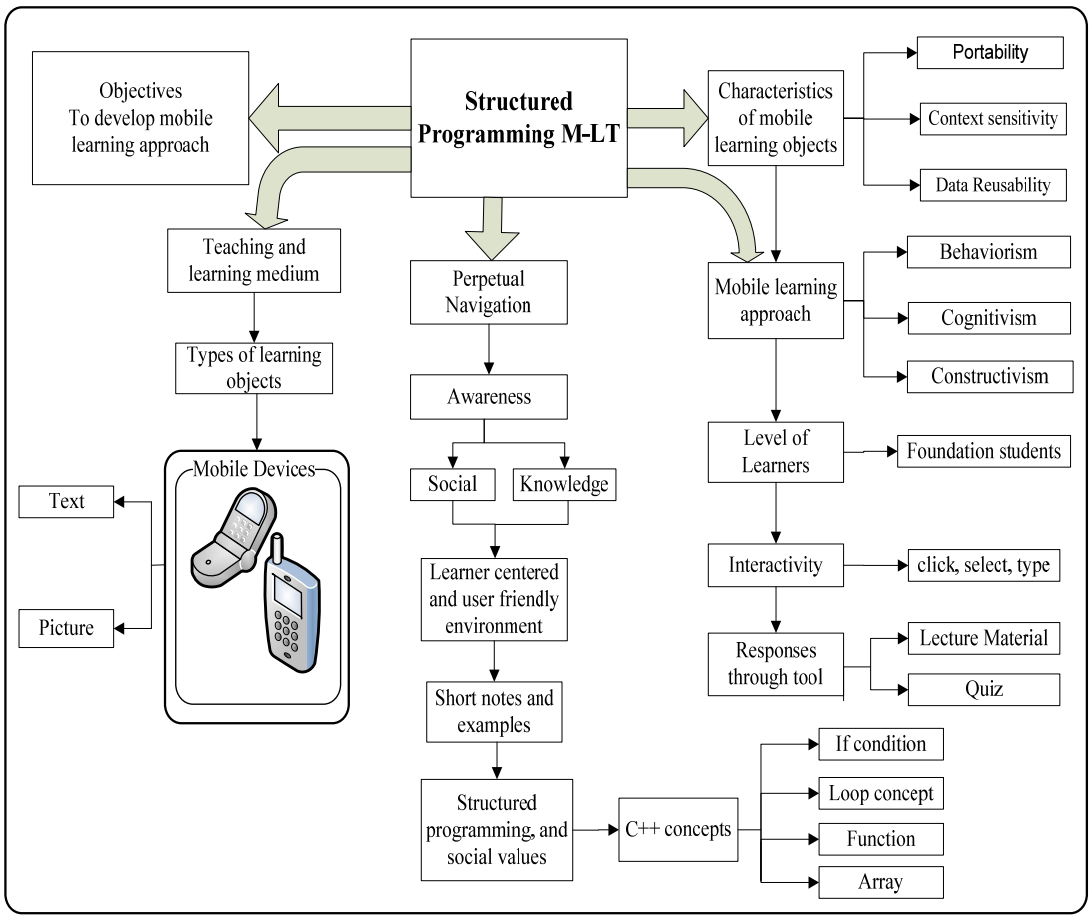

Figure 3.4: ID Model

As shown from the above Figure 3.4, IDM of M-LA contains six major elements which are presents below:

a. Objectives

The main objectives of developing M-LA prototype are to achieve the following goals:

- For better understanding of Fundamentals of Programming by making leaning interactive and fun
- Uses different types of learning approaches based on the nature of learning objects

b. Teaching and learning medium

As per discussed in Chapter 2, M-learning means E-learning through mobile devices. However, mobile device has hardware limitations that makes difficult to use all kinds

of multimedia, especially audio and video files need more memory. Therefore, text and picture are the selected multimedia formats in this research.

c. Perpetual navigation

M-learning needs more of the end users involvement. Hence, the tool should be more of user friendly and learner centred. However, learners should have both social and knowledge awareness. Social awareness means includes information about the interests and capabilities of the other end learners to join participation in a collaborative learning activity about specific topic to share ideas (Gerardo and Sergio 2008). Knowledge awareness refers to the information about the application of knowledge elements by the learners (Ogata and Yano 2004).

d. Characteristics of mobile learning objects

M-learning object means an interactive software component, personalized and reusable in different contexts which are designed to support an educational objective through a mobile device (O'Connell and Smith 2007). The characteristics of M-learning objects are portability, context sensitivity, and individuality.

- Portability: - is a characteristic if it can be used in an operating system other than the one in which it was created without requiring major rework. In other word, it is platform independent.

- Context Sensitivity:- means exhibiting different behaviour depending on the situation. Specifically in M-LS, there are mobile device limitations which are affecting the data compatibility.

- Data reusability:- is used when data is created through a specific application becomes impossible to access if it cannot maintain backward compatibility. However, XML documents are text data, and do not rely on any particular application. The data can be stored for long time without problem.

e. Mobile learning approach

There are so many types learning theories. M-learning is one type of non-formal learning which do not have boundary. In addition, it is personalized and facilitated communication between learners. Therefore, as discussed in Section 2.4, the selected learning theories are behaviourist, cognitivism, and constructivism.

f. Interactivity

As discussed in the earlier sections, the use of mobile as learning instrument makes learning ubiquitous, and interactive to use. In this research, M-LA contains two main modules which are: Lecture materials and Quiz that will be explained in Section 4.2.4. However, there are also some other related and helpful pages such as introduction and objective pages. Due to the limitations of mobile devices, select, type, up and down arrow are involved to manipulate the system.

iii) Platform Classification

Due to the existing wide range of mobile devices and their constraints, that is difficult to have one solid standard and which gives an opportunity to realize different systems for mobile education. As discussed in Chapter 2, in the literature there are various classifications of M-LS which are used to evaluate the system from different viewpoints. However, Evgeniya, et al. proposed a general classification for the existing M-LSs (Evgeniya et al. 2005). This classification is easy to take into account the differences in the implementation of the existing system as well as their common characteristics (Evgeniya et al. 2005). Thus, there is a need to provide a framework for developers and identify systems requirements and specifications.

In order to design framework and evaluate M-LA, platform classification is designed (See Figure 3.5). In this model, the tool is evaluated in terms of its capabilities and services supported by using some of the indicators specified in (Dye and Torstein 2008; Attewell 2005; Evgeniya et al. 2005; Naismith, 2005; Wendeson et al. 2011), these are: supported target devices, types of learning system, access method, communication technologies, types of users, and supported information type. In addition, some other extra indicators are added, these are; supported data format,

and availability of content. Choosing of the aforementioned indicators has been according to the usability of M-LS which is explained throughout the thesis. In addition, these indicators are used to evaluate the capability and services of the application. In fact, the usability of M-LSs can be affected without which one of the aforementioned indicators which have explained the reasons in this thesis, specifically in this section.

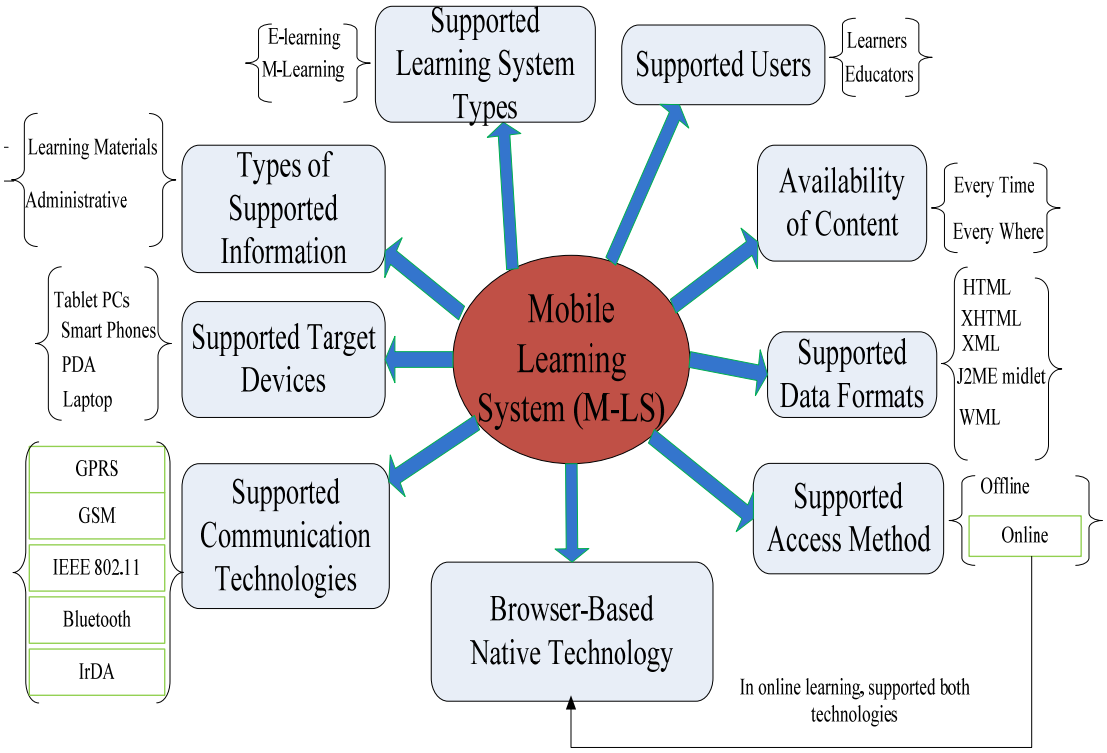

Figure 3.5: Proposed M-LS Platform Classification

Hence, M-LA is evaluated based on the proposed M-LS platform classification which is used to examine various M-learning models. The evaluation result is specified in the following sections:

In this system, the contents are adopted in a variety of mobile devices on different platforms including smart phones, PDA, and laptop. In other word, the tool is platform independent. As discussed in the above sections, it contains two main modules lecture materials, and quizzes. The supported data formats are XML and J2ME midlet which are used to store the educational contents and compatible with most mobile devices. Furthermore, XML is platform and device independent. This

system supports offline access to learning materials, and quizzes. Moreover, content format of M-LA is XML which is used to support native technology to access learning materials. Native technology is one type of online access method by developing a light-ware platform which should be deployed on the mobile devices and used Hyper Text Transfer Protocol (HTTP) (Niazi and Mahmoud 2008). In native technology the application should compile and can be run in a runtime environment.

As discussed earlier under Section 1.1, Fundamentals of Programming in UTP is used as a case study for this research which is compulsory course. In addition, it has E-learning facility in the campus. Therefore, this research is intended to support only M-learning approach. The considerable users of the application are only learners. Due to low power consumption, inexpensive, and interoperability, Bluetooth and Infrared (IrDA) are selected as a communication technology to share the educational materials.

Generally, this method is cost effective, and hardware and software constraints are the main factors which are affected implementation of the application. In addition, the context of being user friendly and customized environment is necessary.

3.2.3 Development

The step in the development phase used the output of the design phase. The designed flows of course content and system flow chart are used to compose the system design. In addition, the system was validated and examined to ensure its functionality before conducting heuristic evaluation. Finally, the system edited and got improvement using the feedbacks from experts, and the completed prototype of M-LA is developed which is the final output. Finally, it is used as input for the next phase, implementation phase. Figure 3.6 depicts the development phase of M-LA.

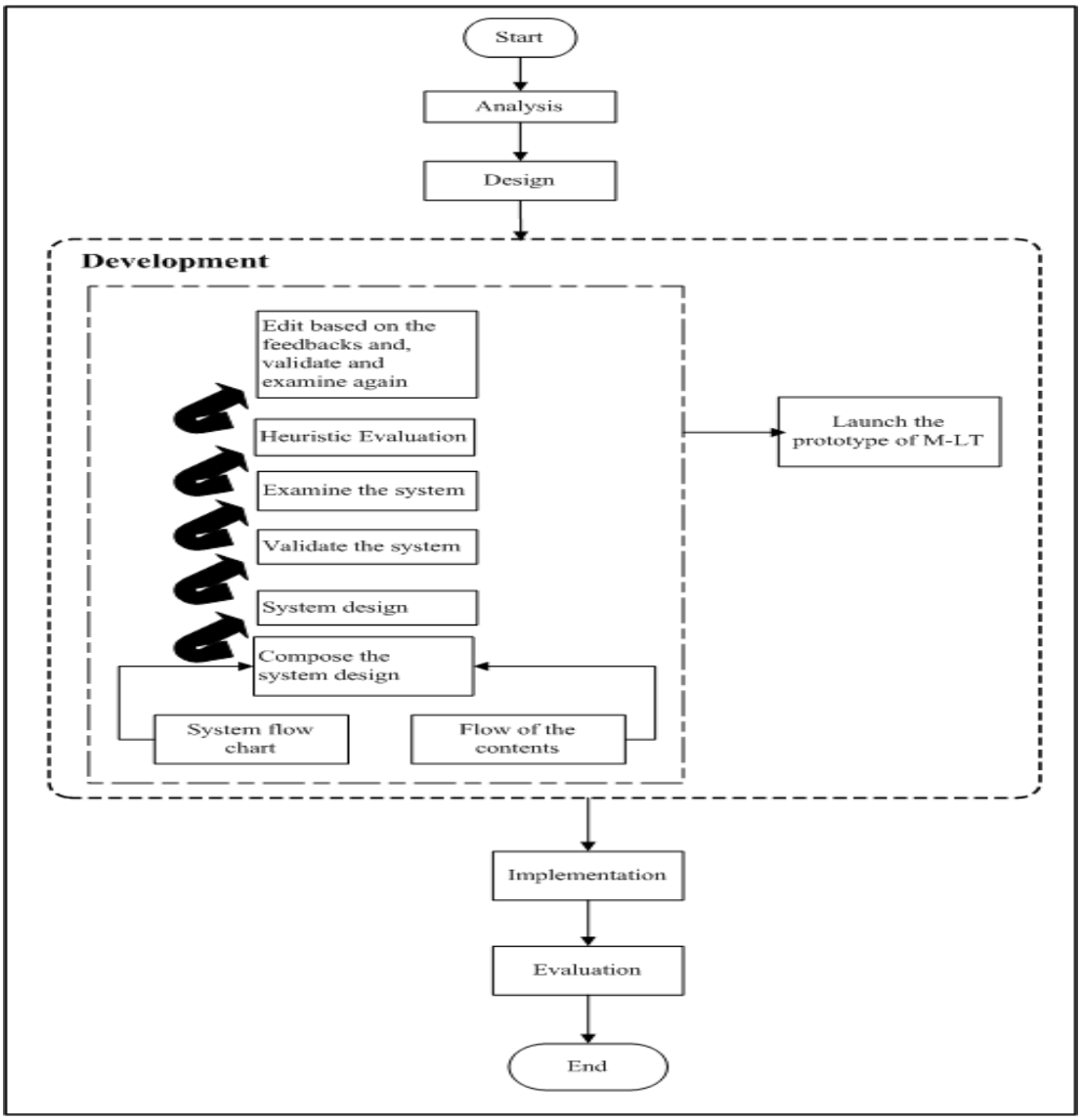

Figure 3.6: Development Phase in M-LA Life Cycle

3.2.4 Implementation

The implementation phase process is depicted in Figure 3.7, starts by applying the Prototype Implementation Guideline which are: the preparation on the established time table, schedule to conduct the survey, notifying the lecturer and students who have been selected for the control and experimental group. Nonetheless, the evaluation of the application process also involves the confirmation with the technicians to install the software of M-LA into forty computers in the laboratory and researcher also installed to some of mobile handheld devices for the testing purpose.

As discussed in Section 3.2.2, Selection Statements, Loop, and Function concepts were addressed from the Fundamentals of Programming course. Hence, these topics were used to evaluate the effectiveness of the system using pre-test and post-test correspondingly. In addition, there are three tests; Test 1, Test 2, and Test 3 which covered Selection Statement, Loop, and Function respectively. After the Prototype Evaluation Guideline sheet has been examined; the Test 1 pre-test was conducted for both selected groups. 120 students were involved in this study. The students were divided into two groups; 60 students in the conventional system and another 60 students using M-LA application. Due to limited number of configured computers, the first forty experimental group students were treated first, after they finished the remaining students were followed. Both groups had to one week to complete this topic. Table 3.1 shows the composition of each group that has participated in this experiment. At the end of the study, Test 1 post-test was given for both groups. Next, through the same procedure of Test 1, both pre-test and post-test of Test 2 was conducted for both groups. Finally, Test 3 was also undergone through similar approach.

The pre-test and post-test of Test 1, 2 and 3 are attached in the Appendix C. The results of these three tests are briefly presented in Chapter 4.

Table 3.1: Sample Number for Testing

Types of group	Number of Students				Total	
	ME	CHE	PE	CE	ME + CHE + PE + CE	
Controlled Group (C_o)	15	15	15	15	60	
Experiment Group (E_x)	15	15	15	15	60	
					Total:	120

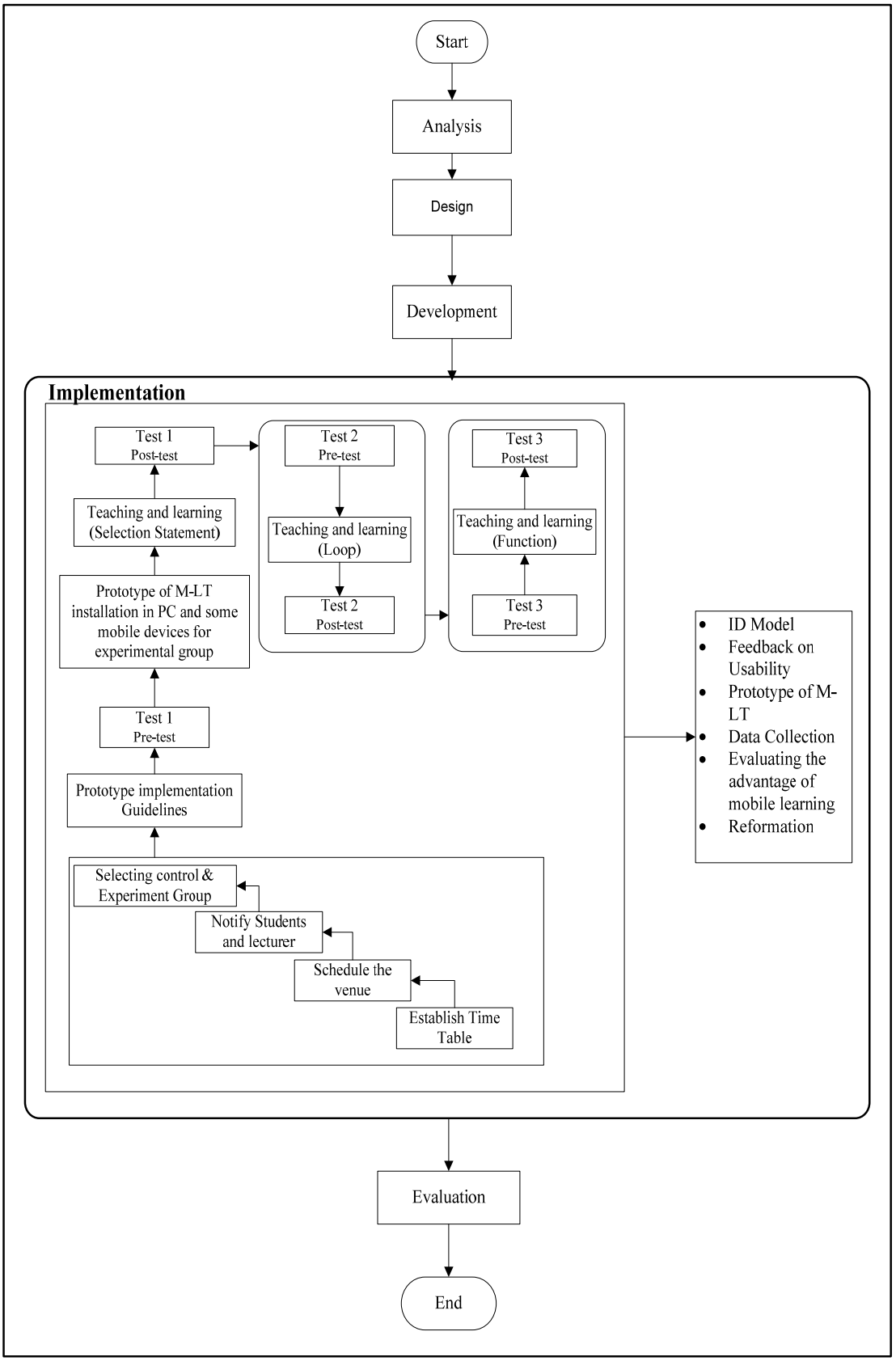

Figure 3.7: Implementation phase in M-LA Life Cycle

3.2.5 Evaluation

Evaluation phase is the last phase in M-LA life cycle model. In this stage, all the data from the implementation phase were being examined. Both pre-test and post-test were used to test effectiveness. The results of this effectiveness evaluation are discussed in Section 4.3. Learnability, Memorability, Satisfaction, and Simplicity attributes were used to test usability of M-LA. Usability evaluation was conducted only for experiment group. Usability questionnaire is attached in Appendix E; while the results are briefly discussed in Chapter 4. Figure 3.8 shows evaluation phase.

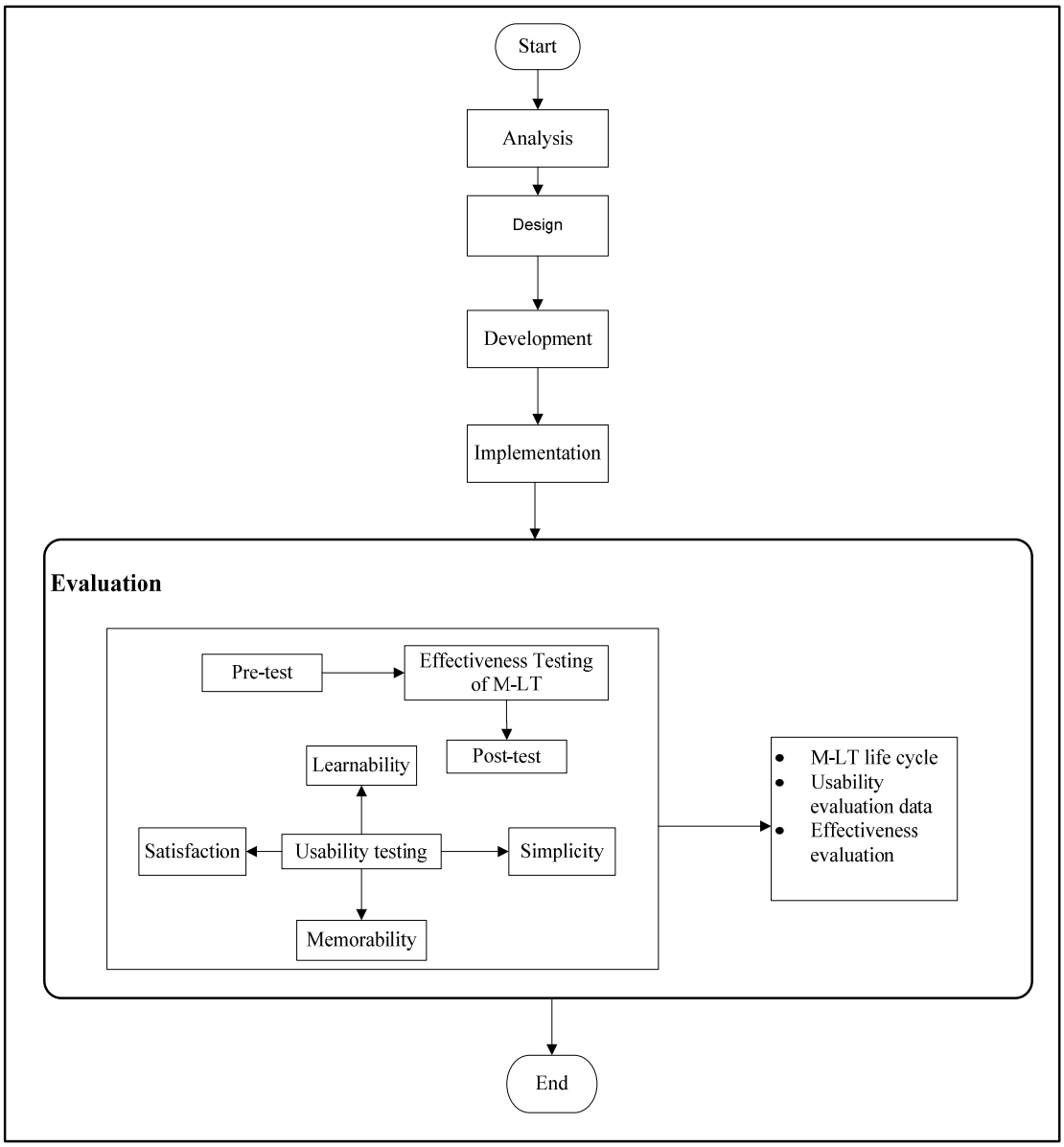

Figure 3.8: Evaluation phase in M-LA Life Cycle

3.3 Software and Tools for Development

The selection of the programming environment is done after analyzing the requirement set in the previous sections. The primary objective is to select programming language and design the system in order to develop the mobile application. A number of programming environments are available in the market for mobile application development. The availability, cost, independence, familiarity, and capabilities were the factors used to select the languages. Additionally, from the survey, respondents were using different mobile operating systems mainly Java, Windows, Symbian, Blackberry, and Palm OS. As discussed in Chapter 1, the main objective of this research is to develop platform independent application which can be deployed on all of the above platforms.

Based on the above key factors and the survey result, appropriate software tools were chosen to develop the application which is platform independent. As discussed above, to compose the prototype of the system in the development phase of M-LA life cycle, there should be some related languages. The tools involved are; Netbeans Integrated Development Environment (IDE) 6.9 (List of platform and configuration selection is attached in Appendix B), Extensible Markup Language (XML), K-Extensible Markup Language (KXML), and Microsoft Visio and paint to draw pictures.

The interface is shown in Figure 3.9; Netbeans IDE 6.9 is a free, open-source IDE for software developers. It has facilities to create professional desktop, enterprise web, and mobile applications. As shown in Figure 3.10, it supports three major modules which are Java 2 Enterprise Edition (J2EE), Java 2 Standard Edition (J2SE), and Java 2 Micro Edition (J2ME). J2EE is used to develop large server based applications. J2SE is used to develop Java applications for individual computers, and has applications up and down requirements ladder, filling needs for both J2EE and J2ME, and complicated users. J2ME is used to develop applications that run on small constrained devices like, cell phones, Palms, PDA, Pocket PCs and others. Due to its incredibility of being powerful, open source, platform independence features and most of the students' owned Java-enabled mobile devices, J2ME is selected to develop the application.

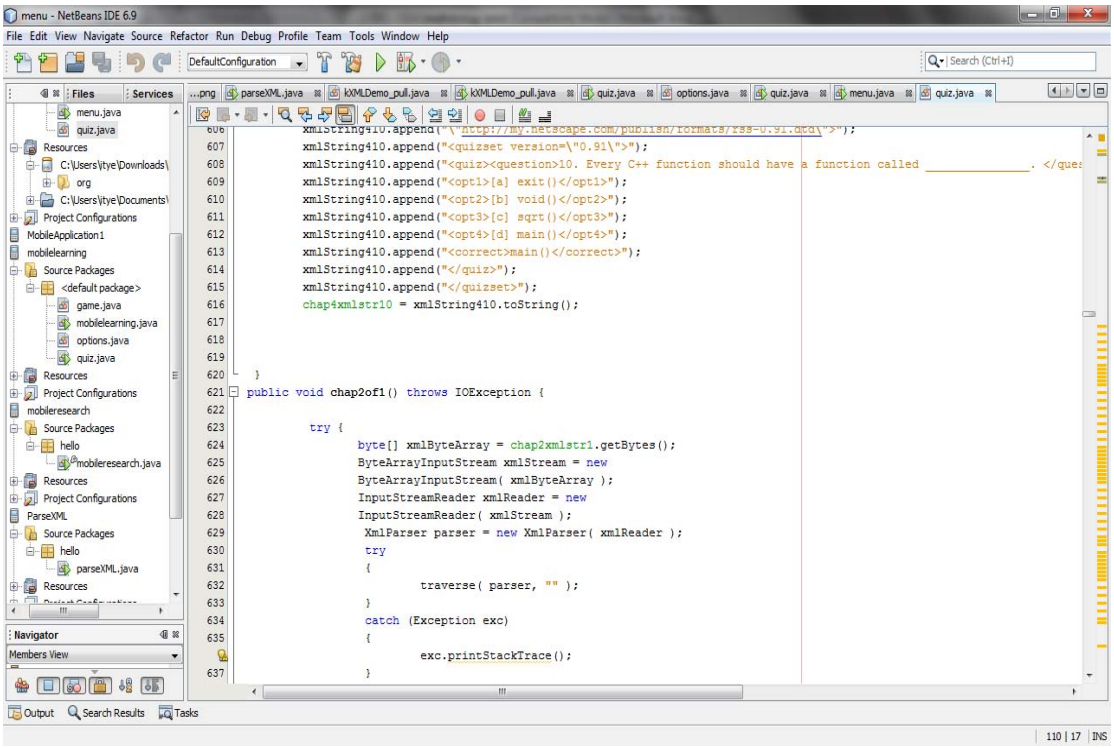

Figure 3.9: Screen shot of Netbeans 6.9 IDE

It can be seen from Figure 3.10 that J2ME has two design centres depending on memory constraints and designed in the form of layers. Hence, this platform has two configurations: Connected Limited Device Configuration (CLDC), and Connected Device Configuration (CDC). Configuration is used to provide the basic minimum functionality for a particular category of devices and it is common for all devices in this category. CLDC has been designed for all resource constrained devices such as today's cell phones, PDAs, and so on. It uses K-Virtual machine (KVM) as a compiler which is small and some of the java language features are not supported. On the other hand, CDC is designed for the devices that are not constrained as the CLDC targeted devices. CDC target devices are with 32-bit processor and 2MB or more memory. It uses Conventional Virtual Machine (CVM) as a compiler which can support all the features in KVM and more. Due to the selected mobile devices in this research, CLDC configuration is used and KVM as interpreters.

As discussed above, configuration prepares a common ground on which to add functionality. To get more functionalities profile is also used. From Figure 3.10 it can be seen that Mobile Information Device Profile (MIDP) and Foundation Profile are

extensions of CLDC and CDC respectively. Due MIDP is extension of CLDC; it is used in this research as discussed in Section 4.2.

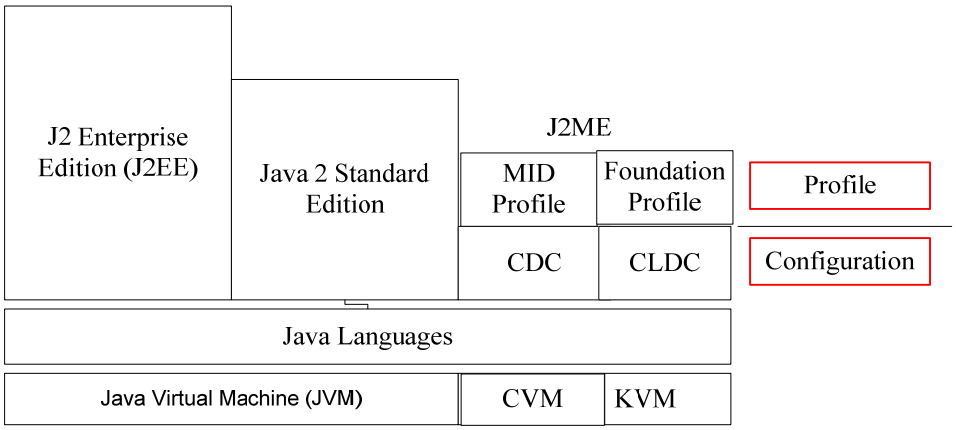

Figure 3.10: Java Platform needs configuration and profile

XML is a markup language much like HTML. XML was designed to transport and store data, but HTML was designed to display data. XML tags are not predefined like HTML. In other word, developers should define XML tags as per their interest. In addition, XML is platform independent, and needs small memory space. The XML data is stored in plaintext format and easier to create. To store data, there are other possibilities to use like Database Management Software (DBMS). But, they need much memory space which is one of the main mobile device constraints. Therefore, XML is used to transport and store data through the development of M-LA.

In order to read the XML data, XML parser is used. XML parser is a parser that is designed to read XML and create a way for programs to use XML (Stylus-Studio 2005). There are three fundamental types of XML parsers, these are:

- *Model parser*: - used to read the entire documents to create representation of the document in memory. But, it uses significantly more memory than other types of parser. Document Object Model (DOM) is best example for this parser.
- *Push parser*: - read the entire documents, but a number of callback that would be called by the parser when a certain events occur. It uses comparatively much memory and processing power. SAX (Simple API for XML) is best example for this parser.

- *Pull parser*: - reads a little bit of document at once, but it goes through the document by repeatedly requesting the next piece. It uses less memory and processing power. Hence, it is suitable for J2ME applications. KXML 2.0 alpha (9kB), KXML 1.2 (16kB), and MinML 1.7 (14kB) are examples of pull parser.

Since J2ME was used; pull parser is selected as XML parser. Due to its size, KXML 2.0 alpha pull parser was picked.

In this research, Java ™ platform Micro Edition SDK 3.0 device was used as emulator. In developing M-LA, Java Specification request (JSR) 118 for MIDP 2.1, and JSR 139 for CLDC 1.1 and JSR for XML parsing (KXML) were used.

3.4 Methodology of Usability study

Usability can be designed to provide feedback in the software development that is used to achieve specific tasks effectively, safely, efficiently, and satisfactory. There are three types of usability evaluation testing methods (Hom 1998). These are:

- *Testing:* - is a technique that representative users work tasks on the system to test how the user interface supports the user to do the tasks, and evaluators use the result and gather their reply. Testing methods include the following methods: coaching, co-discovery learning, performance management, question-asking protocol, remote testing, retrospective testing, shadowing method, teaching method, and thinking aloud protocol. From the aforementioned types of testing methods, performance management, thinking aloud, and coaching method are used in this research.
- *Inspection:*-this kind of approach used experts, specialists, users, and software developers to examine the usability of the system. Commonly used inspection methods are: cognitive walkthroughs, feature inspection, heuristic evaluation, pluralistic walkthrough, and

perspective-based inspection. Only heuristic evaluation is used in this research.

- *Inquiry:* - is the most familiar types of usability evaluation method either orally or written by using the system or understanding of the system by talking. Inquiry methods include; field observation, focus group, interviews, logging actual use, questionnaires, and proactive field study. Questionnaire is used in this research.

According to Silius and Tervakari, "the importance of usability is consistency regardless of the focus of teaching either traditional or web-based learning" (Silius and Tervakari 2003). Usability testing is an evaluation method to measure how the end users can use the system. It can be represented either in quantitative or qualitative methods. Based on the standard ISO 9241 (Zhang and Adipat 2005), HCI handbooks, and existing usability studies on mobile applications, there are nine generic usability attributes (Arman D., Kori I. et al. 2001; Öquist G. and Goldstein M. 2003): learnability (ease to use); error; efficiency; memorability; user satisfaction; effectiveness; simplicity; comprehensibility; and learning performance. However, in this research the following four usability attributes are selected.

- Learnability (easy to use): - is used to measure easiness of using the system and users level of performance improvement.
- Memorability:-is measured how well users can re-establish the skills of using the system.
- Satisfaction:-is measured based on the students' level of satisfaction while using the software.
- Simplicity:-is measured based on the quality of menu structures as well as navigation design of the application.

Presently, there are two major methodologies that have been used to evaluate usability of mobile applications (Zhang and Adipat 2005): laboratory experiment (Beck et al. 2003) and field studies (Umer Farooq, Wendy Schafer et al. 2002). Laboratory experiment is used when learners are required to accomplish specific task using a mobile application in a controlled laboratory setting. On the other hand, field study allows users to use mobile application in real environment. Naturally, due to

various features of mobile devices and other external factors that is challenging to evaluate usability testing. However, in this study, emulators and E-63 Blackberry Nokia phones were used to evaluate usability of the application in a controlled laboratory setting.

In addition, Carsten and Patterson (2005) have categorized usability tests in different techniques consists of such as performance measurement, thinking aloud protocol, coaching method, retrospective testing, constructive interaction, and questionnaire (Nielsen 1993; Lazar 2001).

In this research the following techniques are used:-

- Performance measurement

  It is the quantitative measurement, such as the number of tasks completed successfully by the students, number of errors done by students, quantity of right answer provided by the students and etc.

- Thinking aloud protocol

  Think aloud technique is introduced by Anders and Simon (1985) to examine different problem solving strategies of people. As the name suggests, students have to speak their opinion loudly on the system which might be positive or negative interpretation for every features of the system. In this way, demonstrator can observe users' responses, mistakes made by a user, see user's actions, and able to analyze why the user has done that kind of action in the application and make notes. This process is used to externalize user's thinking. In this research, this technique of testing is applied for experimental group in the implementation phase.

- Coaching method

  Users can ask the demonstrator any question while running the system, and the demonstrator insight better technology design to improve the system and suit the needs of the users by considering their questions and comments.

- Heuristic Evaluation

  It is a guideline or general principle or rule of thumb that can guide a design decision or be used to critique a decision that has already been made. Nielsen Jakob and Rolf Molich developed Heuristic evaluation which is a method for structuring the critique of a system using a set of relatively simple and general heuristics (Nielsen and Molich 1994). The general idea is that several experts or evaluators evaluate the system independently to come up with a given potential usability problems. As per Nielsen's experience shows that about 5 evaluators have a potential to discover 75% of the overall usability problems. Therefore, in this research 6 lecturers from Computer and Information Sciences department are selected as evaluators in the development phase.

- Questionnaire

  It is a type of testing to provide a chance to gather more usability feedbacks from users after testing sessions. It used the aforementioned usability attributes.

3.4.1 Design for Usability Study

The usability study for M-LA prototype is divided into two types:

i. Quasi Experiment Design to test students' performance and evaluate their efficiency of learning Fundamentals of Programming course using M-LA.
ii. Data from learners using Thinking Aloud Protocol method to observe students' view points and actions towards the application.

Quasi Experiment Design is an experiment involving two groups: control (C_o) and experiment (E_x) (Sekaran 2000; Yueh-Min Huang, Yen-Ting Lin et al. 2010). To implement Quasi in M-LA, the procedure starts by selecting both the control (C_o) and the experimental (E_x) groups. Both groups must attend the pre-test (P) before learning the selected topic. Then they will complete the teaching and learning through the two planned treatments, conventional and M-learning. After completing the teaching and

learning process, students in both groups must take part in the post-test (P1, P2). The hierarchy of Quasi Experiment Design and its explanation is presented in Table 3.2 and Figure 3.11.

In Quasi Experimental Design; the variables for the testing must be identified. The variables involved in this case study are explained based on the hypotheses and coefficient variance statements is discussed in Section 4.3.

Table 3.2: Hierarchy of Quasi Experimental Design

Entity	Explanation
Control Group (C_o)	This group has been chosen to attend the treatment class about a week for each of the three topics using conventional learning.
Experiment Group (E_x)	This group has been chosen to use the M-LA.
Pre-test (P)	Both groups had to take part in the pre-test before learning the topic to assess students' baseline towards the given topic.
Post-test (P1, P2)	Again, the students in both groups were conducted post-test which is similar with pre-test after treatment to measure their performance by comparing pre-test result.

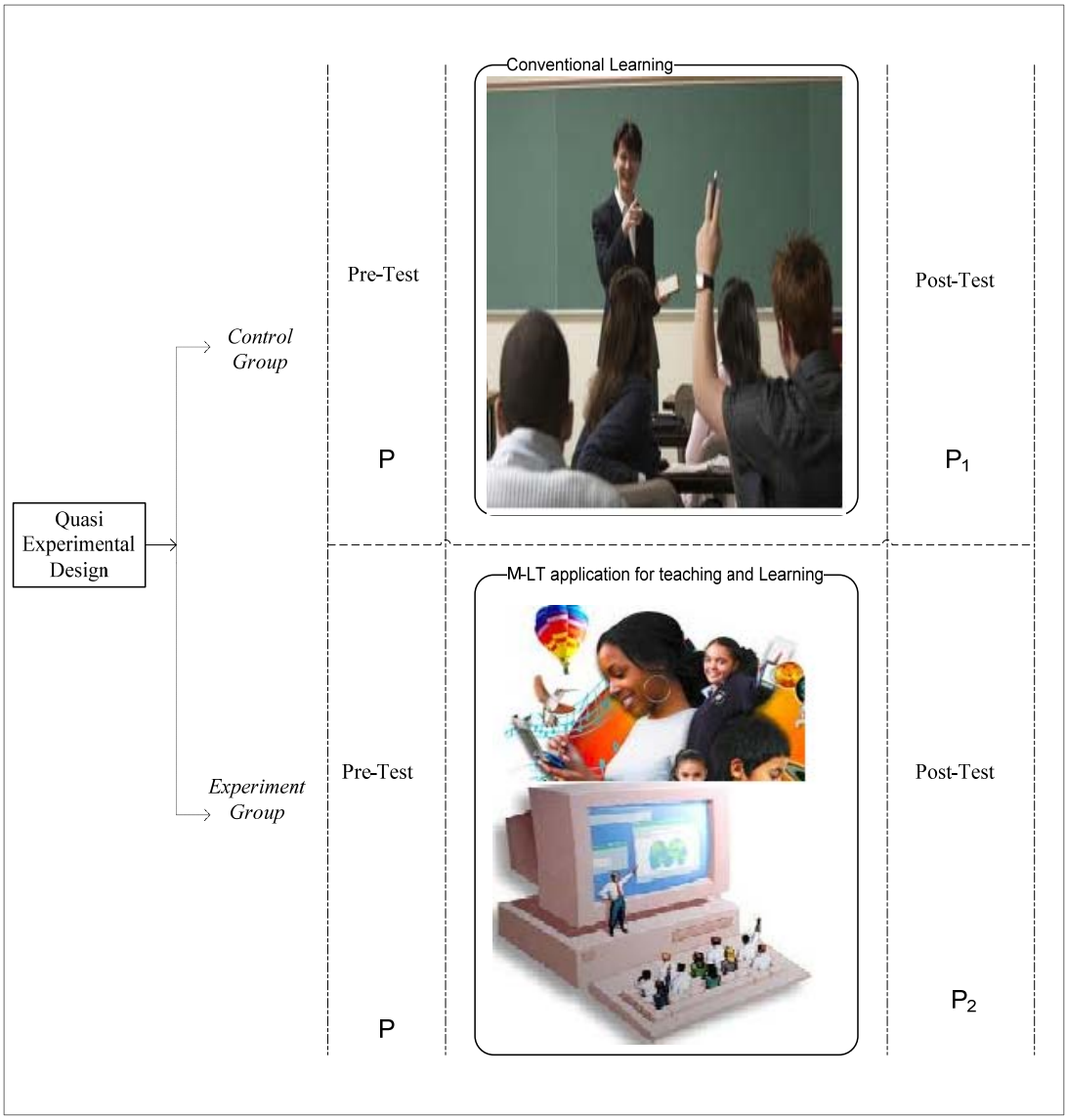

Figure 3.11: Hierarchy of Quasi Experimental Design

3.4.2 Sample of Study

As discussed in the above section, Quasi experiment is used in this study and conducted survey for two independent groups: control and experiment groups. Students from four programs; Chemical Engineering (ChE), Mechanical Engineering (ME), Civil Engineering (CE), and Petroleum Engineering (EE) of UTP foundation students have been selected randomly as the sample set. These students were chosen from different Fundamentals of Programming classes. The concept of this course is

new almost for all students, but some students had exposure about C++ programming language. Therefore, these students did not include in this experiment. Considering the above mentioned ground, 30 students were involved from each of the aforementioned programs for this experiment.

The number of samples in each group was decided based on the previous literatures. According to Anang Hudaya et al. (2006), 30 students have been selected as the evaluator for the M-Learning application, and also involved in the survey that has been conducted. In addition, Motiwalla (2007) used 44 students to conduct the survey from two courses in the subsequent semester to evaluate students experience towards the developed system and also their feedback. Therefore, in this study, under each group 60 students were selected to accomplish the experiment successfully.

During the heuristic evaluation, Nielsen and Molich (1990) recommended to use three to five evaluators which have a potential to detect 75% of usability problems during heuristic testing. Hence, in this study six experts from Computer and Information Sciences Department were involved in the heuristic evaluation.

3.4.3 Tools for Testing Process

In this study, survey, pre-test and post-test, and usability questionnaires were used to gain information pertaining students' need and test the application.

- Survey

  A survey was conducted among ninety foundation students to get information about the problems faced in traditional learning, their experience towards M-learning and using mobile for other applications, and constraints of mobile devices. These inputs were used to accomplish students' interest in the development of M-LA. The survey set is as in Appendix A.

- Pre-test and post-test

  A set of question for pre-test and post-test were created before and after the treatment class (Yueh-Min Huang, Yen-Ting Lin et al. 2010 ;

; Jacobijn Sandberg, Marinus Maris et al. 2011). The questions were to test students' comprehension on Fundamentals of Programming. The question sets are as in Appendix C. In addition, their results are attached in Appendix D.

- Usability questionnaires

  The usability questionnaire contains the elements to measure the usability of M-LA. The questionnaire is as in Appendix E which are adopted from different literatures (Tan-Hsu Tan and Tsung-Yu Liu 2004; Trifonova et al. 2004; Anang et al. 2006; Motiwalla 2007) , and the results are explained in Chapter 4.

3.4.4 Analyzing the Usability Data

This study had been collected and used two types of data which are quantitative and qualitative. The quantitative data were analyzed using the Parametric Statistic which was divided into two styles of calculation: Descriptive and Inferential Statistic. In the meantime, the qualitative analysis was analyzed from open ended questions and comments either written or oral. The following sections are discussed about the methods how both the aforementioned types of data are analyzed.

i. Quantitative analysis

As discussed under Section 3.2.4, the techniques were explained how to conduct the three tests. This quantitative data was analyzed using coefficient variance and independent t-Test for each of the tests (Yueh-Min Huang, Yen-Ting Lin et al. 2010). On the other hand, Cronbach's alpha is used to measure the reliability of the usability attribute data. Independent t-Test uses hypotheses to measure effectiveness. The three t-Test hypotheses were proposed as follow:

Null Hypothesis 1 ($H_0$1):- There is no significant difference in the pre-test scores between the Control and Experimental group.

Null Hypothesis 2 ($H_0$2):- There is no significant difference in the post-test scores between the Control and Experimental group.

Null Hypothesis 3($H_0$3):- There is no significant difference in students' increment scores between the group using M-LA and the students with conventional method of learning.

The Parametric Statistic technique has been applied to analyze the data as Descriptive and Inferential on the C_o and E_x group, each consisting 60 students.

Descriptive Statistics is to describe the data structure. It involves four types of calculation which are Mean, Variance, Frequency, and Percentage is calculated.

Inferential Statistics is to summarize and make a conclusion on the relationship between the samples that have been used in the experiment. Independent t-Test is used to test for a difference between two independent groups on the means of a continuous variable. Moreover, coefficient variance is used to measure the dispersion of data series around the mean (Yong Liu, Hongxiu Li et al. 2011).

Both of the aforementioned statistics are calculated using the Statistical Package for Social Science (SPSS) version 14.0.

- ***Coefficient variance***

It is a statistical parameter which is used to measure the dispersion of values in a series of data around the mean.

The coefficient variance represents the ratio of the standard deviation to the mean which is used to compare the degree of variation from one data series to another. It is calculated as follows:

$$c.v = \frac{\sigma}{\overline{x}} \qquad (1)$$

Where:

$c.v$ is coefficient variance.

σ is standard deviation (refer Equation 2)

$\overline{x}$ is mean of the population

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \overline{x})^2}{n - 1}} \qquad (2)$$

The coefficient variances of different distributions are compared, if the coefficient is large means it has a greatest relative variation from the mean value.

- ***Independent t-Test***

This test had been used two different samples (control and experiment) involved in the experiment. When two samples are involved, the samples are from different individuals who are not matched. In other word, the two samples should be independent each other. It is calculated as follows:

$$t = \frac{\overline{x}_1 - \overline{x_2}}{\sqrt{\frac{(\sigma_1)^2}{n_1} + \frac{(\sigma_2)^2}{n_2}}} \qquad (3)$$

Where:

$\overline{x}_1$ is the mean of the first sample.

$\overline{x}_2$ is the mean of the second sample.

$(\sigma_1)^2$ is the variance or standard deviation squared of the first sample.

$(\sigma_2)^2$ is the variance or standard deviation squared of the second sample.

n_1 is sample size of the first sample.

n_2 is sample size of the second sample.

- ***Cronbach's Alpha***

It is a statistic method which used to measure the internal consistence or reliability of values for the given set of variables. In this study, it is used to test the internal reliabilities of usability evaluation. It is calculated as follows:

$$\alpha = \frac{N * \overline{C}}{\overline{V} + (N - 1) * \overline{C}} \quad (4)$$

Where:

N	Number of items
$\overline{C}$	Average inter-item covariance among the items
$\overline{V}$	Average variance

ii. Qualitative Analysis

Data from the observation and subjective questionnaires part like opinions are classified as qualitative data. These data will be analyzed using descriptive method of statistics to elaborate and explain in an expressive structure. This analysis is used for discussion making and used as input for the future work as well. In the next chapter, Section 4.4, the result is discussed in detail.

3.5 Conclusion

This chapter has discussed all about the methodology which are used in this research. Mainly, ADDIE model is used to design the instructions. It consists of five phases: Analysis, Design, Development, Implementation, and Evaluation. Each phase has different objectives and the output of one phase is used as input for the next one. In Section 3.3 of the chapter was discussed the type of tools proposed in this research. In the last section, the methodology behind effectiveness and usability studies have discussed in detail. Quasi experiment is used to test the effectiveness of the system by assuming two groups: control (C_o) and experiment group (E_x). For control group, the considered learning system was conventional learning while M-learning was adopted for experimental groups. In addition, such attributes as Learnability, Memorability, Satisfaction, and Simplicity are selected to test usability of the system. The collected data could be analyzed using both quantitative and qualitative methods. Finally, researcher has proposed both coefficient variance and Independent t-Test hypothesis methods to analyze quantitative data. On the other hand, qualitative data is planned to be analyzed using descriptive method of statistics which is used for discussion

making. The next chapter will discuss the results of this research using the techniques that are presented in this chapter to achieve the objectives.

CHAPTER 4

RESULT AND DISCUSSION

4.1 Introduction

This research had been conducted to achieve the objectives that are mentioned in Section 1.3, and this chapter is intended to present the results of thesis using the techniques that is discussed in the previous chapter. The main aim of this chapter is to present about the development of M-LA, and testing of its effectiveness and usability.

In the first section, the technical details of the system implementation, demonstration of the system (operational scenario), and designing of platform classification are discussed. In the next section, both the results of effectiveness and usability evaluations are explained correspondingly. As discussed in the previous chapter, effectiveness evaluation used coefficient variance and t-Test Independent.

4.2 Development of the Mobile Learning Application (M-LA) prototype

As discussed in the previous chapter, the life-cycle of M-LA consists of 5 main phases starting from analysis to evaluation phase using ADDIE which is used for instructional design model. In addition, due to the expansion of java enabled mobile operating system and its platform independence feature, M-LA is implemented using J2ME, XML, and KXML on Netbeans IDE 6.9 as a working environment as presented in Section 3.3. Thus, in this section the outcomes from the development process, and its effectiveness and usability evaluation will be discussed in detail.

4.2.1 Technical Details

The architecture of system is organized into four layers (See Figure 4.1). It includes:

i. User Layer (UL),
ii. Logical Layer (2L),
iii. Application Layer (AL), and
iv. Storage Layer (SL)

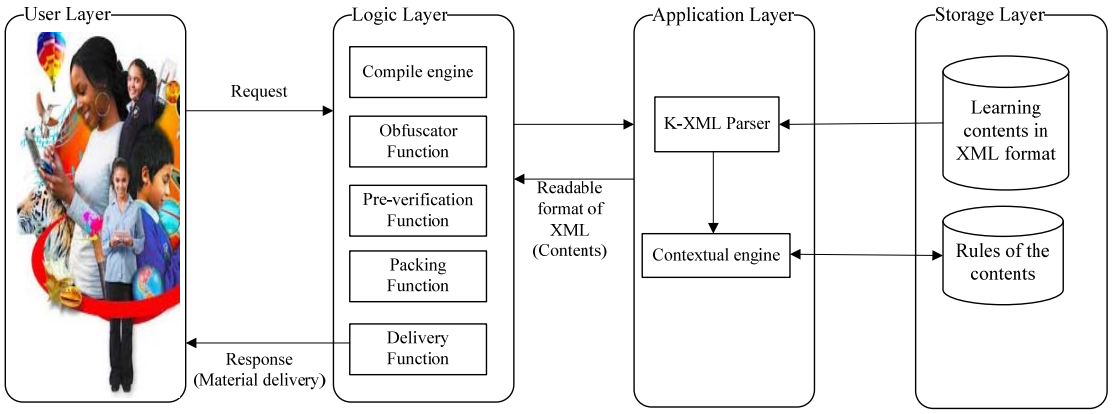

Figure 4.1: M-LA platform architecture

The main task of M-LA is to use mobile devices as a learning instrument to support learners by making learning all present. As shown from the above figure, M-LA architecture consists four fundamental layers which are explained below.

i. User Layer

User or client layer used mobile devices as a learning instrument to access the learning materials. M-LA is supported offline access. Currently, there are several mobile operating systems. Attwell categorized the possible mobile operating systems (OSs) options: Symbian, Blackberry, Andriod, J2ME, Palm OS, Windows CE, and Pogo (Attewell 2005). Even though, there are different types of OSs. But, Java mobile application is platform independent.

ii. Logic Layer

This layer mostly provides and performs functions to generate, compile, obfuscator, pre-verify, pack and delivery of materials in XML format. The followings describe these functions:

- Compile Engine: - has the responsibility for compiling Java source codes to bytecode class files. This architecture used J2ME compiler.

- Obfuscator Function: - improves the size, performance and security of J2ME mobile application.

- Pre-verification Function: - J2ME bytecode class files should be valid bytecodes to be run on mobile phone devices. Therefore, pre-verification must be applied to convert J2ME bytecodes to valid bytecodes. This function only acts on J2ME Connected Limited Device Configuration (CLDC) application bytecodes.

- Packing Function: - is necessary to generate special format such as jar or code files that can be able to run on mobile phone devices.

- Delivery Function: - is responsible for delivering educational materials in XML and J2MEidlets format.

iii. Application Layer

This layer is responsible for reading the XML using K-XML parser, and checking the compatibility of the platform and size of the application using contextual engine process.

- K-XML: - is a software module used to read XML documents and a means to provide access to their content.
- Platform Adaptive content: - analyzes the platform of the devices and deploy by considering rules of the content like, hardware constraints of the mobile devices.

iv. Storage Layer

Educational materials are stored in J2ME midlet and XML data format which is used as a repository. Metadata in an XML data format is used to hold information about the materials.

In the proposed platform, there are two kinds of XML data: one the quiz XML which contains quiz and the other one is metadata holding lecture materials of each chapter's content. For instance, here XML quiz data is demonstrated the schema

format along with an XML. Each of the generated quizzes is stored in an XML data format, DTD schema for the XML data is as follows:

<? Xml version="1.0" standalone="no"?>

<! **ELEMENTS** QuizSet (Coursecode, Title, Qtype, Quiz*)>

<! **ELEMENTS** Quiz (Question, Option*, Correct)>

<! **ELEMENTS** Coursecode (#PCDATA)>

<! **ELEMENTS** Title (#PCDATA)>

<! **ELEMENTS** QType (#PCDATA)>

<! **ELEMENTS** Question (#PCDATA)>

<! **ELEMENTS** Option (#PCDATA)>

<! **ELEMENTS** Correct (#PCDATA)>

The following is an example of the DTD schema:

<? xml version="1.0" standalone="no"?>

<QuizSet>

<CourseCode> TBB1073 </CourseCode>

< Title> If Condition </ Title>

< QType> mchoice < /QType>

< Quiz>

< Question>

1. Which of the following is the Boolean operator for logical-and?

</ Question>

< Option> [a] & </ Option>

< Option> [b] && </ Option>

< Option> [c] | </ Option>

< Option> [d] |& </ Option>

< Correct> b </ Correct >

</ Quiz>

< Quiz>

< Question>

2. Evaluate !(1 && !(0 || 1)).

</ Question>

< Option> [a] True </ Option>

< Option> [b] False </ Option>

< Option> [c] Unevluable </ Option>

< Option> [d] none </ Option>

< Correct> a </ Correct >

< /Quiz>

……

<QuizSet>

4.2.2 Operating Scenario

As discussed in Section 2.3.2, there are two major types of availability of contents which are online and offline materials. Due to the scope of the research, M-LA is supported from learners' side, and offline materials of both lecture materials and quizzes. The use of offline materials has several advantages over online materials: learners are always able to upload offline materials into their cell phones in different ways including infra-red, USB, and Bluetooth (Attewell 2005; Yanhui et al. 2007;Niazi and Mahmoud 2008). Secondly, when learners upload offline materials into their devices, these materials will always be available; no matter there is signal disruption or network disconnection; and very cost effective for learners because they do not have to use bandwidth to upload these materials (Niazi and Mahmoud 2008).

Due to the limitations of memory and processing power of mobile devices, using of offline materials is challenging. Hence, there should be some strategies to optimize and design mobile applications and learning content in size and memory usage. The other challenge is wide variety of mobile devices which are different hardware and also their operating systems. Hence, there should be strategies to support some customization by making platform-independent delivery of content materials to these mobile devices.

Based on the preliminary survey as discussed in Section 3.2.1, and nature of the mobile devices and course contents, the selected mobile devices are smart phones,

PDA, and laptops. Accordingly, the tool is developed for the following devices (See Table 4.1) with the given offline contents.

Table 4.1: Offline Quiz Format

Targets	Devices
CLDC 1.1, MIDP 2.1	Java-enabled device
CLDC 1.0, MIDP 1.0	Java-enabled device

The type of emulators used in this research is Sun Java ™ platform Micro Edition SDK 3.0 for both PDA (Touch Screen) and Smart Phones emulators. The following screen shots generated using the aforementioned emulators (Refer Figure 4.2).

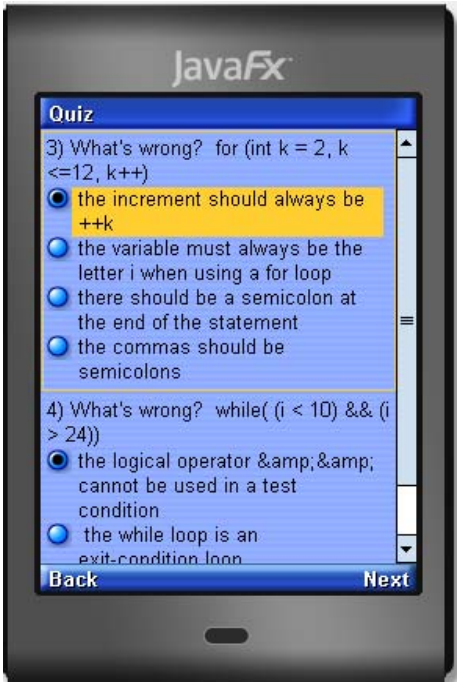

Figure 4.2: Sample Quiz

4.2.3 The Process Flow of Each Module

As discussed in the entire thesis, M-LA is developed for Fundamentals of Programming course. Herein, Figure 4.3 shows that Lecture Material and Quiz are the main modules of the system. Under each of them there are three sub-modules; Selection, Loop, and Function. Lecture Material module presents the main concepts of

the above mentioned areas of the course Quiz module contains multiple choice tests out of five under each section.

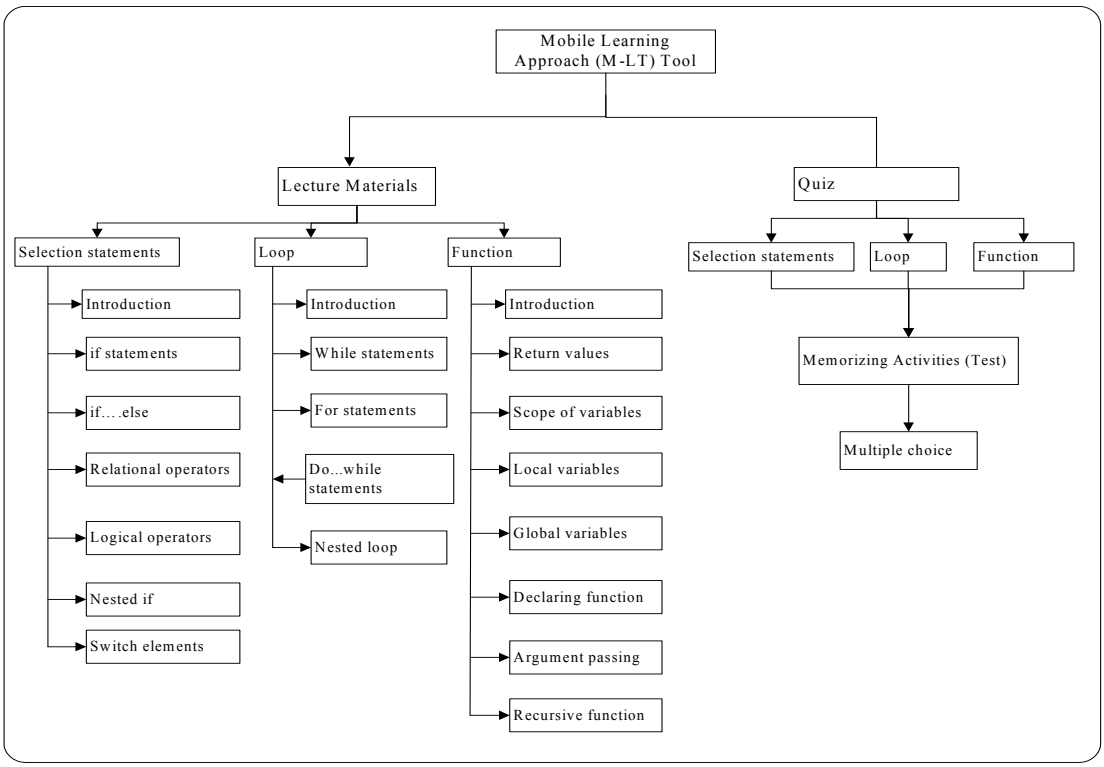

Figure 4.3: The Main Modules in M-LA prototype

The first sub-module of the Quiz is Selection Statements followed by Loop and Function. Therefore, students can start navigate from the Selection sub-module of Lecture Materials and took Memorizing Activities (Tests) from the Quiz module. If their score is equal to or more than 3, they will be allowed to enter the Loop module instead of revising it and took the test again. After the learners finished the Loop sub-module of Lecture Material, they will take the Memorizing Activities (Test). If they scored below 3 that will not allowed to precede the next sub-module unless they revised and took the test, and scored satisfactory result. On the other hand, they will access the next Function sub-module. The rating of 3 is chosen as the measurement scale since it is the average point of the experiment groups' in the effectiveness evaluation. These flows of navigation for the two modules are shown in the Figure 4.4 as follows:

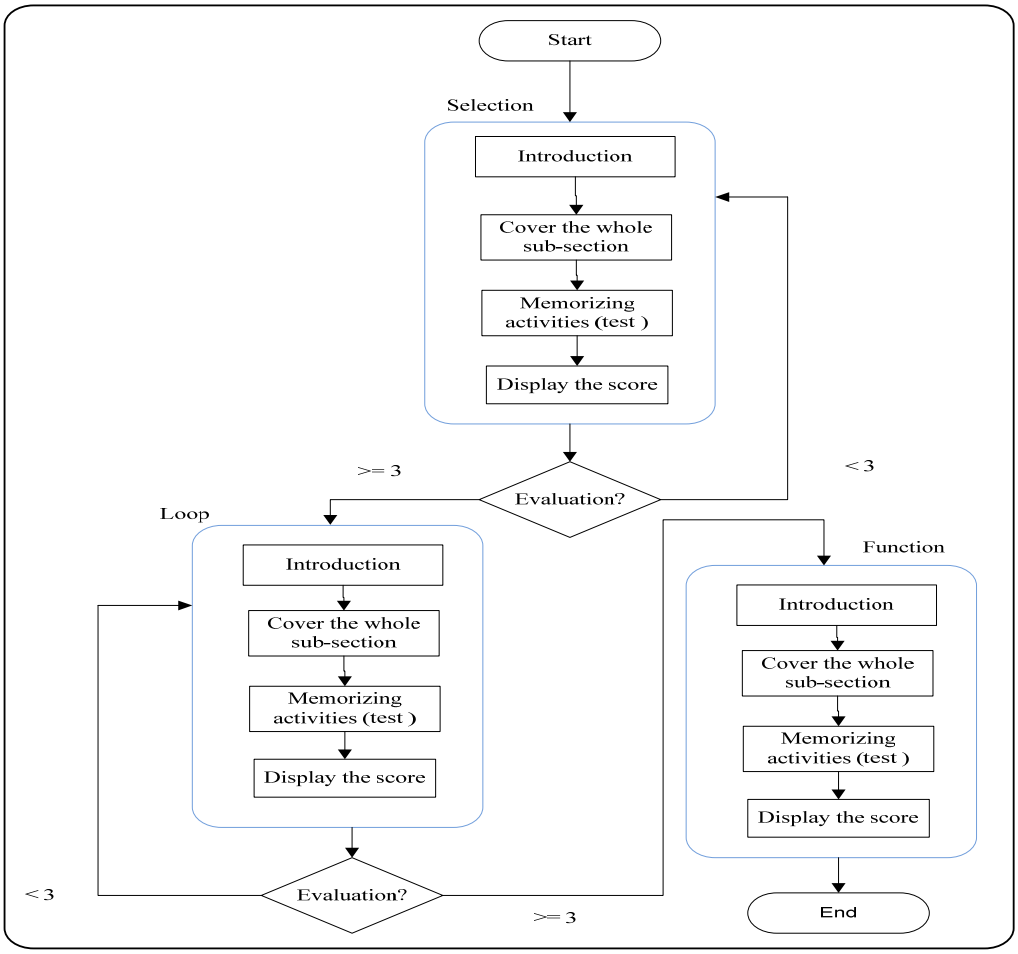

Figure 4.4: Module Flow Chart

The application starts by presenting learning objectives of the course. Therefore, the purpose of having objective page play as the opening page is to capture the attention among students by giving the main aims of the course. However, students can skip the objective interface if they so desire. The interface for the objective is as shown in Figure 4.5 below using Sun Java ^{TM} platform Micro Edition SDK 3.0 device as emulator.

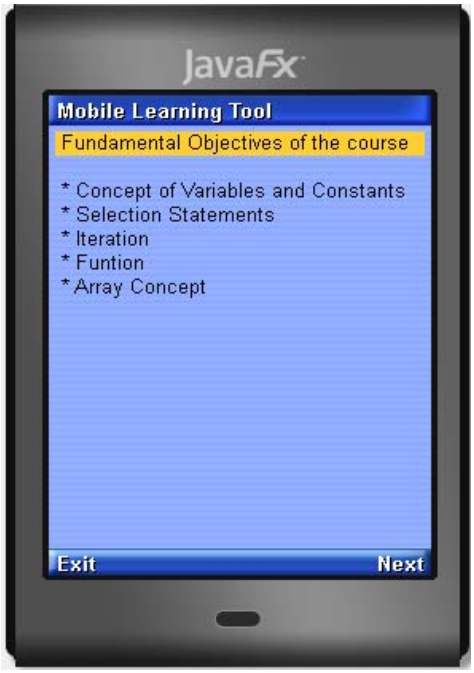

Figure 4.5: Introduction Module

The next page after the objective presentation is the main menu page. Then the users are free to explore and navigate since M-LA applies the perpetual navigation concepts. Due to lack of standard to design mobile application interface, limitations of mobile devices and types of content are considered as the main factors to design the interface and make consistent in terms size, location, and function. Figure 4.6 depicts that the main menu interface screen shot of M-LA which has two main modules, these are; lecture materials, and quiz. In addition, the detailed flows of each module are presented in the next sub-sections in detail. These modules have been designed according to the Fundamentals of Programming syllabus (as shown in Figure 3.3), and have adopted the educational theories which are summarized under Section 2.4.

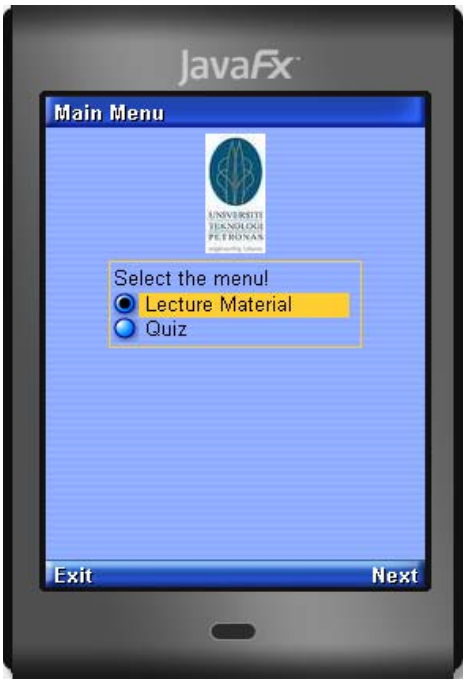

Figure 4.6: Main Menu Page on PDA (Touch Screen)

4.2.4.1 Lecture Materials

Based on the outline of Fundamentals of Programming course and Figure 4.5 and 4.7 there are about five major chapters. But, in this study three of them are selected depending on their nature of contents and basic to understand the remaining concepts of C++ programming chapters. These selected sub-modules are Conditional Statement, Loop, and Function. These sub-modules are aimed to provide lecture notes and examples to the students under different sections (Refer Figure 4.5). For instance, as seen from the Figure 4.7 and 4.8 that Conditional Statements sub-module contains seven sections. Furthermore, the second sub-module comprises five sections, and the last sub-module is divided in to eight sections. These sections are designed based on the guide that has been discussed in Section 3.2.2. All of the sub-modules are arranged according to the course outline. Moreover, learners have to understand the first sub-module and scored passing mark before going on to the next sub-module.

Each of the selected sub-modules is presented as simple as possible using text and picture. Figure 4.9 and 4.10 shows that some screen shots of Lecture Materials in the Java ^{TM} platform Micro Edition SDK 3.0 device as emulator

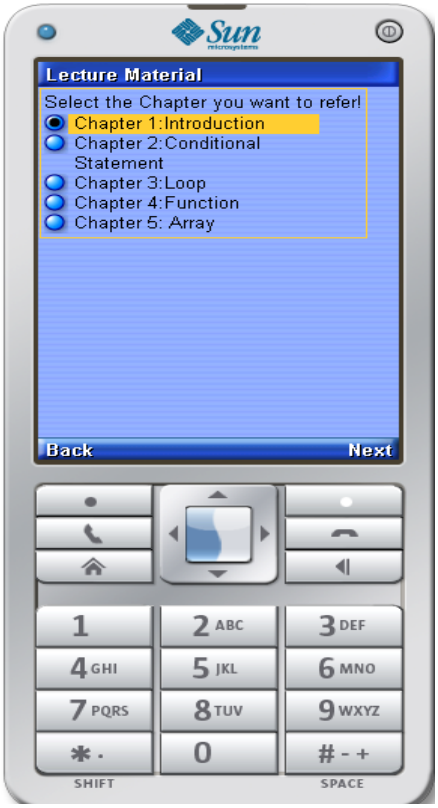

Figure 4.7: Lecture Material Main Menu

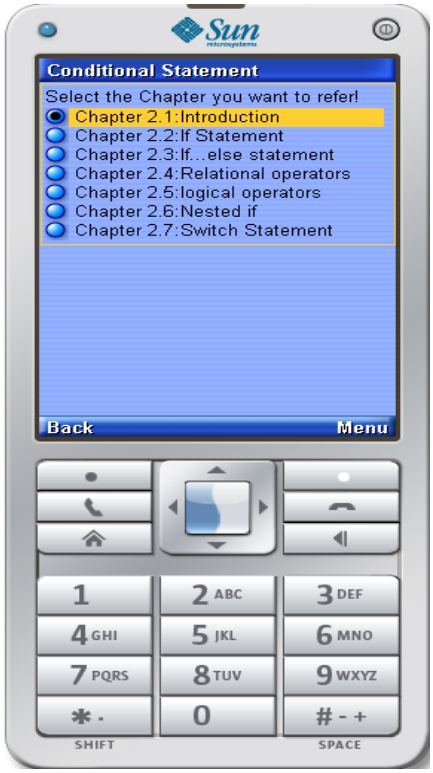

Figure 4.8: Conditional Statement List of contents

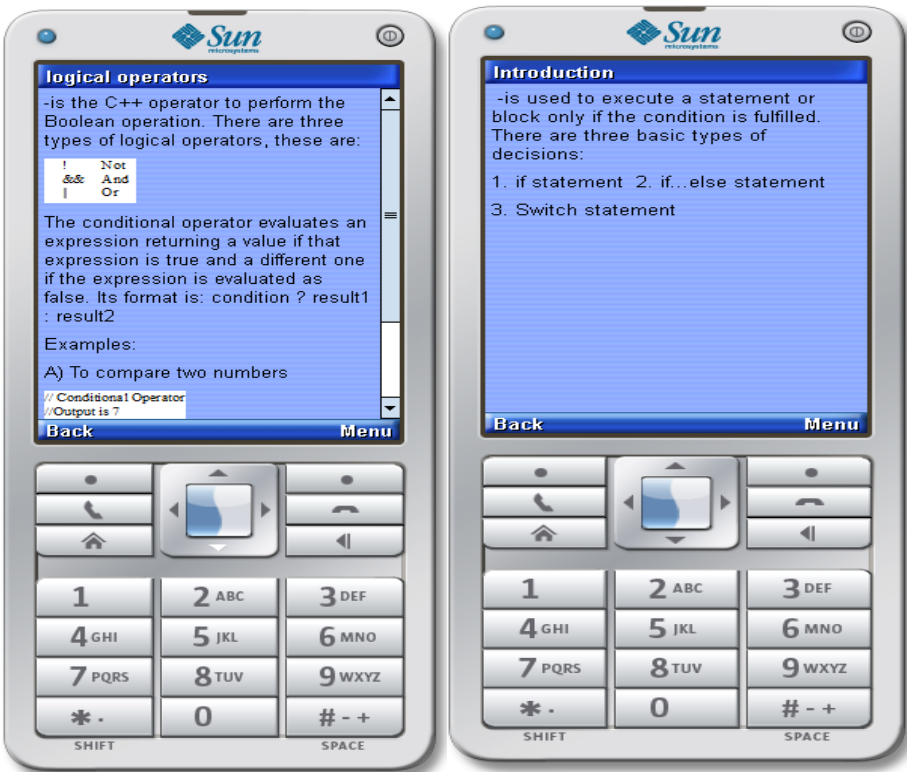

Figure 4.9: Conditional Statement and Logical Operators Lecture Notes

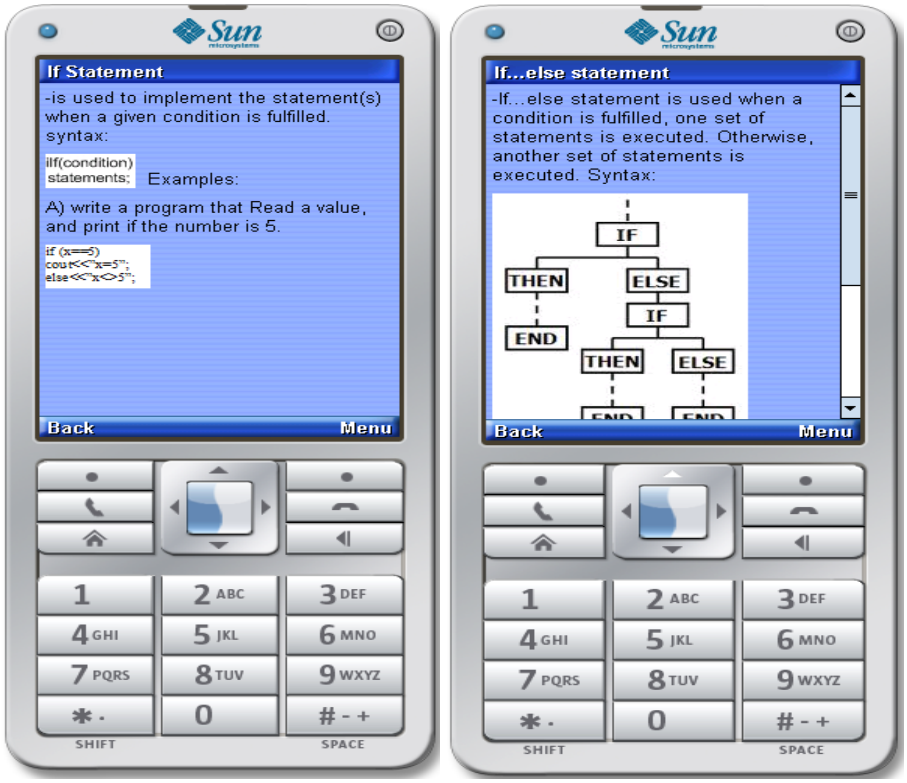

Figure 4.10: Conditional Statements Lecture Note (If statement)

4.2.4.2 Quiz

As discussed in the above section, the selected sub-modules are Conditional Statements, Loop, and Function. To examine learners' understanding, memorizing activities are prepared for all of the selected sub-modules. Figure 4.11 shows that the menu of Quiz module. In the Quiz module, students will navigate the Memorizing Activities (test) for each section in the form of multiple choices. As discussed in Section 3.2.4, students should score greater then two to proceed the next sub-module. Figure 4.12 and 13 shows some screen shots of Quiz using Java ™ platform Micro Edition SDK 3.0 as device emulator.

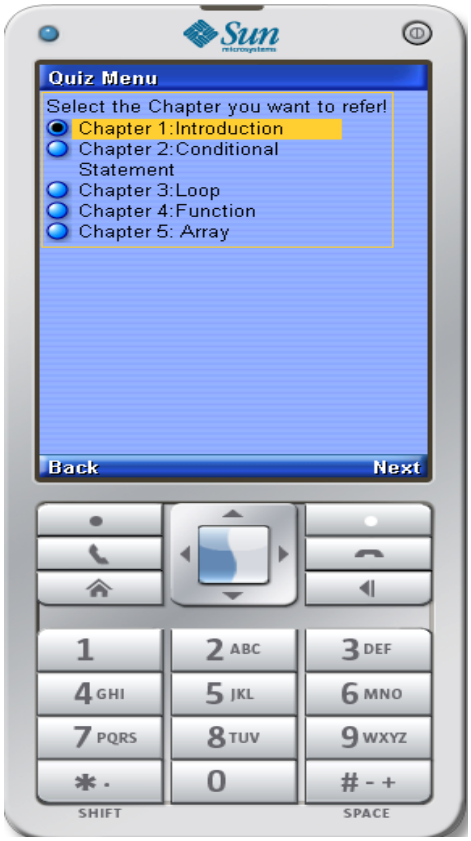

Figure 4.11: Quiz Main Menu

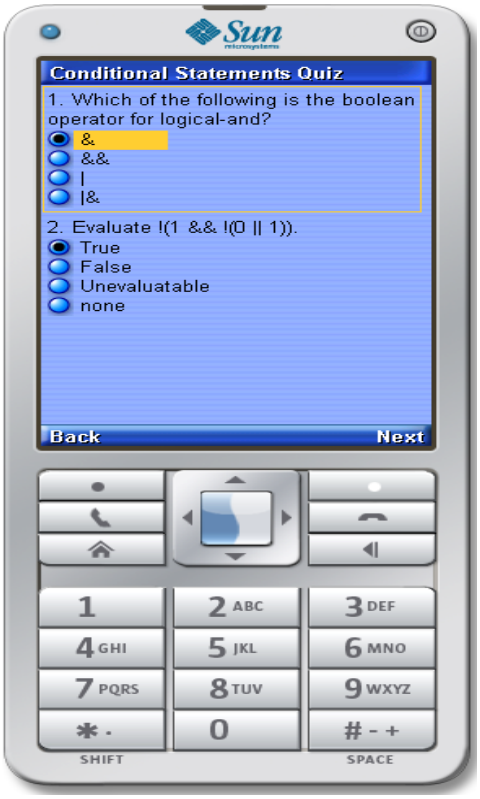

Figure 4.12: Sample Quizzes on Conditional Statements

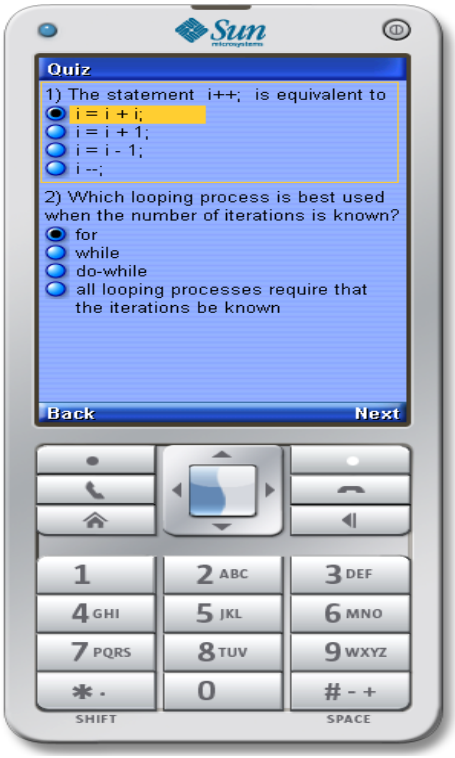

Figure 4.13: Sample Quizzes on Loop Concept

4.2.4 Summary of the Section

One of the main objectives of this research is to develop M-learning application prototype for Fundamentals of Programming has been achieved as presented under the entire of sub-chapter 4.2. Two main modules which are Lecture Material and Quiz have been created in the prototype of M-LA. The modules are designed based on the course outline of the course at foundation level. This M-LA design and development have adapted the following techniques such as M-learning approach, learning theories, interactivity, supported target devices, supported data format, and availability of the content. These techniques have been applied either directly or indirectly in the development of M-LA prototype. Table 4.2 summarizes the techniques that have been applied in M-LA prototype.

Table 4.2: The Techniques Applied in the M-LA Prototype

Technique	**Type**	**Module / Sub-module**	**Explanation**
Approach	Mobile learning approach	All modules	One type of learning approach that used mobile as a learning instrument.
Learning Theories	Behaviorist	Quiz module Figure 4.12, 4.13 (memorizing activities)	This application provides both course content and quiz which are used to implement behaviorism learning theory. In behaviorism learning theory, the drill and feedback concept need to be used to ensure the learners' understanding of the discussed topic. Here, quiz acts as drill whereas course content and displayed message (also called reinforcement) acts as feedback.
	Cognitivism	Lecture Material module Figure 4.9, 4.10	According to Siemens and George (2006), Cognitivism learning theory is used to interpret the realities which exists and mediated through symbols and signs. Therefore, due to limitations of mobile devices figurative representation has been applied in this application.
	Constructivism	Quiz module Figure 4.12	Constructivism learning theory was used to put the main ideas of the area by considering the end users' level of understanding to wards the subject matter. In which it is used to make learners active in order to apply their previous and present knowledge to construct new ideas. This is also important to use the space efficiently.
Interactivity	Click, select, and types	All modules	Due to the difficulties of keying inputs, both click and select are used in this application.

Supported Devices	Smart Phones, PDA, and Laptop	All modules	This are the list of mobile devices that are supported this courseware
Supported Data Format	XML, and J2ME midlets	All modules	XML is one type storing data which is device and platform independent. In this application both XML and J2ME midlets are used to store lecture materials.
Availability	Anywhere	All modules	Is an approach that support accessing of learning materials any place, if it support online access there should be connectivity, else no need of communication.
	Anytime	All modules	To build ubiquitous learning the learning materials should be accessed any time. Therefore, M-learning approach has this facility.

4.3 Effectiveness Evaluation on M-LA

As discussed in Section 3.2.5, evaluation of M-LA has been conducted to determine its effectiveness towards enhancing students' understanding of Fundamentals of Programming course using three different tests for each of the selected sections which are attached in Appendix C. The maximum mark of every test is five. The evaluation was done in a Quasi experiment by comparing the control (using conventional learning) and experimental (using M-LA) group. This effectiveness evaluation of M-LA aimed to answer the following questions:

- Does M-LA able to improve learners' comprehension of the Fundamentals of Programming course?
- Does using of mobile devices as a learning instrument been effective to students in teaching and learning by enhancing conventional learning?

In addition, the decisive factor is to conduct post-test was to measure the students' performance by comparing their pre-test results. In other word, both groups should have similar baseline towards the test topic to make the population favourable and the result more reliable. Otherwise, according to Gribbons and Joan (1997), post-test Quasi experimental design can be conducted when the two groups (C_o and E_x) are equivalent in term of characteristic which can affect the observed differences in post-test scores (Gribbons and Joan 1997). Table 4.3 summarizes students' demographic according to their gender. As discussed in Section 3.4.1, the Quasi experiment has

been designed to include both pre-test and post-test for all the three tests on the selected sample, which consist of a total of 120 students and 30 students from each of the following departments: Mechanical (ME), Chemical (CHE), Petroleum (PE), and Civil (CE) engineering. As seen in the Table 4.3 that both experimental and control groups contain 60 students each.

Table 4.3: Summery of Sample Students According to Program and Gender Classification

	Number of Students								**Total**
Program	ME		CHE		PE		CE		
Gender	Male	Female	Male	Female	Male	Female	Male	Female	
Experiment	6	9	10	5	7	8	4	11	60
Control	8	7	4	11	5	10	9	6	60
Total	30		30		30		30		120

4.3.1 Pre-test and Post-test Analysis Effectiveness Evaluation on M-LA

As discussed in the above section, pre-test is a preliminary test to determine students' baseline knowledge or performance towards the given area prior to the treatment class and conduct post-test. The comparison of the pre-test and post-test will indicate the effectiveness of M-LA or the conventional learning in terms of improving students' performance. In the following section the statistical analysis and descriptive statistics of the three tests results will present for both control (C_o) and experimental (E_x) groups. If a student did not complete both a pre-test and a post-test, or if it was not possible to match a pre-test with a post-test, the data for that survey were not used in the matched pair analysis.

4.3.1.1 Test 1

As discussed in Section 3.2.4, test is used to measure the effectiveness of the system by comparing pre-test and post-test result. Hence, initially Test 1 was conducted which is covered about Conditional Statements topics of Fundamentals of Programming course. In the following section both the M-learning and conventional learning students' pre-test and post-test results' are summarised to measure the efficiency of M-LA.

✓ **Pre-test**

It can be seen from Figure 4.14 that presents the statistical analysis of the results in Appendix D. According to Figure 4.14, none in C_o group obtained zero score while 8.33% (5) of E_x students obtained it. About 38.33% (23) and 36.67% (22) of students from the respective C_o and E_x groups achieved only one. While, 53.33% (32) and 40% (24) students of both groups scored two, but about 8.33% (5) and 15% (9) of students from the respective C_o and E_x groups obtained three which is beyond the average value, and none of the groups scored four and five. These results clearly demonstrate that the students' baseline performance is almost in equal level. In other words, the result is favourable to conduct the post-test to measure the efficiency of the system.

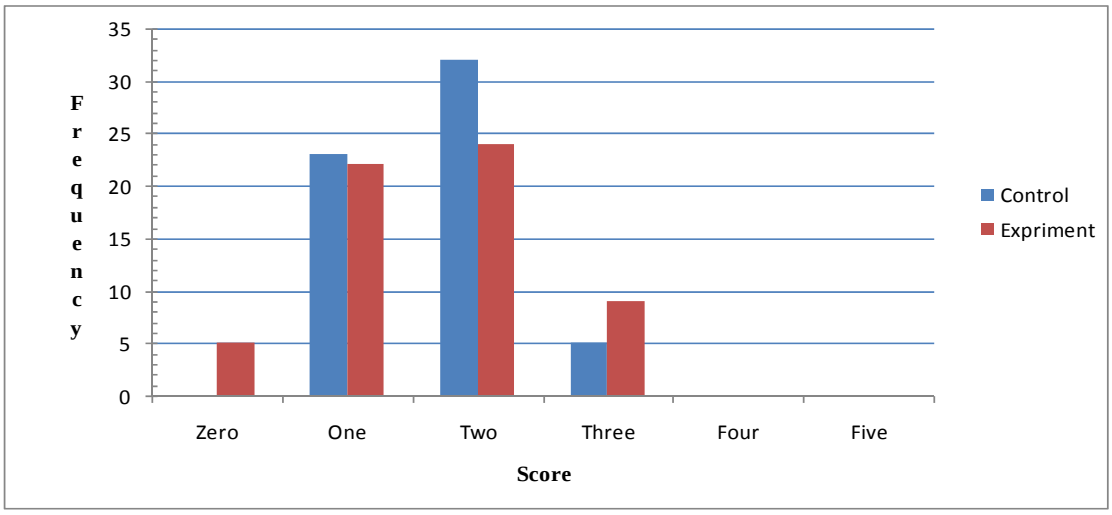

Figure 4.14: Test 1 Statistical Analysis of Pre-test Marks for C_o and E_x Groups

Table 4.4 summarizes the descriptive statistics for the entire data for the pre-test results of test 1 scored by C_o and E_x groups of students. The mean scores of C_o and E_x groups are 1.70 and 1.62 respectively which are less than the average of the total mark. In addition, both C_o and E_x groups' minimal points are 0 and 1 respectively, and the maximum point for both groups is three. In conclusion, students' basic knowhow in these two groups towards the subject area of test 1 are almost similar. Therefore, this sample is feasible to measure the effectiveness of M-LA in terms of improving performance by conducting post-test after treating them using conventional and M-learning approach.

Table 4.4: Descriptive Statistics Summary for Test 1 of Pre-test

	C_o Group	**E_x Group**
Minimum	1.00	0.00
Maximum	3.00	3.00
Mean	1.70	1.62
Coefficient Range	2.00	1.00

✓ **Post-test**

Figure 4.15 depicted that the statistical analysis of the results which are presented in the Appendix E which was scored by the students from both C_o and E_x groups out of five. According to Figure 4.15, none of C_o and E_x group learners obtained zero while 1.67% (1) and 30% (18) of students from the C_o group scored one and two respectively. But, none of E_x group scored one and two. In addition, 50% (30) and only 13.33% (8) from the respective C_o and E_x groups achieved three. However, about 18.33% (11) of students in C_o group scored four and 40% (24) for E_x group scored the same, and none in C_o group while 46.67% (28) in E_x obtained five or full mark. These results clearly demonstrate that M-LA is able to get better the students' performance, which answers the question of *"Does M-LA able to improve learners' comprehension of the Fundamentals of Programming course?"*

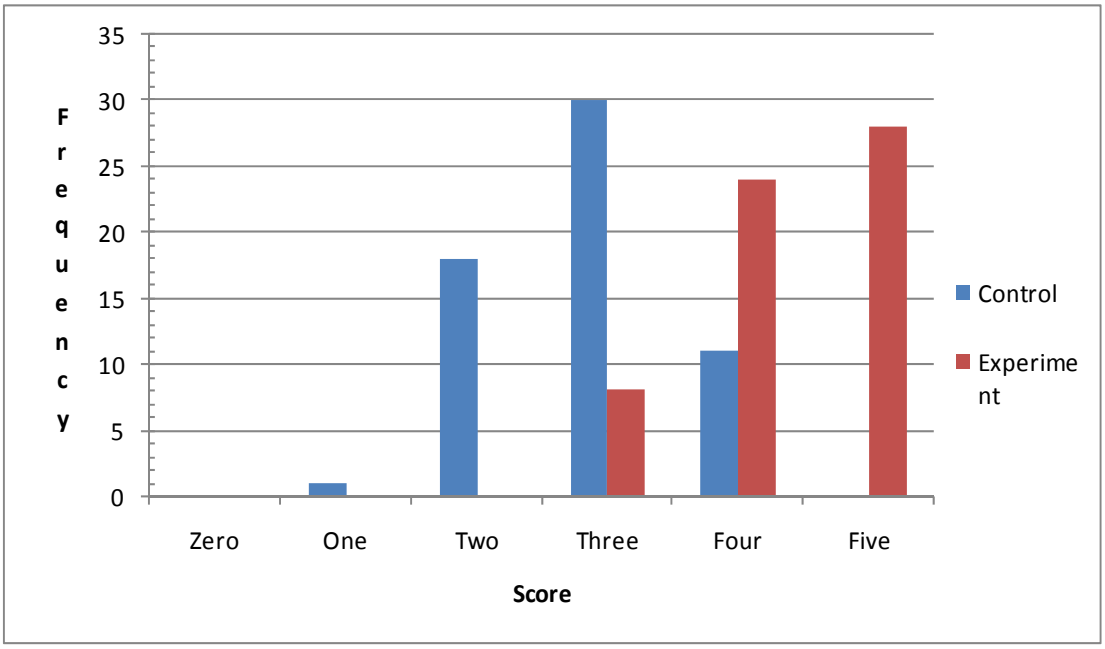

Figure 4.15: Test 1 Statistical Analysis of Post-test Marks for C_o and E_x Groups

Table 4.5 summarizes the descriptive statistics for the entire data for test 1 post-test scored by C_o and E_x groups of students. The mean scores of C_o and E_x groups' was 2.85 and 4.33 respectively. In addition, the minimum scores of C_o and E_x groups' was 1.00 and 3.00 correspondingly while the maximum values are 4.00 and 5.00 respectively. Hence, the difference between the minimum and maximum value of E_x group was two (5-3) which shows that students in E_x group was getting effective and scored full mark after using the system. Therefore, these results clearly demonstrate that M-LA is able to improve students' performance, which answers the question of "*Does M-LA able to improve learners' comprehension of the Fundamentals of Programming course?*"

Table 4.5: Descriptive Statistics Summary for Post-test of Test 1

	C_o Group	**E_x Group**
Minimum	1.00	3.00
Maximum	4.00	5.00
Mean	2.85	4.33
Coefficient Range	1.67	4.00

4.3.1.2 Test 2

As discussed in the above section, Test 1 result was conducted and analyzed the results to evaluate the effectiveness of the system by comparing the pre-test and post-test results of the students. And the same procedure was used for Test 2 which covered about Loop concept. In the following section, the Test 2 results are summarized to measure the efficacy of M-LA.

- ✓ **Pre-test**

It can be seen from Figure 4.16 that presents the statistical analysis of the results in Appendix D. According to Figure 4.16, none in C_o group and 3.33% (2) of E_x students obtained zero. About 55% (33) of students in C_o scored one and 51.67% (31) of students from the E_x group scored the same result, while 40% (24) and 51.67% (31) of students from the respective C_o and E_x groups obtained two. However, none in E_x group scored in the 3-5 range, whilst only 5% (3) of C_o students scored three and none in this group obtained 4-5 score. These results clearly demonstrate that 100% and

95% of the students from the respective E_x and C_o groups obtained a score of below the average value. In conclusion, students' background towards the area of Test 2 almost is similar and sufficient evidence to use this population to test the effectiveness of M-LA.

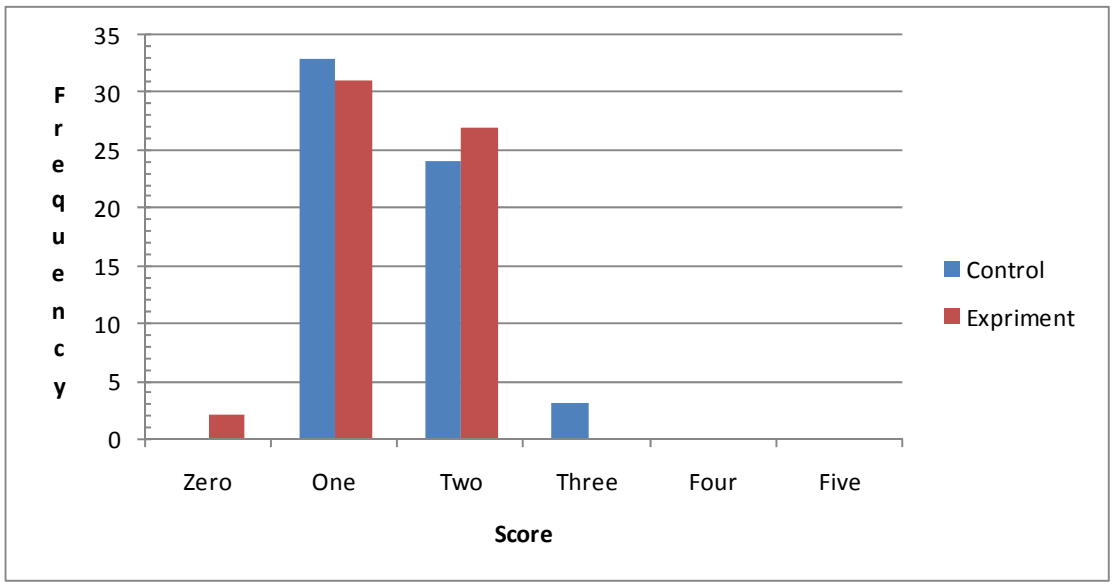

Figure 4.16: Test 2 Statistical Analysis of Pre-test Marks for C_o and E_x Groups

From Table 4.6 it can be seen that the descriptive statistics for the entire data for Test 2 pre-test scored by C_o and E_x groups of students. The mean score of C_o was 1.50 while the E_x groups' mean score was 1.42. In addition, the minimum mark of C_o groups was 1 and the minimum mark in E_x groups' was 0, whilst the maximum mark in C_o groups' was 3 and the maximum mark in E_x groups' was 2. These results indicated the students had almost the same background on this area and realistic to use this sampling in order to evaluate the effectiveness of the system. In other word, the overall results were quite favourable.

Table 4.6: Descriptive Statistics Summary for Pre-test of Test 2

	C_o Group	**E_x Group**
Minimum	1.00	0.00
Maximum	3.00	2.00
Mean	1.50	1.42
Coefficient Range	2.00	1.00

✓ **Post-test**

Figure 4.17 presents the statistical analysis of the results in Appendix D. From Figure 4.17 it can be seen that none of the two groups of students obtained zero, while none in E_x group and 10% (6) of students in C_o group achieved one. In addition, 50 % (30) and only 5% (3) of students from the respective C_o and E_x groups scored two which means above 60% (36) of C_o groups obtained below average. However, about 35% (21) from C_o and 51.67% (31) from E_x achieved three, 41.67% (25) of students in E_x group achieved a score of four and only 5% (3) for C_o group, and none in C_o group obtained full mark (5) while 1.67% (1) obtained it. These indicated that the improvement of experimental students through using M-LA and answer the question of "*Does M-LA able to improve learners' comprehension of the Fundamentals of Programming course?*"

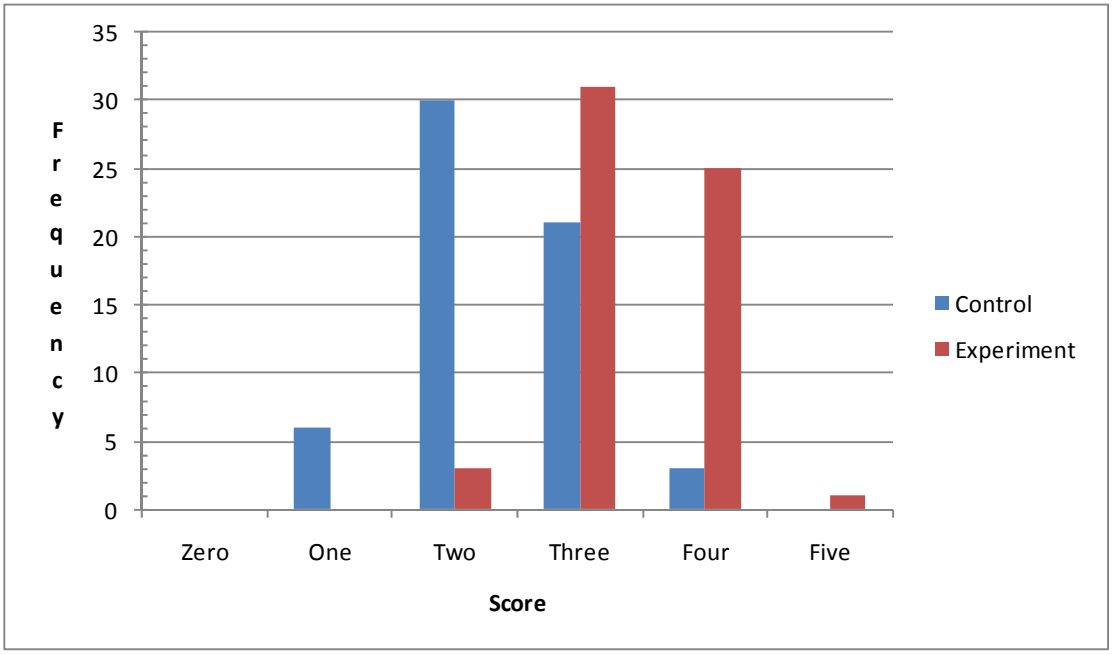

Figure 4.17: Test 2 Statistical Analysis of Post-test Marks for C_o and E_x Groups

As seen in the Table 4.7 that summarizes the descriptive statistics of the entire data for test 2 post-test scored by C_o and E_x groups of students. The mean score of C_o group was 2.35 and E_x group scored 3.40. Additionally, the minimum score of C_o obtained 1 and maximum mark was 4, while the minimum score of E_x group was 2 and maximum was 5. Hence, the mean score of E_x group was over 3.0 and maximum

score is full mark (five), showing that students who were using this system improved their performance and M-LA has a potential to promote students' understanding and answer the question of "*Does M-LA able to improve learners' comprehension of the Fundamentals of Programming course?*"

Table 4.7: Descriptive Statistics Summary for Post-test of Test 2

	C_o Group	**E_x Group**
Minimum	1.00	2.00
Maximum	4.00	5.00
Mean	2.35	3.40
Coefficient Range	0.6	0.423

4.3.1.3 Test 3

It is the last test and used the same procedure like Test 1 and Test 2 to evaluate effectiveness of the system. In the following section, results are summarised to measure effectiveness.

- ✓ **Pre-test**

Figure 4.18 presents that the statistical analysis using the results in Appendix D. As seen in the Figure 4.18 that none of in both C_o and E_x groups scored four and five, while 3.33% (2) of them obtained zero. About 30% (18) and 43.33% (26) of students from the respective C_o and E_x groups achieved one, 46.67% (28) from C_o and 36.67% (22) from E_x obtained two. On the other hand, 20% (12) from C_o group and 16.67% (10) from E_x group achieved three which is above the average mark. These results illustrate that 80% and 83.33% of the students from the respective C_o and E_x groups were scored below average, while the remaining students obtained above it. Hence, students' background towards this section was almost similar and also sufficient evidence to use this sampling to test the effectiveness by conducting post-test after treatment.

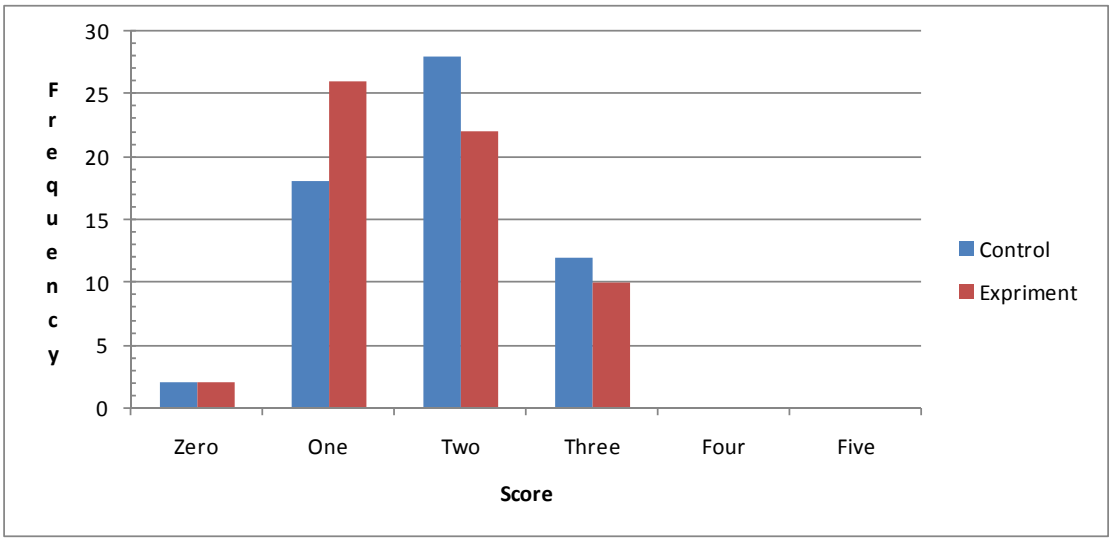

Figure 4.18: Test 3 Statistical Analysis of Pre-test Marks for C_o and E_x Groups

Table 4.8 summarizes the descriptive statistics for the entire data for test 3 pre-test scored by C_o and E_x groups of students. The mean scores of C_o and E_x groups was 1.83 and 1.67 respectively which were less than the average of the full mark. In addition, the minimum and maximum mark of the two groups was the equivalent 0 and 3 respectively. Moreover, their coefficient range is equal to 1.00. These show that the dispersion of students mark is similar. In conclusion, both groups of students' awareness towards this area were almost similar and possible to use this population to measure the effectiveness of M-LA in terms of improving performance by conducting post-test.

Table 4.8: Descriptive Statistics Summary for Pre-test of Test 3

	C_o Group	**E_x Group**
Minimum	0	0
Maximum	3.00	3.00
Mean	1.83	1.67
Coefficient Range	1.00	1.00

✓ **Post-test**

Figure 4.19 presents the statistical analysis of the results in Appendix D. It can be seen from the Figure 4.19 that none of the two groups of students scored zero and one, while only 11.67% (7) and 20% (12) of the students from the respective C_o and E_x

obtained two which is below average. About 48.34% (29) of students in E_x group achieved three and only 28.34% (17) for C_o group, 36.34% (22) from C_o and 23.34% (14) from E_x obtained a score of four, and only 8.34% (5) from E_x group scored five while 14 of C_o obtained full mark. These results clearly demonstrate that 60% (36) of C_o students scored four and five which means students who are using conventional learning were performing well while only 31.67% (19) of students from E_x group. As discussed in Section 2.5.3, the nature of the content and also mobile devices limitations mainly hardware constraints are the main factors to affect the implementation of M-learning approach. Hence, due to the nature of Test 3 lecture content that makes difficult to cover the whole area like the above two contents. Wherein, it affects the effectiveness and students did not score good enough compare to the above tests. But, it is important to enhance teaching and learning system, and complement conventional learning.

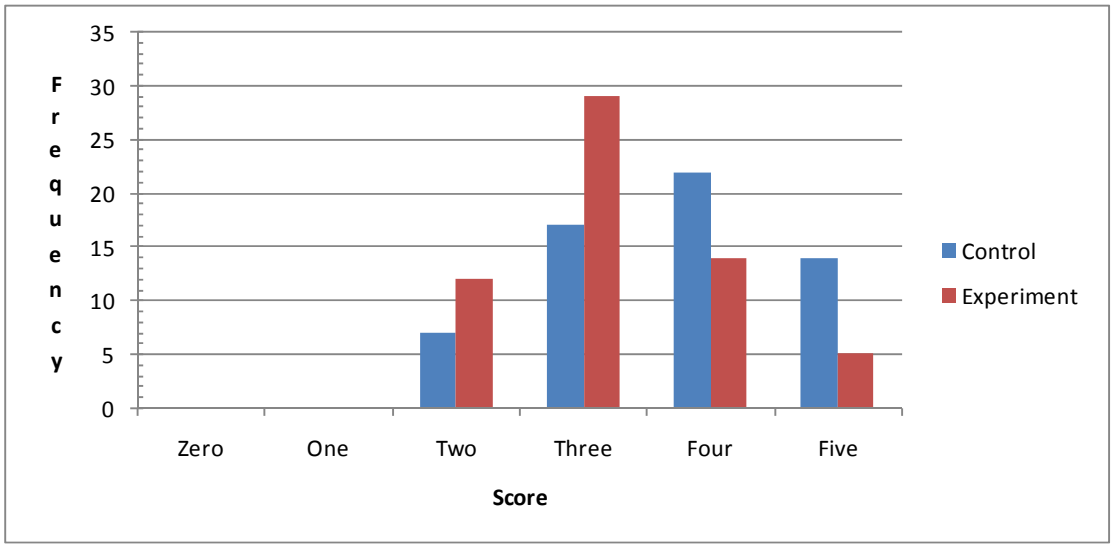

Figure 4.19: Test 3 Statistical Analysis of Post-test Marks for C_o and E_x Groups

As seen in the Table 4.9 that presents the statistical analysis of the entire data for test 3 post-test scored by C_o and E_x groups of students. The mean score of C_o groups is 3.72 and E_x groups scored 3.20. However, both E_x and C_o groups' minimum and maximum score was equivalent 2 and 5 respectively. Hence, the mean score of both groups' was over 3.0 which demonstrated that students who were using the M-LA system and conventional learning were improved their performance. Nevertheless, the C_o group mean value was better than E_x group due to different reasons such as, the

nature of the course contents of this section it needs much space which is one of the constraints of mobile devices as. But, it shows that M- learning approach has a potential to add value and complement conventional learning.

Table 4.9: Descriptive Statistics Summary for Post-test of Test 3

	C_o Group	**E_x Group**
Minimum	2.00	2.00
Maximum	5.00	5.00
Mean	3.72	3.20
Coefficient Range	2.33	2.33

4.3.2 Hypothesis Testing for Effectiveness Evaluation on M-LA

In addition to pre-test and post-test evaluation techniques, there are hypotheses testing to evaluate the effectiveness of the system. Hypothesis is a testable statement which can be two or more possibilities that are contradictory, only one can be true, exhaustive; they cover all possibilities outcomes of a logical conjectured relationship between two or more variables (Statistics and Tutorial; Sekaran 2009). The variables are tested to determine whether a statistical hypothesis is true and used to examine the entire population. On the other hand, if sample data are not consistent with statistical hypothesis, the hypothesis is rejected. However, in this study there are three hypotheses under every test as discussed in Section 3.4.4. Using those hypotheses, calculate the difference between the variables and prove the effectiveness of M-LA as "true". Independent t-test was used to test the hypotheses using SPSS version 14.0. In the following sections all of the three hypotheses are analyzed for each the three tests. Hence, there are total nine hypothesis tests.

4.3.2.1 Test 1

i. *Hypothesis 1 (H_01):- There is no significance difference in the pre-test scores of Test 1 between the Control and Experiment groups*

The result from this hypothesis is given in Table 4.10. The mean score for pre-test of C_o is 1.70 while the mean score for E_x is 1.62. However, the significant (2-tailed) value of p=0.539 which is greater than α = 0.05 which implies that the result is failed

to reject the null hypothesis $H_0$1 and there is no significant difference in the pre-test scores between the two groups. Therefore, the results revealed that the sampling is homogenous and students' level of knowledge on the Selection Statements concept prior to the effectiveness testing of M-LA was almost at the same level.

Table 4.10: Test 1 Pre-test Hypothesis

Students	N	Mean	SD	t-value	Sig. (2-tailed)
Pre-test C_o	60	1.70	0.61891	0.5914	0.539
Pre-test E_x	60	1.62	0.84556		

ii. *Hypothesis 2 ($H_0$2):- There is no significance difference in the post-test scores of Test 1 between the Control and Experiment groups*

It can be seen from Table 4.11 that the mean score for post-test of C_o group is 2.8 while 4.33 for E_x group. The mean score comparison shows that the experimental group achieved significantly more in the post-test compared to the control group. On the other hand, the significant (2-tailed) value, p = 0.00, is less than α = 0.05 which implies that $H_0$2 should be rejected. This means that there is a significant difference in the post-test scores between the two groups; thus M-LA prototype is effective and learners performed well in their post-test. Therefore, M-learning approach is recommended as one type of learning system to improve learners' performance.

Table 4.11: Test 1 Post-test Hypothesis

Students	N	Mean	SD	t-value	Sig. (2-tailed)
Post-test C_o	60	2.85	0.73242	11.2761	0.000
Pre-test E_x	60	4.33	0.70511		

iii. *Hypothesis 3 ($H_0$3) :- There is no significance difference in the students' Increment scores of Test 1 between the group that uses the M-LA compared to the group subjected to Conventional method of learning*

From Table 4.12 it can be seen that the mean score for increment of C_o is 1.15 while the mean score for E_x group is 2.72. This comparison shows that experimental group has performed better by using the application. The significance (2 tailed) value, p=0.000 is less than α = 0.05, which implies that $H_0$3 should be rejected. This shows

that there is significant difference in the increment scores between the two groups. Thus indicates that M-LA is effective.

Table 4.12: Test 1 Increment Hypothesis

Students	N	Mean	SD	t-value	Sig. (2-tailed)
Increment C_o	60	1.15	0.89868	8.4629	0.000
Increment E_x	60	2.72	1.12131		

As a conclusion for this section, the pre-test and post-test have been conducted on the control (C_o) and experimental (E_x) groups shown that; students in E_x group have performed better in this Test 1 topic. M-LA prototype is helpful to enhance students' performance.

In general, M-learning is the recent application to make learning all-present and complement conventional learning. In addition, these results have answered the question of *"Does using of mobile devices as a learning instrument been effective to students' in teaching and learning by enhancing conventional learning?"*

4.3.2.2 Test 2

i. *Hypothesis 1 (H_01):- There is no significance difference in the pre-test scores of Test 2 between the Control and Experiment groups*

Table 4.13 inferred that the result of this hypothesis. The mean score for pre-test of C_o is 1.50 while the mean score for E_x is 1.42. However, the significant (2-tailed) value of p=0.423 which is greater than α = 0.05 which implies that the result is failed to reject the null hypothesis H_01 and there is no significant difference in the pre-test scores between the two groups. Hence, the results illustrated that the population has the same level of background towards this content prior to the effectiveness testing of M-LA.

Table 4.13: Test 2 Pre-test Hypothesis

Students	N	Mean	SD	t-value	Sig. (2-tailed)
Pre-test C_o	60	1.50	0.5966	0.7566	0.432
Pre-test E_x	60	1.42	0.5612		

ii. *Hypothesis 2 ($H_0$2):- There is no significance difference in the post-test scores of Test 2 between the Control and Experiment groups*

The result from this hypothesis is given in Table 4.14. The mean score for post-test of C_o group is 2.35 while the mean score for E_x is 3.40. The mean score comparison shows that the experimental group achieved significantly more in the post-test compared to the control group. The significant (2-tailed) value, p = 0.000, is less than α = 0.05 which implies that $H_0$2 should be rejected. This means that there is a significant difference in the post-test scores between the two groups; thus M-LA prototype is effective. While, M-LA learners performed well in their post-test and improved their performance. Therefore, M-learning approach is recommended as a learning system to get better their performance and enhance conventional learning.

Table 4.14: Test 2 Post-test Hypothesis

Students	N	Mean	SD	t-value	Sig. (2-tailed)
Post-test C_o	60	2.35	0.73242	8.4975	0.000
Post-test E_x	60	3.40	0.61617		

iii. *Hypothesis 3 ($H_0$3):- There is no significance difference in the students' Increment scores of Test 2 between the group that uses the M-LA compared to the group subjected to Conventional method of learning*

From Table 4.15 it can be seen that the $H_0$3 hypothesis. The mean score for increment of C_o is 0.85 while the mean score for E_x group is 1.98. This comparison shows that experimental group has performed better by using M-LA. The significance (2 tailed) value, p=0.000 is less than α = 0.05, which implies that $H_0$3 should be rejected. This shows that there is significant difference in the increment scores between the two groups. Thus indicates that the effectiveness of M-LA.

Table 4.15: Test 2 Increment Hypothesis

Students	N	Mean	SD	t-value	Sig. (2-tailed)
Increment C_o	60	0.85	0.79883	8.2363	0.000
Increment E_x	60	1.98	0.70089		

To conclude this section, the students in E_x group have performed better. Additionally, it is used to enhance learners' performance, complement conventional

learning, and answer the question of *"Does using of mobile devices as a learning instrument been effective to students' in teaching and learning by enhancing conventional learning?"*

4.3.2.3 Test 3

i. *Hypothesis 1 (H_01):- There is no significance difference in the pre-test scores of Test 3 between the Control and Experiment groups*

As seen in the Table 4.16 that the mean score for pre-test of C_o is 1.83, while the mean score for E_x is 1.67. However, the significant (2-tailed) value of p=0.250 which is greater than α = 0.05 which implies that the result is failed to reject the null hypothesis H_01 and there is no significant difference in the pre-test scores between the two groups. Therefore, the results show that the two groups scored around the same range and homogeneity of their level of knowledge towards the Function concepts prior to the post-test.

Table 4.16: Test 3 Pre-test Hypothesis

Students	N	Mean	SD	t-value	Sig. (2-tailed)
Pre-test C_o	60	1.83	0.78474	1.1091	0.250
Pre-test E_x	60	1.67	0.79547		

ii. *Hypothesis 2 (H_02):- There is no significance difference in the post-test scores of Test 3 between the Control and Experiment groups*

The result from this hypothesis is given in Table 4.17. The mean score for post-test of C_o group is 3.72 while the mean score for E_x is 3.20. The mean score comparison shows that the control group achieved significantly more in the post-test compared to the Experiment group. Both groups' mean value is greater than three which shows that the effectiveness of M-LA to add value and complement the current learning system. However, the significant (2-tailed) value, p = 0.002, is less than α = 0.05 which implies that H_02 should be rejected. This means that there is a significant difference in the post-test scores between the two groups; thus control group was scored better. As discussed in Section 2.5, due to the nature of the content and constraints of mobile devices that makes difficult to cover the entire contents which was appeared in the post-test. Even though, the control group was scored better than

the experiment group, but experiment group was also improved their performance using M-LA. Thus, M-learning is recommended as one type of learning system to improve their performance and enhance conventional learning.

Table 4.17: Test 3 Post-test Hypothesis

Students	N	Mean	SD	t-value	Sig. (2-tailed)
Post-test C_o	60	3.72	0.95831	3.1288	0.002
Post-test E_x	60	3.20	0.85964		

iii. Hypothesis 3 ($H_0$3):- There is no significance difference in the students' Increment scores of Test 3 between the group that uses the M-LA compared to the group subjected to Conventional method of learning

From Table 4.18 it can be seen that the $H_0$3 hypothesis. The mean score for increment of C_o is 1.88 while the mean score for E_x group is 1.53. This comparison shows that control group has performed better, but their difference is insignificance. The significance (2 tailed) value, p=0.080 is greater than $\alpha = 0.05$, which implies that the result is failed to reject the null hypothesis $H_0$3 and there is no significant difference in the increment (post-pre test) between the two groups. Thus indicates both groups were improved their performance in equal level, even though the controlled group mean value is greater than the experimental group. Therefore, M-LA is effective to complement the conventional learning.

Table 4.18: Test 3 Increment Hypothesis

Students	N	Mean	SD	t-value	Sig. (2-tailed)
Increment C_o	60	1.88	1.00998	1.7655	0.080
Increment E_x	60	1.53	1.15666		

As shown the results of Test 3 $H_0$3, control (C_o) group was performed better than experimental (E_x) group due to different reasons such as the nature of the contnets and limitations of mobile devices that makes difficult to address the complete sections of the Function chapter of Fundamentals of Programming course. But, the t-Test of increment hypothesis of the two group does not have significant difference. In other word, both groups performed better with out any signifint difference. Hence, M-learning approach is used to make learning beyond classroom and add value for conventional learning.

4.3.3 Coefficient Variance Testing for Effectiveness Evaluation on M-LA

4.3.3.1 Pre-test Coefficient Variance Comparison

Table 4.19 summarizes the descriptive statistics for all the three tests' of pre-test results in the Appendix D. The mean value for both C_o and E_x groups' is less than average, while the mean value difference is 0.11 (1.68-1.57) which means the results' of the two groups' pre-test was in the same range. The coefficient variance of E_x groups' was 8.44% and C_o groups' was 9.99% which shows that the dispersion of the students' result in all of the three tests around the mean value. These results clearly show that the distribution of students in E_x group marks' is near to the mean value compare with the students' from the C_o group. However, the coefficient difference of the two groups is 1.54% (9.999781-8.443887) which is very small and insignificant. Hence, the two groups were scored in the same range and it is favourable to evaluate the effectiveness of the application.

Table 4.19: Coefficient Variance Pre-test for all Tests

	Experiment (E_x)	Control (C_o)
Test 1	1.62	1.70
Test 2	1.42	1.50
Test 3	1.67	1.83
Mean	1.57	1.68
Standard Deviation	0.132288	0.167774
Coefficient variance (%)	8.443887	9.999781

4.3.3.2 Post-test Coefficient Variance Comparison

Table 4.20 depicts that the descriptive statistics for all the three tests' of post-test results in the Appendix D. The mean value of E_x group is greater than three (3.64), but C_o groups' mean value is less than three (2.97). All in all, this mean value difference shows that E_x group was performed better than C_o with the exception of the third test mean value. 16.598% and 23.265% are the coefficient variance of the respective E_x and C_o groups which shows that the dispersion of the students' result in all of the three tests around the mean value. These results clearly show that the distribution of students in E_x group marks' is near to the mean value with the difference of 0.16598 compare from the C_o group (.23265). However, the coefficient variance difference of the two groups is 6.667% (0.667) which is a significant

difference. Therefore, the E_x group was performed well and scored around the mean value, but the C_o group scored in dispersed way from the mean value.

Table 4.20: Coefficient Variance Post-test for all Tests

	Experiment (E_x)	Control (C_o)
Test 1	4.33	2.85
Test 2	3.40	2.35
Test 3	3.20	3.72
Mean	3.64	2.97
Standard Deviation	0.604918115	0.691483
Coefficient variance (%)	16.59836291	23.26483

4.4 Usability Evaluation of M-LA

As discussed in Section 3.4, the selected usability testing attributes in this study have been divided in to four key factors which are Learnability, Memorability, Satisfaction, and Simplicity. The overall purpose of conducting usability testing of the developed prototype is to get complete assessment of its function. As discussed in Section 1.3, this section of usability evaluation is used to describe and prove the following objectives;

- To verify if the application provides all the performance support services (modules) that the users require to perform a given task (i.e. lecture materials and Quizzes)
- To verify the ease of use, information organization, categories, and navigation of information
- To determine users' agreement and satisfaction towards the usability elements of M-LA

Hence, this section is divided into two sub-sections to address the above objectives: quantitative and qualitative analyses on the usability attributes of M-L.

4.4.1 Quantitative Analysis on Usability Elements in M-LA

Group E_x has been assigned to use M-LA. All of the attributes that have discussed in Section 3.4 have been used to test the potential of the application in providing assistance to the learners. Due to their features to influence students' achievement the aforementioned attributes were chosen. As mentioned in Section 3.4.4, close ended type of questions are used quantitative analysis. Learners in group E_x are used to test usability of the application according to the Likert Scale: Strongly Agree is '5', Agree is '4', Neutral is '3', Disagree is '2', and Strongly Disagree is '1'. The result of quantitative analysis for each criterion by the respondents in the questionnaire is summarized as follows.

i. *Usability test*:- The usability test is evaluated with the evaluation criteria number 5 to determine how comfortable the users are by the application such as: Learnability (easy to use) factor is measured easiness of using the system and users level of performance improvement; Memorability is measured based on how well users can re-establish the skills of using the system; Satisfaction is used to measure the students' level of pleasure; and Simplicity is used to measure the organization of user interface based on the quality of menu structures as well as navigation design of the application. The overview of percentage ratings for these attributes is shown in Figure 4.20.

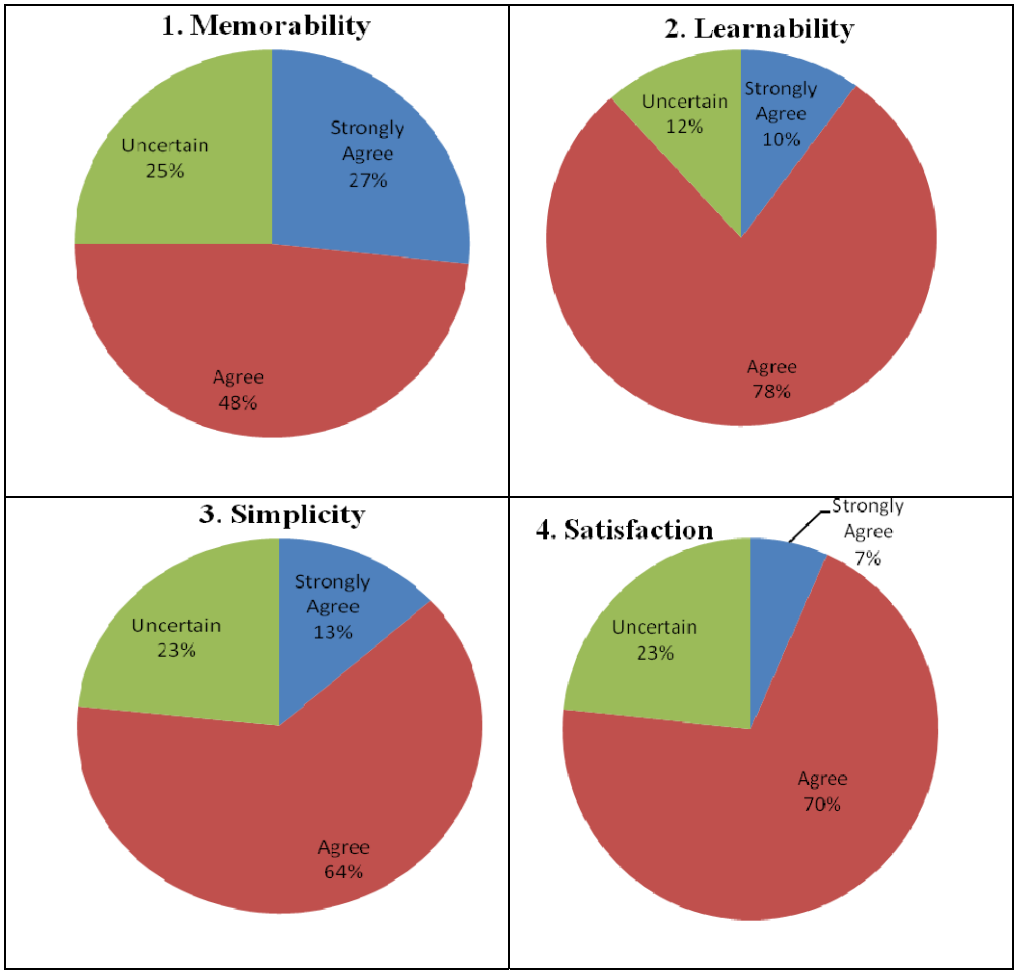

Figure 4.20: Percentage Rating for the Usability Evaluation Attributies of M-LA

ii. *Comparison of Usability Test Attributes*: - From Figure 4.21, it can be seen that the mean value (4.02) for the Memorability is the highest score compared to other three factors. This validates that students can re-establish the skill of using an application. The second highest mean score is Learnability where the mean is 3.98. This shows that the students find that easy to use and improve their level of performance using M-LA. The mean score for the level of Simplicity is 3.84, which indicates that how M-LA is user-friendly and quality of menu structures as well as navigation design. From the survey, all most all of the students are familiar with hi-tech mobile technology. The level Satisfaction mean score (3.81) is also considerably high, which indicates students' level of satisfaction towards the system. However, the mean value of the whole attributes of usability testing is greater than three. The results indicate that majority of the

students are satisfied and also good by fulfilling the requirement of usability elements in learning of basic programming course by considering the mobile devices' limitations which are presented under Section 2.5. Furthermore, Cronbach's alpha used to measure the internal consistency of the four usability attributes, learnability, memorability, satisfaction, and simplicity. In this case, alpha is calculated separately and the reliability coefficients are 0.71, 0.72, 0.75, and 0.75 respectively. George and Mallery (2003) provide the following rules of thumb: "_> 0.9 - Excellent, _> 0.8 - Good, _> 0.7- Acceptable, _> 0.6 - Questionable, _> 0.5 - Poor, and _< 0.5 - Unacceptable". Based on this scaling, all of the above coefficients are between 0.8 and 0.7. Therefore, the data is internally consistent and reliable, and considered as "Acceptable".

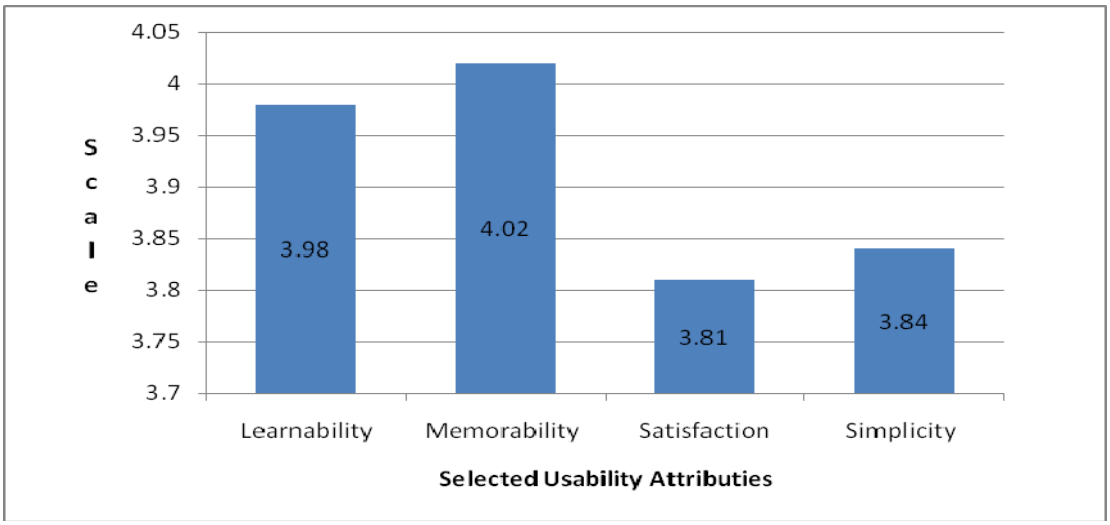

Figure 4.21: Results of Usability Evaluation on M-LA

Generally, the overall result from the usability evaluation test is good indicating areas where further improvements are required.

In addition to the percentage ratings, the respondents also gave comments to improve the application which are analyzed qualitatively and discussed in the next section.

4.4.2 Qualitative Analysis on Usability of M-LA

In this study, as discussed in Section 3.4, the method of inquiry used for qualitative analysis of the system usability involve the survey data, questionnaire, and the pre-test and post-test. The close-ended questions in the questionnaire have been analyzed the usability testing using the quantitative analysis as discussed in Sections 4.3 and 4.4.1. In addition, quantitative analysis was used on the pre-test and post-test data to measure the M-LA efficiency or effectiveness. On the other hand, open-ended questions are not represented numerically and analyzed using qualitative analysis method. However, qualitative analysis is done using descriptive method to elaborate and explain the data in a descriptive structure which are used for discussion making. Most of the studies qualitative research used inductive approach to analyze qualitative data which are collected by the techniques such as in-depth interview, direct observation, written documents, case studies, and oral and written comments (Trochim 2006).

Heuristic test is used in this study to examine the interface and discovering usability problems of the application by involving six experts from Computer and Information Sciences department. It was conducted after the first version of M-LA development. In addition, it is used to generate ideas while experts evaluating the system. All of the selected experts have had experience in teaching Fundamentals of Programming course. The role of these lecturers was to assess and give comments regarding the contents of the system through heuristic testing of the application that is used to improve the system.

In addition, Thinking Aloud Protocol had been used to E_x group during the implementation which is used to know learners' thinking about the system. Presently, most the learners have much exposure towards using mobile technology. Therefore, all most all of the students did not face any difficulty when they were using the system. In addition, they seemed to be excited and attracted while using the M-LA. On the other hand, about half of the learners out of 60 learners stated their opinions in the form of open-ended questions about limitations of mobile devices and suggestions to upgrade the system in terms of navigation, complexity of the interface, and adding some other modules to make the system more interesting and attractive as well.

Additionally, both E_x and C_o groups were commenting either written on the provided space or orally to know learners' opinion regarding the treatments that they have participated either conventional method or M-LA. Qualitative data deals with descriptions that can be observed but not measured. Hence, the data should be categorized in terms of data which seem similar or related. Therefore, the collected data of in this study were analyzed descriptively into two categories: advantages and disadvantages of the two above mentioned learning systems. The result of the descriptive analysis is illustrated in Table 4.21 as follows.

Table 4.21: Results of Descriptive Analysis

C_o Group	E_x Group
Advantage: • Group discussion, team projects, presentation, and face to face assessment • Learning objective is achieved • Students learn through lecturer presentation, face to face that is helpful to build confidence. • Learners are assembled in a lass that is helpful for direct guidance, good socialization, and real time interaction that make it irreplaceable **Disadvantage:** • Lack of concentration after the first 30 minutes maximum • Asynchronous mode of learning when lecturer's actively presenting information and students passively observing • No meant for individual learning • Student must keep pace with the lecturer	**Advantage:** • Exposure to new learning process • Experience of using mobile learning approach • It makes learning enjoyment through mobile devices in the courseware • Learning time is reduced and makes it easy and handy • Learning can be done anytime and anywhere , support continuous learning, Ubiquitous learning • Support collaborative learning • Support personalized or individualized learning **Disadvantage:** • Hardware constraints or limitations, screen size, memory, input keys, storage capacity, battery life, processing speed • Content creation is challenging • Less robust than desktop • There is no conventional standard to develop Mobile Learning System (M-LS)

In general, this section has elaborated the results of the usability evaluation of M-LA using usability attributes. As per discussed under the above subsections, the results through statistical calculations on the questionnaire shows that M-LA is efficient to improve learners' performance. Therefore, the last objective of the study has been achieved through passing this evaluation process.

In the open-ended parts of questionnaire the respondents gave constructive comments which the system supports and will include in the future work. Some of the constructive comments are summarized as follow:

- exposed to new learning process,
- makes learning enjoyable,
- navigation words are easily understandable,
- the content design is suitable,
- appropriate images have been used in the application,
- used standard and normal bullet points, and
- Makes learning personalized.

On the other hand, the respondents recommended to the researcher to incorporate in the next version of this research work. Hence, the researcher recommended the following vies as future works which are:

- The system did not allow saving what have been done and did not use video as a learning material and context-aware M-learning
- All of the quizzes are multiple choice
- To use some other learning objects like audio, video, and also to make context-aware.
- Provide help section

4.5 Conclusion

This chapter has presented the results for the M-LA prototype. It has five sections to answer the research questions which are mentioned in Section 1.3. The first section discussed about the technical details and prototyping of the system. M-LA has been successfully developed according to the design and adapting of approaches and learning theories. Finally, its effectiveness and usability have been evaluated. For the effectiveness evaluation in Section 4.3, it was proven that M-LA is effective for

students in learning Fundamentals of Programming course. In addition, usability evaluation also showed positive in Section 4.4 for all usability attributes namely Learnability, Memorability, Satisfaction, and Simplicity. Besides, there are also the qualitative results in the usability evaluation which are analyzed using open-ended questionnaires, and Thinking Aloud Protocol and coaching methods. Finally, the evaluation is analyzed using qualitative analysis. Hence, these are used to test the system and also input for further study. The following chapter will discuss about the main contribution and conclusion of this research. Finally, it is tried to show the future directions of the research.

CHAPTER 5

CONCLUSION

5.1 Introduction

In this thesis, various forms of educational systems have been discussed and also the trends towards a new form of education called mobile learning (M-learning). Furthermore, its impact have presented on the establishment of pervasive learning environments and how it can facilitate and enhance the current learning systems.

Herein chapter summarizes the whole study and concludes the findings. The conclusion is made based on the design, evaluation, and results of the statistical analysis. Mainly, contributions of the research and limitations of this study are discussed. Finally, recommend ations for future works of this research area are made at the end of this chapter.

5.2 Contributions of the Research

In order to address the issues that are discussed in the above section platform-independent M-learning is designed and implemented. As discussed in Chapter 1, four main objectives were identified prior to conducting this study that aims to develop M-learning application for Fundamentals of Programming course using M- learning approach. Hence, the main contributions of the research presented in this thesis can be summarized as follows:

1. *Adaptation of ADDIE methodology to M-LA life cycle, where this is the first work involving both. Each flow of the work sequence is presented in this thesis*

As discussed in Chapter 2, there are different types of instructional design model (IDM). For instance, Anang et al. (2006) used the normal system development methodology has been adopted, and Devinder and Zaitun (2006) used waterfall. But, in this research ADDIE is used which is one of the basic models of instructional design model (IDM) composed of five steps which are analysis, design, development, implementation, and evaluation. Each of these steps centers on the needs and abilities of the learners, and used to design instructions. Hence, each of the steps is analyzed before going to the next step which is the first work.

2. *To design and develop platform independent model of M-LA prototype for Fundamentals of Programming course by incorporating educational learning theories and features of M-learning approach*

   A platform independent Mobile Learning Application has been designed according to the methods proposed by Anang et al., Niazi and Mahmoud, and also other studies. To make it platform independent, J2ME is used to develop the application and XML to store learning materials.

   A prototype of the system for Fundamentals of Programming incorporates two components which are educational theories and some especial features of mobile devices like portability, mobility and etc are adopted to develop this application. Behaviorism, Cognitivism, and Constructivism are types of educational theories which have been recognized as useful to enhance learning.

3. *To evaluate the prototype of M-learning application for Fundamentals of Programming course in terms of effectiveness and usability*

   The result of the pre-test and post-test calculation were used to measure the effectiveness of M-LA have been discussed. According to the results, students who used the M-LA application improved their performance and showed that it is used to complement conventional learning. Independent t-Test was also performed to evaluate the hypotheses those have been created. Based on the hypotheses both groups showed no significant difference in pre-test. However, significant difference is observed in the post-test and increment scores. Therefore, this shows

that the M-LA is effective in providing a better medium of learning for the Fundamentals of Programming course by complementing conventional learning system.

In order to evaluate usability of the system the following attributes are using namely Learnability, Memorability, Satisfaction, and Simplicity. The data were collected using the questionnaires distributed to the experimental group. The evaluations results show that among the above four attributes, Memorability has been given the highest rank followed by Learnability, Simplicity and Satisfaction. Nevertheless, each attributes showed a higher mean score than the median score. Hence, this research has achieved its objectives. Cronbach's alpha is calculated for all of the above mentioned usability attributes to measure the internal consistency or reliability of the data.

Generally, the main contribution of this research is the exploitation of M-learning approach used to make learning ubiquitous. The approach is applied in the application to make the users or students able to appreciate Fundamentals of Programming course in a fun way and eventually meet the learning objectives. The M-learning approach is used as a complementary of conventional learning by making learning materials accessible anywhere by anytime. In addition, the other objective of the research is to test the effectiveness and usability of the system.

5.3 Limitations

Due to the nature of the learning instrument, there are limitations, which must be noted. The major identified obstacles are: varieties of mobile devices, and have different capabilities and constraints; various definitions of M-learning; no standard framework for M-LS; and other technical issues which are not addressed in this research for instance, wireless network and its disconnectivity, security, lack of location-aware services, cost of online connection, and others. Moreover, this research is limited to the case study in Universiti Teknologi PETRONAS (UTP) and for Fundamentals of Programming course, and M-LA was not aimed to replace conventional learning fully rather to complement to make learning beyond classroom.

5.4 Recommendation for Future Work

Although the research is presented in this thesis has lay down the development of platform independent M-LA by using mobile as a learning instrument to make learning beyond classroom, and also evaluated its effectiveness and usability. In addition, to those pointed out limitations in the whole thesis need further research and which are summarized as follows:

i. The current implementation of M-LA is platform independent. Hence, to upgrade it and makes more exciting better to add some other features like device adaptive, content adaptive and context-aware model.

ii. In addition, it uses text-based quiz, but the researcher plans to support other M-learning objects like images, audio, multimedia, video, and animations.

iii. The system supported only from the client side or learners, there is no system from the educators or administrator side. Therefore, plan to develop server side system that is used to manage the clients and also to add support for synchronous learning system.

iv. To develop the system that can be context-aware by using context acquisition and management, conceptual knowledge modelling for personalized learning, and adaptive information discovery through considering the following context information related to learners, used device, environments, and others.

v. To enhance learning-content provision, Mashup technology (Web Application hybrid) is recommended to make it possible to use multiple search agents in order to retrieve learning resources from multiple sources.

vi. To incorporate the application of cloud computing to enable online execution of programming exercises.

vii. To make it practical and use for other courses which are convenient for such kind of learning system.

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APPENDIX A: SURVEY

Survey on Mobile Learning

Your input on this survey is only for educational purpose and your participation is much appreciated.

Name: _____

Contact number: _____

E-mail: _____

Instruction: *for all multiple choose encircle your choice*

Section 1: Personal background

1. Age

   A. 16-17 C. 20-21 E. 24-25

   B. 18-19 D. 22-23

2. Gender

   A. Male B. Female

3. Level of education

   A. Undergraduate B. Postgraduate

4. Department

   A. Petroleum Eng. E. BIS

   B. Chemical Eng. F. Electrical Eng.

   C. Civil Eng. G. ICT

   D. Mechanical Eng.

5. Do you have Mobile Phone?

   A. Yes B. No

6. Which Mobile Device(s) do you own?

   A. Mobile phone C. Both Mobile and PDA

   B. PDA/Pocket PC/palmtop

7. Number of year(s) using Mobile phones.

   A. 1-3 D. 8-9

   B. 4-5 E. >10

   C. 6-7

8. Brand of your Mobile phone,

   A. LG E. Samsung

   B. Sony Ericcson F. Other. Please specify

   C. Nokia _____

   D. Motorola

Section 2: Mobile application

Definition: - Mobile Learning is defined as Electronic Learning (E-Learning) through Mobile and handheld Devices using Wireless transmission; it combines individualized (individual or personal) learning with anytime and anywhere learning.

9. Have you heard about Mobile learning before?

   A. Yes B. No

(If 'No', please use the above definition)

Instruction: *Please read the following statements and then provide your level of agreement/disagreement using the scale:*

5 = I strongly agree, 4 = I agree, 3 = I'm uncertain, 2 = I disagree, 1 = I strongly disagree

		1	2	3	4	5
10.	Using of Mobile for different application is easy to use.					
11.	Mobile can be used to learn different technologies					
12.	Mobile makes learning more enjoyable and /or interesting.					

Section 3: Advantages of Mobile Learning

		1	2	3	4	5
13.	Mobile learning is good, because it will make the way of teaching and learning, student-centered.					
14.	Mobile learning is accessible anywhere and anytime; hence I recommend is as a complement of the current classroom learning.					
15.	It makes easy to communicate and support collaborative learning; hence I recommend it.					
16.	Generally, I would like to recommend Mobile learning					

Section 4: Didactic Efficiency

		1	2	3	4	5
17.	Mobile learning increases the quality of electronic learning.					
18.	Course learning objectives can be met by mobile learning.					
19.	Downloading course content is easy.					
20.	It has a potential to improve the current learning system					

21. Please, write the problem(s) that you face in Classroom learning (on the space provided).

    _____

22. Please, write limitations or constraints of mobile devices you faced when you were using it for different applications (on the space provided).

    _____

Section 4: Technical feasibility

		1	2	3	4	5
23.	Navigation through the mobile learning course is easy.					
24.	Do you like to a learning system which combines audio and video					
25.	Do you like to a learning tools that combines text and picture					
26.	Technically, it will be effective					

27. Which methods of learning do you prefer? And why? (Write your reason on the space provided below).

A. Teacher-Student scenario

_____

B. Online learning using computer

_____

C. Combination of instructor-led and E-Learning.

_____

D. Combination of instructor- led and M-Learning.

_____

E. Other. Please specify

_____

28. What are the functions you would like to have in Mobile learning? (you can select more than one)

A. Lecture materials
B. Assignment
C. Quiz
D. All
E. Other, please specify

29. Please write your opinion about the challenges in using Mobile learning

_____

Thanks!!!

APPENDIX B: LIST OF USED PLATFORM AND CONFIGURATION

As discussed in Chapter 3, Netbeans IDE 6.9 version was used as a working environment to develop this application. It used all of the technologies which are listed in the following table (Refer Table B.1)

The source of Netbeans IDE 6.9 is http://netbeans.org/ , and open source.

B.1. List of software

Table B.1: List of Platform and Configuration Selection

Name	**Version**	**Purpose**
J2ME		To implement application for constrained devices
XML	1.0	To store the lecture materials
J2ME midlets		To store the lecture materials
Java TM platform Micro Edition SDK	3.0	Emulator platform
CLDC	1.0 and 1.1	Device configuration
MIDP	2.0 and 2.1	Device profile

APPENDIX C: PRE-TEST AND POST-TEST

C.1. Test 1, Selection Statements Pre and post test

1. Evaluate !(1 && !(0 || 1)).
   a) True
   b) False
   c) Unevaluatable
   d) none
2. Which of the following shows the correct syntax for an if statement?
   a) if expression
   b) if{ expression
   c) if(expression)
   d) expression if
3. What is required to avoid falling through from one case to the next?
   a) end;
   b) break;
   c) Stop;
   d) A semicolon.
4. Assume there are three bool variables: a=false, b=false, c=true. What is the true or false value of the following statement? a || b && c
   a) true
   b) false
   c) something other than true and false
   d) -1
5. Assume there are two integer variables: min, x = 3, and y = 5. From the following statement, what is the value for min variable? Min = x<y? x: y;
   a) 8
   b) 2
   c) 5
   d) 3

C.2. Test 1, Loop Statements Pre and post test

1. Which looping process checks the test condition at the end of the loop?
   a) for
   b) while
   c) do-while

d) no looping process checks the test condition at the end

2. In a group of nested loops, which loop is executed the most number of times?
   a) the outermost loop
   b) the innermost loop
   c) all loops are executed the same number of times
   d) cannot be determined without knowing the size of the loops
3. The statement i++; is equivalent to
   a) i = i + i;
   b) i = i + 1;
   c) i = i - 1;
   d) i --;
4. What's wrong? while((i < 10) && (i > 24))
   a) the logical operator && cannot be used in a test condition
   b) the while loop is an exit-condition loop
   c) the test condition is always false
   d) the test condition is always true
5. What is the output of the following code? for (int a = 1; a <= 1; a++) cout << a++; cout << a;
   a) 22
   b) 12
   c) error
   d) 23

C.3. Test 1, Function Pre and Post Test

1. To make large programs more manageable, we modularize them in to subprograms called _____.
   a) Array
   b) Function
   c) Loop
   d) String
2. Every C++ function should have a function called _____
   a) exit()
   b) void()
   c) sqrt()
   d) main()
3. A variable that is declared and accessed inside one block function is _____.
   a) global
   b) value
   c) local
   d) reference
4. Which is not a proper prototype?
   a) int funct(char x, char y);
   b) double funct(char x)
   c) void funct();
   d) char x();
5. Which of the following is a complete function?

a) int funct();

b) int funct(int x) {return x=x+1;}

c) void funct(int) {cout>>"Hello"}

d) void funct(x) {cout>>"Hello"}

APPENDIX D: RESULTS OF PRE-TEST AND POST-TEST

D.1. Control Group Test 1 Result

Table D.1: Control Group Test 1 Result

Student	**Pre-test Marks (5%)**	**Post-test Marks (5%)**	**Increment (Post-Pre test)**
C_o1	2.00	3.00	1.00
C_o2	2.00	4.00	2.00
C_o3	3.00	3.00	0.00
C_o4	2.00	3.00	1.00
C_o5	2.00	4.00	2.00
C_o6	2.00	3.00	1.00
C_o7	1.00	3.00	2.00
C_o8	2.00	4.00	2.00
C_o9	1.00	3.00	2.00
C_o10	2.00	3.00	1.00
C_o11	1.00	2.00	1.00
C_o12	2.00	2.00	0.00
C_o13	2.00	3.00	1.00
C_o14	2.00	3.00	1.00
C_o15	1.00	4.00	3.00
C_o16	1.00	3.00	2.00
C_o17	2.00	2.00	0.00
C_o18	2.00	4.00	2.00
C_o19	1.00	3.00	2.00
C_o20	1.00	3.00	2.00
C_o21	1.00	3.00	2.00
Co22	3.00	2.00	-1.00
C_o23	2.00	3.00	1.00
C_o24	1.00	4.00	3.00
C_o25	1.00	2.00	1.00
Co26	2.00	3.00	1.00
C_o27	2.00	4.00	2.00
C_o28	1.00	2.00	1.00
C_o29	1.00	2.00	1.00
C_o30	2.00	3.00	1.00
C_o31	2.00	3.00	1.00
C_o32	1.00	3.00	2.00
C_o33	2.00	3.00	1.00

C_o34	2.00	3.00	1.00
C_o35	2.00	4.00	2.00
C_o36	2.00	2.00	0.00
C_o37	2.00	3.00	1.00
C_o38	2.00	3.00	1.00
C_o39	1.00	3.00	2.00
C_o40	2.00	2.00	0.00
C_o41	2.00	2.00	0.00
C_o42	2.00	3.00	1.00
C_o43	1.00	3.00	2.00
C_o44	2.00	4.00	2.00
C_o45	1.00	2.00	1.00
C_o46	3.00	1.00	-2.00
C_o47	1.00	2.00	1.00
C_o48	3.00	3.00	0.00
C_o49	1.00	3.00	2.00
C_o50	2.00	4.00	2.00
C_o51	2.00	3.00	1.00
C_o52	1.00	2.00	1.00
C_o53	1.00	2.00	1.00
C_o54	2.00	3.00	1.00
C_o55	2.00	2.00	0.00
C_o56	1.00	2.00	1.00
C_o57	2.00	2.00	0.00
C_o58	3.00	4.00	1.00
C_o59	1.00	3.00	2.00
C_o60	1.00	2.00	1.00
Average	1.70	2.85	1.15

D.2. Control Group Test 2 Result

Table D.2: Control Group Test 2 Result

Student	**Pre-test Marks (5%)**	**Post-test Marks (5%)**	**Increment (Post-Pre test)**
C_o1	1.00	2.00	1.00
C_o2	2.00	3.00	2.00
C_o3	2.00	2.00	2.00
C_o4	1.00	3.00	1.00
C_o5	2.00	3.00	2.00
C_o6	1.00	3.00	1.00
C_o7	1.00	3.00	1.00
C_o8	2.00	3.00	2.00
C_o9	1.00	2.00	1.00
C_o10	2.00	2.00	2.00
C_o11	1.00	2.00	1.00
C_o12	1.00	1.00	1.00
C_o13	2.00	2.00	2.00
C_o14	2.00	3.00	2.00
C_o15	1.00	2.00	1.00
C_o16	1.00	3.00	1.00
C_o17	1.00	1.00	1.00
C_o18	2.00	4.00	2.00
C_o19	1.00	3.00	1.00

C_o20	1.00	2.00	1.00
C_o21	1.00	2.00	1.00
C_o22	2.00	2.00	2.00
C_o23	2.00	3.00	2.00
C_o24	2.00	3.00	2.00
C_o25	1.00	4.00	1.00
C_o26	3.00	2.00	3.00
C_o27	2.00	3.00	2.00
C_o28	1.00	1.00	1.00
C_o29	1.00	1.00	1.00
C_o30	1.00	2.00	1.00
C_o31	1.00	2.00	1.00
C_o32	1.00	2.00	1.00
C_o33	2.00	3.00	2.00
C_o34	2.00	3.00	2.00
C_o35	1.00	3.00	1.00
C_o36	1.00	2.00	1.00
C_o37	3.00	3.00	3.00
C_o38	2.00	2.00	2.00
C_o39	1.00	2.00	1.00
C_o40	2.00	2.00	2.00
C_o41	1.00	1.00	1.00
C_o42	1.00	2.00	1.00
C_o43	2.00	2.00	2.00
C_o44	2.00	3.00	2.00
C_o45	1.00	1.00	1.00
C_o46	2.00	2.00	2.00
C_o47	1.00	2.00	1.00
C_o48	2.00	3.00	2.00
C_o49	1.00	2.00	1.00
C_o50	2.00	3.00	2.00
C_o51	2.00	2.00	2.00
C_o52	1.00	2.00	1.00
C_o53	1.00	2.00	1.00
C_o54	2.00	2.00	2.00
C_o55	3.00	3.00	3.00
C_o56	1.00	4.00	1.00
C_o57	2.00	2.00	2.00
C_o58	1.00	3.00	1.00
C_o59	1.00	2.00	1.00
C_o60	1.00	2.00	1.00
Average	1.50	2.35	0.85

D.3. Control Group Test 3 Result

Table D.3: Control Group Test 3 Result

Student	**Pre-test Marks (5%)**	**Post-test Marks (5%)**	**Increment (Post-Pre test)**
C_o1	2.00	3.00	1.00
C_o2	3.00	4.00	1.00
C_o3	3.00	5.00	2.00
C_o4	3.00	4.00	1.00
C_o5	3.00	5.00	2.00

C_o6	2.00	5.00	3.00
C_o7	2.00	4.00	2.00
C_o8	2.00	5.00	3.00
C_o9	1.00	4.00	3.00
C_o10	3.00	3.00	0.00
C_o11	2.00	5.00	3.00
C_o12	2.00	4.00	2.00
C_o13	2.00	3.00	1.00
C_o14	3.00	4.00	1.00
C_o15	1.00	5.00	4.00
C_o16	2.00	4.00	2.00
C_o17	2.00	3.00	1.00
C_o18	2.00	3.00	1.00
C_o19	1.00	4.00	3.00
C_o20	2.00	5.00	3.00
C_o21	2.00	3.00	1.00
C_o22	1.00	2.00	1.00
C_o23	1.00	4.00	3.00
C_o24	3.00	5.00	2.00
C_o25	2.00	5.00	3.00
C_o26	1.00	4.00	3.00
C_o27	1.00	4.00	3.00
C_o28	2.00	3.00	1.00
C_o29	1.00	2.00	1.00
C_o30	3.00	4.00	1.00
C_o31	2.00	3.00	1.00
C_o32	2.00	2.00	0.00
C_o33	2.00	4.00	2.00
C_o34	3.00	5.00	2.00
C_o35	2.00	2.00	0.00
C_o36	2.00	3.00	1.00
C_o37	1.00	4.00	3.00
C_o38	3.00	3.00	0.00
C_o39	2.00	5.00	3.00
C_o40	2.00	4.00	2.00
C_o41	2.00	3.00	1.00
C_o42	2.00	4.00	2.00
C_o43	0.00	2.00	2.00
C_o44	3.00	3.00	0.00
C_o45	1.00	2.00	1.00
C_o46	2.00	5.00	3.00
C_o47	1.00	3.00	2.00
C_o48	1.00	4.00	3.00
C_o49	1.00	3.00	2.00
C_o50	3.00	5.00	2.00
C_o51	1.00	4.00	3.00
C_o52	0.00	3.00	3.00
C_o53	2.00	3.00	1.00
C_o54	1.00	4.00	3.00
C_o55	1.00	2.00	1.00
C_o56	2.00	4.00	2.00
C_o57	2.00	5.00	3.00
C_o58	1.00	4.00	3.00
C_o59	2.00	4.00	2.00
C_o60	1.00	3.00	2.00

Average	1.83	3.72	1.88

D.4. Experiment Group Test 1 Result

Table D.4: Experiment Group Test 1 Result

Student	**Pre-test Marks (5%)**	**Post-test Marks (5%)**	**Increment (Post-Pre test)**
E_x1	2.00	4.00	2.00
E_x2	3.00	4.00	1.00
E_x3	1.00	5.00	4.00
E_x4	2.00	3.00	1.00
E_x5	2.00	4.00	2.00
E_x6	3.00	5.00	2.00
E_x7	0.00	3.00	3.00
E_x8	2.00	5.00	3.00
E_x9	1.00	5.00	4.00
E_x10	2.00	3.00	1.00
E_x11	2.00	5.00	3.00
E_x12	1.00	4.00	3.00
E_x13	3.00	5.00	2.00
E_x14	1.00	4.00	3.00
E_x15	3.00	5.00	2.00
E_x16	1.00	5.00	4.00
E_x17	3.00	3.00	0.00
E_x18	2.00	4.00	2.00
E_x19	1.00	5.00	4.00
E_x20	3.00	5.00	2.00
E_x21	2.00	3.00	1.00
E_x22	1.00	4.00	3.00
E_x23	2.00	4.00	2.00
E_x24	1.00	4.00	3.00
E_x25	2.00	4.00	2.00
E_x26	1.00	5.00	4.00
E_x27	2.00	5.00	3.00
E_x28	1.00	4.00	3.00
E_x29	3.00	5.00	2.00
E_x30	1.00	5.00	4.00
E_x31	0.00	4.00	4.00
E_x32	1.00	5.00	4.00
E_x33	1.00	4.00	3.00
E_x34	2.00	3.00	1.00
E_x35	2.00	4.00	2.00
E_x36	1.00	5.00	4.00
E_x37	2.00	4.00	2.00
E_x38	1.00	5.00	4.00
E_x39	3.00	5.00	2.00
E_x40	1.00	5.00	4.00
E_x41	0.00	4.00	4.00
E_x42	2.00	4.00	2.00
E_x43	2.00	4.00	2.00
E_x44	1.00	5.00	4.00
E_x45	0.00	5.00	5.00
E_x46	2.00	4.00	2.00

E_x47	1.00	4.00	3.00
E_x48	2.00	5.00	3.00
E_x49	3.00	4.00	1.00
E_x50	2.00	3.00	1.00
E_x51	0.00	5.00	5.00
Ex52	2.00	5.00	3.00
E_x53	1.00	3.00	2.00
E_x54	1.00	4.00	3.00
E_x55	2.00	5.00	3.00
E_x56	1.00	5.00	4.00
E_x57	2.00	4.00	2.00
E_x58	2.00	5.00	3.00
E_x59	1.00	5.00	4.00
E_x60	2.00	4.00	2.00
Average	1.62	4.33	2.72

D.5. Experiment Group Test 2 Result

Table D.5: Experiment Group Test 2 Result

Student	**Pre-test Marks (5%)**	**Post-test Marks (5%)**	**Increment (Post-Pre test)**
E_x1	1.00	3.00	2.00
E_x2	2.00	4.00	2.00
E_x3	2.00	4.00	2.00
E_x4	2.00	4.00	2.00
E_x5	1.00	3.00	2.00
E_x6	2.00	4.00	2.00
E_x7	1.00	2.00	1.00
E_x8	1.00	3.00	2.00
E_x9	1.00	4.00	3.00
E_x10	2.00	2.00	0.00
E_x11	2.00	4.00	2.00
E_x12	0.00	3.00	3.00
E_x13	1.00	4.00	3.00
E_x14	1.00	3.00	2.00
E_x15	2.00	4.00	2.00
E_x16	2.00	3.00	1.00
E_x17	1.00	3.00	2.00
E_x18	1.00	3.00	2.00
E_x19	2.00	3.00	1.00
E_x20	2.00	5.00	3.00
E_x21	1.00	3.00	2.00
E_x22	1.00	3.00	2.00
E_x23	2.00	3.00	1.00
E_x24	1.00	4.00	3.00
E_x25	2.00	3.00	1.00
E_x26	2.00	4.00	2.00
E_x27	1.00	3.00	2.00
E_x28	1.00	3.00	2.00
E_x29	2.00	4.00	2.00
E_x30	0.00	4.00	4.00
E_x31	1.00	3.00	2.00
E_x32	2.00	4.00	2.00

E_x33	1.00	3.00	2.00
E_x34	1.00	3.00	2.00
E_x35	2.00	4.00	2.00
E_x36	1.00	3.00	2.00
E_x37	2.00	3.00	1.00
E_x38	1.00	4.00	3.00
E_x39	1.00	3.00	2.00
E_x40	1.00	4.00	3.00
E_x41	2.00	4.00	2.00
E_x42	2.00	4.00	2.00
E_x43	2.00	4.00	2.00
E_x44	1.00	4.00	3.00
E_x45	1.00	3.00	2.00
E_x46	1.00	3.00	2.00
E_x47	1.00	3.00	2.00
E_x48	2.00	4.00	2.00
E_x49	2.00	4.00	2.00
E_x50	2.00	3.00	1.00
E_x51	1.00	4.00	3.00
E_x52	2.00	3.00	1.00
E_x53	1.00	2.00	1.00
E_x54	1.00	3.00	2.00
E_x55	1.00	4.00	3.00
E_x56	1.00	3.00	2.00
E_x57	2.00	3.00	1.00
E_x58	2.00	3.00	1.00
E_x59	2.00	4.00	2.00
E_x60	1.00	3.00	2.00
Average	1.42	3.40	1.98

D.6. Experiment Group Test 3 Result

Table D.6: Experiment Group Test 3 Result

Student	**Pre-test Marks (5%)**	**Post-test Marks (5%)**	**Increment (Post-Pre test)**
E_x1	1.00	3.00	2.00
E_x2	2.00	4.00	2.00
E_x3	2.00	3.00	1.00
E_x4	2.00	4.00	2.00
E_x5	0.00	3.00	3.00
E_x6	1.00	4.00	3.00
E_x7	1.00	2.00	1.00
E_x8	1.00	3.00	2.00
E_x9	1.00	4.00	3.00
E_x10	1.00	2.00	1.00
E_x11	1.00	3.00	2.00
E_x12	1.00	5.00	4.00
E_x13	2.00	4.00	2.00
E_x14	2.00	2.00	0.00
E_x15	2.00	3.00	1.00
E_x16	2.00	3.00	1.00
E_x17	2.00	5.00	3.00
E_x18	1.00	3.00	2.00

E_x19	2.00	4.00	2.00
E_x20	2.00	3.00	1.00
E_x21	3.00	2.00	-1.00
E_x22	1.00	3.00	2.00
E_x23	1.00	2.00	1.00
E_x24	2.00	3.00	1.00
E_x25	1.00	4.00	3.00
E_x26	3.00	3.00	0.00
E_x27	1.00	4.00	3.00
E_x28	1.00	3.00	2.00
E_x29	2.00	2.00	0.00
E_x30	1.00	3.00	2.00
E_x31	2.00	3.00	1.00
E_x32	2.00	4.00	2.00
E_x33	1.00	3.00	2.00
E_x34	1.00	3.00	2.00
E_x35	3.00	5.00	2.00
E_x36	2.00	3.00	1.00
E_x37	1.00	2.00	1.00
E_x38	1.00	4.00	3.00
E_x39	2.00	3.00	1.00
E_x40	2.00	4.00	2.00
E_x41	3.00	3.00	0.00
E_x42	3.00	2.00	-1.00
E_x43	2.00	5.00	3.00
E_x44	1.00	3.00	2.00
E_x45	3.00	3.00	0.00
E_x46	3.00	2.00	-1.00
Ex47	1.00	3.00	2.00
E_x48	2.00	4.00	2.00
E_x49	2.00	3.00	1.00
E_x50	1.00	2.00	1.00
E_x51	2.00	4.00	2.00
E_x52	1.00	3.00	2.00
E_x53	2.00	2.00	0.00
E_x54	0.00	3.00	3.00
E_x55	3.00	3.00	0.00
E_x56	1.00	5.00	4.00
E_x57	1.00	3.00	2.00
E_x58	3.00	4.00	1.00
E_x59	3.00	3.00	0.00
E_x60	1.00	2.00	1.00
Average	1.67	3.20	1.53

APPENDIX E: USABILITY QUESTIONNAIRE

Survey on Mobile Learning Application

The objectives of this survey are to get user's feedback regarding the developed mobile learning system for different learning performances and usability of the application.

This survey contains of five (5) sections: For Section **A**, please tick your choice.

For the remaining sections **B, C, D** and **E** please read the statements and provide your level of agreement/disagreement by ticking using the scale:

1=strongly disagree, 2=disagree, 3=fair, 4=agree, 5=strongly agree

Section A: Student's Information		
1.	Age	○ **16-17** ○ **18-19** ○ **20-21** ○ **22-23** ○ **24-25**
2.	Gender	○ **Female** ○ **Male**
3.	Year of study	○ Foundation ○ 1st
4.	Department	○ **Petroleum Eng.** ○ **Mechanical Eng.** ○ **Chemical Eng.** ○ **Civil Eng.**

Section B: Learnability		
5.	Each of the lecture materials is short and well generalized	1○ 2○ 3○ 4○ 5○
6.	Introduction is easy to understand	1○ 2○ 3○ 4○ 5○
7.	The contents suit the objective	1○ 2○ 3○ 4○ 5○
8.	The objectives of the coursware is clear	1○ 2○ 3○ 4○ 5○
9.	The application contains pictures that are helpful for learning by observation	1○ 2○ 3○ 4○ 5○
10.	The questions compiled according to the objectives	1○ 2○ 3○ 4○ 5○
11.	This application serves well the notion of student-centered learning	1○ 2○ 3○ 4○ 5○

12.	Coursware is always keeps me informed about what it is doing	1○ 2○ 3○ 4○ 5○
Section C: Memorability		
13.	Logout button in every page gives flexibility to the user to exit from the application anytime	1○ 2○ 3○ 4○ 5○
14.	The logical progression of lecture material, academic information, and quizzes are coherent and easy to use	1○ 2○ 3○ 4○ 5○
15.	Sequence of chapters, sections, and pages are very clear	1○ 2○ 3○ 4○ 5○
16.	It is flexible and very clear to use; therefore this application design is recommend for other courses too	1○ 2○ 3○ 4○ 5○
17.	Remembering names and use commands is easy	1○ 2○ 3○ 4○ 5○
18.	Tasks always can be performed in straight manner	1○ 2○ 3○ 4○ 5○
19.	I can react towards the coursware easily and joyful	1○ 2○ 3○ 4○ 5○
Section D: Simplicity		
20.	Terminologies used for navigation are intuitive	1○ 2○ 3○ 4○ 5○
21.	Computer terminology is related to the task i am doing	1○ 2○ 3○ 4○ 5○
22.	Terms throughout the coursware used are consistet	1○ 2○ 3○ 4○ 5○
23.	Navigation is handy and user friendly in every page	1○ 2○ 3○ 4○ 5○
24.	Main menu of the application is helpful to move to any section according to one's desire	1○ 2○ 3○ 4○ 5○
25.	Utilization of bulletin and numbering are consistent	1○ 2○ 3○ 4○ 5○
26.	Position of texts, and pictures on the screen is consistent	1○ 2○ 3○ 4○ 5○
27.	Words used in the application are familiar	1○ 2○ 3○ 4○ 5○
28.	It is user friendly	1○ 2○ 3○ 4○ 5○
29.	The application is easy and simple to use	1○ 2○ 3○ 4○ 5○

Section E: Satisfaction		
30.	The application is visually appealing	1○ 2○ 3○ 4○ 5○
31.	I would imagine that most people would learn to use this application very quickly	1○ 2○ 3○ 4○ 5○
32.	The size and font text is attractive	1○ 2○ 3○ 4○ 5○
33.	The color of text is suitable and attractive	1○ 2○ 3○ 4○ 5○
34.	The text arragement is clear and effetive	1○ 2○ 3○ 4○ 5○
35.	Overall, I am satisfied that this application is easy to use	1○ 2○ 3○ 4○ 5○
Section F: Overall Reaction to the courseware		
36.	Overall, i am satisfied with the easiness of the coursware	1○ 2○ 3○ 4○ 5○
37.	It is simple to use	1○ 2○ 3○ 4○ 5○
38.	I can effectivelly complete basic C++ concept using this coursware	1○ 2○ 3○ 4○ 5○
39.	I feel comfort using this coursware	1○ 2○ 3○ 4○ 5○
40.	It is easy to learn using this coursware	1○ 2○ 3○ 4○ 5○
41.	Overall, this coursware is interesting	1○ 2○ 3○ 4○ 5○

42. Please, write other opinions you have about the application

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