ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DEPARTMENT OF COMPUTING

DESIGN AND DEVELOPMENT OF MOBILE LEARNING SYSTEM ARCHITECTURE: THE CASE OF ASTU

BY:

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May, 2017

Adama, Ethiopia

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

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DECLARATION

The thesis is my original work, and it has not been presented for a degree in any other university. All sources of materials used for the thesis have been acknowledged.

_____

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This thesis has been submitted for examination with my approval as university advisor

_____

Dr. Tibebe Beshah

May, 2017

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ABSTRACT

The accessibility of multimedia web resources and the rapid development of mobile devices are two major factors that have paved the way towards the development of mobile learning systems. One of the typical applications of modern technology in mobile learning is the capability of software architecture design and development of the system that can be applied to mobile learning solution and provides an ability to support a range of individual requirements in higher educational institution. The fast pace of using this new technologies', similar to tablet computers and smart phones; have been adopted in the last decades.

Moreover the architecture design and development of the mobile learning has been mostly technology driven and particularly mobile devices are as much social objects as technical ones. They impact how we organize our lives, how we work, and, perhaps, how we learn. Designing and developing a mobile learning system therefore is not simply a technical challenge but one that has to take into account the social context of using a mobile device as a learning tool and considering that it become one of the most prominent interface with which lecturers and learners interact with the teaching-learning process and has been mediated through technology.

In this research we designed and developed a mobile learning system that delivers learning materials which fit the actual need of the ASTU learners. The system manages the gathering, authoring, packaging and delivery of learning materials. The architecture of the developed system uses a set of web services to retrieve information and learning resources from the web 24/7 for students in higher educational institutions.

After completion of the data collection and data analysis consecutively; the research findings shown that 3-tier architecture has been proposed as a solution for ASTU mobile learning system need and a working prototype has been developed. Since the proposed system has needed to be deployed and tested, the researchers have conducted both an emulator test and experts' detail evaluation as per requirements of the need assessment. And finally, the researchers have achieved a successful test result which realizes the accomplishment of the stated research objective.

Keywords: mobile learning system**,** 3-tier architecture, mobile device, design and development

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LIST OF ACRONYMS AND ABBREVIATIONS

AMMAS: Ambient Mobile Multi-Agents System

API: Application Programming Interface

ASTU: Adama Science and Technology University

CASE: Computer-Aided Software Engineering

CSS: Cascading Style Sheets

GPRS: General Packet Radio System

ICT: Information Communication Technology

IMLS: Interactive Mobile Learning System

JAD: Joint Application Design

LAN: Local Area Network

LBS: Location Based System

LMS: Learning Management System

MLS: Mobile Learning System

MOODLE: Modular Object Oriented Dynamic Learning Environment

OOAD: Object-Oriented Analysis and Design

OS: Operating System

PDA: Personal Digital assistance

PDF: Portable Document Format

PDIML: Platform and Device Architecture for Mobile Learning

RAM: Random Access Memory

RFID: Radio-Frequency Identification

RUP: Rational Unified Process

SDLC: System Development Life Cycle

SDM: System Development Methodology

SME: Subject Matter Expert

SMS: Short Message Service

SOA: Service Oriented Architecture

UML: Unified Modeling Language

UMTS: Universal Mobile telecommunications System

URL: Uniform Resource Locator

UTA: Unified Theory of Acceptance

UTAUT: Unified Theory of Acceptance and Use of Technology Model

VGA: Video Graphic Adapter

WAMP: Windows, Apache, MySQL, and PHP

WAP: Wireless Application Protocol

Webapp: Web application

CHAPTER ONE

INTRODUCTION

1.1 Background

The role of educational platforms is more than obvious, each foremost evolution in communication media from speech to print to video to electronic form has resulted in changes in our means to create, record, store, distribute, access and retrieve information. The emergence of wireless and mobile devices helped electronic learning extend to mobile learning. One of the positive features of mobile learning is that there is a high availability of mobile devices worldwide and this trend continues to grow in higher educational institutes.

Adama Science and Technology University (ASTU) is one of the Science and Technology Universities in Ethiopia who has been given a new mandate of producing well qualified researchers and technologists who can adapt best technologies and speed up the transformation of the country. In this regard, ASTU's mission recognizes and addresses both the current and emerging technologies to successfully meet this ambitious national goal; therefore, Mobile learning is one of these means of mediums for modern educational system that provides students utilizing various technologies that allow them taking courses independent of time and location constraints with a low-cost, flexible option and abundant resources.

In the near future traditional face-to-face learning process may even become a peripheral activity. Some of the main reasons in the forms of the teaching-learning process taking into consideration of the technological innovations are from: institutional-based to home-base learning, fixed curricula to personal curricula, knowledge transmission to learning facilitation, front-end education to life-long/distant learning, classroom study to learning packages students.

Modern educational systems brought online improvements with the introduction of specifically designed course management systems which adopted a collaborative learning approach. These systems were integrated with conferencing, chat, and assessment tools. As a result of this, the collaborative approach provided a contemporary framework. It has been noted that course management systems also brought about a standard way to organize course materials and

integrate multimedia technologies in the course delivery. More significantly, these systems were designed to support collaborative learning, knowledge building, and multiple representations of ideas and knowledge structure. In the advancements of the 21st century, integrating the teaching-learning practices to the latest information and communication technologies would be indisputable to achieve high results in learning and educational process [66].

A prototype is designed and developed to show how the web-based architecture is going to be implemented and provided additional possibilities of making learning materials to be abundantly rich and make the teaching-learning process be available online to mobile devices and as a result, this integrated feature of the mobile learning can also be considered as the third wave of technology oriented learning with mainframe and, desktop computers as the first and second waves.

Considering these facts this thesis is primarily aided to incorporate its part of design and development of a mobile learning system to substantiate the accessibility of learning materials to students and make them utilize their smart devices to access digital learning resources through a wireless network medium and to immerse in both personalized and seamless learning. Therefore, the objective of this research is not to replace traditional learning with mobile learning, rather it provides an architectural design and development how mobile learning can go together with the traditional learning to add value to the learning and administrative activities. A prototype of Mobile Learning System (MLS) is developed during this research to show how the system platform delivers the services.

1.2 Statement of the Problem

Mobile learning is now become a new-fangled phenomenon in higher educational institutions. Most known universities have already created working procedures to get learning materials already published for students and in several ways for the open public. In addition, classic systems like personal computers have also been used extensively for online learning management systems. Most of these systems' components are organized and configured independently on a non-integrated architecture rather you will be expected to install each and every packages and respective plugins separately from the services rendering company freely or purchasing them with license to access their features.

As far as the researchers know, research studies and findings addressing the ASTU regarding architectural design and development of mobile learning system and its use with the conventional class room as a blended approach cannot be found. Also research of the actual benefits of using and publishing online learning materials to students has not been widely distributed and get a scholastic attention to the community. Moreover, research documents of the actual benefits of using mobile learning system for conventional class room were almost impossible to find however, there were some practical attempts of using MOODLE learning management system in the university wide before 3 years ago.

Therefore, the present study attempts to solve this specific problem by conducting a survey and proposing an appropriate architectural design and development of a mobile learning system prototype to Adama Science and Technology University to meet the minimum requirements desired by the ASTU respondents.

1.3 Research Questions

1. What type of architecture best suite the need of ASTU's Mobile learning system?
2. What components should be incorporated to build up the proposed architecture?
3. How well the proposed architecture supports type of multimedia file formats?
4. How well the proposed system addresses platform compatibility?

1.4 General Objective

The objective of this study is to design and develop a mobile learning system architecture which deals with the pedagogical requirements of the need assessment issued by academic staff, managers and students of ASTU for better learning.

1.4.1 Specific Objectives

1. Conduct a survey data to address ASTU's need assessment of mobile learning system.
2. Design appropriate mobile learning system architecture as per the need assessment.
3. Develop a prototype of the proposed mobile learning system.
4. Deploy the developed mobile learning system so as to be tested.

5. Test both the functional as well as the non functional requirements of the proposed system using emulators and human experts.
6. Evaluate the test result

1.5 Scope of the Study

The scope of this paper is the issue of design and development of a mobile learning system that supports multimedia file formats which mainly include: pictures, texts, audio and video on the system architecture with no need of incorporating additional tools to be downloaded as an additional plug-ins and packages for functioning.

Moreover, the system is expected to support ASTU's wireless services via Wi-Fi facility in a local area network of ASTU premises so as to avoid incurring of extra charges for accessing a data network service using 2G, 3G or 4G via the mobile devices.

1.6 Limitation of the Study

The architecture's capability regarding capturing the significant semantics of mobile learning and rendering multimedia and teaching pedagogies has not yet been thoroughly assessed. On this respect, handling storage volume, multimedia dissemination requirements, high-band width, costly investment and student-side gadgets are not readily addressed in parallel to the system operation.

In addition, details security mechanism, course evaluation methodologies, social engineering tools like: chat and forum and network bandwidth consumption issues have not yet been discussed.

1.7 Significance of the Study

The major significance of designing and developing mobile learning system architecture is to bring a paradigm shift from using mobile devices for the regular dialing functions, internet browsing, SMS and real time chatting to mobile learning system services which brings additional values so as to support the use of mobile devices for academic purposes. This additional function of the Mobile learning should ideally let students, browse learning materials on line, download, and share the learning materials from anywhere, on any mobile device and wherever they are on the proximity area of ASTU's WAP devices.

This study will also benefit ASTU's stakeholders. The information gathered from the results of this thesis study will provide managers, educators, e-learning center staff, ICT Information Technology Teaching-Learning Staff and librarians with knowledge of determinants of students' interest to utilize their mobile devices to frequently access their online courseware resources in the campus.

Managers: This study can assist school managers, e-learning center staff and ICT Information Technology Teaching-Learning Staff with information useful for planning implementation of mobile learning system and support. This will also provide adequate information on student perceptions of using the mobile technology, actual usage of PDA devices, expected level of technical support, and methods to deal with the students' acceptance and rejection. Furthermore, the proposed system will share a technical software engineering skills and knowledge for software developers and show the capability of integrating ASTU's e-studio facility for the production of multimedia online courseware resources like: audio and video lecture recording files to be delivered via the mobile learning system.

Educators: This study provides academic staff with additional knowledge and information on general mobile learning system. It offers data from both actual survey data and interviews conducted by the researcher to explain how ASTU students currently behave on using their mobile devices. In addition, it also identifies the academic-oriented content that the students currently use or would like to have access to on their mobile devices.

Librarians: This study will also provide a future provision of mobile learning technology for ASTU librarians to have an optimistic implementation plan of integrating the already existing digital library system with the newly proposed mobile learning system so as students will obtain and access the digital resources abundantly via their mobile devices.

1.8 Organization of the Study

As it is indicated in the title, this section includes the research methodology of the master thesis. In more details, in this part the author outlines the research strategy, the research method, the research approach, the methods of data collection, the selection of the sample, the research process, the type of data analysis, the ethical considerations and the research limitations of the project.

This study is presented in six chapters as follows:

In Chapter-1, the introduction part of the thesis document describes a general background of the study, statement of the problem, research questions, objective, scope and limitation of the study and finally explains the significance of the study.

In Chapter-2, first, we review and analyze the state of the art literature on architecture of a mobile learning system in order to know which features, if any, they include guiding designers, overview of the technology, history and usage patterns of PDAs and theories of mobile learning system are also introduced. Second, we study a set of tools that implement features aimed to improve the architecture quality. Third, the literature encompasses the challenges of evaluating mobile devices, and the strategies that can be used to perform such evaluations. Evaluating mobile device use involves unique challenges due to the mobile nature, screen size, platform compatibility and the breadth of uses.

In Chapter-3, we specify the research methodology of the study such as study site and population, sampling technique and size, data collection and analysis, design and implementation, evaluation approach and summary will be discussed.

In Chapter-4, we report the results of the findings from the analysis of the data collected and provide information about how the data was explored and visualized, and the iterative process that took take place in order to analyze the complex set of collected raw results, the student questionnaires and the interviews. The main results obtained are going to be explained in details.

In Chapter-5, we present, system implementation software and hardware requirements, system development methodology and its flow chart, the proposed system architecture, system model design, the sample algorithm (pseudo code), and finally the evaluation of the proposed system will be presented.

In Chapter-6, we conclude the thesis with a short review of the conclusions extracted based on the finding of the study and it also sketches some notes about future work that has to be done in order to have a fully functional architecture running on top of a real modeling.

CHAPTER TWO

REVIEW OF RELATED LITERATURE AND STUDIES

Emerging technologies are leading to the advancement in education and training at a distance can be characterized as a shift from distance learning to electronic learning to mobile learning. Mobile learning has become a new focus for technical issues as well as pedagogical issues for instructional technology and has so many architectures in different systems.

This chapter presents the affordances and constraints of mobile learning architecture, and addresses how mobile learning system is being deployed as a supplement to traditional classroom as well as the existing theories and technologies that have been considered and used in order to develop the mobile learning system are presented after the thorough and in-depth search done by the researchers. This will also present the synthesis of the art, theoretical and architecture to fully understand the research to be done and the definition of terms for better comprehension of the study in different section as follows: Section 2.1 discusses the definition of mobile learning. Section 2.2 describes about the overview of the mobile learning theories that are addressed in the literature. Section 2.3 describes the paradigm shift of mobile learning in higher educational institutes. 2.4 Limitations of hardware components regarding screen size, processing power and user interface design patterns for mobile learning system development. Section 2.5 describes the design and development of mobile learning architecture that has been used for its implementation. Section 2.6 describes the architecture for Mobile learning form the literatures point of view. Section 2.7 reviews literature that deals with architectural design and development of mobile learning system for higher educational institutes along with tabulated summary and Finally Section 2.8 reveals some of the gaps in research literature regarding architectural design and development with a concise theory and reflects the features of the proposed architecture

2.1 Definition of Mobile Learning

It is obvious that mobile learning combines the characteristics of both electronic learning and mobile computing. Mobile learning is sometimes considered merely an extension of electronic learning, but quality mobile learning can only be delivered with an awareness of the special limitations and benefits of mobile devices. Mobile learning has the benefits of mobility and its

supporting platform. Mobile learning is a means to enhance the broader learning experience. Mobile Learning is a powerful method for engaging learners on their own terms. [11]

Mobile Learning means "acquisition of any knowledge and skill through using mobile technology anytime, anywhere that result in alteration of behavior". Mobile Learning also brings strong portability by replacing books and notes with small RAM's filled with tailored learning contents. Mobile learning implies different things to different people. Here there are some definitions of mobile learning given below:

1. "Mobile learning is learning through mobile computational devices". [51]
2. Any form of learning (studying) and teaching that occurs through a mobile device, or in a mobile environment. [67]
3. Mobile learning is broadly defined as the delivery of learning content to learners utilizing mobile computing devices. [46]
4. It is a subset of Electronic learning, a step toward making the educational process "just in time, just enough and just for me". [49]

Mobile learning has been defined as learning that takes place via wireless devices such as mobile phones, personal digital assistants (PDAs) and other hand held devices. According to [34] "learning is mobile in terms of space, i.e. it happens at the workplace, at home, and at places of leisure; it is mobile between different areas of life, i.e. it may relate to work demands, self-improvement, or leisure; and it is mobile with respect to time, i.e. it happens at different times during the day, on working days or on weekends". Mobile technologies currently are capable of supporting learning practices in both blended and stand-alone contexts. Thus as a new model for learning, it has become an emerging field of research and development activities [1]. The field is now getting to be more prepared for supporting excellent learning practices and learners are progressively requesting more incredible portability and adaptability.

2.2 Overview of Mobile Learning

Researchers have denoted these technology-supported learning approaches as "mobile learning" [60]. The combination of mobile technology and its affordances that create a unique learning environment and opportunities that can span across time and place. [61] Mobile-Learning exploits interactive technologies and communication systems to foster the learning experience. It has a great potential to transform the way we teach and learn across the world [65].

There are innumerous explanation which can be found in literatures on mobile learning from technical, spatial and context driven perspectives.[51] has defined mobile learning as “elearning through mobile computational devices” this context is almost similar with the idea of “There is common agreement that mobile learning is elearning through mobile computational devices” [67]. Taking additional considerable perspective, [44] have describe mobile learning as “any sort of learning that happens when the learner is not at a fixed predetermined location or learning that happens when the learner takes advantage of the learning opportunities offered by mobile technologies”. Likewise, “The field is concerned with learners’ mobility in the sense that learners should be able to engage in educational activities without the constraints of having to do so in a tightly delimiting physical environment.” [29]. Consequently “mobile learning is not just about learning using portable devices, but learning across contexts” [70].

Many features which differentiate mobile learning from other forms of electronic learning can also be found. Thus distinguishing qualities propose site-specific learning and degree of ownership and control over the learning process [33]; personalization, adaptation, engagement, self evaluation and reflection by the learner [62]; change in the personal relations between teacher and student, student generated context, and student generated understanding [71]; and the affective dimension offered by the mobile learning experience [27]. Learning activities apparently supported by mobile learning also point to some difference. They comprise: exploring a physical environment discussing with peers synchronously and asynchronously recording data through sound, images and text adapting learning in the light of social media or feedback reflection using shared knowledge products [33].

Moreover the issues mobile learning engender such as profiling of learners [10], learning conditions [62] accessibility and user control [64], usability factors [30], evaluation of mobile learning, learning design [40], and combining mobile devices with broader educational setting [21] offer insights which assists to distinguish mobile learning from other forms of learning.

The work of Wisharta J. [72] and Matasuura, K., et al. [37] provides specific examples of case studies which reflect some of these issues of mobile learning. Moreover, the study of the McFarlane, A., Roche, N, Triggs, P. [39], Rekkedal, t, Dye. [52], and Jawad, B. & Mohammed, A. [26] also provides additional elaboration and justification regarding the mobile learning and

its impact on educational technology with respect to the advancement of software and hardware improvements through time.

2.3 Paradigm Shift of Mobile Learning

There has been a distinctive revolution takes place on higher education and training to learning over the past two decades; from teacher-centered to student-centered education; that means from rote learning to learning as reflection; and from face-to face to online distance and electronic learning [25]. One principal characteristic of this change is the innovative application of technology to improve the delivery of education. The coming out of a new approach to learning characterized electronic learning has directed to new perspectives on learning presented all the way through different hypothetical lenses [15].

Mobile learning, as this is now commonly known has grown as an extension of the elearning frontier from a minor research interest to a set of significant projects in schools, workplaces, museums, cities and rural areas around the world [56].The pedagogical latent offered by handheld devices, is one such perspective called mobile learning. This signal of concern in the educational potential of handheld technology is seen as an intentional endeavor targeted at "domesticating" mobile devices for learning purposes [8]. Combined with web 2.0 technologies, mobile devices are nowadays seen as offering new learning promises which symbolize an energetic transformation in the strategies employed by learners and their production and consumption of learning products [16]. It is known that there is a considerable interest from instructors and technical developers in utilizing the unique capabilities and characteristics of mobile technologies to make possible of the new and engaging forms of learning [42].

Many higher educational institutions are implementing mobile learning to provide flexibility in learning [68]. Using mobile technology to reach students will benefit higher education by increasing enrolment and having a broader student population, since students in different age groups will be able to access course materials anywhere and anytime [35].

The use of mobile application is changing the way we live and how we access education. One clear development is a blurring of our social, business, learning and educational lives as the prototype of our communication and relations across time and space changes [17]. All countries are starting to perceive that Internet access anywhere and anytime is a human right for peoples

and have set goals to establish the infrastructure to allow access by all, which will facilitate the use of mobile technology in education [9]. There is great potential for mobile learning in developing countries, but watchful planning is required for mobile learning to be victorious [41].

For general speaking, mobile learning is not merely about the technology, it is rather about the learner. The learner is mobile and is at the centre of the learning, and the technology allows the learner to learn in any subject matters. [69] State that mobile learning is a social rather than technical experience of community on the move, building spontaneous learning contexts and advancing through each day life by negotiating knowledge and meanings throughout the interactions with settings, people and technology.

Students can use the wireless facility of their mobile devices to access the latest and appropriate educational materials from the learning management system on the web and they can simply communicate with subject matter experts in the field of their studies. Situated learning, which is the application of knowledge and skills to specific contexts, is facilitated, since students can complete courses in their own space, and apply what they learn at the same time.

Mobile technology creates a great opportunity to connect learners from different parts of the world to exchange and share information with each other. Students can use the mobile communication system to explain where they are so that students from other parts of the world can discover about those places. The process used to generate and share information with different cultures resulted in the growth of intercultural competencies and skills to communicate between cultures.

Mobile learning has confined the opinions of many professors and instructors in higher educational institutions as they have capitalized on the features and tools embedded within dominant mobile devices [23]. Osaka Jogakuin College in Japan became the first higher institution to provide mobile learning devices (i.e. iPods) to their students to assist in English learning [38]. This achievement was soon followed by the initiative of Duke University in the United States to provide all first year students with iPods [12]. Moreover, existing literature pointed out that Columbia University in the United States has started to commence mobile learning to explore how instructors and students can utilize the mobile phones for learning. Oxford University in the United Kingdom also has explored the integration of iPad as effective

technology for taking online programs [53]. According to [34], there are also been numerous successful attempts by higher education institutions everywhere in the world in using text messages to support distance students such as the University of Ulster in the United Kingdom and Kingston University, the Srinakharinwirot University of Thailand, the Sheffield Hallam University branch in India, University of Victoria in Australia and the Chinese University of Hong Kong. Supplementary research is also being conducted to determine the effect of mobile learning in traditional forms of higher educational settings.

Nevertheless, mobile learning in higher educational institutions settings has not become extensive and is still in the testing phase. In addition, the research into mobile learning mainly has been based on the challenges and opportunities of this technology in education in general and in online distance learning in particular. Many new research topics have been emerging in various areas, including technological, pedagogical, and methodological issues and problems related to course content and user interface adaptation. Both university officials and educators have been working to come across the paramount approach to extensively use mobile devices in their education system.

2.4 Limitations of Hardware Components

One of the most considerable issues in multimedia application for mobile learning is the display's size for showing the smallest pieces of data elements.

It is obvious that the screen size recently become a serious barrier to mobile learning applications for current devices, but hopefully expect the future mobile devices like: the smart phone, iPhone with Flash & Flash Lite, and especially the iPad which has the facility to enlarge font sizes and give access to e-books, may reduce this problem, even though perhaps eliminating the problem is so difficult [31].

Therefore, to fit graphical elements in the display, bring the information together and keep the user in the context the user interface needs to be designed according to the display size of these devices. Recently, the displays size and resolutions be likely to increase VGA leading to better user experience.

Since much processing power has been a reason for less battery duration so here it must be a compromise between them. The reduced dimensions involve difficulties in interaction with the device and the user interface. For example, Smart phones tend to have larger screens, less hardware buttons and having touch screen interface, finger-controlled. The issue of connectivity is very imperative for multimedia applications when media streaming is used because, it is directly affected by different technologies which have diverse bandwidths and availabilities due user's mobility. Moreover, individual characteristics of these various devices affect the way of designing, implementing and testing the mobile learning applications. These typically include the limitations of mobile devices in terms of memory, display, storage, bandwidth leads to less functionality than for desktop devices.

2.5 Design and Development of Mobile Learning Architecture

Mobile learning is now one of the most thematic areas where many researchers are carrying out their contributions but, recent research shows that there are certain priorities in research works which can have effect on better design and development phase. "1) teaching and learning strategies; 2) affordances; 3) theory; 4) settings of learning; 5) evaluation/assessment; 6) learners; 7) mobile technologies and interface design; 8) context awareness and augmented reality; 9) infrastructure and management; and 10) country and digital divide." [22].

Honestly speaking, the design and development of mobile learning architecture determined as hard procedure concerning to technical phase such as software programming knowledge, graphic and interface design knowledge, instructional design knowledge, content localizing, designing and familiarity with smart phone hardware. According to [20] they argued about characteristic of virtual learning environment which permit students to experience high levels of presence, they are interactive and they are autonomous" Based on mobile application flexibility some educational institutes, universities or schools started to develop specific mobile architecture for their students according to their curriculum and particular need. In 2010, Princeton University implemented their mobile learning services and students can have "Access documents in multiple formats, post announcements, create threaded discussion posts, upload media as attachments to discussion boards and blogs, create content items within the course map, take tests, and receive push notifications for important course updates or changes" [5].

There are many mobile application builders worldwide which have been developed and help users to create their ideal custom mobile applications to avoid these types of particulars. Moreover, in absence of some infrastructures, lack of confidence, lack of competence, and lack of access to resources might be reason for unsuccessful integration of ICT based solution in education [13]. On the other hand, some researchers suggested that there must be learning strategy in design and development phase such as active learning, collaborative learning, authentic learning and multiple perspectives in higher educational institutes [28].

2.6 Architecture for Mobile Learning

With the successful improvement of Bluetooth, WAP, GPRS and UMTS, the technological structures for wireless telephony and wireless computing are currently become implemented everywhere in the world. Mobile learning involves delivery of digitized content to either wireless phones hooked into laptops or PDAs. The wireless technologies of the mobile revolution have seen the worldwide production of wireless communication devices [32]. What makes mobile learning is different from the other is that it allows on-the-go professionals to connect to training courses anytime and anywhere 24/7. Mobile learning can also include anything from job aids and courseware downloaded on personal digital assistant to Net-based, instructor-facilitated training via laptop [3]. Mobile learning, allows users to access IT courseware modules via the Palm operating system.

2.7 Related Works

The concern of mobile learning system architecture is one of the prominent parameter in administrating and customizing the online learning systems with respect to delivering learning materials for students in various multimedia file formats. The heart of this literature review will be on the architectural perspective, which is a central core of all the mobile learning systems. Therefore, we will particularly review the work existing in the literature by presenting respective approaches and platforms of mobile learning systems for higher educational institutes.

On the other hand, the review covers many literatures concerning on the existing architectures which are modulated for mobile learning system from highly cited authors. After analyzing the papers, it was found that most of the previous reviews focused on the number of articles published, selected year, authors, learning platforms, research sample groups, designing learning

environments. It was observed that most studies showed the focus on social learning, formal and informal learning, learners' engagement, evaluation and assessment of learners', learners' attitude toward mobile and ubiquitous learning.

For the current interest in mobile learning system, some theories have been proposed. Those theories have focused on the design of mobile learning system architecture and the mobile devices technologies. When compared to the state-of-the-art mobile learning systems, these are found to be incomplete from several aspects. Mobile Phones and PDAs are the most commonly used devices for mobile learning system, but these may be replaced in the future by new emerging technologies.

Here is a list of literature reviews and their respective architectures selected and presented with respect to their functionalities and services regarding their approaches to address a mobile learning system requirement in different styles from the newly proposed architectural design and development solution.

Sushil K. Sharma and Fred L. Kitchens present a method for exploiting web services architecture for Mobile learning [63]. The end user is usually known prior to development as well as the device/application that will be used. In this case, there was no specifically defined user, therefore multiple devices and consumers had to be considered. From a development standpoint, the challenge is to build a dictionary database. Setting up a database that can contain audio, video and text data, and to allow data to be retrieved quickly upon request is a challenge. The most difficult task of developing such a service is how to handle the multimedia files. One can store the multimedia files in the database as binary data, but every time somebody requests them, the program must build a temporary multimedia file, which is expensive from a processing standpoint. The proposed architecture would provide students and teachers the opportunity to obtain any and all class related material on their Palm handheld computers through web services architecture.

Luvai F. Motiwalla explores the extension of electronic learning into wireless handheld computing devices with the help of a mobile learning framework [36]. This framework provides the requirements to develop Mobile learning applications that can be used to complement

classroom or distance learning. He points out the key benefit of his architecture are that it allows the course interactions and communications between users on personal computer (PC) with users on wireless handheld device. Messages posted on PC can be instantly accessed on wireless handheld device and students with wireless handheld devices can exchange messages with students using PCs or notebooks. This is good for the Mobile learning environment as the critical mass (network effect) of wireless handheld device users is not essential for this service to get started. Another benefit of this integration is that students can receive alerts when new messages are entered on the discussion board on their wireless handheld device. The overall goal of this architecture was to value-add to the anytime/anyplace flexibility of electronic learning.

Parsons, D., & Ryu H. describe four software architectures for mobile learning; non adaptive mark-up, adaptive mark-up, mobile client side application and smart client with server connectivity that can be applied to Mobile learning systems and provides an overview of their comparative strengths and weaknesses in meeting the various requirements of the mobile learner [46]. The most important aspect of designing Mobile learning system architecture is to consider all aspects of the user context rather than just focus on the technical platform. Therefore deciding on suitable software architecture for a specific Mobile learning system depends not only on technical factors but also an analysis of the user context.

A. M. Riad & H. A. El-Ghareeb present a Service Oriented Architecture (SOA) consists of two layers: Interface layer and Service layer to integrate mobile assessment in LMS [2]. Interface layer interacts with instructors and learners via portals, and with external organization services via Web services whereas the Service layer contains core system services and has three sub layers: Orchestration, Application Services, and Agents layer. Finally, an automated mobile assessment is presented. Utilizing SOA to integrate Web services and software agents in LMSs highlighted the unlimited advantages of Web services and its capabilities to facilitate software agents' integration within systems.

Paul, P. presents a survey on multimedia technologies for mobile learning applications, focusing on multimedia programming techniques for Windows Mobile, Symbian, and Java ME [47]. The researcher observed that Distributed platforms have a similar architecture as Web-based platforms, but the client application is a rich application and not a simple mobile Web browser.

The researches understood and emphasis that the Web-based platforms are very common in mobile learning process. As a result he summarizes the article as: using operating system native API leads to faster applications but long development curves and difficulties on porting applications to other operating systems.

Paul, P. presented the main steps in development of a distributed mobile learning application for Android [48]. The client application communicates with the server using Web services. The developed prototype includes the testing module as a part of a Mobile learning system that will also be developed for other mobile platforms in order to cover a wide area of mobile devices and users. There is a variety of plat-forms and technologies to choose from. Mobile devices resources are limited and using Web services for mobile learning applications helps the process of development by providing a standardized way of communication between mobile clients and servers.

Jawad, B. & Mohammed, A. constructs a personalized learning web for a mobile user who needs to learn about a specific topic [26]. The system manages the gathering, authoring, packaging and delivery of learning material. The architecture of the implemented system uses a set of web services to retrieve information and learning resources from the web. These learning resources are packaged into lightweight learning objects designed according to preset layouts. Besides, the system constructs an ontology-like hierarchical content structure to organize learning objects into a learning web allowing the learner to navigate freely according to his/her needs and constraints. The researchers finally proposed the design, implementation and conduct an evaluation of the mobile learning system and as a result they found the system that it can generates multimedia structured learning content from the web, packages it into lightweight learning objects and delivers it on the learner's mobile handset.

Iyabo, O. A., & Adewuyi, O. O. the main objective of their research is to design a content-rich Wireless Application Protocol system for higher educational institutions [24]. They propose a mobile portal architecture that would enable portal application to be used on mobile phones. The system was developed using MySql as the backend and the front comprising of a mobile device that must be WAP enabled. The WAP gateway acts as the middleware and the web server on which Hypertext Preprocessor would run. The system is divided into two modules: the mobile

front-end module and the application server and database module. As a result of this, the system could assist students of educational institutions, especially, higher institutions in developing countries to do on-line registration and payments of fees on their mobile phones.

The research of Di, J., Wang, J. & Zhang, L. mainly identified user and market requirements regarding cell phone manufacturers and operators about how they rely on Android Smartphone Platform Application development for mobile learning [18]. They also added information about how the popularity of the system's flexibility, openness, and open Internet concept, will benefit the technology to realize liberalization, set individuation, and show impact of multiple mobile learning. According to the characteristics of mobile development of system underlying data format, network communication, embedded database, some of the key code given platform upon completion of this learning-based Android mobile terminal platform based on the design and implementation, and in a simulated environment verify the availability of mobile terminal platform learning. Android is an entirely open platform for third-party software developers for its development process have a greater degree of freedom, breaking the traditional mobile phones, that the software can only add a small number of fixed yoke.

The researchers also tried to assess the readiness and perceptions of faculty members and college students in the use of mobile devices for learning inside and outside the classroom to determine the respondents' prior knowledge on the personal and educational use and application of mobile phones. As a result of this, the study then identified the respondents' perception on the effectiveness of mobile devices as used in the teaching-learning process and proposed new mobile learning application framework.

In the research of Christianne, L. & Cabanban, G. [14] at Don Mariano Marcos Memorial State University-South La Union, they provided valued data for future studies on respondents' intention to use mobile devices for learning and for the development of mobile learning system using android platform. They could also be able to integrate factors of mobile learning perception into the design and implementation phases of a mobile learning system initiative via Ubiquitous Mobile Learning Architecture which has three main factors that consists of the learning environment. The model signifies the "anytime, anywhere learning" which can be conducted in the traditional classroom setting or outside the classroom like travelling in a bus or being at home

using a wireless network with both 3G and WiFi to connect with the University server at all-time using Web Services architecture.

On the other hand, considering the same factors, the researchers seek to explain intentions to use an information system and subsequent usage behavior by using a Unified Theory of Acceptance (UTA). The theory holds that the key constructs performance expectancy, effort expectancy, social influence, and facilitating conditions are direct determinants of information system usage intention and usage behavior.

Nie, H. research mainly discusses the cross-platform key technologies of mobile learning system, its characteristics, advantages and disadvantages regarding the dynamic nature of technology [43]. According to the researcher, mobile learning system design is one of the determinant factors to identify the needs of different functions under different technical support, and discusses the construction plan of the cross-platform of the mobile learning system regarding the type of the mobile devices used especially the smart phone.

Consistent with the function of the mobile learning system, cross-platform technologies such as cross-compilation, mobile webapp, mixed mobile web app, development kit, and mobile widgets can be applied to different mobile learning system design and development. The researcher emphasis the JavaScript as it can be used as a common language of developing the system, needing to choose Mobile JavaScript framework, and the more popular are jQTouch, jQuery Mobile and Sencha Touch. Aiming at the new type of computing environment with rapid development for the future, mobile learning will play a more and more important role, and in the new environment mobile learning will have a better and more complicated application mode.

Olutayo, B. & Dupe, F., conducted their research regarding the architecture and the implementation of an interactive mobile learning system and showed how the system is used for enhancing traditional learning in the classroom [45]. They have implemented an interactive mobile learning system with a web based IMLS that is suitable for use as supplement with a traditional classroom learning system. They suggested that if IMLS is implemented successfully, it will bring drastic change for modern education and make the classroom learning to be more interactive, relief lecturer fatigue, improve student engagement and their literacy skills. In addition, They also emphasizes an appropriate usage of Smartphones, Apple iPhones, Pocket PC

s, Mobile Computers, Android phones, Tablets, Ipads can bring a great development of for the mobile learning technologies and it can made instructional messages to be sent from the educators to the learners very easily through their mobile devices such as; communication between the instructors and the students can be done through text messages, voice as well as through images. They finally, conclude the proposed system to provide current, updated information and ensure user convenience and easy accessibility features.

Adnan, M. in his research presented an analysis of the mobile learning and education using his proposed architecture of mobile learning in university environment [4]. The terminal of the system is connected with the infrastructure inside the university LAN and also connected with the external network environment. His proposed architecture offer services to the teacher and student in the university premises so that students might access the platform directly from the university LAN or through the internet in order to collect and download the learning materials. From the infrastructure of the university point of view, students can access the data center of the university from Wireless Local Area Network as well as from local area network. The university offer server platform for course management system for educational resources and it is connected on the university LAN. In addition, when students and teachers are at home they usually use their own personal computer or laptop using high speed internet connection with GPRS and UMTS for learning.

Tamhane, K.D., Mr. Wasim T. Khan, Mr. Sagar R. Tribhuwan, Mr. Akshay P. Burke, Mr. Sachin B. Take. This research offered the design and development of Mobile Learning Application based on Android Platform using Java Programming Language to help students in computer courses at the Department of Computer Engineering [65].

Alla, E. M., Yusmadi, Y. J., Masrah, A. B., Binti, A. J., Noraini, C. P., & Shaima, M. Al T. In this study, the researchers introduced a platform and device architecture for mobile learning (PDIML), which provides contents based on the characteristics of mobile devices and their capabilities [6]. A prototype was developed based on the proposed architecture and validated to measure students' satisfaction. The results showed a high satisfaction about the delivered materials and their suitability the student's devices, which mean that the architecture is capable of delivering suitable learning materials for students' devices on different platforms.

Qingchun, Z. In this study, the researcher finds out that a practical application of the information educational pattern is realized in mobile learning system. Learners have different requirements about the kinds and types of resources, because their learning emphasis is different. The system mixes the learning environment and natural environment together, and pushes resources, which are close to present situations; therefore, when learners are studying, they maintain a close relationship with the external world, which improves learning's rapid transformation [52]. Mobile learning resources push system, based on RFID, integrates the conception of resources push into mobile learning, improves the easy-interferential state at the present mobile learning's process and solves the problem of low efficiency of learning, so that learners can acquire resources service in time and satisfactorily. It has a certain application value to improve students' attention and expand using of a mobile learning pattern.

Riyadh, A. In this study, the researcher gathered valuable data about the possible advantages and disadvantages of mobile learning, and the barriers do students expect facing when implementing the mobile learning technologies [53]. The findings of the study showed that students had highly positive attitudes toward mobile learning, and they had the necessary technical knowledge to implement mobile learning. However, students were found to have very little experience in electronic and mobile learning.

Shili, M., Moez, C., & Santosh, K. B. the researchers review the evolution of learning technologies in general and recent advances in mobile learning and pervasive learning in particular [58]. In the research work, details study, model and simulation have been done on an ambient mobile system based on intelligent agents approach. The mobile agent concept is not based on the traditional client-server model, but on distributed executive models.

Xiaojie L. & Xianmin Y. In this study, the researchers determined that the learning concentration of the college students was not satisfactory achieved while students learning via mobile phones. [73] Investigate the interaction effects of interest and learning styles on the learning concentration and academic achievement of college students who used mobile phones to learn conceptual knowledge in a classroom setting. As a result, designers of m-learning materials and teachers who use these tools must implement several measures to stimulate the interest of students include: adjusting the attitude of students toward m-learning, preparing learning materials in connection with their needs and interests, and immediately providing learners with

relevant feedback. Moreover, the researchers propose, wider screen size of mobile devices should be used for m-learning.

Asir, D., Jebamalar, E., Janani, S. In this study the researchers presented a native-based mobile application for m-learning for engineering students. Using this mobile application, students can read their course contents [7]. This application can work even offline since the learning contents are updated to the mobile devices when the mobile device is connected with internet. Moreover, this application is more useful where the students are not able to attend their classes due to the personal or medical reasons.

Farooq, A. investigated the actual academic use of mobile phones among students and teachers, their attitudes toward using them as learning or teaching tools, and if there is a significant difference in attitudes of the participants toward using mobile as learning or teaching tools based on the job criteria [17].

Shi-Jun, Z. & Gui-Hua, Y. The researchers focus on mobile learning model and its effect. The empirical results show that the mobile learning model can fully mobilize the enthusiasm, initiative and creativity of the students in the mobile learning process and help to improve the quality of learning, efficiency and effectiveness of teaching [57]. Moreover, adopting mobile learning model can significantly improve learning quality, and it provides empirical support to carry out large-scale mobile learning and teaching as well as provide a theoretical basis and operation guarantee for O2O (online and offline) mixed teaching system in the future.

Shili, M., Moez, C., Santosh, K. B. In this study, the researchers have presented AMMAS (Ambient Mobile Multi-Agents System) architecture for the M- learning, the agents of the system are implemented using the JAVA language and the Jade platform [59]. The highlight of this architecture is to allow the student to manage the course by using smart phones (laptops, PDAs, etc ...) at anytime and anywhere. The application of AMMAS in M- learning allow created mobile agent independently responsible in their moving to perform the task requested by the student.

Ya-Li, Z. & Xiao-Kan, W. In this study, the researchers introduced and analyzed characteristics of mobile location technology and intelligent terminal [74]. It was suggested to apply LBS technology in mobile learning area and to integrate LBS and mobile learning. Application values

of LBS in mobile learning were showed and improved, application of new technologies in education area was promoted to a certain extent. Mobile communication technology, LBS technology and mobile learning studies were analyzed; plan of mobile learning system based on LBS was established. LBS and currently popular mobile learning modes were also combined. Finally, LBS mobile learning system based on Android platform was proposed to fulfill the personalized needs of the mobile learners on basis of location information.

2.8 Tabulated Category of Related Works

The newly developed application basically concerned on the smart phone and reduced all the drawbacks of the existing system and from the internet access point of view the application run only on Android OS, with 2G or 3G Network facility. Primarily, the researchers approach was to incorporate multimedia animations concept with command language to create the pervasive learning environment in presenting the mobile learning application and then, students can easily learn at their owns pace, anywhere and anytime.

This mobile learning system intends to complement the current traditional classroom and electronic learning systems. In addition, if a user (student or teacher) has any inquiry then he/she will post it on the feedback session and starts discussion so as the administrator on the other side will provide the solution to the user's inquiry thus; the system provides a feedback service in asynchronous mode. Finally, the proposed architecture consists of the real time electronic learning plus social engineering concept that provided a reliable mobile learning system.

Year	Author	Article Title	Advantages (Successes)	Challenges (Drawbacks)
2004	Sushil K. Sharma and Fred L. Kitchens	Web Services Architecture for Mobile learning	▪ Creation of virtual files	▪ Build a dictionary database ▪ Handle multimedia files
2006	Parsons, D. & Ryu, H.	Software architectures for mobile learning	▪ Consider all aspects of the user context	▪ Focus on the technical platform

2007	Luvai F. Motiwalla	Mobile learning: A framework and evaluation	▪ Allows the course interactions and communications ▪ Receive alerts	▪ Small sample size of study limits generalization
2008	A. M. Riad And H. A. El-Ghareeb	A service oriented architecture to integrate mobile Assessment in learning management systems	▪ facilitate software agents integration within systems	▪ Integration
2009	Paul POCATILU and Catalin Boja	Survey on Multimedia Technologies for Mobile Learning Applications	▪ Minimal effort to set up application ▪ The user doesn't need to learn how to use ▪ Updating Electronic learning content	▪ Not so rich user interface ▪ Multimedia content is limited ▪ Possible additional costs for traffic usage.
2010	Paul POCATILU	Developing Mobile Learning Applications for Android using Web Services	▪ New Functionalities ▪ Interface improvement, ▪ Modules Implementation ▪ User Management ▪ Modules Integration	▪ Security ▪ Refactoring
2010	Mohammed Alzaabi, Jawad Berri and Jamal Zemerly	Web-based Architecture for Mobile Learning	▪ Provides videos related to the search topic ▪ Uses a content structure ▪ Adapt to learner profile ▪ and the mobile ▪ device specifications constraints	▪ APIs need to be developed ▪ Modeling the user behavior
2012	Iyabo Olukemi Awoyelu* and Adewuyi Olusegun Ojo	A Mobile Portal Architecture for Higher Educational Institutions	▪ Register for courses on-line, ▪ Check results and view transcripts ▪ Access lectures and examination time tables ▪ Short Message Services	▪ Only run on a WAP browser
2012	Di Jiaqi, Wang Jianhua, Zhang Long	The Research in Mobile Learning Based on Android Smartphone Platform Application	Open platform Integrates advanced mobile communication technology The software only need a small fixed yoke	▪ Lack of user experience ▪ Gap between Android platform for mobile phones and the IPhone
2013	Christianne Lynnette G. Cabanban, Don	Development of Mobile Learning Using Android Platform	▪ Higher level services for applications ▪ Reuse software and	▪ Performance Expectancy ▪ Effort expectancy

	Mariano and Agoo		consistent user experience ▪ Supplement to existing technology acceptance literature	▪ Social influence ▪ Facilitating Conditions ▪ Self-Management of Learning
2015	Adnan Majeed	Survey Paper Mobile Learning & Education	▪ Host the digital educational resource ▪ Access the server platform ▪ Download the data	▪ Appropriateness ▪ Quality ▪ compatibility ▪ cost of the devices. ▪ misuse mobile apps and mobile services
2015	Nie Huiyu	Research on mobile learning system construction based on smart phones	▪ Application of Cross-platform technologies ▪ Contribution of JavaScript for Mobile Learning system development	▪ Status quo of the smart phone ▪ Constant development ▪ Choosing suitable technology
2015	Olutayo Boyinbode and Dupe Fasunon	Deploying an Interactive Mobile Learning System in the Classroom	▪ Simple Design ▪ User Friendliness	▪ No student responses about the system ▪ No questionnaire attached & explained ▪ There is no any data analysis and interpretation about the architecture
2015	Tamhane, K.D., Mr. Wasim T. Khan, Mr. Sagar R. Tribhuwan, Mr. Akshay P. Burke, Mr. Sachin B. Take	Mobile Learning Application	▪ Offline learning facility ▪ Real time electronic learning plus social engineering concept are added ▪ Developed by Java Programming Language	▪ Use only android platform phones ▪ The system runs only on 2G and 3G Network
2016	Alla, E. M., Yusmadi, Y. J., Masrah, A. B., Binti, A. J., Noraini, C. P., & Shaima, M. Al T.	Platform and Device Independent Mobile Learning Architecture	▪ The architecture supports the implementation of Mobile portal	▪ The architecture may not support all mobile devices ▪ Tested results are not shown and mentioned using different types of platforms and screen sizes ▪ No external validity
2016	Qingchun, Z.	Mobile learning resources push system design based on RFID	▪ Non-contact recognition ▪ Reading and writing functions of data are strong ▪ Tags can be used repeatedly ▪ Environmental suitability is strong ▪ The security is steady	It incurs much cost for: ▪ Each server is distributed to different regions. ▪ Each server includes resource database and learning record database.

2016	Riyadh, A.	Mobile Learning as a Method of Ubiquitous Learning	▪ abundance of information for exceeding students' capacity ▪ Use of Mobile Phone as a Tool for Mobile Learning	▪ Inactive e-learning portal ▪ No uploaded e-content ▪ Limited wireless network coverage	
2016	Shili, M., Moez, C., & Santosh, K. B.	Pervasive Mobile Learning System in the New Millennium	▪ use of ambient mobile agents as a communication entity ▪ reducing of network traffic and amount of exchanged information ▪ minimizes customer wait time ▪ use ontology and semantic web for security	▪ No usability test is conducted ▪ No platform test is reported or mentioned at all ▪ No security test report	
2016	Xiaojie L.& Xianmin Y.	Effects of Learning Styles and Interest on Concentration and Achievement of Students in Mobile Learning	▪ Impact of m-learning materials	▪ Usability test was conducted only on Android, iOS, and Windows Phone 7	
2017	Asir, D., Jebamalar, E., Janani, S.	Mobile Application for m-Learning	▪ Overcomes the drawbacks of web-based leaning	▪ No framework and architecture ▪ Only java toolkit is used for implementation ▪ No test conducted at all	
2017	Farooq, A.	Mobile Phones for Teaching and Learning: Implementation and Students' and Teachers' Attitudes	▪ Best adoption possibility of Gadgets for students	▪ No implementation ▪ Unfamiliarity with mobile phone ▪ No hands-on practice	
2017	Shi-Jun, Z. & Gui-Hua, Y.	Mobile Learning Model and Process Optimization in the Era of Fragmentation	▪ Develop structure of mobile learning model for the fragmented era	▪ Mobile Learning model is not explicitly explained ▪ No experiment is conducted regarding platform compatibility and usability ▪ No prototype is developed	
2017	Shili, M., Moez, C., Santosh, K. B.	Ambient Mobile Multi-Agents System: Simulation of the M-Learning	▪ Use of ambient mobile agents ▪ Reduce network traffic and amount of exchanged information	▪ No integrated security mechanism ▪ Profile adaptation and career dynamism are not discussed yet	

2017	Ya-Li, Z. & Xiao-Kan, W.	LBS Mobile Learning System Based on Android Platform	▪ Integration of LBS and mobile learning	▪ No detail analysis presented ▪ Platform not yet developed ▪ Incomplete Architecture ▪ No system test evaluation

Table-2.1 Category of mobile learning system

2.9 Summary

In this thesis, we presented a comparison literature review of fourteen researchers in the area of mobile learning systems. And as a result of this, the relevant components of the proposed systems by each researcher have been properly reviewed and summarized with some comparisons categories using a tabulated format along with a short review brief of each paper. The applications and architectures of the presented literatures are almost interesting and address the technological advancement of the mobile learning theories and implementations with various features of their services and their respective future work recommendations.

However, all the presented architectures are very well and impressive we could not take every detail of their mobile learning system architectural designs and developments.

Therefore, the researchers select the best architectural designs which resembles to ASTU's current scenario and adopt it concerning the basic requirements stated during the need assessment of the data survey. This work can be taken as an Ice Break to start up thinking about the theories and implementation aspects of a mobile learning system architecture and its prototype development for the best accomplishment of ASTU's mission on research-oriented teaching–learning approaches for the adaptation of this modern technology to supplement the traditional learning practices to blended learning paradigm via a mobile learning system.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

A research problem is one that needs a solution and in some cases, the type of problem determines the approach to solving it. This research work seeks to investigate and propose an architecture design and development for mobile learning system for Adama Science and Technology University.

The researchers explain how the necessary data and information are organized in order to achieve the research objectives and questions. Data collection, presentation, analysis and development of theory were used to design and develop the research methodology.

This chapter elucidates the research method, the research study site and population, the sampling techniques, the data collection and the analysis approach for the empirical data, the design and implementation method, the evaluation approach used generalizability, reliability and validity issues are discussed and finally, the summary concluded the research methodology used in a nut shell and pointed out the next chapter.

3.2 Research Method

The population contains about 7500 regular undergraduate students and 394 local academic staff not including the expat staff members and 28 middle management bodies. In this research, a small survey comprising of a total of 200 randomly selected respondents were planned to be participated and among this 36 of them were academic staff, 9 of them were management bodies and the rest 155 were students from each schools and Divisions. The students cut across different years of undergraduate studies ranging from pre-engineering up to 5^{th} year graduating class students.

Almost all questionnaires were distributed to the students and response was collected almost immediately while some others questionnaires distributed to academic staff and management bodies were collected a few days after. Overall, the administration of the questionnaire was done within a period of 3 weeks in each school and division at different departments and lecture halls

as well as in each concerned office and the participants in the survey were informed on the aim of the study.

It was originally intended that the self-administration method of survey for the questionnaires be employed in this study. In addition, only few participants were involved for an interview both from management bodies and academic staff. However, as a result of envisaged low response rate and the limited time available for the study, self-administration appeared more advantageous in terms of response rate. From the 200 questionnaires, 36 were distributed to Academic Staff, 9 were distributed to Management Bodies and eventually all the questionnaires were returned and filled accordingly whereas the remaining 155 questionnaires were sent out and only 135 received after completion. 5 of the 135 collected questionnaires were ultimately rejected as the respondents were skeptic and therefore did not qualify for inclusion in the target population. The difference of 20 questionnaires fell into the category of badly filled (5 questionnaires) and unreturned (15 questionnaires). From the scenario, we generally conclude that the high response rate was found in this study to be 87.5%, this ensures a representativeness of the wider population from where the sample has been drawn.

3.3 Study Site and Population

Population is the total collection of elements about which we wish to make some inferences. A population can be defined as all elements (individuals, objects and events) that meet the sample criteria for inclusion in a study. It can also be defined as the group of people from which a sample can be drawn for the purposes of a research. The population of this research consisted of the ASTU's Management Bodies, Academic Staff, ICT Staff, e-Learning Staff, Information Technology Teaching-Learning Staff and Students from the five schools namely: Schools of Civil Engineering and Architecture (SoCEA), Schools of Mechanical Chemical and Materials Engineering (SoMCME), Schools of Electrical Engineering and Computing (SoEEC), Schools of Applied Natural Sciences (SoANS) and Divisions namely: Division of Liberal Arts and Social Science (DoLS) and Division of Pre-Engineering Program (DoPE).

3.4 Sampling Technique and Size

A sample is a group in a research study in which information is obtained. Or a population selected for observation and analysis. It is a representative of a population taken to show what

the results are like especially; if the population is very large, it can be satisfactorily covered through sampling.

The sampling technique and size has been described followed by the Data Collection and analysis Method. The survey instrument has been designed using Likert categorical scale to measure respondents' attitude towards the important factors consistent to relevant research findings.

Sampling techniques mainly used to sample the research participants. Commonly sampling methods can be categorized into two, probabilistic and non probabilistic. Sampling procedures can also be categorized as stratified random, judgmental and systematic. For the purpose of this research, stratified random and judgmental sampling techniques were used to find the right sample size.

Stratified Random Sampling

Stratified random sampling is used to ensure an equal representation of each of the identified segments or strata in the research.

According to the procedure, the total population is divided into segments or strata. And then, individuals to be included in the sample are then being selected from these segments or strata. In this case the population was divided as Management Bodies, Academic Staff, ICT Staff, e-Learning Staff, Information Technology Teaching-Learning Staff and Students. They are then reorganized in to three as per the appropriateness for the study and the knowledge they have regarding the area.

Judgmental Sampling

Judgmental sampling is a non-probability sampling technique based on judgment. Judgmental sampling occurs in a situation whereby the interviewer selects respondents who are judged to be representative of the population in the study. It is common to use the technique to ensure optimization of time and resources since data is sought from those people with valuable information and knowledge about the specific area of the study. This makes the judgmental sampling technique to be cheaper and easier since a few individuals with relevant information are chosen.

Therefore, the researchers chose the participants who were viewed as the best source of information as the sample was likely to bring out the required data particularly to the research problem regarding their experiences in the university.

Sample Size

The researchers made the sample relatively smaller so as to cut down on costs and save time as well. Deciding on a sample size for a qualitative enquiry can be more difficult than for a quantitative one because there are no rules to follow. It all depends on what will be useful, what will have credibility and what can be done within available time and resources. A sample refers to a representative sub-group of the population. For the purpose of this research the sample chosen comprises of randomly selected individuals from the selected population and the information is tabulated below.

Sample Frame	Sample Population	Male	Female	Percentage
Academic Staff	36	32	4	21%
Management Bodies	9	9	-	5%
Students from each schools and Divisions	130	64	66	74%
Total	**175**	**105**	**70**	**100%**

Table-3.1 Research sample size

A total of one hundred seventy five respondents which constitutes 21% Academic Staff, 5% Management Bodies and 74% Students from each schools and Divisions of the entire population were selected to represent the whole population.

3.5 Data Collection Techniques

Data collection techniques are the common activities conducted while research is made for data gathering from a specified environment using different types of mechanisms such as questionnaire, interview, observation, and so on. More than one data collection technique was used in order to eliminate the weaknesses inherent in each technique. Consequently, this study was carried out using questionnaires and interviews.

A deductive approach was used and this implied that the existing theory on the research subject determined the method. Data was collected from both primary and secondary sources, processed, analyzed and presented. After data has been collected, it needs to be presented in a way that communicates the information and enables conclusions to be drawn. The research relied on both primary and secondary data in order to come up with accurate and objective findings.

For this particular research, primary data and secondary data were collected using interviews and questionnaires. Interviews were done only to some of the Academic Staff and Management Bodies, but questionnaires were distributed for all respondents of Students, Academic Staff and Management Bodies.

Interviews

An interview is an interactive forum involving two or more people engaged in a conversation initiated and coordinated by the interviewer so as to get information specific to a certain area of aspect.

Face to face interviews were carried out in ASTU at the offices of the Management Bodies, Academic Staff, ICT Staff, Electronic-Learning Staff, and Information Technology Teaching-Learning Staff with key respondents being permanent workers in the university. All interviews were carried out prior to setting of appointments with the concerned respondents. The interviews had specified time limits of approximately 15 - 30 minutes. All interviews were carried out with the help of already prepared interview guide question papers and were recorded alongside the respective questions.

Sample Frame	Sample Population	Male	Female	Percentage
Academic Staff	9	6	3	60%
Management Bodies	6	5	1	40%
Total	**15**	**11**	**4**	**100%**

Table-3.2 Interviews conducted

Interviews were used to gather data in this research because they allow for probing on answers and questions that require further clarification. Unclear questions and answers can be clarified in the dialogue between the interviewer and the interviewee. When carrying out a research the

researchers must be in control and interviews allow the interviewer to be in control. The interviewer has control over he who is being interviewed in comparison to the questionnaires which maybe passed from one person to the other. Also this helped the researcher to obtain information that cannot be obtained by using questionnaires such as the technological jargon that required more clarification. Face to face interviews enabled the researcher to build strong relationships with the respondent because after or before the interview informal discussions could be held. This helped both parties to demystify any fears and there was openness hence accurate information was obtained.

Questionnaires

A questionnaire is a formalized list of questions that are used to solicit information from respondents. For this research the researcher made use of structured questions to gather necessary data. Structured or closed questions are meant to save the respondents' time and get definite answers.

The questionnaires were delivered in person. Questionnaires were distributed in after initial communication with the respondents to seek consent. The respondents were given one day to answer the questionnaires after which the questionnaires were collected for analysis. No public postal service, web site or email service was used to distribute questionnaires.

The questionnaire survey also provides greater uniformity across research situations as respondents respond to the same standardized questions. At the same time the questionnaire survey technique gives the respondents enough time to respond to the questions as they were given the whole day to answer the questionnaires. Finally the element of anonymity associated with the questionnaire survey technique enhances the chances of getting honest responses.

3.6 Design and Implementation Method

A research design is simply a plan or structure for an investigation or a list of specifications and procedure for conducting and controlling a research project. In other words it can be described as a master plan which indicates the strategies for conducting a research. A research design serves as a master plan of the methods and procedures that should be used to collect and analyze data needed by the decision maker.

The geographic coverage and scope of the study is limited by resources and time. Self-completion questionnaires were administered to the respondents via hand delivery. The quantitative approach of research was used based on the identified underlying theory and the fact that the research questions had been drawn. The unit of analysis in the study is made up of undergraduate students from different programs, year of study and cuts across various age ranges.

A cross sectional approach which involved a one-time collection of data was utilized. The survey was carried out within 3 weeks in each case. After which the collection of data, the responses were coded and analysis was carried out using the Microsoft Excel software.

The specific research design employed in this study is descriptive approach. Descriptive research design is concerned with describing characteristics of a problem. Questionnaires and interviews are the two methods used to elicit information in a descriptive research. It helps portray an accurate profile of persons, events and situations and allows for in-depth analysis of variables and elements of the population to be studied as well as collection of large amounts of data in a highly economical way.

It also enables generation of factual information about the study. This is so because the descriptive design relies much on secondary data which helps in developing the case basing on facts, sustained by statistics and descriptive interpretations from archival materials and data. In addition to the descriptive approach, a prescriptive design was also used in the process to "prescribe" a number of different possible actions to and guide them towards a solution.

Finally, for the actual design and implementation of the proposed architecture and its prototype, UML diagrams and development tools were used

3.7 Data Analysis

The data collected from the surveys by the researchers were entered into a MS Excel spreadsheet and was collated and finally analyzed using descriptive statistics.

These techniques were used by the researchers because the techniques do not construct a rigid methodology but rather permit the researchers to explore alternative explanations and get a feel

of the situation on the ground so as to understand the nature of the problem much better. Therefore, for the interview result thematic analysis was used and this analysis allowed us to provide discussions around the major themes.

Clear, accurate and appropriate ways of presenting data were chosen out of the several ways of data presentation. The several ways of presenting data include tables, pie charts, bar graphs and line graphs. Only tables, pie charts and bar graphs were used in this research.

The researcher used tables to present data because measurement units are shown clearly. Tables are also easy to refer and the data can be easily interpreted. Tables are used to present large quantities of data arranged in labeled rows and columns.

Pie charts are easy to understand and quick to interpret. Pie charts are useful when presenting data which is to be compared.

The researchers used bar charts to present data because they help facilitate comparisons by virtue of their clear visual impact. They are also easy to use when presenting quantitative data. Bar graphs are one type of graphs that uses bands of standard width and varying length to present magnitude. They are used to present data covering time.

The use of frequency tables and diagrams such as pie charts and bar graphs were employed to present some of the findings of the work.

Tools such as measures of central tendency (for example, the mean value) and measures of dispersion (for example, standard deviation) were also useful in interpreting some of the results since it allowed for comparisons to be made. An instance in this research is in the evaluation of the skill of the students.

The Pearson's chi–square value for the cross tabulation was one of the methods used in measuring the strength of association between the variable employed in the design. For example, cross tabulations were carried out between the mobile device types and their mode of internet access as well as requiring the various multimedia file forms which can be supported while they are using the mobile learning system in the future.

Finally, this technique was used to check the interrelationship between different variables such as Gender, Frequency of Internet use, and others.

3.8 Evaluation

This portion presents how the employed research methodology is evaluated to substantiate the feasibility of the proposed architectural design and mobile learning system development. The evaluation process was conducted by introducing the underlying techniques which include: expert-review, use of questionnaires, literary analysis and participant observation.

The objective was to involve those participants who have commendable experience and knowledge about the concept, theory and application of the mobile learning system requirements and its functionalities for the case of ASTU. A total of 175 questionnaires were distributed, almost 15 people were interviewed, and about 14 related literatures were reviewed. The criterion was based on their role and involvement with the key studied systems.

Finally, this research methodology has been evaluated widely depending on the participants' reflective awareness of their own needs, interests, abilities, interpretation and interactions through developing multiple type of evaluation process to meet the desired goal.

3.9 Summary

This chapter concludes the research methodologies used and their purpose to maximize valid answers to the research questions. Justifications on why the researchers chose to use those methodologies were also given. This was achieved by conducting literature reviews, interviews, questionnaires and observation which were the main methods of data collection used to gather relevant data to achieve the research objectives. In data presentation, both qualitative and quantitative methods were used. Data was totally analyzed using both the descriptive and prescriptive approach. Chapter 4 discusses the details of the findings and results.

CHAPTER FOUR

RESEARCH FINDINGS AND RESULTS

4.1 Overview of Research Findings

The findings of this research will contribute a lot for the acceptance of the proposing mobile learning system with respect to considering the technological impact of the system for higher educational institute like: ASTU. It will also build a positive attitude among students and academic staffs for accepting the technology and also create initiatives to conduct other possible studies regarding understanding, elucidating, and predicting factors influencing individuals to exercise mobile learning system in higher institutions. The study will provide valued data regarding on the intention of the respondents' to use mobile devices and tablets as supplementary channel to support the regular teaching-learning processes through technology.

The detailed analysis of the methodology used has been started after completing both the data survey and literature review. The management bodies of ASTU, lecturers and students of all years of study have contributed a lot to start up writing about the details of this research findings so as to approve the proposed mobile learning system for the case of ASTU.

It is believe that functional specification of the proposed system is the most expected deliverable of every research Analysis phase. The major contents of this functional specification are detailed description of the system's requirements, the functional modeling which are going to be designed using the Unified Modeling Language for describing the structural as well as the behavioral diagrams of the system objects.

With the purpose of achieving detailed requirements of a particular system like the mobile learning system, conducting a survey in terms of using questionnaires, interviews, observation or other data collection methods can be used to acquire the actual data of the study area. The students are selected from 1st year to 5th year graduating students. The requirements are finalized after analyzing the data of questionnaires using the Microsoft Office Excel software and using intensive prototyping model of the system. A domain analysis is performed to find a suitable architecture for the system to be developed. An architectural design model of the system

is developed that enables a software engineer to evaluates efficiency of design, judge options of design and minimize potential threats coupled with the system development process.

4.2 Instrumentation

To determine the level of knowledge and perception of the respondents on mobile learning system, a Likert type questionnaire was introduced based on considering the architectural design and development of the prototype will be employed. The questionnaire is composed of the following six areas: (a) Need of System development, (b) Access online resources, (c) Internet Service Satisfaction, (d) Improvement of learning, (e) Flexibility of learning, and (f) Social Constructivism.

In addition to this questionnaire, the researchers have conducted an interview which serves as basis in developing the system with selected respondents to explore diverse views, further ideas, principles, theories and concepts related to the study.

The respondents participated in this research questionnaire are selected from both genders during the distributions of data. Therefore, the researchers have taken an aggregate result of females and males to display tables and pie charts regardless of the gender differences.

The data collection technique for the Likert type questions of the questionnaire has been formulated both for Students and Academic staff survey analysis as follows: Frequency counts and means are the primary statistical treatment to be used to analyze and interpret the survey results. The mean scores obtained along the different areas will be analyzed using the following scale of equivalents: 1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, and 5=Strongly Agree. The Means and the standard deviations were calculated for six items specifically related to participation and engagement. Means above 3 indicate a positive response while means below 3 indicate a negative response to the question.

4.3 Findings and Discussions

4.3.1 Students Survey Analysis and Results

4.3.1.1 Demographic-based Questions

The first section of this survey contained three demographic associated questions: age, gender, schools and division. However, the demographic section is significant in association with some other variables in the study; the researchers have taken it basically to consider the proportion of the three variables for fairness distribution of the survey questionnaire.

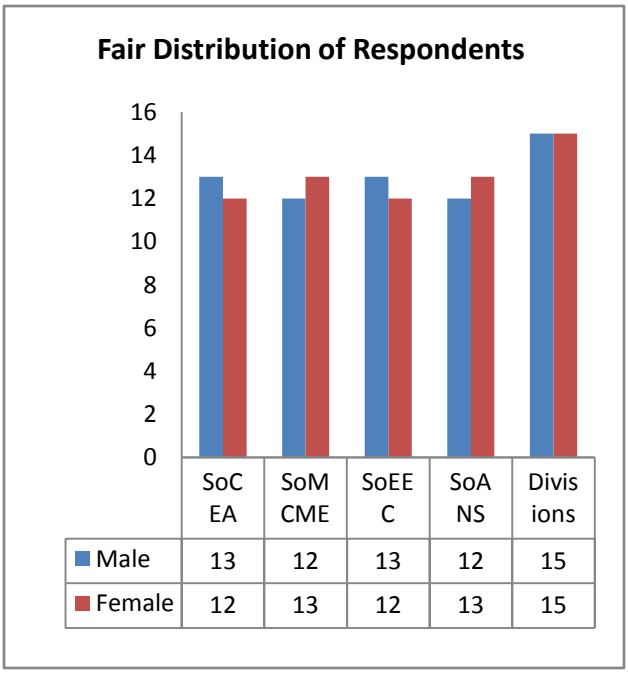

Figure-4.1 Distribution of respondents

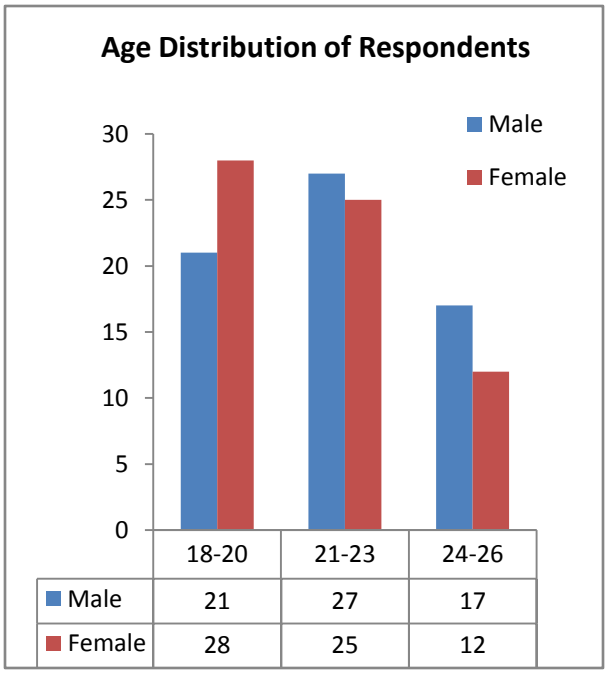

Figure-4.2 Age distribution of respondents

Therefore, the following 2D-bar-charts are generated to display a reasonable distribution of the survey so as to encourage female respondents as per their Schools and Divisions and display the Age ranges of the respondents while the study was conducted.

4.3.1.2 Questions with Likert-based Responses

As can be seen from the questionnaire in the Appendix-III, the evaluation form contains 4 sections: functions, content, appearance, and overall usability of the system. Overall in these sections, there are 5 meanings have been given by the students' opinions on the MLS: Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. From the results above, we found that

the majority of the students agree on the development of the Mobile Learning System to support their teaching and training in ASTU. The summary scores of each section are given in Table-4.1

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
ASTU students need Mobile Learning Systems for their studies	0	10	5	49	66
Accessing educational learning materials online via mobile device is very significant students	0	2	0	51	77
ASTU broadband services satisfy your internet access need	5	11	9	90	15
Usability of mobile devices for teaching-learning improves your learning capacity	2	14	22	61	31
Mobile Learning could be instrumental in increasing learning flexibility	0	0	2	63	65
Mobile learning supports social constructivism amongst learners	1	7	20	42	60

Table-4.1 Summary of students' opinion

Question	Mean	SD
ASTU students need Mobile Learning Systems for their studies	4.315405	0.87191
Accessing educational learning materials online via mobile device is very significant students	4.561540	0.584076
ASTU broadband services satisfy your internet access need	3.761540	0.904801
Usability of mobile devices for teaching-learning improves your learning capacity	3.807692	0.973256
Mobile Learning could be instrumental in increasing learning flexibility	4.484615	0.531702
Mobile learning supports social constructivism amongst learners	4.176923	0.935645

Table-4.2 Mean of students' opinion

From the analysis of results, we understood that the majority of the respondents were Agree in all the six Likert questions presented and put their opinions which are calculated as Mean and Standard Deviation values as follows for comparison: for question number one, which is about the need assessment requested students to develop a Mobile Learning Systems for ASTU (M=4.31, SD=0.871), The second question was about the significance of accessing educational learning materials online via mobile device (M=4.56, SD=0.584), the third question was about the satisfaction of students on ASTU Internet services (M=3.76, SD=0.904), the forth question basically requests about how this usability of mobile devices can improve the learning capacity of students (M=3.80, SD=0.973),the fifth question was about the level of students understanding about how mobile learning could be influential in increasing learning flexibility (M=4.48, SD=0.531), the last question was about how students perceive social constructivism since they have been accessing internet in their daily life (M=4.17, SD=0.935).

4.3.1.3 Topic-based Questions

This section refers the questionnaire in the Appendix-III: Students' Questionnaire, Part-III. The questionnaire mainly focused on three major topic-based questions to determine the types of mobile devices students use to access internet services in ASTU, frequency of internet services usage using their mobile devices and the type of file formats they need to be incorporated with the proposed MLS. Therefore the actual results are presented accordingly as follows.

4.3.1.3.1 Mobile Device Distribution among Students

Based on the findings regarding devices used by ASTU students with respect to access internet services, a profile of the most appropriate mobile device used by the students in this sample has been derived. The most popular mobile device according to the finding is smart phone which takes about 39% of the total population, the second competing device is personal laptop which incorporate about 33% of the sample students, the third rank is tablet which takes about 19% and the remaining iPad and ordinary phone take 5% and 4% respectively.

Therefore, this mobile device profile result is very important when designing and developing mobile learning system architecture for higher education to ensure the effective usage of such a system by students. Moreover, the researchers could get input a supplementary input data to easily figure out and identify the appropriate mobile device browsers to be integrated according

to respondents' device types and nature for the architecture design and development process to avoid platform inconveniences.

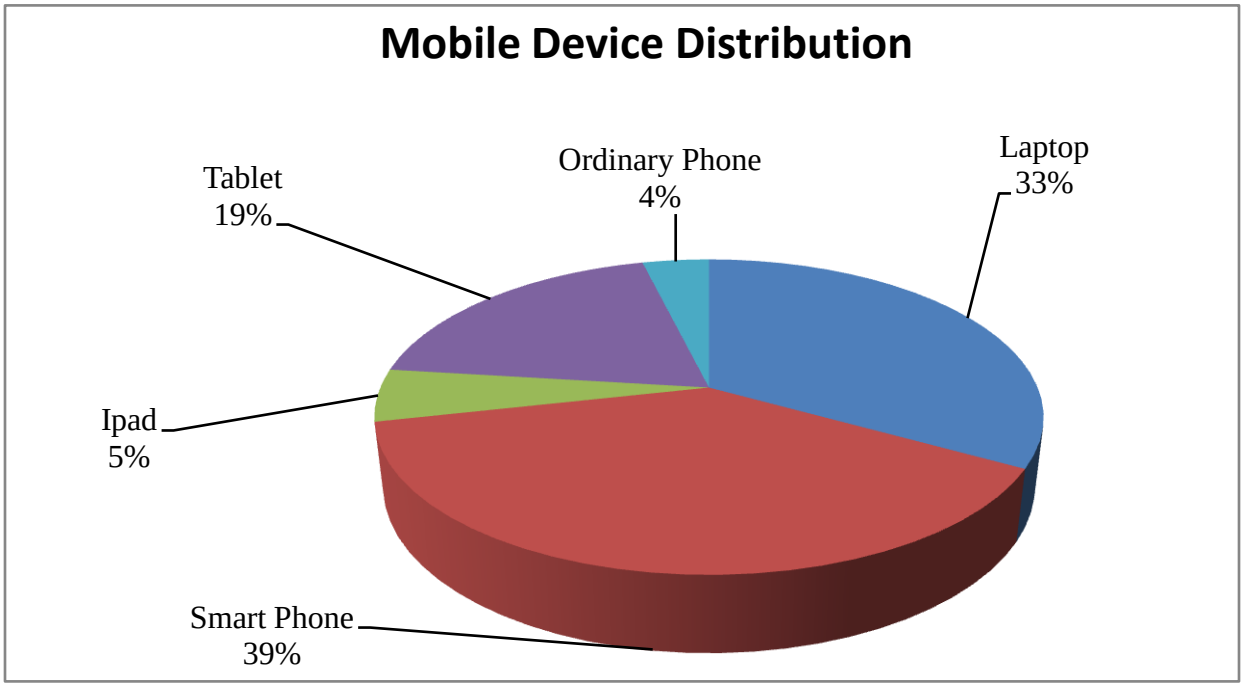

Figure-4.3 Mobile device distribution

4.3.1.3.2 Frequency of Internet Services Usage

It is obvious that, one of the significant facilities the higher universities provide for their students is free accessing of internet services in the campus wide wireless and wired network. This second set of survey items relates to the frequency usage of the internet services by ASTU students in the campus. Regarding their internet service usage the following data has been analyzed by four variable items to be chosen like: 1-2 Hrs/Day, 2-3 Hrs/Day, 3-4 Hrs/Day and Other which is considered to be neither of these variables rather answered by the respondents.

Therefore, 46% of the students answered they use the Internet for 1-2 Hrs/Day, 20% of students use for about 2-3 Hrs/Day, 32% of the respondents use internet services for 3-4 Hrs/Day. The remaining 2% of all the respondents do not have Internet services enabled on their mobile devices.

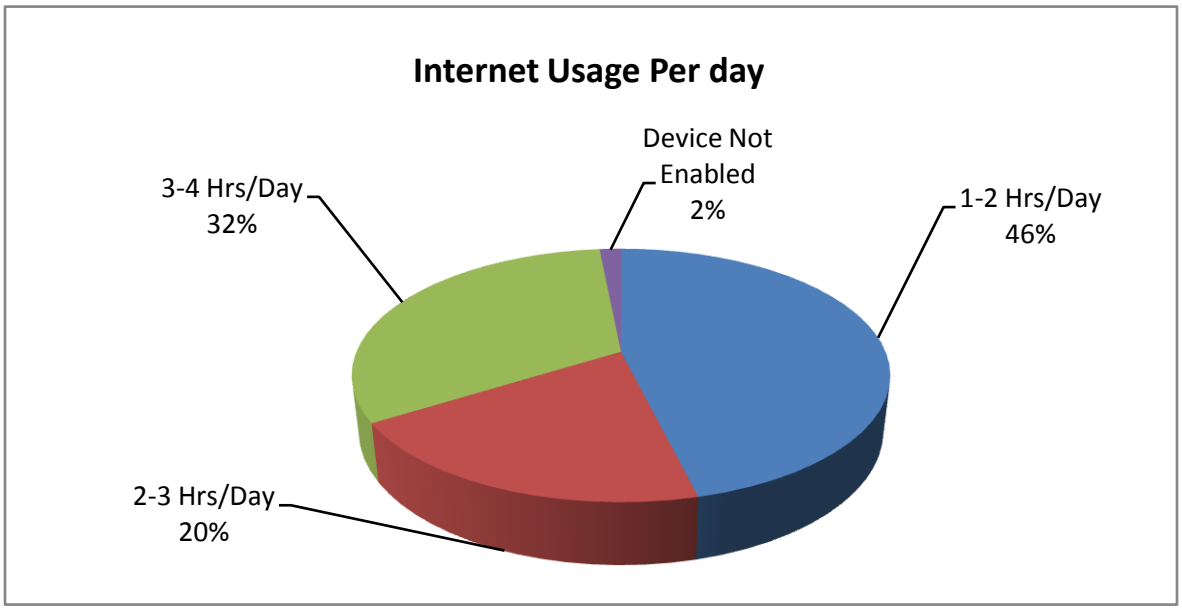

Figure-4.4 Frequency of internet access

4.3.1.3.3 File Format Selection

In this topic of findings, students were asked to choose what type of content should be provided for the proposed mobile learning system regarding the type of file format which is most appropriate for their studies.

Regarding the file format for their devices, the distribution is presented in figure below. As it can be observed, about 54% of students preferred office type documents (word processing, spreadsheets, presentations etc.) followed by PDF documents (45%), about (25%) preferred Audio files, tutorial Video clips (20%), Pictures/Images (7%) and the remaining (3%) of the students selected Zip files formats.

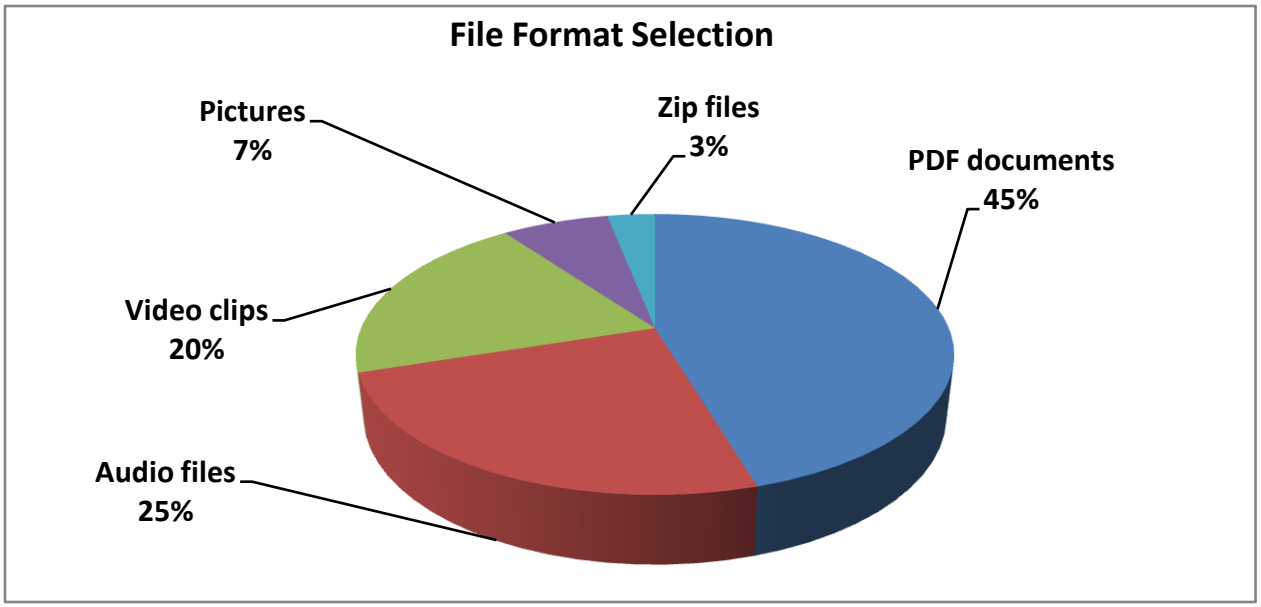

Figure-4.5 File Format Selection

4.4 Academic Staffs' Survey Analysis and Results

In this section of the survey, the researchers have been interested only on the Likert-based questions since the demographic and Topic-based questions part is not as such significant for this particular analysis.

Therefore, for creating a mutual understanding between the ASTU students and Academic staffs, the researchers decided to take similar questions to be selected, presented and analyzed using Likert-based questions considering that this diverse view of the academic staff members on top of the students would be considerable to refine the consistency of the analysis in both sides.

4.4.1 Questions with Likert-based Responses

As can be seen from the questionnaire in the Appendix-II, the evaluation form contains four sections: functions, content, appearance, and overall usability of the system. Overall in these sections, there are five meanings have been given by the students' opinions on the MLS: Strongly Agree, Agree, Neutral, Disagree and Strongly Disagree. From the results above, we found that the majority of the academic staffs agree on the development of the Mobile Learning System to support their teaching and training in ASTU.

Question	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
ASTU academic staff need Mobile Learning Systems for their students	2	1	8	17	8
Accessing educational learning materials online via mobile device is very significant for your students	0	1	5	24	6
ASTU broadband services satisfy your internet access need	7	1	5	5	18
Usability of mobile devices for teaching-learning improves your students' learning capacity	7	0	9	5	15
Mobile Learning could be instrumental in increasing the learning flexibility for students	3	1	7	21	4
Mobile learning supports social constructivism amongst learners	2	2	7	17	8

Table-4.3 Summary of academic staffs' opinion

Question	Mean	SD
ASTU academic staff need Mobile Learning Systems for their students	3.777778	1.01731
Accessing educational learning materials online via mobile device is very significant for your students	3.972222	0.654047
ASTU broadband services satisfy your internet access need	2.583333	1.204159
Usability of mobile devices for teaching-learning improves your students' learning capacity	3.722222	1.031258
Mobile Learning could be instrumental in increasing the learning flexibility for students	3.944444	0.983999
Mobile learning supports social constructivism amongst learners	3.75	1.052209

Table-4.4 Mean of academic staffs' opinion

From the analysis of results, we understood that the majority of the respondents were Agree in all the six Likert questions presented and put their opinions which are calculated as Mean and Standard Deviation values as follows for comparison: for question number one, which is about the need assessment requested academic staff to develop a Mobile Learning Systems for ASTU (M=3.77, SD=1.017), The second question was about the significance of accessing educational learning materials online via mobile device (M=3.97, SD=0.654), the third question was about the satisfaction of academic staff on ASTU Internet services (M=2.58, SD=1.204), the forth question basically requests about how this usability of mobile devices can improve the learning capacity of students (M=3.72, SD=1.031),the fifth question was about questioning academic staff members about how mobile learning could be influential in increasing the learning flexibility of their students (M=3.94, SD=0.983), the last question was about how academic staff perceive the concept of social constructivism since students are commonly adopted such practices during group study time, assignment work, project work, presentation and so on (M=3.75, SD=1.052).

4.5 Management Bodies Survey Analysis and Results

In this part of the survey study, all the mentioned topics of discussions are inclined to gather basic information and further organizational issues rather than directly concerning the software architectural issues. Therefore, the researchers conducted the data survey and used it for the documentation as supplementary information and appended the topics as follows: Number of students often attends the normal lecture in a single class room is about, 44.44%, 30-45 and 55.56%, 45-65.Number of undergraduate students attending this academic year, 100% 7000-8000, Number of academic staff members, 100%, 300-450. Incentive issues for academic staff if the system is going to be developed and implemented, 88.89%, say “Yes” and the remaining 11.11% say “No”. Issues concerning copy rights for online learning materials, 88.89%, say “Yes” and the remaining 11.11% say “No”. Existence of Mobile learning related policy or frame work in ASTU, 100% of the respondents say “No” binding policy has been prepared yet concerning legal matter as per the university legislation and the last question was about the willingness of the management bodies to support the development and deployment of the mobile learning system for ASTU and they all convinced about the idea and say, “Of course, ASTU will grant and support such valuable creativity so as to adapt and transfer best learning technologies to solve academic problems.”

4.6 Interview Analyses and Results

As can be seen from the interview questions in the Appendix-I, the interview questions were presented for discussion as follows: The first question which needs to explain about the need for the development of Mobile Learning System where answered by the respondents during the interview, they emphasized the need for the development and implementation of the mobile system is mandatory to align the university with this educational technology oriented learning system, it is also a good opportunity to integrate the ASTU e-studio and smart lab content development activities to share abundant resource of online courseware through the mobile learning system. Moreover, since the university has been established as a Science and Technology University in Ethiopia the need for developing and implementing the mobile learning system would be unquestionable to be an exemplifier and pioneer to start-up the application of the system for other public universities in Ethiopia.

The second question was about the kind of learning materials (contents) which should be included for the proposed Mobile Learning System and the response of the respondents have been presented as follows: Word files, Power Point Files and PDF file Contents, Audio files, Video Clips and Web pages are the most commonly addressed and favorable file formats discussed to be incorporated. Moreover, from the project context of ASTU's academic staff activities, especially some SMEs has been selected and completed a video lecture recording session to deliver an online course materials. Therefore, this creates a good opportunity for the system to integrate such precious video as well as audio lecture recordings to be incorporated into the mobile learning system database.

The third question was emphasized about the benefit of Mobile Learning System both for Academic Staff and Students in common. And the respondents answered this question as follows: It reduces burden and creates flexibility, creates a provision to utilize mobile technology for educational purposes, creates a user-friendly environment to share resources and supports the concept of social constructivism to be flourished.

The fourth question was all about the major challenges for applying Mobile Learning System in ASTU case. Same wise, the respondents briefly explain the following main points: Lack of continuous follow up, interface design, mobile battery capacity, continuous improvement of the

system, reliability of the system, electric power fluctuation, band width of ASTU internet capacity and users' mobile processing capacity are some of the major challenges should be alleviated. Moreover, discussions regarding mobile browsers were also introduced. And as a result of this, almost all of the interviewees suggested the newly proposed architectural design should support the most commonly used mobile and tablet browsers like: Chrome, Firefox and Opera Mini and should show the compatibility of these browsers during the development of the entire mobile learning system prototype.

The fifth question was about what should be done in the future for sustaining the Mobile Learning System if it is once developed and implemented for service. And according to the responses the following issues should be addressed which include: Promotion, Awareness among academic staff, students and management bodies about mobile learning system, Support of ICT infrastructure, Usage of latest framework and architecture to address ASTU need, Mobile learning policy, Intensive training and continuous maintenance should be applied to sustain the newly expected mobile learning system for ASTU.

4.7 Summary

The comprehensive study of this findings showed that every aspect about the mobile learning was still necessary because mobile learning is in the early stage in Ethiopia. We could use the results from this preliminary study for supporting the development such mobile learning system for ASTU students in the future. It is observed that these students engaged in the study actually approve the mobile learning as a supplement to their classroom learning. If the proposed system is implemented, it will make classroom learning more interactive, relief lecturer fatigue, improve student engagement and their literacy skills.

Its known that the objective of this research is to develop an architecture which incorporate the acceptance of mobile learning system by focusing on students', academic staffs' and management bodies' perceptions and also examine the factors that had a positive relationship with behavioral intention to use mobile learning based on the proposed architecture. Despite the fact that students in this study were not familiar with mobile learning before, they had a good perception with mobile learning and the results showed that the effort expectancy and facilitating

conditions had high level of acceptance and promising to start-up the development of the system even this is also reflected from the Academic staff too.

The final part of the findings shows that students are open to the new technology. Even if the concept of mobile learning is not widely known in Ethiopia and particularly even in ASTU, students already hold impressions and expectations regarding the use of mobile devices in education.

Furthermore, students indicated clear preferences regarding content types and are aware of advantages and disadvantages related to this advancement of educational technology as well as they showed readiness and willingness to use their mobile devices for learning purposes, yet, the impeding role of technology, designers of mobile devices and mobile learning applications should make these devices and applications as intuitive and simple as possible so that students can focus on the learning process instead of figuring out how to use their devices and applications.

Finally, this research findings and results section was acknowledged as an interactive mobile learning system with a 3-tier architecture that is suitable for use as supplement with ASTU traditional classroom learning system. Students are willing and motivated to use mobile devices in their educational process to improve their general knowledge and technical skills.

The next chapter describes the implementation and evaluation of the proposed architectural design and development of the mobile learning system prototype based up on the actual output generated from the findings and results of this section.

Chapter FIVE

System Implementation and Evaluation

5.1 System Implementation

In this paper the authors proposed architecture of mobile learning in ASTU environment. The terminal connected with the infrastructure inside the university LAN and also connected with the external network environment. The university offer server platform for course management system for educational resources and it is connected on the university LAN. A student might access the platform directly from the university LAN or through the internet in order to collect the learning materials. The student can access the data center of the university from Wireless Local Area Network as well as from Local LAN network. In ASTU, there are plenty of distributed wireless mesh devices which deliver better Wi-Fi services to students to connect with the internet.

Most of the students depend on internet bandwidth and its usability. Wireless Local Area Network has of advantage and benefits for students to easily watch recorded audio and video lectures online. The most advantage of this architecture is, to offer a mobile learning system services both for ASTU teachers and students in the university premises. The authors suggest that the mobile learning system lets students freely browse and download their learning materials and enrich them with abundant multimedia learning resources.

The university MLS server platform provides facilities to host the digital educational resources, which can be accessed by the lecturers and all students locally throughout the campus intranet to access or download online courseware.

5.1.1 Basic Software and Hardware Requirements

5.1.1.1 Software Requirements

Regarding the software requirements as per the data survey from the respondents for developing the ASTU MLS system, all the documentation of this thesis paper is going to be directed and guided by the users' requirements to meet their interest from the system. Therefore, the following minimum software requirement have also been granted by the researchers to address

the need assessment of the survey to incorporate the type of file format and the type mobile devices which most students used in the campus as well as the type of internet services that system support considering the cost of 2G, 3G broadband access rather using ASTU's Wi-Fi for their Laptop, Smart phones, Tablets and Ipad as per the respondents demanded. Finally, the researchers decided to use these software which include: WAMP Server, since it has integrated (Apache Web Server, MySQL Database and PHP Scripting Language) as a package of service all-in-one, Microsoft Office Word, Microsoft Office Excel, Microsoft office Visio, Enterprise Architect, Notepad++, Windows 7 OS, Windows 10 OS, Linux OS, Android OS, Apple iOS, Connectify Hotspot to test Wi-Fi connectivity and Mobile and Tablet Emulators to test plat form compatibility.

5.1.1.2 Hardware Requirements

Here are list of the hardware devices which are used for the entire development of the system as well as finalizing the documentation part of the thesis: Hp Server, Hp Laptop, Dell Desktop computer, External Hard Disk, Samsung Galaxy Smart phone, Apple Tablet, and SanDisk Flash Memory.

5.1.2 System Development Methodology (SDM)

SDM is literally a standard process model followed in an organization to conduct all the steps necessary to plan, analyze, design, implement, test and maintain information systems. Here are list of various types of SDMs which are extensively used as methodologies of worldwide standard to manage the software development life cycle (SDLC): Traditional Waterfall, Prototyping, Computer-Aided Software Engineering (CASE) Tools, Joint Application Design (JAD), Agile Methodologies, Extreme Programming, Object-Oriented Analysis and Design (OOAD) and Rational Unified Process (RUP). Thus, the implementation of the proposed mobile learning system needs to have one of these listed system development methodologies.

A process model proposed for this research is prototyping model. The original purpose of a prototyping model is to allow users of the system to evaluate developers' proposals for the design of the eventual product by actually trying them out, rather than having to interpret and evaluate the design based on descriptions. Prototyping can also be used by end users to describe and

prove requirements that have not been considered, and that can be a key factor in the commercial relationship between developers and their clients.

The main process of prototyping model involves the following steps:

1. **Identify basic requirements**

   Determine basic requirements including the input and output information desired. Details, such as security, can typically be ignored.

2. **Develop Initial Prototype**

   The initial prototype is developed that includes only user interfaces.

3. **Review**

   The customers, including end-users, examine the prototype and provide feedback on additions or changes.

4. **Revise and Enhance the Prototype**

   Using the feedback both the specifications and the prototype can be improved. Negotiation about what is within the scope of the proposed product may be necessary. If changes are introduced then a repeat of steps #3 and #4 may be needed.

5. **Implement and Use Prototype**

   The final version of the prototype will be developed for implementation and use.

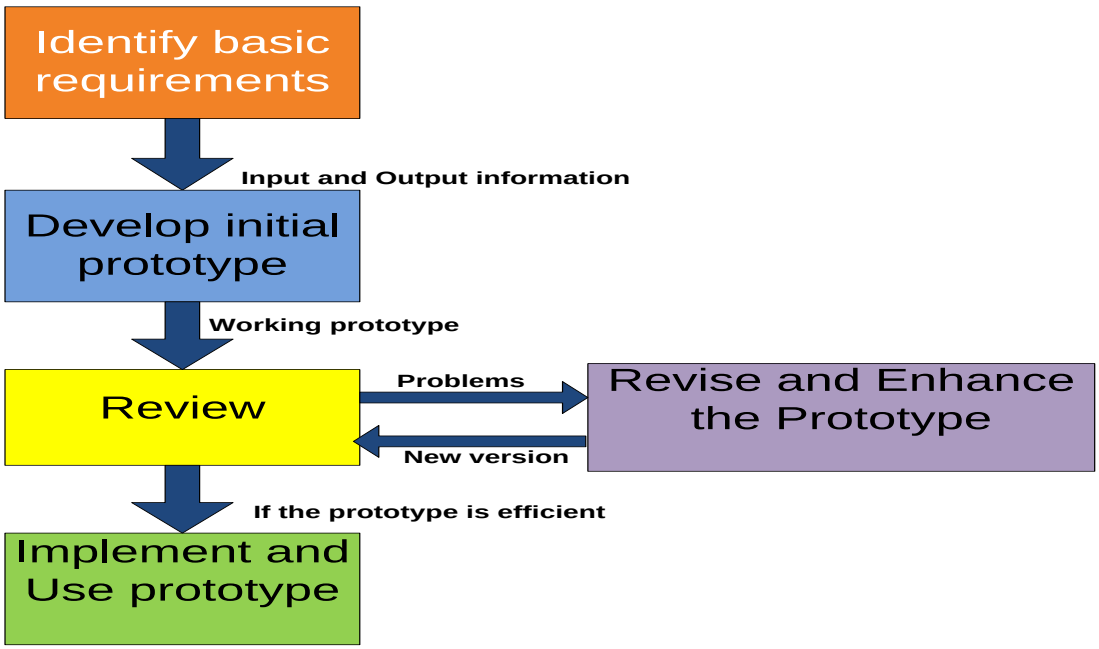

Figure-5.1 Prototyping model

Based on the architectural requirements identified in the previous section, we have instantiated a web-based architecture (WBA) for mobile learning system, enabling the development of a web-based educational environment together with the integration of mobile aspects. The proposed architecture has been defined in accordance with the architectural requirements previously discussed. The business logic layer illustrates specific modules of the educational domain. Furthermore, it incorporates elements related to WBA, fostering a better reuse and interoperability. The elements described in this view can be built using the most appropriate technologies and languages to their implementation. Each layer is using components to exchange information to pass from one layer to another.

Prototyping model is used to approve the interface and functions. Review of technical specification is also performed based on the feedback steps of ASTU students, management bodies and academic staff during data collection.

5.1.3 The proposed system architecture

Nowadays, designing a mobile learning architecture has become very complex and need architectural design and development considerations since it has been characterized by a permanent change in context connected or disconnected, low or high bandwidth, change of location, widescreen or small screen, varying input devices, and so on.

Architectural design and development of a Mobile learning system is very imperative particularly in higher education, and the major utilization of mobile devices is in the field of science and technology. In fact, ASTU students are highly engaged during their undergraduate studies. The technological advances can be capitalized to promote and facilitate situated learning. Actually, face the considerable growth of data, the heterogeneity of roles and needs, the rapid development of mobile systems and architectural design and development become significant to provide the users efficient online mobile learning facilities.

Therefore, the architecture of the proposed mobile learning system has been developed according to the design and development of 3-tier architecture. The system is comprises with the functionalities of the three basic layers such as presentation layer, business logic layer and data layer. In 3-tier architecture, the database server does not share a server machine with the web application server. The client is on the first tier, as it is in two-tier architecture. On the third tier,

the database server serves the data. For performance reasons, the database server typically uses stored procedures to handle some of the business logic layer. The application server resides on the second tier. The application server handles the portion of the business logic layer that does not require the functionality that the database server provides. In this approach, hardware and software components of the second and third tiers share responsibility for the availability, scalability, and performance characteristics of the web environment.

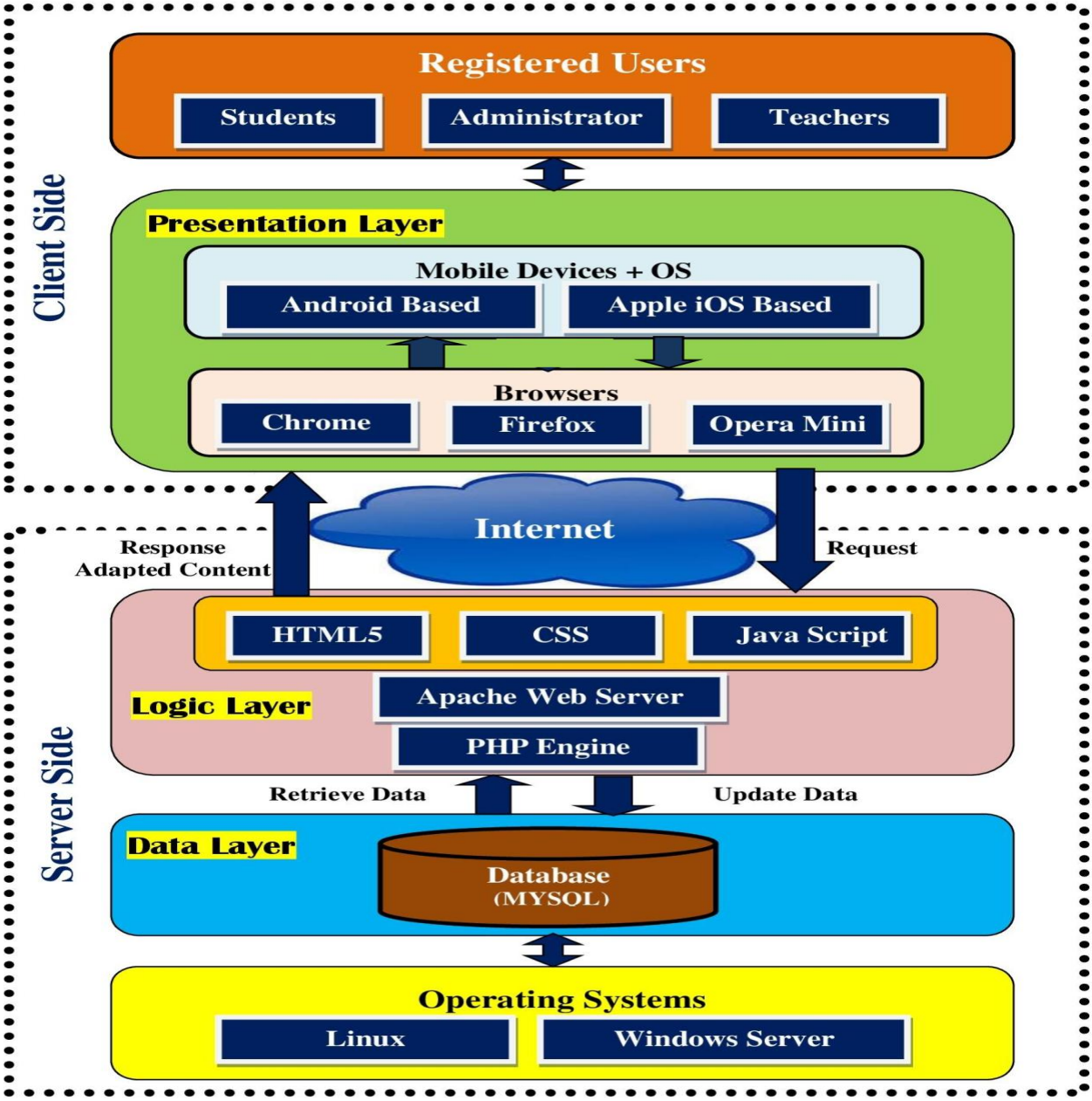

Figure-5.2 Proposed Architecture

A. Data Layer

The Data layer contains the data base management system (DBMS) for the realization of the dynamic learning environment (DLE) using MySQL database that runs on a server side. This is the layer where all data necessary for implementation of services provided by the DLE as well as those necessary for its functioning. The ASTU mobile learning system needs the MySQL database both for permanent storage and retrieval of information when ever needed by the system users.

B. Business Logic Layer

Every application includes some data processing and this may also involve database interactivity especially the business logic layer plays the main role in mobile learning system. For example user authentication requires the logic unit to read username-password combinations from a database and compare until a good comparison (hopefully) is arrived at. It consists of a web server and a server side scripting language on which the logic of the entire system are being deployed and computed for each system modules and realizing the functionality. For the implementation of the proposed system, Apache HTTP Server is used. The business logic layer is programmed in PHP and the communication of the mobile devices and the mobile learning system is implemented based on the HTTP User-Agent Header which is part of the web browser's request.

All services of the business logic layer are condensed and have a duty to concern the application request of the presentation layer and create the logical appraisal on the result. If the logical approximation is authorized then the data is called by the system from the database, and make the contract with the data, finally the results have to be return to the presentation layer. As mobile learning system should be able to work on mobile devices with limited screen size, this business logic layer has two special modules: module for the device recognition and module for content adaptation.

C. Presentation Layer

The presentation layer is implemented using web browsers on the mobile devices. It is used to add interactivity between the users and the system and also to visualize the content. Its main duty

is deal with the dialog between the users and the system. If the users request data from the mobile learning system, the presentation layer takes the responsibility of accessing the server via the web browsers installed on each mobile device and as a result the server responses each requests accordingly. These manifest themselves in the form of information display and user data input facilities. Generally the front-end for user interaction, like logging in requires interaction in the form of collecting username and password information using a HTML-form.

At this stage, the initial use case of the system engineering part is designed as per the requirements of ASTU community to be referred during the preparation of the system technical requirement specification and elicitation. The next session presents the details of the Unified Modeling Language (UML) diagrammatic representation of the proposed system architecture as follows.

5.1.4 System Model Design

As it is known, after the findings and results the requirements specification will be discussed under this section of this thesis. In this stage of system development, the requirements needed are defined and analyzed. A requirement is a statement about a feature that should be included in the system being developed. For this paper, the preliminary and the interface requirements are first presented, followed by both the functional and non-functional requirements of the application.

Functional Requirements:

Functional Requirements are statements of features and services that the system should offer. For this thesis, only 10 functional requirements of the prototype are presented as minimum functional requirements to be addressed.

1. Create Account
2. Login
3. View list of courses/learning materials
4. View learning materials
5. Enroll/Register in a course
6. Access courses' content
7. Access Feedback
8. Remove Users

9. Delete a course
10. Log out

Non-functional Requirements:

Non-functional requirements are statements of characteristics that the proposed system as a whole should provide to ensure its effectiveness. Non-functional requirements can be categorized as Product Requirements, Organizational Requirements and External Requirements. For this part we will discuss only about the expected deliverable product / system prototype requirement and the organizational requirement as follows.

Product requirements:

Product requirements are the features that make any software efficient; they specify in what way the delivered product must behave. Product requirements enable turning the abstract idea of a product into reality by specifying what engineers should build. Product Requirements include Usability, Performance, Security and Space.

Usability:

1. The mobile learning system should be user friendly.
2. The system should be well organized and easy to use by ASTU student.

Performance:

Performance is a very important requirement for a mobile learning system because the response time should be taken into consideration. For instance, accessing data such as images and videos should not take time.

External Requirements are those requirements which arise from factors which are external to the system and its development process, such as safety, privacy and ethical requirements.

Security:

The implementation of the system should protect the personal information of students such as their credentials, profile and personal data. In addition, the system implementation should not allow direct access to the database; instead it should require passing through the PHP files in the server.

Regarding volume of data, the database size of the system should be taken into consideration since the learning materials are directly downloadable to users' smart phones, iPad, and tables. Therefore, the system successfully controls and manages the total number of course materials, file sizes and file formats to be uploaded on the system.

Environmental Requirements:

Environmental Requirements are a consequence of organizational policies and procedures such as process standards used.

This system shall be used as ASTU tool to help and assist those students, which means it will only be used by the people involved in the university. To do that, the students are required to login the system via their username and password.

5.1.4.1 Use Case diagrams of the system

Use case diagrams are part of the behavior diagrams, which are in their turn part of the Unified Modeling Language models. They actually show the interaction between a system and its environment. They are composed of:

- Actors: who are in our case students, teachers and the system administrator
- Use cases: which represent an action that involves external interaction with a system
- System boundary: which limit the scope of the system, use cases are inside the boundary and actors are outside of it.
- Relationships: which show an interaction between actors and use cases, actors and actors, or use cases and use cases.

The following diagram captures the behavioral requirements of the system using use case elements, and their interaction with participant actors: Student, Teacher and Administrator. And next to the Use Case diagram of the registered users, only the characteristics of the student's Use Case will be presented.

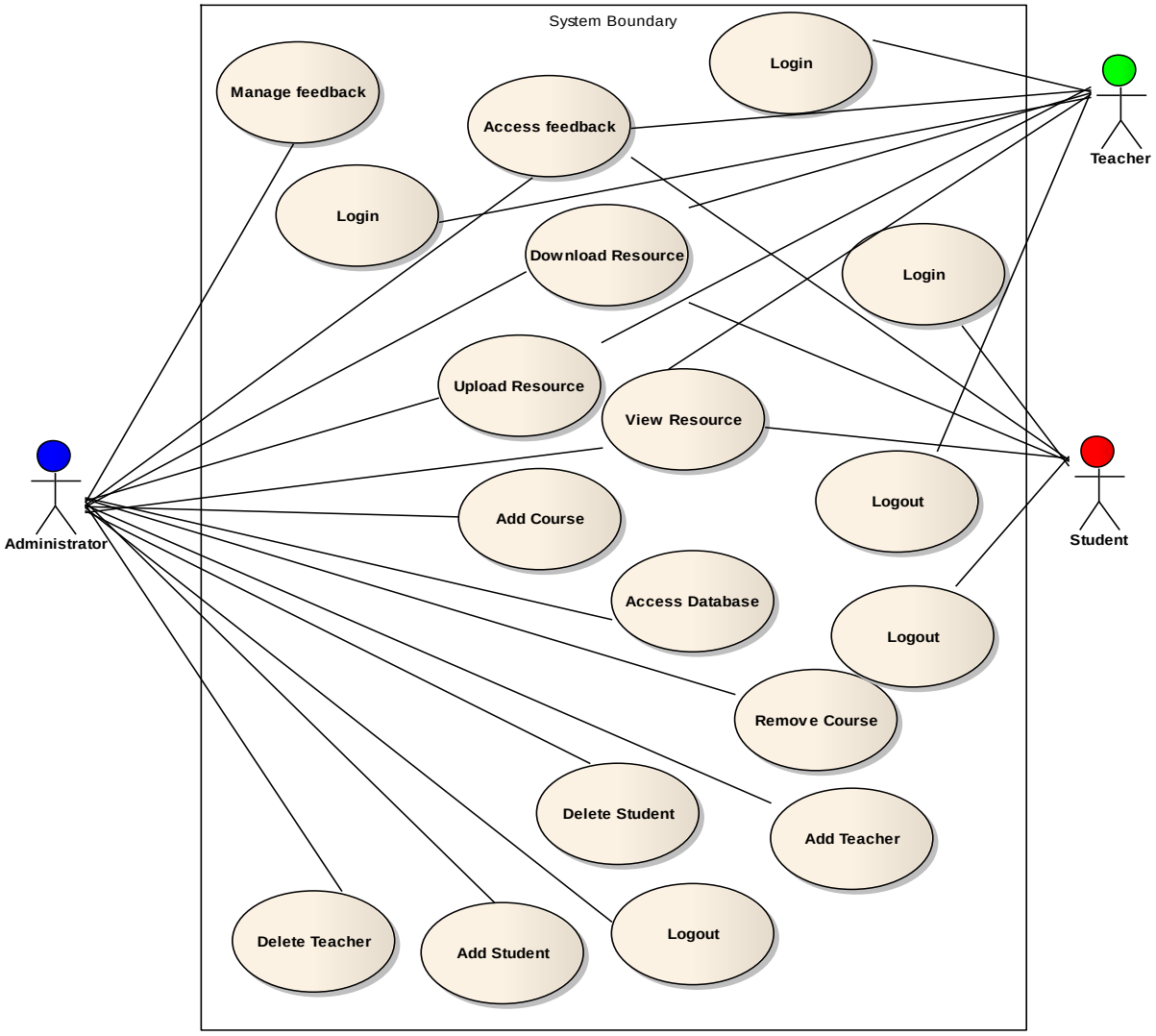

Figure-5.3 Use Case diagram for user type “Student”, “Teacher”, and “Administrator”

The characteristics of students Use Cases are presented in the following tables.

Use Case Name:	Login
Use Case ID:	01
Use Case Description:	In order to access their learning materials in the mobile learning system, students shall login the system using their credentials (Username and Password).
Actors Involved:	ASTU Students who have already registered in the system.
Pre-Conditions:	ASTU Students who have already registered on the MLS.

Main Flow:	Students should enter their credentials and click on Login.
Post-Conditions:	Students can open or download the available learning materials only from the school where they have been registered.

Table-5.1 Use Case 01

Use Case Name:	View Resource
Use Case ID:	02
Use Case Description:	Students shall be able to view the list of learning materials offered by the Schools.
Actors Involved:	ASTU Students who have already registered in the system.
Pre-Conditions:	ASTU Students who have already registered on the MLS.
Main Flow:	Students shall be able to view the list of learning materials offered by the School, which will be organized depending on the field of study. Moreover, students can choose a specific course using the course title. If a course does not exist, the system shall display an error message.
Post-Conditions:	Students cannot enroll themselves in any one of the schools.

Table-5.2 Use Case 02

Use Case Name:	Download Resource
Use Case ID:	03
Use Case Description:	In order to download their learning materials from the mobile learning system, students shall login using the Student Login Form found on the main page of the system using their credentials.
Actors Involved:	ASTU Students who have already registered on the MLS.
Main Flow:	Students should select their learning material and click on "Open/Download file" link.
Post-Conditions:	Students can download their learning materials from the school html page some other time.

Table-5.3 Use Case 03

Use Case Name:	Access Feedback
Use Case ID:	04

Use Case Description:	In order to send a feedback in the mobile learning system, students need not to login into the system rather they can directly send their feedback from the main page by clicking the contact link.
Actors Involved:	Any ASTU Students can send a feedback.
Main Flow:	Students shall click on Contact link from main page and need to write name, telephone, email and their message. Finally, they need to click on Submit button.
Post-Conditions:	Students can use a reset button whenever they need to rewrite their data correctly.

Table-5.4 Use Case 04

Use Case Name:	Logout
Use Case ID:	05
Use Case Description:	The students shall logout from the view html page where they can download the learning materials.
Actors Involved:	ASTU Students who have already registered on the MLS.
Main Flow:	Students should enter their credentials and click on Login, click on the welcome page, click on their school and finally after they open or download any of their materials, they can click on the logout link at the above of the view html page.
Post-Conditions:	Students can login again anytime.

Table-5.5 Use Case 05

5.1.4.2 Class diagram of the system

Class diagrams are part of the static diagrams, which are in their turn part of the Unified Modeling Language models. They actually show the system's main classes, their attributes and methods, as well as the associations between them. They are composed of a name, a set of attributes and an optional set of operations.

The class diagram of this mobile learning system is presented in figure below:

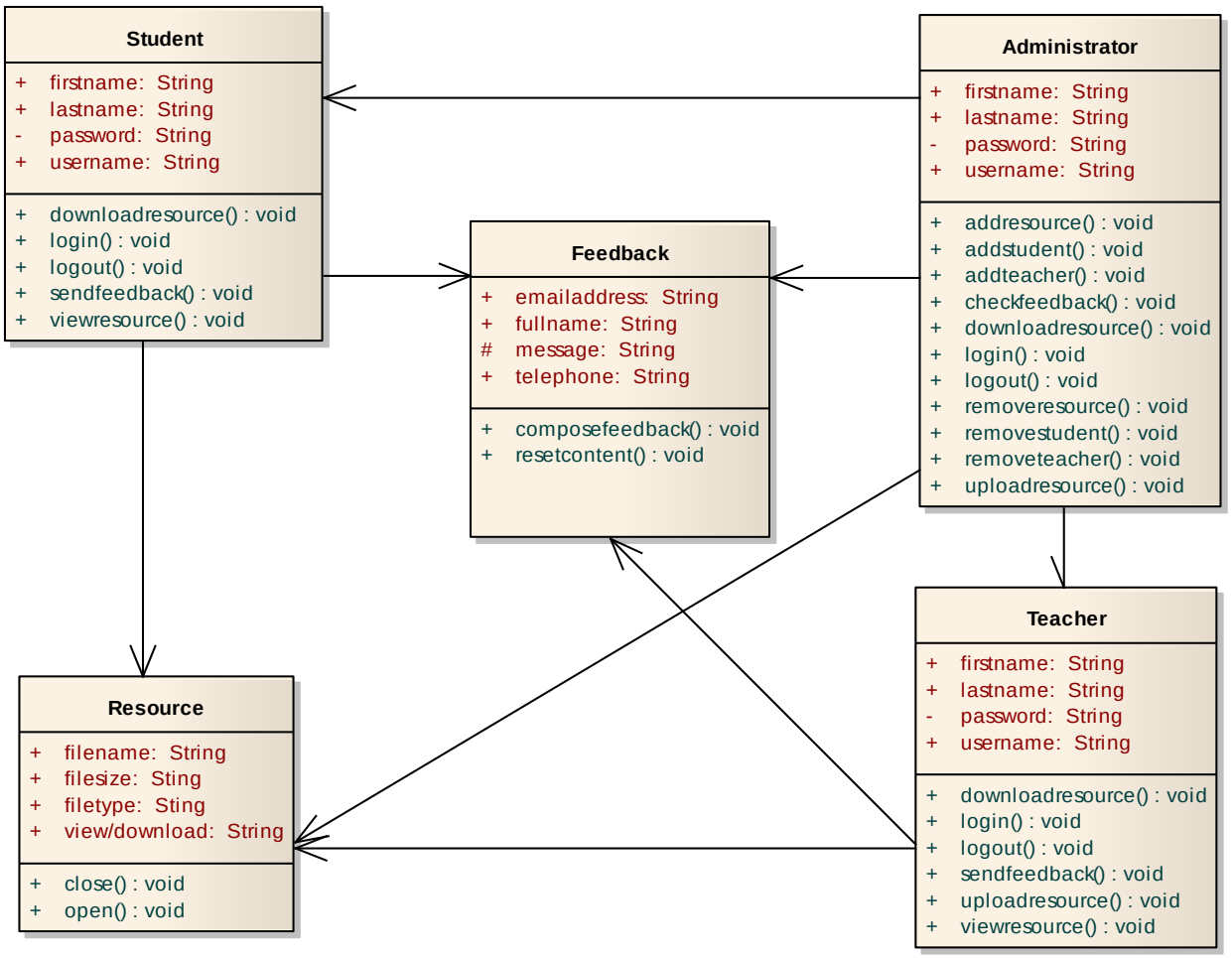

Figure-5.4 Class Diagram of ASTU mobile learning system

5.1.4.3 Sequence diagram of the system

Sequence diagrams, which are part of the dynamic diagrams, are used to show the sequence of actions and interactions that take place between objects. Their main components are:

- Objects: which are arranged horizontally across the top.
- Life-Line (dots vertically): which represents the object's life during the interaction.
- Arrows: represents the sequence of interactions between objects.
- Thin rectangle in life line: represents the time when the object is performing an action.

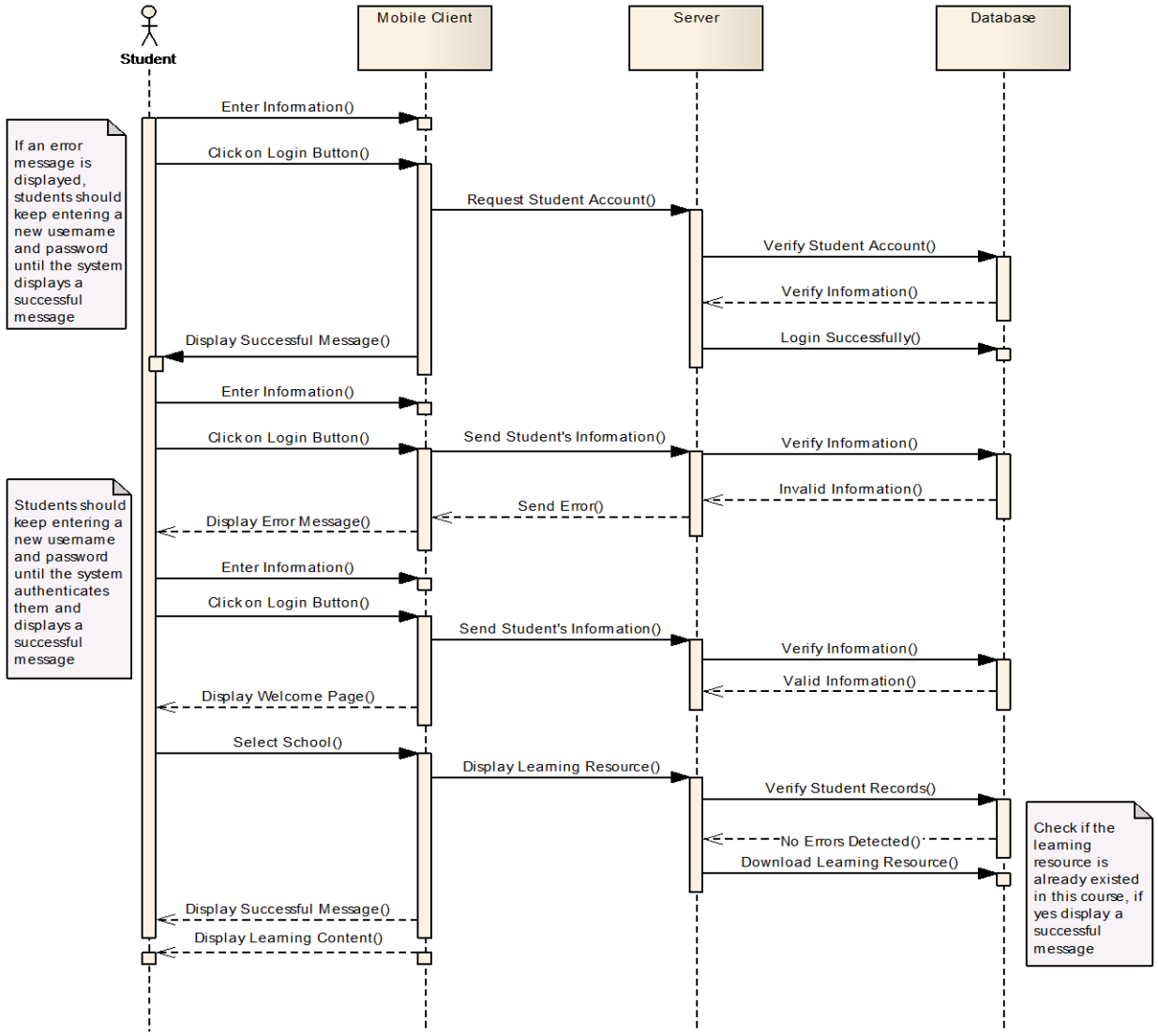

Figure-5.5 Sequence of "Student" actions and interactions

5.1.4.4 Activity diagram of the system

In the activity diagram of the system, Administrators, Teachers, and Students are the only registered users who can access the system. As just shown in the diagram below, these users request the login page and enter the username and password. Then, the system verifies the credentials and checks whether each of these users are authorized or not. For example, if one of these users is authorized then he/she can access the pages, otherwise a notification will be displayed to inform that the access is failed and prompts the user to try again. In addition the diagram also shows the details about some of its core activities.

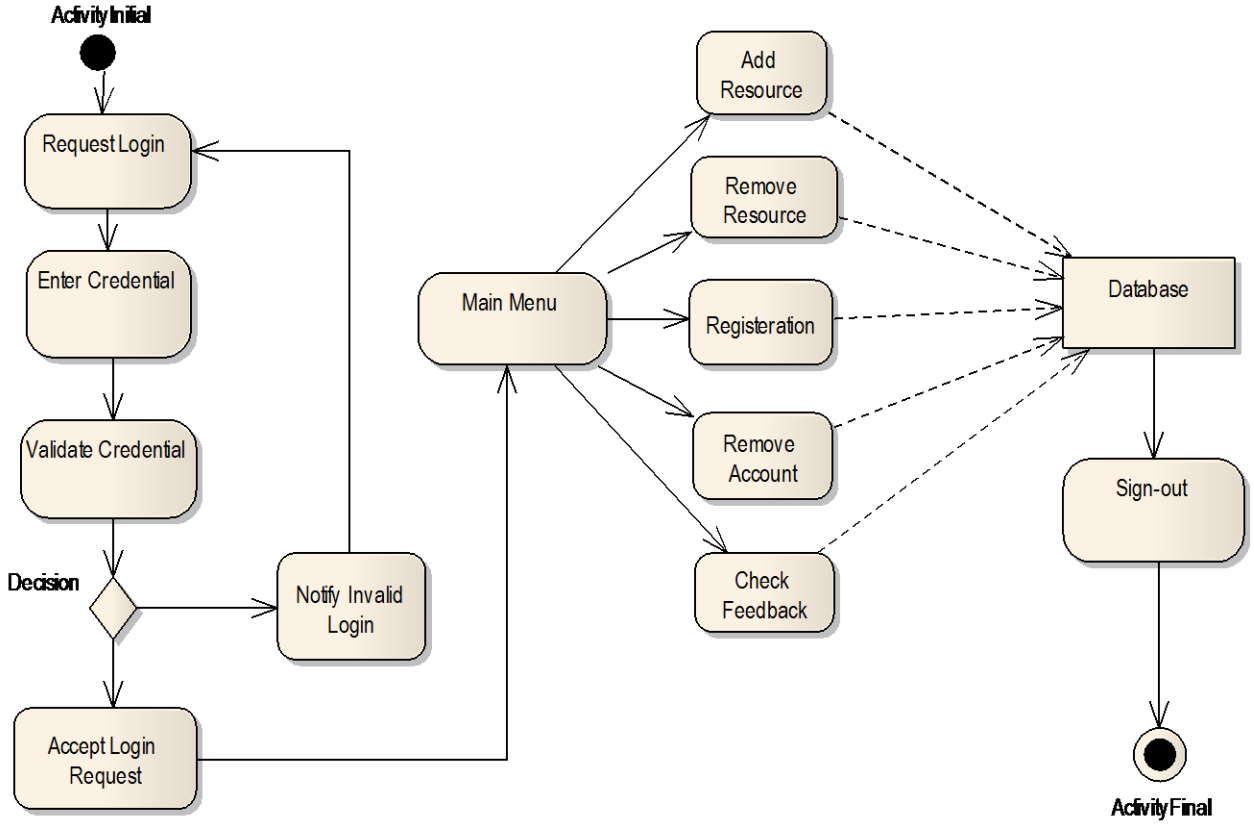

Figure-5.6 System Administrator activity diagram

The following pseudo code has been used in the prototype development of the ASTU Mobile Learning System. The code provides a tangible proof for the implementation of the system authentication process, file uploading configuration and registration activity. Therefore, most part of this pseudo code has been written by a PHP Scripting language and a java script also has been used for writing a particular echo messages.

Database Connection File

Connection = mysqli_connect(Enter username, Enter password)
If (connection)
die(database connection failed. Mysqli_error(connection)
Select_db = mysqli_select_db(connection, Enter db_name)
If (select_db)
die(database selection failed . Mysqli_error(connection))

Database Configuration File

dbhost = Database hostname
dbuser = Database username
dbpass = Database password
dbname = DatabaseName
// Create connection mysql_connect(dbhost,dbuser,dbpass) or die(cannot connect to the server)
// Check database conncetion mysql_select_db(dbname) or die(database selection problem)

Authentication process File

require Database connection file
if isset POST user_id and isset POST user_pass
username =POST user_id
password = POST user_pass
//authenticate credential query = SELECT FROM tablename WHERE username=usernamre and Password=password
//result = mysqli_query connection, query or die mysqli_error connection
count = mysqli_num_rows result
if count == 1
call a *.php file to display a course category
else
// call echo for Error Message
echo script type=text/javascript alert message script

Data Entry

// Create connection conn = new mysqli Localhost name and Password
// Check connection if conn->connect_error
  Die Connection failed conn->connect_error
// call echo for echo Errror
// this will select the Database registration mysqli_select_db conn,Db_name
echo
// create INSERT query
sql=INSERT Fieldnames INTO yourtable () VALUES POST username POST password POST firstname, POST lastname
if conn-> query sql === TRUE
echo success messageappear
else
//call echo for Error
Close mysql program mysqli_close conn

5.1.4.5 Web Component diagram of the system

The component diagram of the ASTU MLS shows three major Web components of the proposed system these include: Web classes which contain the methods and functions used to access the

MLS database, the Web configuration component which is used to configure the MLS functionality and to specify the application settings and finally, the Web services component which is used to transfer the data from the database.

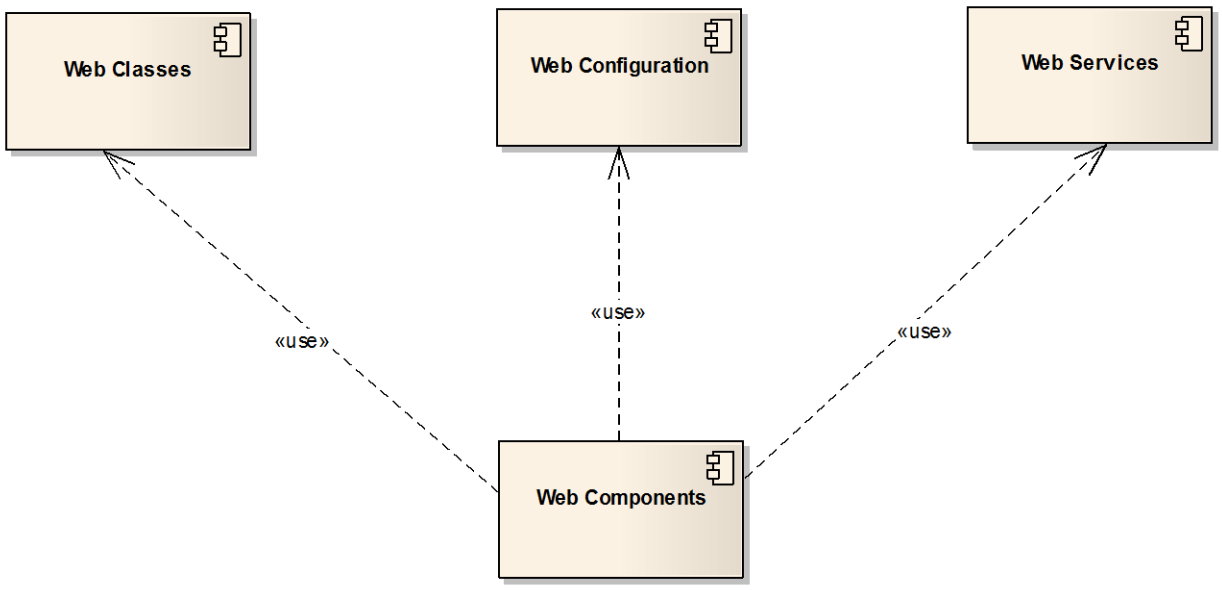

Figure-5.7 Web components of the system

5.1.4.6 Deployment diagram of the system

The system used a Wamp Server which is composed of: Apache Web Server, MySQL Database and PHP a Server Side Scripting Language as a unified component to manage the system's clients connected to the network. Within it, the web server along with the database keeps records for each client who is later used for making connections.

The web server is the main entity responsible for handling the connection of each of the clients who connect to the network for the first time. It is also responsible for authenticating the client and maintaining an entry for each client and its information within itself. This web server has a back-end database attached to it which keeps the static client information. The web server consults this database whenever it needs any information about the client or needs to verify any particular client's credentials.

The web server stores dynamic information about all the registered users within itself so that the database does not have to be queried for client each time.

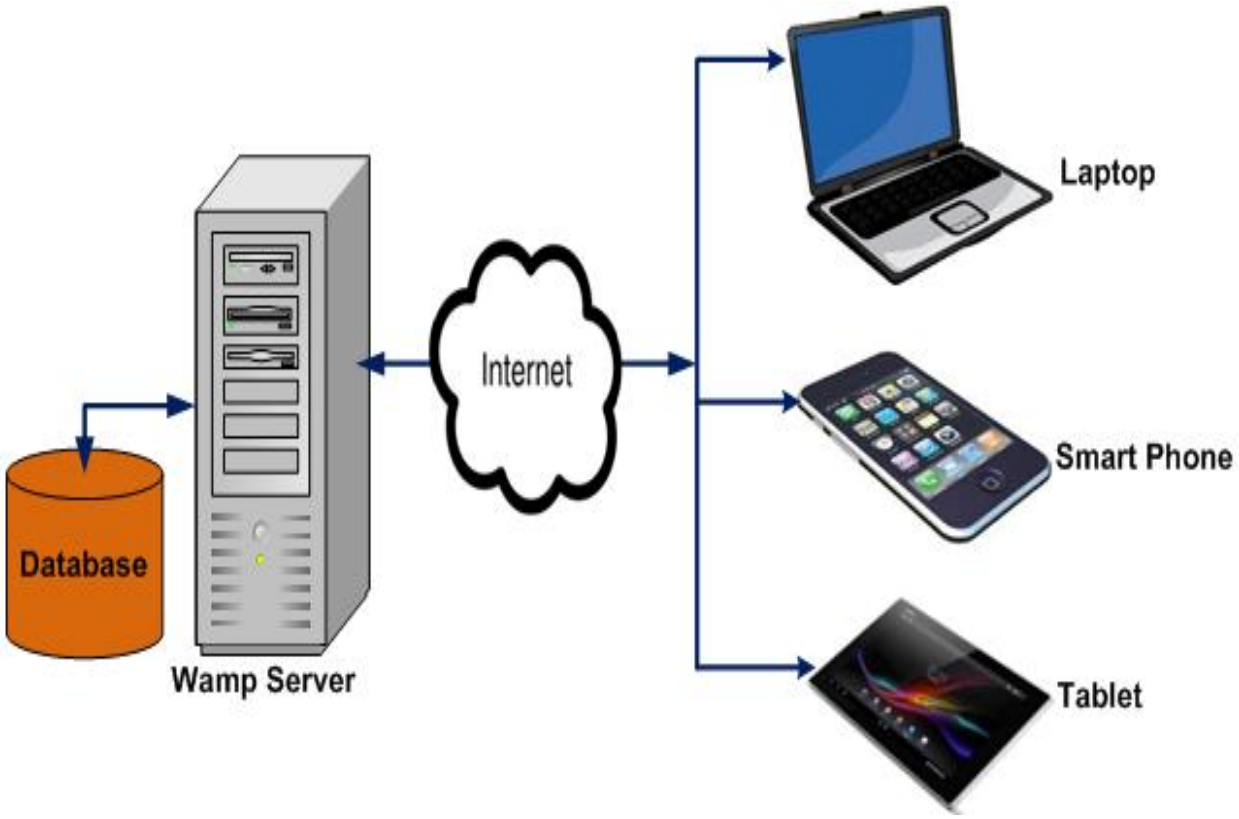

Figure-5.8 Web Server and Database connection

5.1.5 System Implementation Design

For proper implementation of the proposed system, the learners' mobile devices should have to contain a certain software application for accessing the multimedia resources from the mobile learning system. Initially the clients have to establish the Wi-Fi connection with the MLS server module which is activated by the business logic layer. The function of the business logic layer is condensing all the services and concentrates the user request which is present in the presentation layer. If the user is valid then it called the system for accessing the database. There is a data layer in the system server which controls, manages and administers the overall data retrieval and update operation of the learning materials inside the database. In the database, all information about the users is already stored in the users information file to let them access the login access into the system.

To start up the MLS services, connection first be established between the user and the backend server. The system is accessed on the internet via wireless access points by typing in the URL of

the web server unto the address bar of the clients' web browser and the index page of the system will be displayed as a home page.

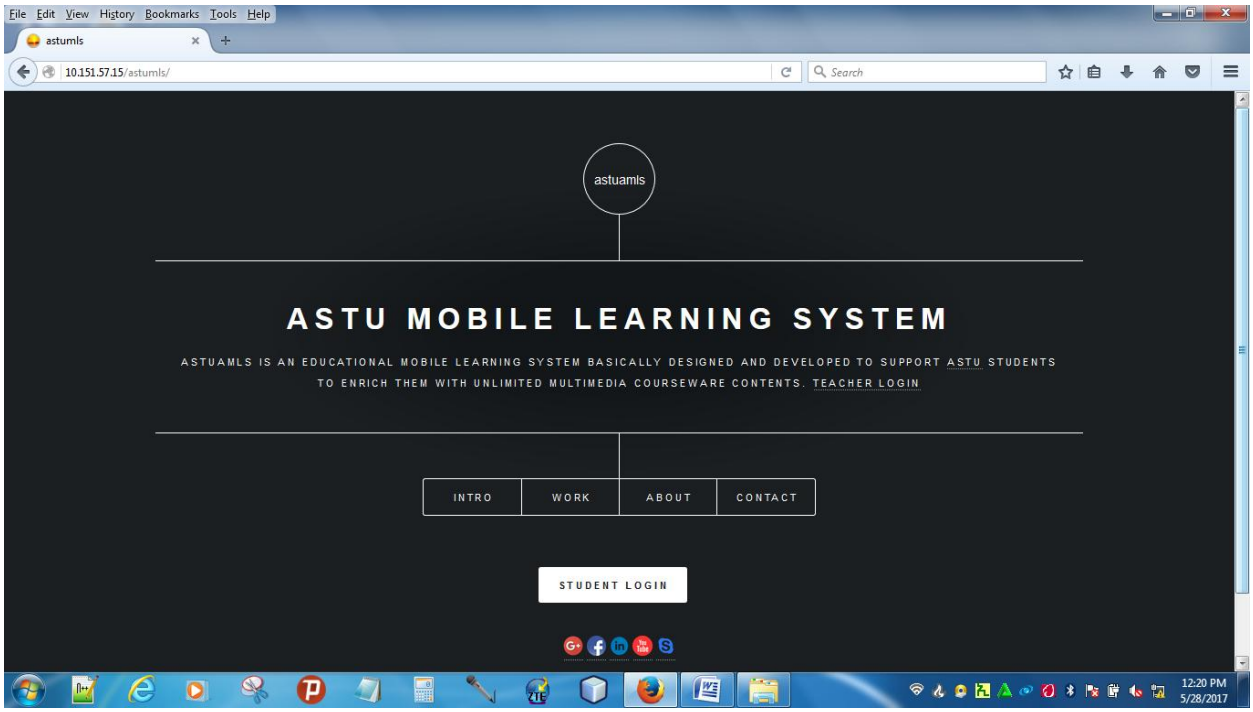

Figure-5.9 ASTU mobile learning system home page on laptop

The remaining screenshots of the ASTU Mobile Learning System have been taken both as portrait and landscape orientations of a Samsung Galaxy Mega smart phone for general view of the contents in both ways.

These interfaces come up after the mobile has been connected with the web server of the ASTU Mobile Learning System.

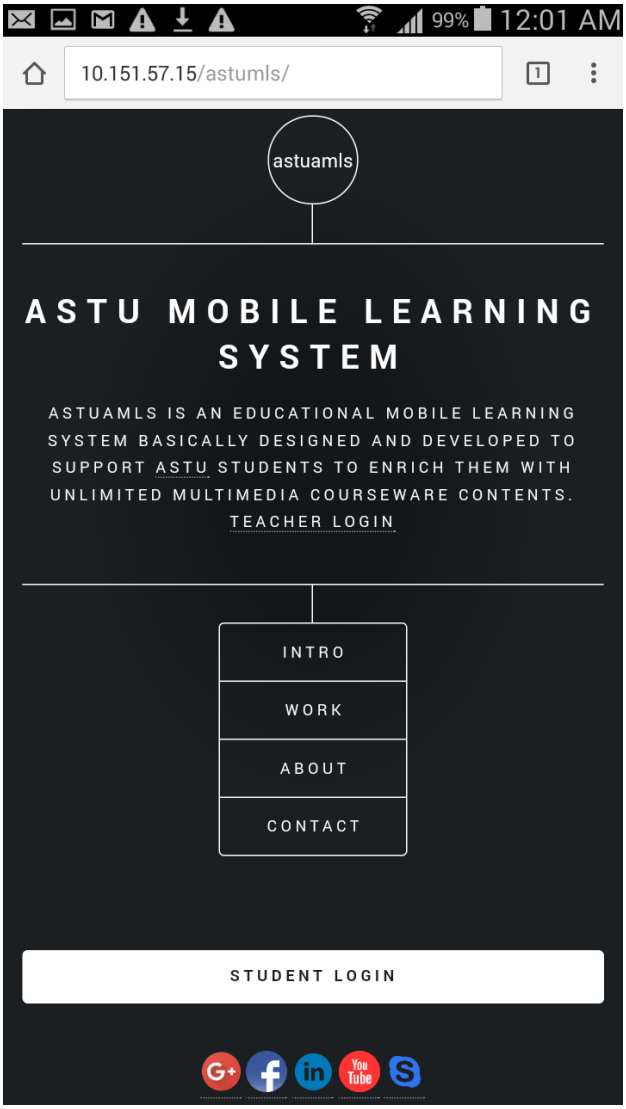

Figure-5.10 Home page of the MLS

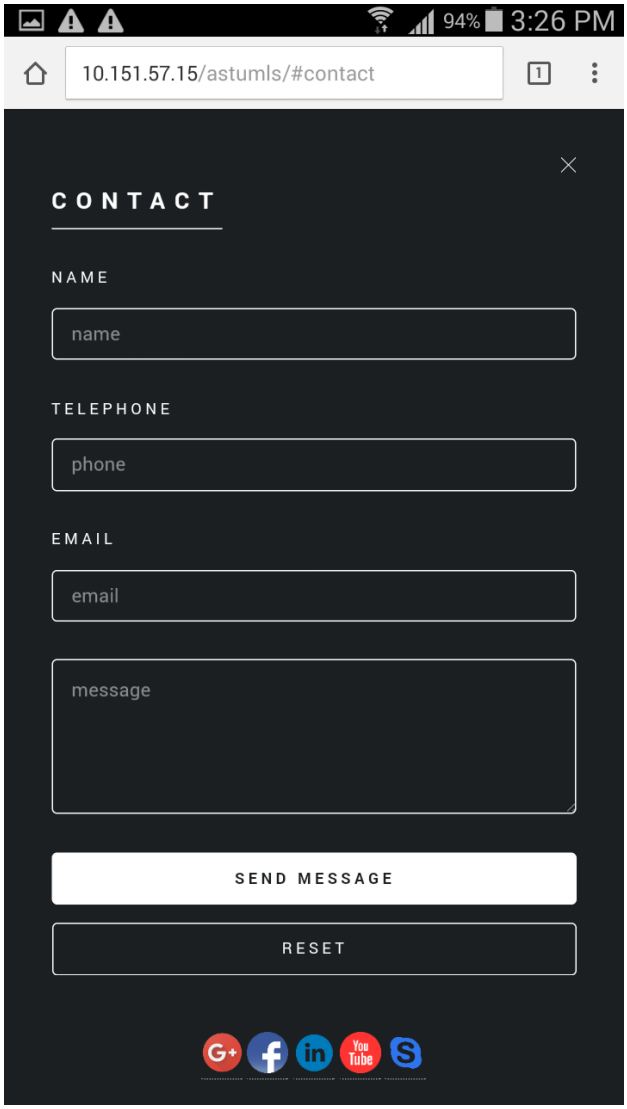

Figure-5.11 Contact page of the MLS

The next screenshots display the student login page where the student will input their username and password and the student registration page along with some details like: the username, password, first name and last name.

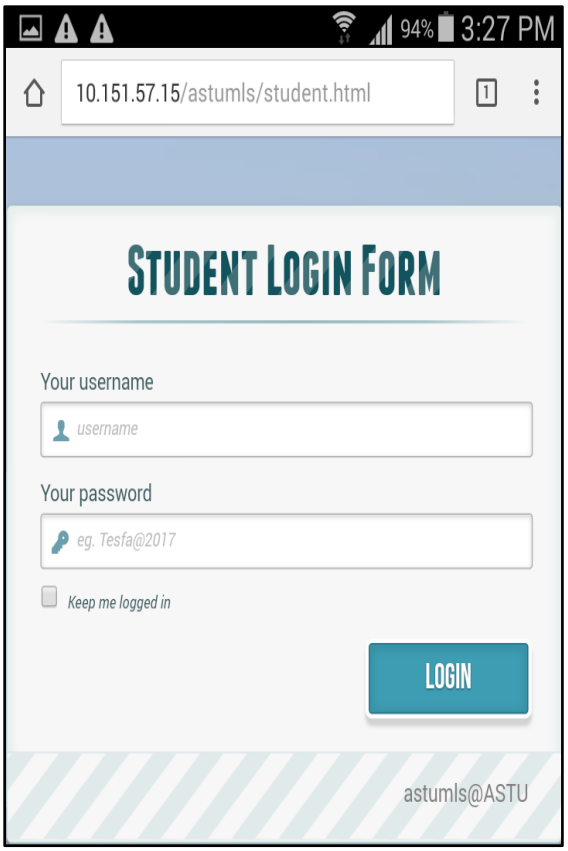

Figure-5.12 Student login page

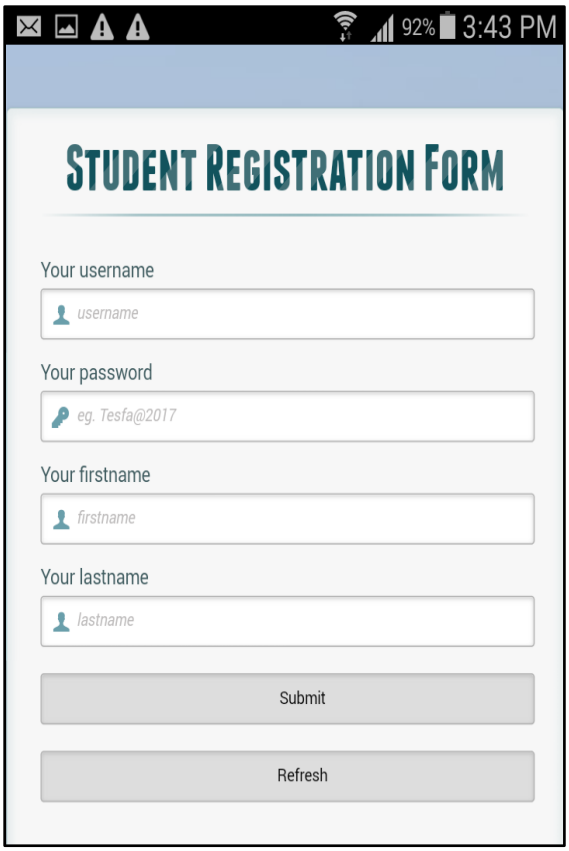

Figure-5.13 Student registration page

This interface displays the operations that will be performed as that of the Administrator page.

Figure-5.14 Main administrator menu

This interface displays a free feedback sent by the system user from a contact page and the messages can be accessed by the system administrator as an electronic feedback for future improvement of the system.

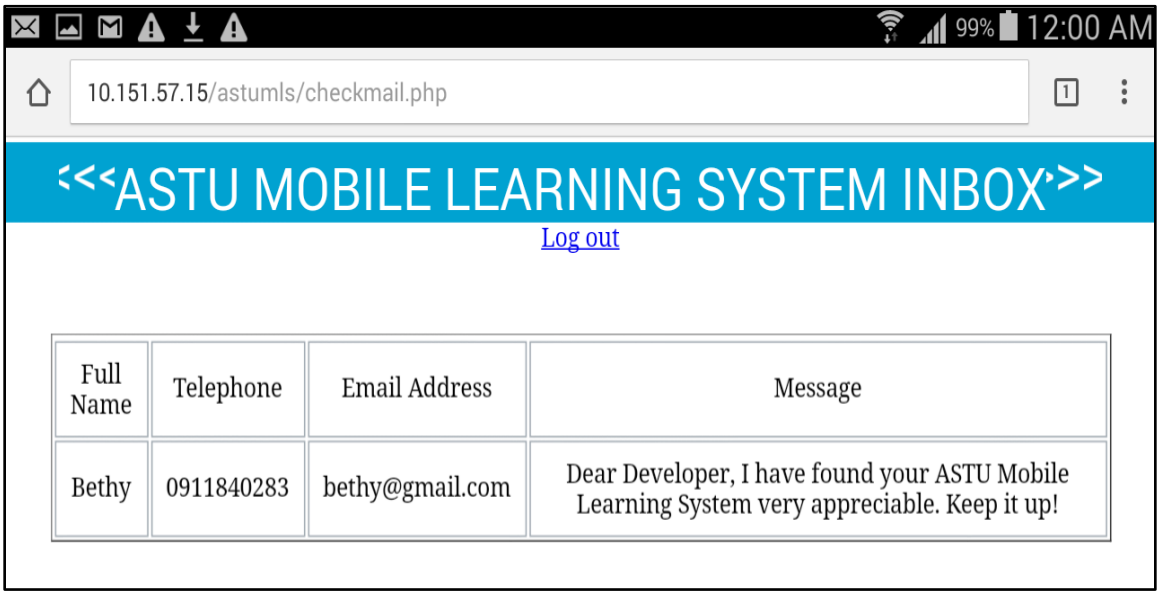

Figure-5.15 Check inbox page

The interface shows how a Lecturer/Administrator uploads any multimedia file format as supplementary online learning materials.

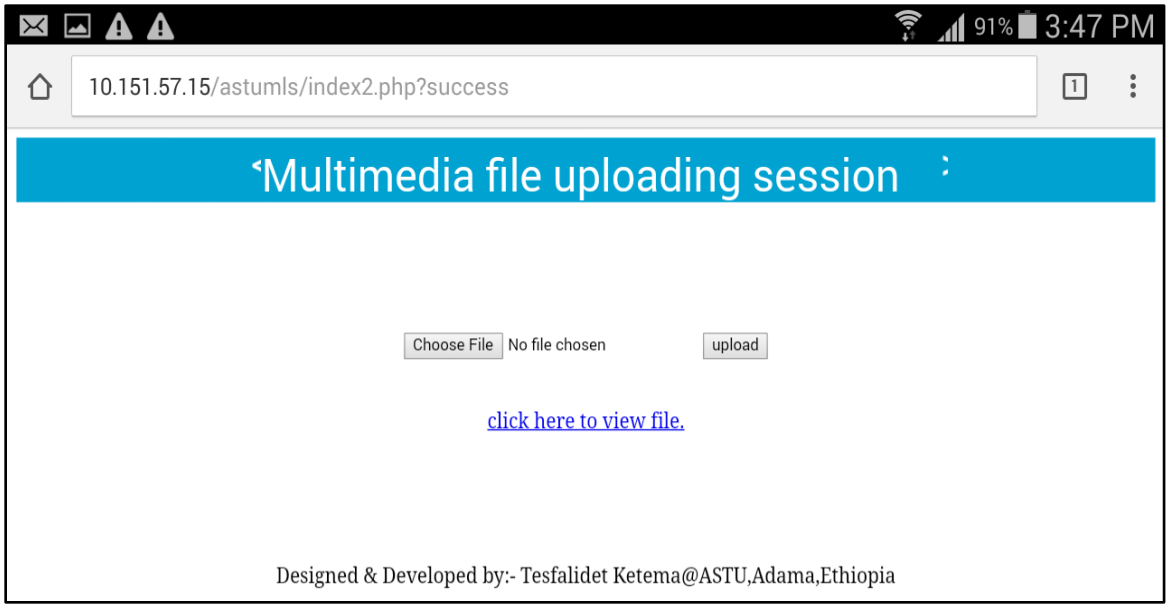

Figure-5.16 File uploading session

This interface is one of the amazing features of the system in collaborated with Smart Phones of Android OS to provide services of capturing events by lecturers or administrators in terms of Photos, Videos and Audio Recordings so as to upload and post them instantly from anywhere, anytime.

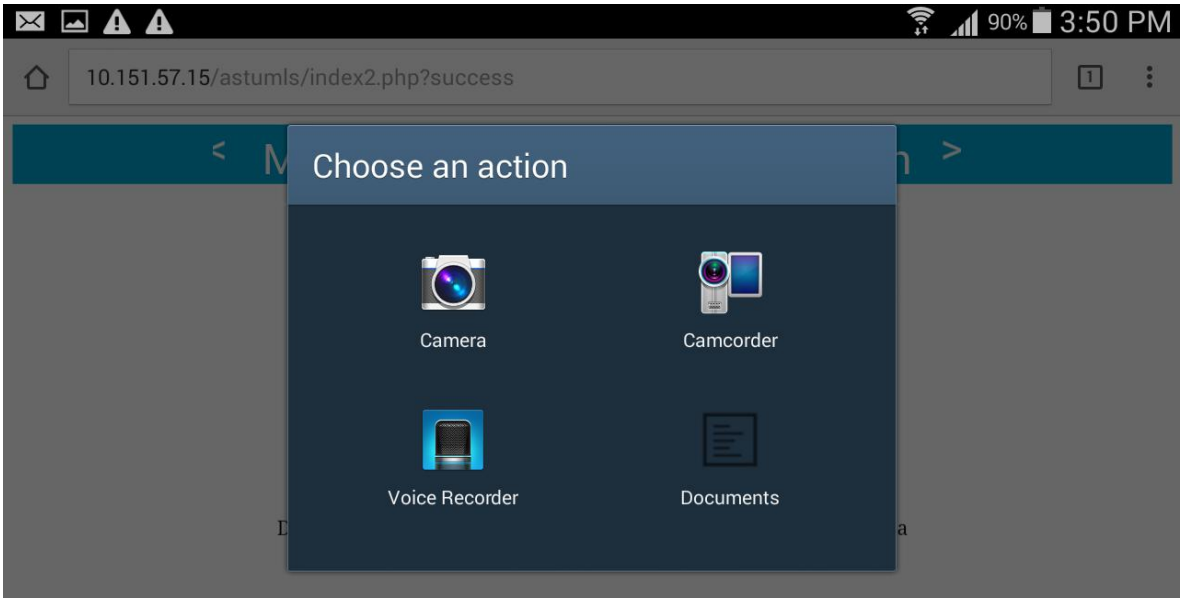

Figure-5.17 Instant files uploading session

This interface displayed the lecture materials uploaded by the lecturer/administrator with video attached.

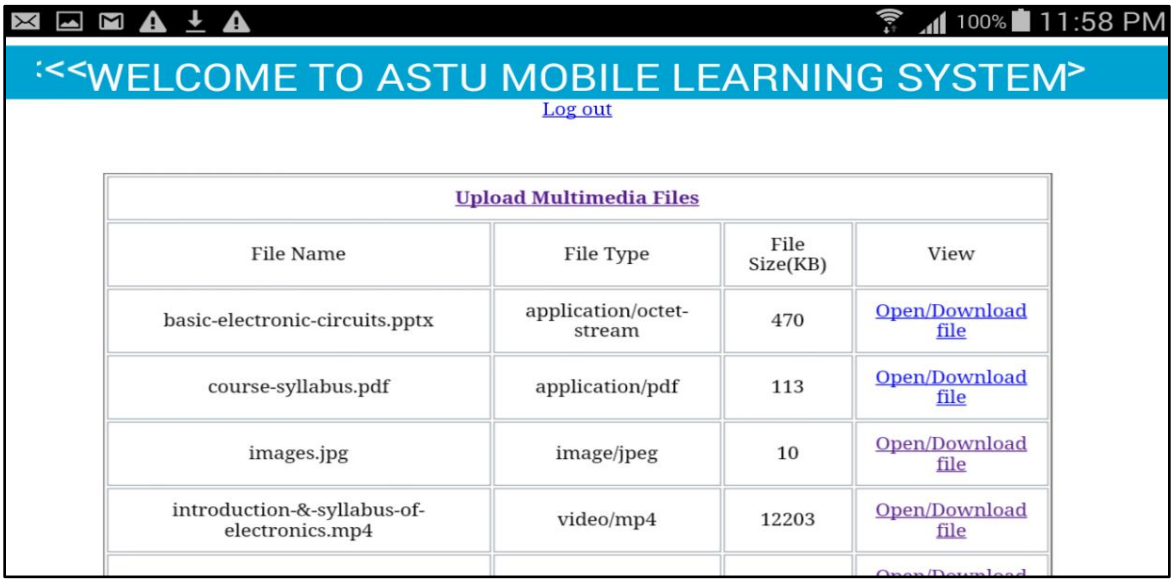

Figure-5.18 Sample uploaded learning materials

This interface displayed the lecture materials uploaded by the lecturer/administrator with video attached.

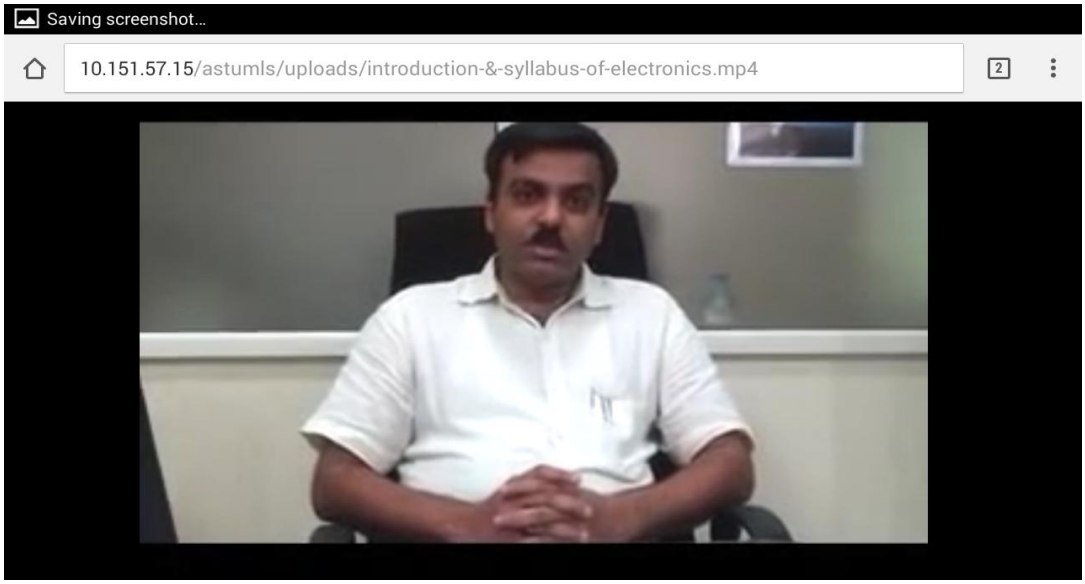

Figure-5.19 Lecture video uploaded in the course room

5.2 System Evaluation

5.2.1 Overview of the Evaluation Process

The system evaluation report of this page basically started from the detail analysis which has been conducted after the management bodies of ASTU approved the proposal of the said system. Functional specification is end product of Analysis phase. Its main contents which are the description of the system's requirements and the UML diagrams of the functional modeling were presented in detail. In order to achieve detailed requirements a survey is distributed and collected well-answered questionnaire papers among hundred (130) Students from each schools and Divisions, ASTU.

The requirements are finalized after analyzing the data of questionnaires using the Excel Spreadsheet program and using extensive prototyping to customer. A domain analysis is performed to find a suitable architecture for the system to be developed. An architectural model of system is developed that enables a software engineer to evaluates efficiency of design, judge options of design and minimize potential threats coupled with software development. The properties, behavior and relationships among components are identified.

Students will interact with ASTU wireless Access Point (WAP) internet service using their mobile devices. The Logger interface of the system creates session for starting communication and if this is done successfully and the user request has been validated by the system, the MLS grants access to its resources. Since the architecture of the ASTU MLS has been already developed, it is used as a Prototype for the research work i.e., each component has its own job.

The process of student authentication is performed by using the MLS core component comprising control functions and subscriber database. Administration component defines different users of the mobile learning system with their designated roles. Interface component publishes graphical user interfaces (GUIs) for the users. The database component allows teachers or lecturers to access the database to add or upload the course materials.

5.2.2 System Evaluation Process

From the technology advancement on mobile devices and services, people probably say, "The future of the web is mobile", and obviously it becomes true that developers can't afford to forget smartphone platforms when they are building a web–based mobile-friendly environment to let their audience to be able to access. So, it is important that these developers should conduct different evaluation methods. For this evaluation, the researches could come up with Emulator test for platform compatibility test using mobile and table emulators as well as they also applied a peer evaluation test report conducted by ASTU software development team members for checking the system effectiveness and efficiency.

So in the first evaluation test, the below listed mobile phone and tablet emulators were introduced by the software developers to test the compatibility of the system on all popular smart phones and tablets emulators. The emulators have been used to check the responsiveness and functionality of the proposed system with respect to web interfaces across different mobile platforms, such as iPhone, iPad, Android and BlackBerry, without actually having the devices in hand. They can also help to pinpoint problems and issues related the platform and allow taking corrective measures to make the web interface visually appealing and functional on mobile devices.

5.2.2.1 Result of Researchers' Evaluation

The following table displays the technical evaluation of the mobile as well as the tablet emulators used to conduct the test operation.

Type of Emulator	Manufacturer	Name	CSS Resolution	Pixel resolution	Operating system	Device type
Apple iPhone 5	Apple	iPhone 5	320x568	640x1136	iOS 6.0	Phone
HTC One	HTC	One	360x640	1080x1920	Android 4.1.2	Phone
Nokia Lumia 920	Nokia	Lumia 920	460x768	768x1280	Windows Phone 8	Phone
Samsung Galaxy Y	Samsung	Galaxy Y	240x320	240x320	Android 2.3.5	Phone
Google Nexus 7	Google	Nexus 7	603x966	800x1280	Android 4.1	Tablet
Apple iPad mini	Apple	iPad mini	768x1024	768x1024	iOS 6.0	Tablet

Table-5.6 Technical evaluation of emulators

The second evaluation test then continued and this evaluation particularly involves assessing and demonstrating the effectiveness and the efficiency of the developed artifact in solving the identified problems. Evaluation is also taken as a crucial component of research process so as to demonstrate the effectiveness and usefulness of the developed system regarding the goals and objectives of developing the artifact.

Therefore; the ASTU MLS has passed through this evaluation process conducted by a software development team of having seven members of ASTU ICT staff rigorously assess the usability of the developed prototype. The first usability testing scenario was testing the functionality of the system and this involved number of tasks that test team would encounter in real world

environment when using the system and it was basically related with tasks that relates to the learning resource service of the system.

For the team to start-up the testing process, the researchers told them to access the resource delivery service after they got the actual credentials for the test purpose and then the test user was asked to log on to the system with the username and password that was provided for the evaluation purpose. The main tasks the test users would perform in this scenario were checking for available resources and downloading one of the resources.

The second scenario involved a task that relates to the collaboration service of the system. The sub-tasks test users would be performing in this scenario were sending and reading a feedback message in different role of the system like student and administrator respectively. During the test, the test users verbalize their thoughts, feelings and opinions, one of these were written as comment in the discussion part whilst others drew our attention and expressed how they felt testing the system and see its performance.

After conducting the usability test, the test users were asked to check for resources that are available to them. Some of the test users encountered couple of issues such as logging onto the system due to slow connection of the internet and their mobile low processing capacity. Some of these test users using Samsung S6 and it was excellent with that specific moment to compare the processing capacity of the device with the same bandwidth, and finally, one of the test users felt reducing the steps involved in checking available resources, but after overcoming the initial problem, he was able to check for the resources available on the system database.

5.2.2.2 Result and Discussion of Team Evaluation

Both the resource service and the collaboration service worked well except the download task which did not worked properly on the previous mobile device which we understood that the problem can be attributed to low processing capacity issues and not the system. Most of the test users are of the view that the system would be beneficial to them. One of the test users stated: “I hope ASTU will own the system and this prototype should include some additional pedagogical features like: online-chat and I got the system very helpful and would make students’ life easy especially access relevant online learning materials rather than paying money for hardcopies”.

5.3 Summary

Efficient implementation of object-oriented programming languages such as PHP and JavaScript can improve the ability to deploy several services of a web-based mobile learning system. Web-based services provide a better alternative as services are loosely coupled and can be subscribed anytime any place. Moreover, leveraging web standards in a mobile learning environment will facilitate the dynamic integration of system components distributed over the web and foster reuse of the learning objects.

The development of mobile learning system is not as such an easy development activity. In this paper the researchers present the main steps in development of a mobile learning system for the case of ASTU. The client application uses an internet browser to start-up communication with the web server to access and download the online learning materials. The prototype development of the system has include a testing module which is conducted by mobile and tablet emulators. The testing result showed that the prototype worked appropriately in various smart phones' and tablets' specification in the vicinity of ASTU local area network nearby the wireless access points.

As a result of conducting these mobile and tablet emulators' tests, the proposed architectural design of the system platform could cope up and pass all the mentioned tests successfully in a friendly manner. During the platform test operation, all the mobile and the tablet emulators provided free feedback, and it was extremely easy to conduct the test process.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Mobile learning and education rapidly increased in these days. The majority of abroad universities provides online education program. Mobile learning evolves in the entire educational institutions and training center, and it has lot of business and education application. Student felt that they are very busy in their lives and have no time to stay in front of desktop computer to write assignment and projects, with the increasing usage of Smartphone, tablet, Ipad and PDA devices and have built in online education apps.

Typically, information systems development starts from the user or business perspective. We might talk about user needs, university requirements, use cases, functional and non-functional requirements, etc. When doing so we are approaching the system in terms of a problem and the primary need to understand the potential problem. On the other hand, we might see the system as a set of technical constructs, organizational principles, procedures, algorithms, data structures, data communication patterns, and so on. We then see the system as a solution to the problem. The main constituents of the system are then the design and architecture of the mobile learning system and its prototype development in the solution context.

The ultimate objective of the architectural design and development of the ASTU MLS is to obtain the learning materials on hand-held devices particularly on mobile devices. When ASTU students applying the system, they would get so many advantages such as: accessing the learning materials anywhere and anytime in the campus and they can use their PDA devices for educational purposes as well. Throughout the research paper, several can be pointed out. First we have conducted a data survey through questionnaires and interviews and then analyzed the collected data to show my findings and its results to startup the system architectural design and development. Second, we have designed 3-tier architecture as per the requirements of the survey data and can provide an efficient and fast way of delivering all types of multimedia files formats to mobile devices. Third, we have developed a working prototype for sharing and delivering learning resources so as to improve ASTU’s teaching-learning trends.

Finally, the architectural design and development of this mobile learning system research work was not an easy task which can be done in short period of time rather it demand the entire efforts and commitments of the researchers' attention and interest. We present the main steps passed through the development of the system. Including how the architecture of the system facilitates the actual communication between the client application and the system server using a web-based platform to access and download online resources via mobile devices anywhere, any time in ASTU premises. Moreover, we have also discussed the MLS user requirements by conducting a usability as well as a platform test to make sure the reliability and consistency of the system including testing module and component integration and as a result, we confirmed that the system worked correctly in different mobile and table emulators as well as any mobile devices having Wi-Fi connectivity features.

6.2 Recommendation

Although, this approach is to device a basic method for effect building of a Mobile Learning System, there are still so many uncovered and touched problems. However, the architecture will properly meet the current challenge of MLS and we will keep focusing on implementing the whole system to meet new user needs and requirements. This system will persist to grow and the future work will include improving the learning materials and adding more teaching-learning modules, assessments tools and interactive type of self-paced learning. We look forward to continuing our research and enhancing the system based on the students' as well as the academic staffs' need of ASTU community. Therefore, the major contribution of this thesis is to provide a stepping stone solution for how to design and develop MLS architecture in order to support the pedagogical needs higher educational institutes.

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APPENDIX

General remark about the questionnaire

Dear Respondent,

This questionnaire is designed to undertake a need assessment survey on a thesis research entitled: "**Design and Development of Mobile Learning System Architecture: the case of ASTU**". The information that you provide will help us to give better understanding about the students' awareness and acceptance about the research ideas in order to ensure its usefulness as well as significance of improving systems and services. We would greatly appreciate if you would respond to the questions sincerely and honestly. Your responses and information will be kept strictly confidential. Thank you very much for your time and cooperation.

General Instruction for Likert type answers

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Example: -

Q. Research and practice in mobile learning are still in their infancy.

1 **2** **3** **(4)** **5**

Appendix-I: Management Bodies' Questionnaire Form

Part-I: Demographic Data

School / Directorate_____

Department / Office _____

Sex: ○ Male ○ Female

Yours Position in ASTU: _____

Years of experience in ASTU: _____

Part-II: Please shade only one circle for your appropriate answer

1. How many students are often attending the normal lecture in the regular class room?
   ○ 20-30 ○ 30-45 ○ 45-65 ○ 65-80
2. How many students are currently attending the regular undergraduate studies in ASTU?
   ○ 2000-4000 ○ 4000-6000 ○ 6000-7000 ○ 7000-8000
3. Number of academic staff in ASTU?
   ○ 200-300 ○ 300-450 ○ 450-550 ○ 550-650
4. Do you think incentives should be given to SMEs/Lecturers for producing online learning materials?
   ○ Yes ○ No
5. Is copyright an important issue in ASTU as far as Mobile Learning Systems content development is concerned?
   ○ Yes ○ No
6. Is there a policy on Mobile Learning Systems in ASTU?
   ○ Yes ○ No
7. If Mobile Learning Systems can be an alternate solution for ASTU students, do you think the top management draws attention and willingness to fund for future implementation and expansion?
   ○ Yes ○ No

Appendix-II: Academic Staffs' Questionnaire

Part-I: Demographic Data

School / Division _____

Department _____

Sex: ○ Male ○ Female

Yours Position in ASTU: _____

Years of experience in ASTU: _____

Part-II: Please circle your appropriate number

1. ASTU academic staffs need architectural design and development Mobile Learning Systems for their students?
   1 2 3 4 5
2. Accessing educational learning materials online via mobile device is very significant for your students?
   1 2 3 4 5
3. ASTU broadband services satisfy your internet access need?
   1 2 3 4 5
4. Usability of mobile devices for teaching-learning improves your students' learning capacity?
   1 2 3 4 5
5. Mobile Learning could be instrumental in increasing the learning flexibility for students?
   1 2 3 4 5
6. Mobile learning supports social constructivism amongst learners?
   1 2 3 4 5

Appendix-III: Students' Questionnaire

Part-I: Demographic Data

School / Division: _____ Department: _____

Year of Study: ***1st*** ○ ***2nd*** ○ ***3rd*** ○ ***4th*** ○ ***5th*** ○

Sex: ○ Male ○ Female **Age**: _____

Part-II: Please circle your appropriate number

1. ASTU students need architectural design and development for Mobile Learning Systems for their studies?
   1 2 3 4 5
2. Accessing educational learning materials online via mobile device is very significant for ASTU students?
   1 2 3 4 5
3. ASTU broadband services satisfy your internet access need?
   1 2 3 4 5
4. Usability of mobile devices for teaching-learning improves your learning capacity?
   1 2 3 4 5
5. Mobile Learning could be instrumental in increasing learning flexibility?
   1 2 3 4 5
6. Mobile learning supports social constructivism amongst learners?
   1 2 3 4 5

Part-III: Please tick (✓) in any of the appropriate boxes

1. What device do you use to access internet in ASTU?
   ☐ Laptop ☐ Ipad ☐ Ordinary Phone
   ☐ Smart Phone ☐ Tablet Other (specify) _____
2. How often do you access internet in ASTU using your device?
   ☐ 1-2 Hrs/day ☐ 2-3 Hrs/day
   ☐ 3- 4 Hrs/day Other (specify) _____
3. Which of the following file formats are most appropriate for you?
   ☐ Audio ☐ Documents ☐ Pictures/Images
   ☐ Video ☐ Zip Other (specify) _____

Appendix-IV: Academic Staffs' and Management Bodies' Interview

1. How could you explain the need for the design and development of architecture for Mobile Learning System in ASTU?
2. What kind of learning materials file format should be incorporated in the architecture for the system development?
3. What would be the benefit of Mobile Learning System both for Academic Staff and Students?
4. What would be the challenges for applying Mobile Learning System?
5. What should be done in the future for sustaining Mobile Learning System?