International Journal of Science, Environment and Technology, Vol. 3, No 5, 2014, 1856 – 1881

ISSN 2278-3687 (O)

AN ARCHITECTURE FOR THE USE OF LEARNERS' MOBILE DEVICES IN THE CLASSROOM IN SUPPORTING CONTACT LEARNING

Alnseerat Nemr, Greyling Jean, Vogts Dieter and Koorsse Melisa
Department of Computing Sciences, Nelson Mandela Metropolitan University
Port Elizabeth, South Africa
E-mail: Nemr.Alnseerat@nmmu.ac.za (*Corresponding Author*)

Abstract: The growth and rapid evolution of mobile technologies have created a significant potential to include them in the learning process. This paper presents a mobile learning architecture for the use of mobile devices in the classroom environment. The aim of this architecture is to utilise the existing infrastructure in the educational environment as well as learners' mobile devices in order to support contact learning. To achieve this objective, this paper investigates the components of mobile learning when applied in the classroom situation. Furthermore, some existing mobile learning architectures are discussed, giving an overview of their characteristics and functions. Based on the limitations of existing architectures in relation to contact learning, the Contact Instruction Mobile Learning Architecture (CIMLA) was designed by the authors. The paper concludes by discussing this architecture and providing typical scenarios of how the architecture would support contact learning.
Keywords: Mobile Learning Architecture, Mobile Learning in Classroom, Contact Learning, Mobile Technologies, Collaboration.

1. INTRODUCTION

Mobile devices (such as tablets, personal computers and mobile phones) have developed significantly in the last decade (Ojala and Korhonen, 2008). These technologies include network connectivity, local storage, touch screens and keyboards. These improvements play a key role, affording mobile devices the potential to support learning by providing and delivering learning content.

Mobile learning has been used in various educational institutions for different purposes. The majority of learners at higher educational institutions have mobile devices with good features and specifications. A survey was conducted at Nelson Mandela Metropolitan University (NMMU) in 2013 among 570 first year learners of the Department of Computing Sciences. The survey shows that 99.8 percent (n=569) of learners have at least one mobile device. Of

*Received Aug 22, 2014 * Published Oct 2, 2014 * www.ijset.net*

these devices, 80 percent (n=456) have Wi-Fi capabilities. These results highlight the opportunity to utilise NMMU learners' mobile devices in the mobile learning process.

Mobile learning (Section 3) came as a natural progression from E-learning (Section 2). In designing architectures for mobile learning in the classroom, it is important to have an understanding of the different components involved. Section 4 identifies these components as the learner, teacher, electronic content, repository, environment and tools to assist with assessment. Before discussing the Contact Instruction Mobile Learning Architecture (CIMLA) in Section 6, Section 5 provides an overview on existing relevant mobile learning architectures. Based on CIMLA, the LiveLearning system was developed as a proof of concept. Section 7 contains an overview of the implementation and evaluation of LiveLearning. A discussion of the evaluation results is contained in Section 8.

2. E-learning

E-learning is a form of using personal computers in education to provide learning content to learners in educational institutions or over the internet (Tick, 2006). The learning content might include text, images, sound, videos and live communications.

Many universities around the world have embedded e-learning as an approach to teaching in the learning process. E-learning overcomes distance by providing the learning content over the internet to learners irrespective of time. This has produced some advantages of using e-learning in education, two of which include flexibility and efficiency:

Flexibility: The improvement of personal computers and internet technologies had a significant impact in providing an educational e-learning environment. These technologies produce tools that allow the usage of different ways to provide learning materials to learners. E-learning uses live presentations, communication tools, the delivery of images and videos as well as the presentation of learning materials (Bonanno, 2005). These facilities create a suitable learning environment for a wide range of learners.

Efficiency: Modern learning tools save time by allowing educators to create, modify, deliver and receive learning materials (Bonanno, 2005). In addition, learners' interactions with the learning material and teachers (such as chatting and voice discussing) minimise the time of knowledge acquisition.

E-learning as a distant learning approach which depends on the network connectivity and physical place to provide learning content, has its disadvantages. These disadvantages include slow connections and geo-location education (Song, 2010):

Slow connections: E-learning provides varied learning materials such as sound, videos and photos (Virtič, 2012). Sending and receiving such large amounts of data over a network might pose problematic due to the internet speed or bandwidth limitations.

Geo-location education: Since e-learning provides learning content to personal computers online, the learners must be located in certain places where they are able to gain access to content. These factors limit e-learning from being accessed anywhere which might be uncomfortable for learners.

E-learning focuses on remote education using information technology. The increasing use of mobile devices has caused e-learning to evolve into mobile learning.

3. Mobile Learning

The implicit mobility of mobile learning is the essential difference from e-learning. Because learners can use their mobile devices to access educational content at any time irrespective of their locality (Tortosa *et al.*, 2011), it directly addresses the limitation of geo-location education as mentioned in Section 2.

Since 2001, the concept of using mobile devices in education has been applied in different educational institutions around the world (Attewell, 2005). The technological advances in mobile devices established new possibilities for diffusion of learning among learners and provided an opportunity for the realisation of mobile learning in an educational environment. One of the most important features was the decreasing weight and size of mobile devices which allows for mobile learning to be brought into the classroom. These features provide mobile learning with the following advantages: learning convenience, teaching personalisation and abundant alternatives.

Learning convenience: the learners can review the learning content on their own mobile devices, as well as read and answer an assessment simply by clicking on a few buttons (Ah-choo *et al.*, 2012). These facilities create a convenient learning way for learners.

Teaching personalisation: Since the main concept of mobile learning is to deliver learning content to learners' mobile devices, each learner has the potential to customize the learning content on his / her mobile device (Yarandi *et al.*, 2011). Personalisation can be applied by selecting the required information which relates to a current topic or by adapting the appearance of the user interface.

Abundant alternatives: The modern technology of mobile devices allows educators to produce learning content in different styles such as text, videos, sound and graphics (Wolf and Rummler, 2011).

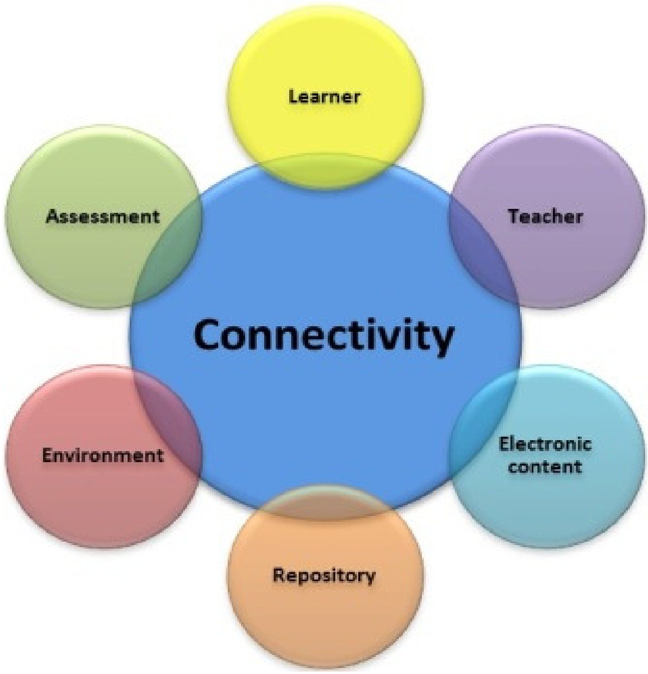
These advantages have a good potential to adopt a mobile learning system in the classroom. Before implementing an effective mobile learning system, it is important to understand the basic components of a mobile learning framework and to define the characteristics of these components.

4. Components of mobile learning in the classroom

Applying mobile learning in the classroom means that there must be an architecture in order to serve as guideline for applications that would allow learners to improve their academic performance and understanding of the learning materials (Ozdamli and Cavus, 2011). Understanding and identifying the basic components of a mobile learning framework is important to design a useful mobile learning architecture. The following components have been identified: the learner, teacher, environment, repository, electronic content, connectivity and assessment (Figure 1). **Figure 1:** Mobile learning components

4.1 Learner

Since mobile learning focuses on providing learning content to learners, the learner is an essential component of the mobile learning process (Ozdamli and Cavus, 2011). Mobile learning affords learners the opportunity to interact and collaborate with their mobile devices in an effective way. The features of these mobile devices must be taken into consideration.



4.2 Teacher

In traditional teaching, the role of the teacher is to manage the learning process and determine what learning content needs to be presented to learners (Avalos, 2011). This role in mobile learning should not be less than in the traditional way. To enable this role, mobile learning must provide appropriate tools and functionality to support the teacher. Teachers must be able to send tasks or messages, respond to assignments, present results and give feedback instantly without any barriers (Mostakhdemin-Hosseini and Tuimala, 2005).

4.3 Electronic content

Mobile learning should take advantage of new mobile devices' technologies , such as the provision of rich media content and the presentation of content in an attractive and simple way (Magal-Royo, Montañana and Alcalde, 2010). Presentation of the learning content must also be sensitive to the features of the phones being used.

4.4 Repository

The repository refers to the data storage which allows teachers to save the learning objects and materials (text, photos, videos, audios and supplemental materials) which can later be delivered to learners (Almstrum, Owens and Adams, 2005). It creates an available source of information that can be accessed at any time as authorised be teachers.

4.5 Environment

The traditional learning environment is a convenient venue where the teacher can interact with learners. Mobile learning environments take advantage of technologies which adds value to the learning process (Ozdamli and Cavus, 2011). These technologies are mainly a presentation display device and network connectivity. The presentation display should display information in a clear way for all learners irrespective of their locality in the classroom (Sharp *et al.*, 2012).

4.6 Assessment

Assessment is an important part of any mobile learning process (Savill-smith, 2004). In traditional education, assessment generally takes place in the allocated classroom. Conducting an assessment for a large number of learners in the classroom time might pose problematic (Park, 2011). Embedding assessments in the mobile learning system helps teachers to assist learners better by measuring their knowledge and understanding of a specific topic. In addition, this encourages learners to assess themselves during the classroom time, which will give them a chance to improve their level of knowledge when needed.

4.7 Connectivity

Connectivity is the core of the mobile learning component which creates a possibility for the rest of the components to communicate and share data (Padiapu, 2008). It allows for supporting an effective, communicative, interactive and collaborative learning environment. Short range connectivity and Wi-Fi are the two most popular connectivity mechanisms considered for contact learning.

5. Existing mobile learning architectures

Several mobile learning architectures have been designed for supporting the use of mobile devices in education. These architectures are designed for various educational purposes in different ways of usage. The author investigated four existing mobile learning architectures as a representative sample of architectures in the mobile learning domain. For discussion in this paper two of these architectures were excluded due to their obvious deficiencies in supporting contact learning in the classroom. These excluded architectures are Mobile Game-Based Learning and Web-Based Mobile Learning. The Mobile Game-Based Learning was designed by Mitchell, Lane and Inchingolo in 2006 (Mitchell, Lane and Inchingolo, 2006). This architecture aims to supplement education via mobile games which are pervasive among youths. The Web-Based Mobile Learning architecture considers existing web resources in generating and providing learning materials to learners' mobile devices (Alzaabi, Berri and Zemerly, 2010). The lack of supporting contact learning by these excluded architectures will be shown in Table 1.

The Architecture for Adaptive Mobile Learning (Section 5.1) and the Architecture for General Mobile Learning (Section 5.2) are now discussed in more detail.

5.1 Architecture for Adaptive Mobile Learning

The Architecture for Adaptive Mobile Learning was developed by Jung and Park (2006) and considers learners' knowledge level by providing learning materials based on individual learners' cognitive load and learning achievements. Figure 2 depicts the architecture which consists of four parts: repository, web server, client and relay server (Jung and Park, 2006). The repository represents a store of learner materials created by educators, such as courses and assignments. The other parts are discussed in detail below.

Web server Most of the functionality of this architecture is located in the web server which makes it the core of the architecture. It has an adaptation engine linked to three models. These models help the adaptation engine to customise the learning content based on the learner's experience. The domain model contains the organised learning materials which is relevant to the current subject. The user model comprises general information about learners that describes the attributes, subject interests and level of knowledge. The adaptation model is responsible for updating the user model about the latest marks, assessments and learning activities that have been done by the learner. The manipulation engine generates reports about learners' progress and achievements.

Client It supports the communication of learners and the teacher with each other as well as with the learning content. Learners will interact with the mobile learning system from their mobile devises while teachers could either access the learning system via a mobile device or a laptop.

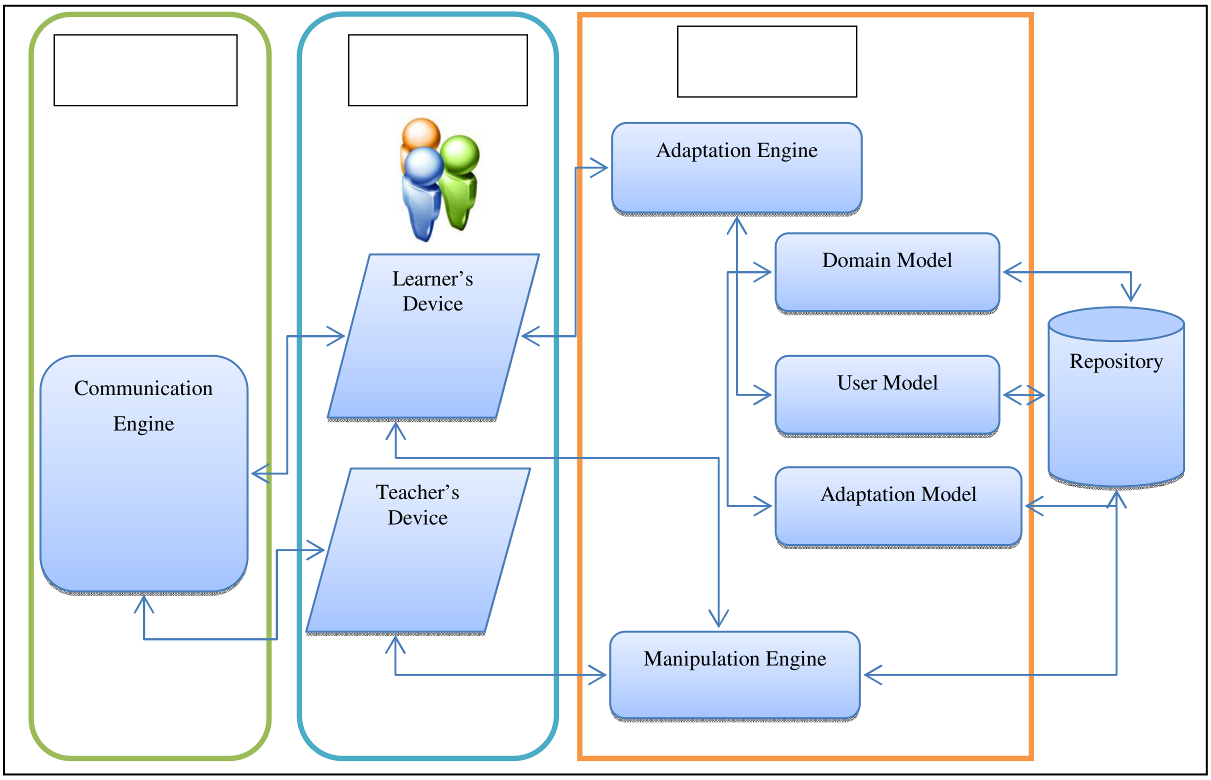


Figure 2: Architecture for Adaptive Mobile Learning (Jung and Park, 2006)

Relay server The relay server provides communication channels between the learners and the teacher via the communication engine. The communication engine allows learners to gather needed information from the repository. It also permits a teacher to create and manage learning materials.

This architecture considers most of the mobile learning components discussed: learner, teacher, repository, learning content and connectivity. It, however, does not address the issues related to the environment and assessment.

5.2 Architecture for General Mobile Learning

As discussed in Section 2, E-learning had prevalence and gained broad acceptance as a distance learning approach among various educational institutions long before mobile learning (Mavengere, Ruohonen and Nleya, 2011). This architecture uses the advantage of e-learning to extend an existing e-learning system to mobile learning.

Figure 3 depicts the Architecture for General Mobile Learning and describes the method of extending e-learning to mobile learning. This architecture presents two main platforms, namely the E-Learning Management System (eLMS) and the Mobile Learning Management System (mLMS).

The eLMS contains three layers for providing learning materials to mobile devices: the storage layer, business layer and presentation layer.

Storage layer This layer stores all the digital learning materials such as courses, lectures, tests and quizzes which are created by teachers.

Business logic layer This layer considers the procedure of sourcing learning materials from the repository according to the learners' needs. The business layer prepares learning materials to present them on a mobile device.

Presentation layer In this layer the architecture displays learning content by considering the capacities or features of personal computers.

The mLMS is responsible for expanding e-learning management systems to mobile learning. The following components need to be added to this architecture. It contains three components which assist the existing e-learning system to adapt the learning content to be presented on mobile devices.

Mobile content management and presentation adaptation: This component considers the method of transferring data to a mobile device (Wi-Fi or internet) to improve the speed of transactions between the repository and mobile devices.

Packaging and synchronisation: These components offer offline usage of learning materials in case of no connectivity. When a mobile device connects to the learning system, the system starts packaging learning materials to prepare for transfer from the server to save them on the connected mobile device.

Context discovery: In order to adapt learning content to different mobile devices, this model discovers the capacities and limitations of the learners' devices. Content is created that fits each mobile device according to it features.

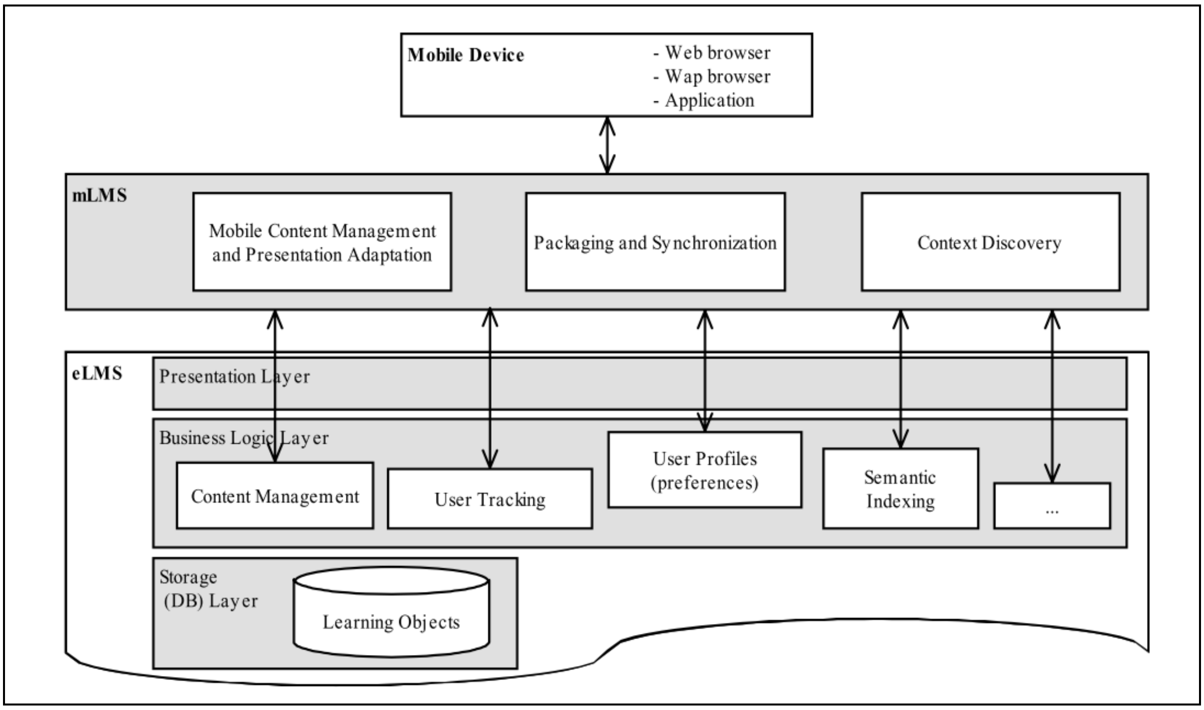


Figure 3: Architecture for General Mobile Learning (Kromer, 2010)

This architecture makes learning materials more accessible by extending existing e-learning to mobile learning. However, this architecture is not fit to be used for the use of mobile devices in the classroom environment. This is due to the lack of some components of mobile learning in the classroom, namely assessment and environment.

5.3 Discussion

Table 1 compares the four mentioned mobile learning architectures. It indicates which components of mobile learning (as listed in Section 4), are supported. This table confirms the lack of an architecture that specifically supports the use of learners' mobile devices in the classroom environment. It therefore provides evidence of a need to design a mobile learning architecture for contact learning. This novel architecture is discussed in Section 6.

		Connectivity	Assessment	Environment	Repository	Electronic	Teacher	Learner
Architectures	Adaptive	✓	✗	✗	✓	✓	✓	✓
	General Mobile Learning	✓	✗	✗	✓	✓	✓	✓

	Mobile Game-Based Learning	✓	✗	✗	✓	✓	✗	✓
	Web-Based Mobile Learning	✓	✗	✗	✗	✓	✗	✓

Table 1: Comparison of mobile learning architectures

6. Contact Instruction Mobile Learning Architecture (CIMLA)

Mobile devices have the potential to impact the educational environment significantly by offering tools for learning that provide an affordable and sustainable method of using mobile technologies for education (Vosloo, 2012). Section 5 has concluded that a new architecture needs to be designed for the use of mobile device technologies to enhance education in the classroom.

The learning components that should feature in a mobile learning architecture, were defined in Section 4. Figure 4 depicts the main components of mobile learning, which are needed specifically for contact learning.

Based on these identified components as well as the features of existing architectures (as discussed in Section 5), a novel architecture was designed. This architecture, called Contact Instruction Mobile Learning Architecture (CIMLA), offers functionality that makes use of mobile devices, allows the teacher to create learning activities and to deliver them to the learners.

The mobile learning architecture comprises has a star topology, with the Server module at the centre, which seamlessly connects with three types of clients and a data repository at the periphery. The five main modules are based on the components of mobile learning in the classroom identified earlier (Section 4). These modules are the Learning Server, Teacher Client, Learner Client, Presentation Client and Repository. Each module has different components (Figure 5). Each of these modules are now discussed in further detail.

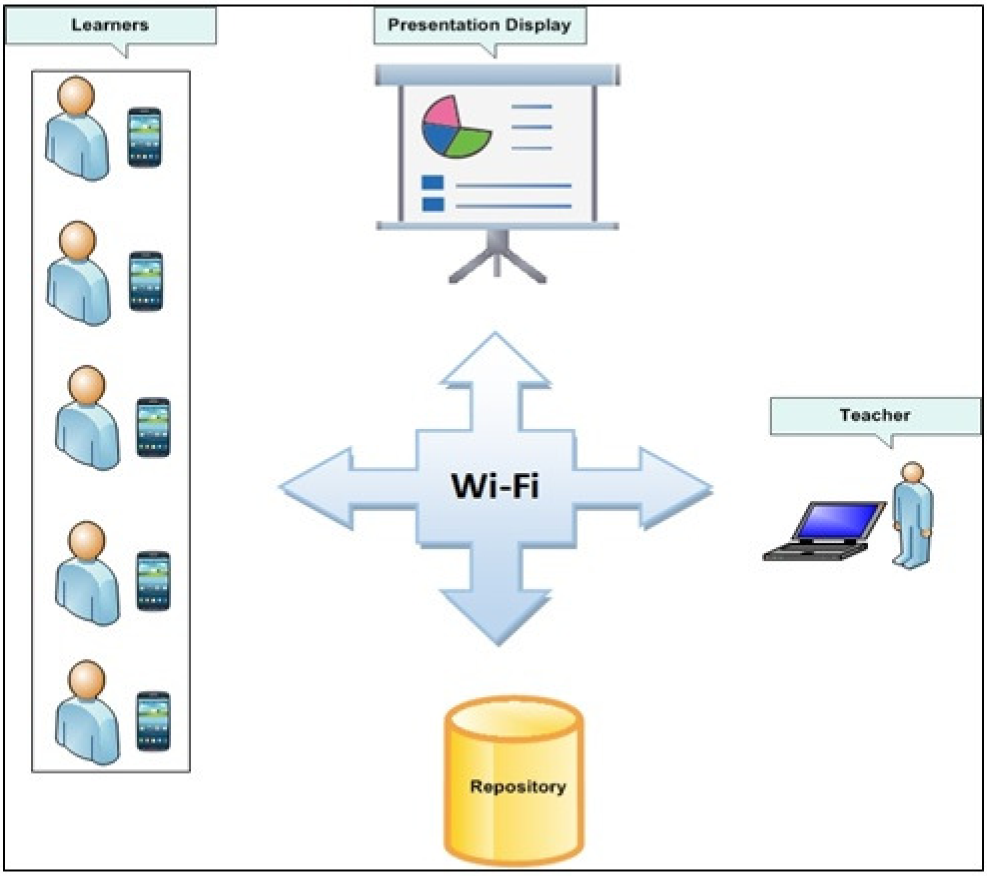


Figure 4: The main components of mobile learning in the classroom

6.1 Learning Server

The Learning Server is the central module in the architecture and co-ordinates communication and the flow of data between the different clients. The architecture takes the capacities of different mobile devices into account in order to deliver the content to a mobile device in an appropriate format and to reduce the amount of processing performed on each client (Learner, Teacher and Presentation). It consists of several components - Communication Engine, Reporting Engine, Context Model, Assessment Engine, Domain Service and Presentation Engine.

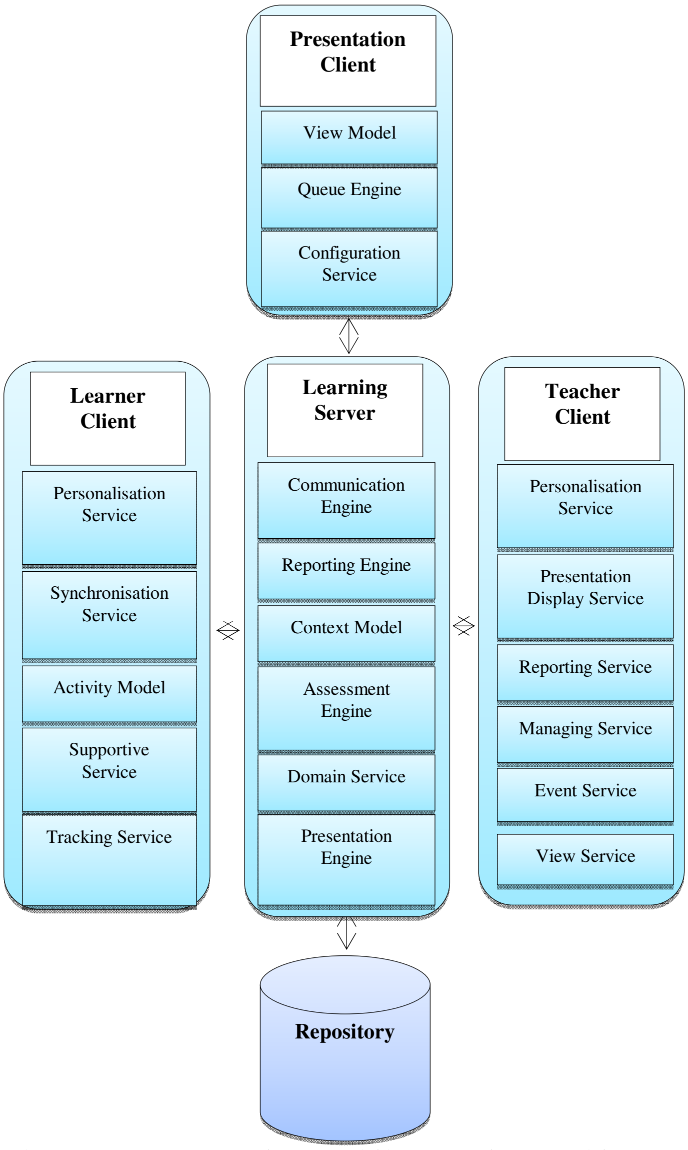


Figure 5: The Contact Instruction Mobile Learning Architecture (CIMLA)

The **Communication Engine** of the Learning Server supports and manages real-time communication between the teacher and learners in the classroom. It is responsible for receiving and delivering data between the Teacher Client and Learner Client and storing it on the Repository for asynchronous retrieval later.

The **Reporting Engine** gathers parameters from the Reporting Service of the Teacher Client in order to generate reports.

The **Context Model** describes information about learners' mobile devices such as screen resolution, processor capacity, local memory storage and the model of the mobile device.

The **Assessment Engine** is responsible for fetching the relevant prepared learning activities during a classroom activity from the Repository. It also marks the learners' multiple choice tasks and sends the results to the Supportive Service of the Learner Client via the Communication Engine.

The **Domain Service** converts the learning content from the original source files into suitable formats for different mobile devices. This conversion is dependent on the mobile devices' specifications that are obtained from the Context Model.

The **Presentation Engine** is the interface between the Teacher Client and the Presentation Client. This engine is responsible for capturing the configuration of the display elements from the Presentation Display Service and storing it in the Repository. Presentation elements include a collection of different display components used to present and visualise the content of learning activities such as image, text and chart elements. The configuration of elements includes changing the location and size of the elements on the presentation display as well as showing or hiding the elements.

6.2 Teacher Client

The components of the Teacher Client facilitate and simplify the teacher's role as leader in the classroom. These components are Personalisation Service, Presentation Display Service, Reporting Service, Management Model, Event Service and View Service.

The **Personalisation Service** notifies the teacher of the lecture venue, lecture time and the current module, based on the lecture timetable, once the teacher has logged into the system. This information is retrieved from the Repository via the Communication Engine of the Learning Server.

This **Presentation Display Service** is responsible for manipulating the presentation display elements in real time from the teacher's application. This allows the teacher to show, hide, resize and move components that display different information in the Repository, such as the results of an assessment, questions that are being asked by leaners or static content. After the manipulation is completed, the Presentation Display Service captures and delivers the configuration to the Presentation Engine of the Learning Server, which notifies the Presentation Client of the new configuration.

The **Reporting Service** captures a set of parameters from the teacher for specific reports the teacher would like to see and sends it to the Reporting Engine of the Learning Server.

The **Managing Service** provides functionality that assists the teacher in creating learning content and learning activities, such as assessments and surveys. All content created may include both text and graphics.

Once the teacher completes preparing learning content and activities, the **Event Service** sends these to the Communication Engine of the Learning Server to be stored in the Repository.

The **View Service** enables the teacher to view the results of the learning activities, such as assessments, by receiving it from the Assessment Engine.

6.3 Learner Client

The Learner Client provides several components that allow a learner to use a mobile device in the classroom during a lecture. The Learner Client is comprised of the following components: Personalisation Service, Activity Model, Tracking Service, Synchronisation Service and Supportive Service.

The **Personalisation Service** allows the learner to log into the mobile learning system. In addition to authenticating the learner, the Personalisation Service also gathers information about the features of the current mobile device being used and sends this to the Context Model of the Learning Server. Similar to the Personalisation Service of the Teacher Client, the service notifies the learner of the lecture venue, lecture time and the current module, based on the lecture timetable.

The **Synchronisation Service** pulls the latest learning activities and messages that are applicable to the learner from the Repository via the Communication Engine of Learning Server.

Once the learning activities are obtained, the **Activity Model** describes learning activities and controls the process of administering and presenting the activity on the learner's mobile device.

After the completion of an activity, the **Supportive Service** packages and sends activity information to the Assessment Engine of the Learning Server for marking and retrieves the results once the marking is complete. The Supportive Service can also email a summary of results to learners providing almost instant feedback on their progress.

The **Tracking Service** is responsible for tracking and recording a learner's interaction with a learning activity or the system as a whole. This allows the teacher to see metrics describing a learner's behaviour, by viewing information, such as time spent performing tasks, number of questions asked, etc. The tracking information is stored in the Repository for individual learners.

6.4 Presentation Client

The Presentation Client displays learning activities or assessment results on the presentation board as indicated by the teacher. Showing and sharing this data encourages immediate interaction between a teacher and the learners. The Presentation Client contains the following components: Configuration Service, Queue Engine and View Model.

The **Configuration Service** is responsible for obtaining the current configuration after the system initiates. The configuration is received from the Repository via the Presentation Engine for the current teacher.

The **Queue Engine** contains commands sent by the teacher and places them in a queue. The commands are processed one at a time, which updates the View Model.

The **View Model** determines how information received from the Learning Server should be displayed (as text, charts or otherwise).

6.5 Repository

The Repository plays an important role in this architecture because all the other modules save their settings, configurations and generated content in it. Learning content may include text data, Portable Document Format (PDF) files and graphics. The teacher may access the Repository to create or send data to learners when needed.

7. LiveLearning Mobile Learning System

LiveLearning was designed and implemented based on the CIMLA for the use of mobile devices in the classroom as a proof of concept. This section contains a discussion of the implementation of LiveLearning which was developed in four different applications: a mobile application for learners, a desktop application for a teacher, a presentation application to connect to a projector and a server application.

Server Application

The server application contains two modules, namely the learning server and the repository. It was developed in C# and SQL database. The server application has the most responsibilities and addresses the limitations of mobile devices. These limitations include processor speed, screen sizes and memory. To overcome these limitations, reduce the complexity and improve the stability of other applications, the server application plays as a middleware layer between the other applications. Three main functions were developed to be performed in the server application to address the limitations of mobile devices and stability. These functions are database, media types and communication.

Database

The server application is responsible for inserting, updating and deleting data in the repository. The Repository contains all database structures and is responsible for access, queries, storing and retrieving as well as interacting with the Learning Server.

Media Types

The learning content requires different media types, PDF files, such as text and graphics, to be stored in the Repository. Due to the mobile different platforms of LiveLearning (Windows and Android) and mobile devices limitations, the server application deals different types of media. The server application determines the quality of the graphic required based on the mobile device's features before sending it. This processing ensures that high quality graphics are stored in the database and delivered to mobile devices in a short time.

Communication

The server application provides the communication layer over Transmission Control Protocol (TCP). The Communication Engine of the Learning Server manages all procedures and interactions with low-level network programming interfaces. The communication protocol organises the communication between the server application and the rest applications of the system. This protocol tags each message with sender, receiver and content. These tags assist the server to exchange messages and data between the server and clients.

Learner Mobile Application

The learner mobile application was developed as an independent application to make it possible to use the application on a mobile device without the need for any additional hardware or software. The synchronisation method was developed to ensure that mobile devices have the latest learning activities from the server. Synchronisation occurs only when a teacher sends a task to a particular group of learners during classroom time. Once mobile device obtained the latest sent tasks, the mobile learning application will categories received learning activities according to their classifications.

Once the learner taps on the Assessments item, the mobile application navigates him or her to the list of assessment tasks. Figure 6 depicts a question with multiple answer options in a wizard. The wizard contains two buttons and text information for moving forward and backward easily.

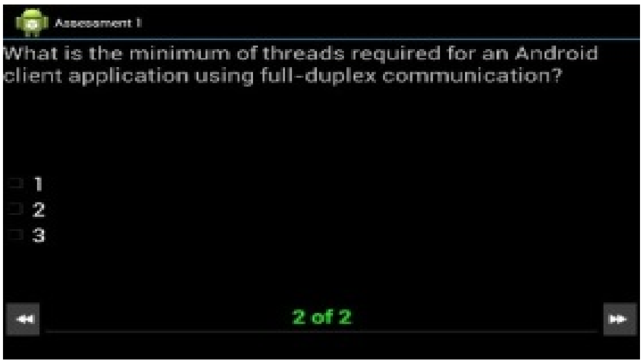


Figure 6: Wizard for multiple-choice questions

Teacher Application

The teacher is responsible for managing the classroom and the LiveLearning system during sending, receiving and presenting learning activities. The teacher application was developed on Windows platform to simplify and accomplish tasks in a simple and efficient way with minimum effort. The design and development of teacher application was based on Teacher Client of CIMLA. This application possesses functions which allow the teacher to create learning activities, send, receive and send tasks to presentation display. The teacher application provides reporting tools to generate various types of reports. These reports show learners' achievements during a certain period as well as their results. It provides an option to generate reports for a class, group of learners or an individual learner.

Presentation Display Application

The Presentation Display Application allows the display of results in more than one slide. This application was designed and implemented as an independent application connected to a data projector. The application allows the user to control presentation display application remotely from the teacher application.

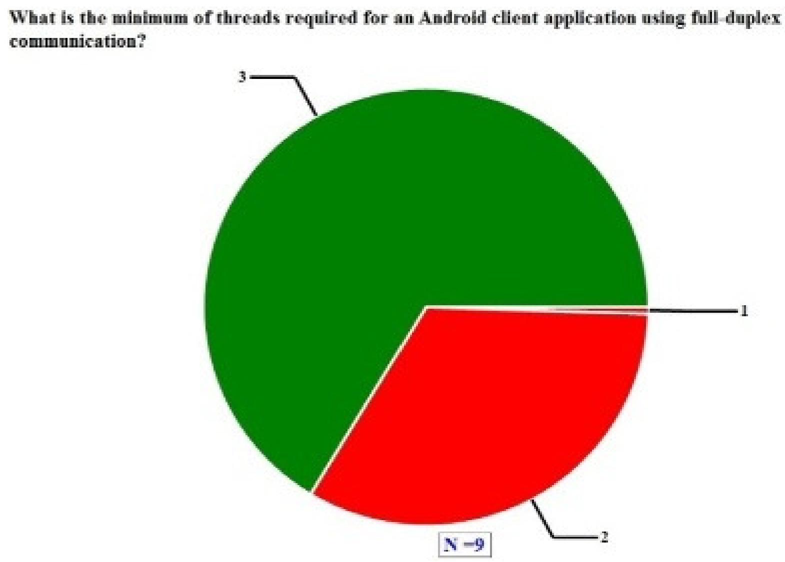


Figure 7: Pie chart tool

When the teacher clicks to display a task, the system sends the content of the task and displays it on the presentation display using specific presentation tools based on the type of data. The presentation display application displays three types of information, namely text, graphics and charts. The first tool is a text presentation tool, which displays text information in a clear font and colour. The second presentation tool is a graphics tool. This tool supports the presentation of different types of images, such as JPG and PNG. The third tool is a chart tool, which presents the results of learners' tasks. The presentation display application presents data in two different types of charts, namely pie and column or bar charts. The application displays the result of an assessment using a pie chart as it shows the percentage of correct and incorrect answers (Figure 7).

The second chart is a bar chart, used to display the values of options where each option displays in an individual column

7.1 Application Evaluation

An evaluation was conducted to determine the usability of LiveLearning in the classroom environment. The main objective of this evaluation is to show that an effective prototype could be developed based on the proposed architecture. The evaluation process begins with an overview of participants' selection, evaluation metrics, questionnaires, evaluation structure, tasks and the procedure of the evaluation.

Participants

To identify most usability problems, the evaluation requires at least 5 participants who take part in a test to identify most usability problems (Nielsen, 2010). A group of eighteen participants were chosen to evaluate the prototype. The participants were selected from the third-year learners in the Advanced Programming course in the Department of Computing Sciences at Nelson Mandela Metropolitan University. During the evaluation, the participants were divided into pairs at random. Each pair had access to LiveLearning on a mobile device.

Evaluation Metrics

To determine the usability of LiveLearning, three groups of metrics for each task were considered to measure the usability. These metrics are as follows:

- Efficiency: measured by the time taken for learners to complete each task successfully;
- Effectiveness: measurement of the task completion rate by the teacher and participating pairs; and
- User satisfaction: measured by ratings provided in the questionnaire at the end of entire evaluation by participating pairs and the teacher.

Tasks

The teacher was provided with a task list in every lesson to perform learning activities in the classroom. The following tasks illustrate the tasks selected for the teacher:

1. Send an assessment to learners
2. Send a survey to learners
3. Send a message to learners
4. When a learner sends a question, present it on the presentation display
5. Send a document to learners

The participants had to complete tasks received on their mobile devices. These tasks included the following:

1. Respond to an assessment
2. Respond to a survey
3. Send a short message

Questionnaires

After completing each the tasks, participants were provided with a session questionnaire which it used to evaluate the respondents' satisfaction with LiveLearning. The final post-intervention questionnaire was based on the Systems Usability Scale (SUS) measuring usability (Finstad, 2006),

Procedure

The evaluation began with a briefly overview of LiveLearning and procedure to the participants. Each of the participant pairs received either a Samsung Tablet 10.1 or a Samsung Galaxy S3 mobile with LiveLearning installed. The teacher received a laptop with the teacher application installed on it as well as a task list to be completed. The Wi-Fi connectivity was used in the classroom to transfer data from server to laptop and mobile devices. The participant pairs had to complete tasks on their mobile devices. Once the participant pairs completed their tasks, the teacher sent the results to the presentation display. The teacher and participants discussed the outcomes of the tasks. The participant pairs had to complete a session questionnaire after completing the lesson. The session questionnaire consisted of three categories: the most positive aspects of LiveLearning, the most negative aspects of LiveLearning and general comments or suggestions for improvement.

After completing the entire evaluation, the researcher required the participant pairs to complete a final post-intervention questionnaire to evaluate the respondents' satisfaction with LiveLearning.

7.2 Evaluation Results

Three evaluation metrics were used in the usability evaluation, namely effectiveness, efficiency and user satisfaction. These metrics used tracking data to measure the performance results and questionnaire data to identify user satisfaction.

Efficiency

The efficiency of LiveLearning was identified by measuring the time taken to complete each task. Each of the nine participant pairs received a task from the teacher via the mobile device. The prototype tracked the time spent on each task from start to finish while participants interacted with the mobile application. To measure efficiency, assessment and survey tasks were considered as the interaction time was measurable. Figure 8 outlines the time taken on the assessment task.

The assessment task had two questions where each question had multiple options. Only one of these options was correct and the rest incorrect. The participant pairs were requested to select an option for each question and the mobile application would allow the participants to choose only one option.

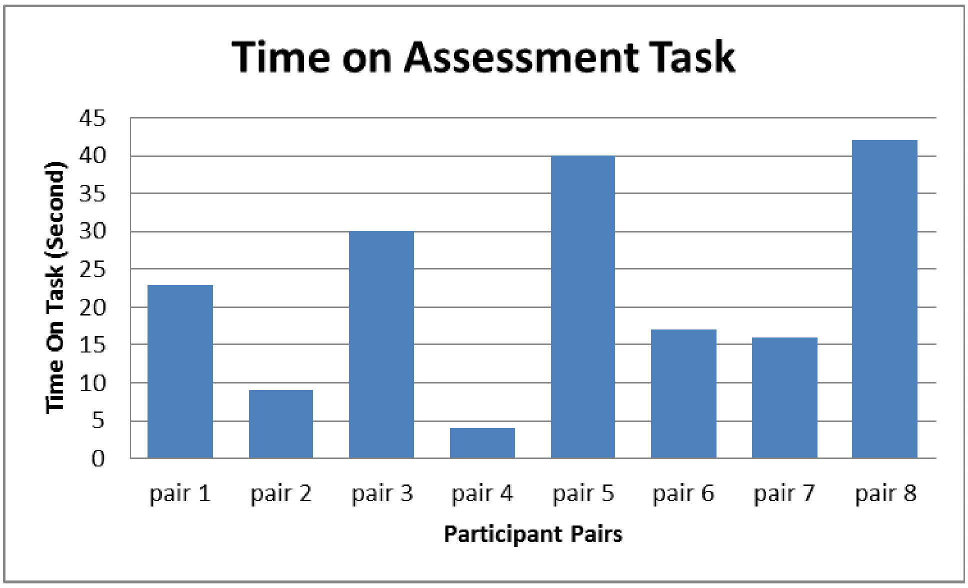


Figure 8: Time spent on assessment task across nine participant pairs

Figure 8 shows that participants spent different time to complete the same task. The longest time was 42 seconds and the shortest time was 4 seconds. However, even with the highest time spent is relational time compared with the normal answering an assessment on the paper.

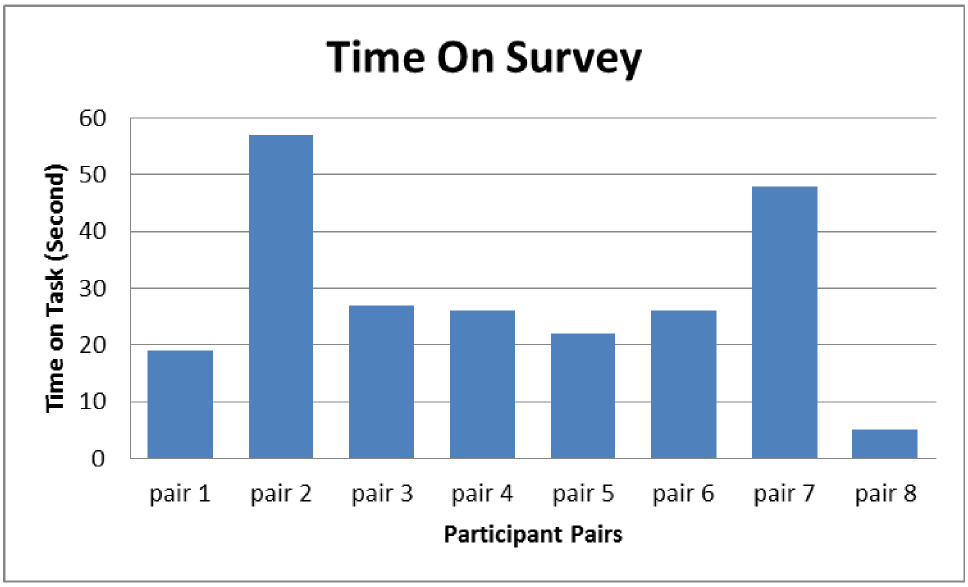


Figure 9: Time spent on survey task across nine participant pairs

Participant pairs received on their mobile devices a multi-choice survey task that had more than one correct answer per question. They reviewed the survey and answered it. Figure 9 depicts the time taken to complete the survey.

It should be noted that the longer time spent on the assessment and survey was almost the same. The longer time spent on first survey was 48 seconds, while the shorter time was 6 seconds.

Effectiveness

All tasks were sent by the teacher to participants and display the results on the presentation display successfully. The extent to which the teacher could complete the tasks provided and participants' ability to complete or review tasks successfully determined effectiveness.

Satisfactions Results

The session questionnaires and the final post-intervention were captured to identify the user satisfaction results.

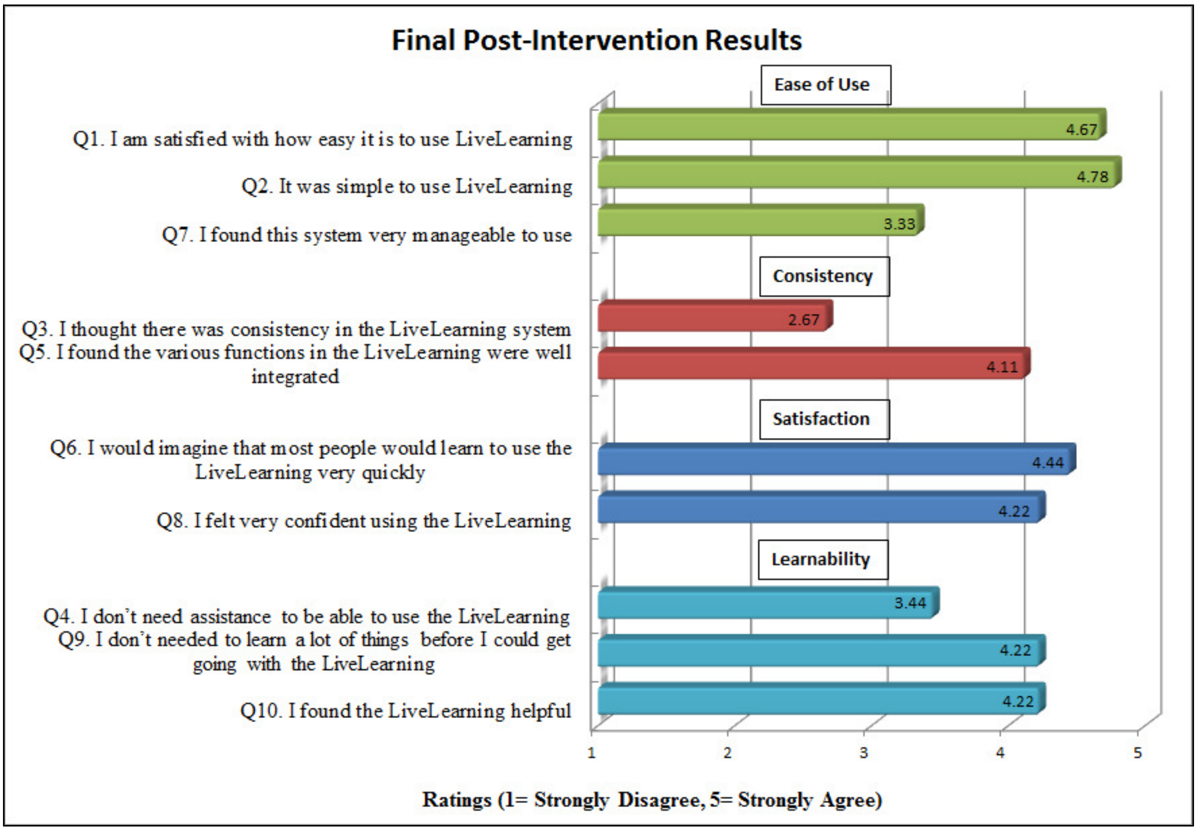


Figure 10: Final post-intervention results (n=18)

The session questionnaire contained three questions, which asked participants to list the positive aspects of the prototype, the negative aspects of the prototype and general comments. The majority of the participants responded positively, as they felt comfortable, to the use of LiveLearning in the classroom. One of the most positive common comments was that the system provided results as the participants completed tasks in real time.

The participants provided useful negative comments about LiveLearning throughout the evaluation. Some of the participants felt that the interface of the mobile application was not intuitive.

Quantitative data was collected from the final post-intervention questionnaires. This questionnaire contained 10 questions intended to measure the learners' satisfaction. These questions were adapted from and based on the SUS measuring the usability of LiveLearning (Finstad, 2006). Each question made use of a five-point Likert scale (5 strongly agree, 1 strongly disagree). Figure 10 presents the results of the 10 questions of the final post-intervention questionnaire.

The results for the questions in the final post-intervention questionnaire were positive. From Figure 10, it is noticeable that the ease of use questions received the highest ratings of the 10 satisfaction questions.

7.3 Results Discussion

The aim of the evaluation was to evaluate the usability of LiveLearning in supporting contact learning in the classroom environment. The results of the evaluation were captured to analyse the performance and user satisfaction. The efficiency results show that LiveLearning can competently support learning in interaction with the mobile learning prototype.

The metrics of effectiveness were positive, as the results indicated that the teacher completed all the tasks successfully in acceptable period of time.

Results indicate that the user satisfaction was generally positive and it illustrated the ease of use LiveLearning. This evaluation proves that the prototype as a proof of concept is usable in the classroom and the proposed architecture is functional.

8. Conclusion

In this paper, an architecture (CIMLA) was proposed which is suitable for using mobile learning in the classroom environment. The design of CIMLA was based on the components of the mobile learning in the classroom to fit the identified contact learning needs. These components are learner(s), teacher, environment, electronic content and assessment. The proposed architecture contained five modules, namely Learning Server, Teacher Client, Learner Client, Presentation Client and Repository.

The architecture allows the teacher to create the learning content and distribute it to the learners in real time based on the capacities and features of their mobile devices. It also supports communication between a teacher and learners. The architecture is not prescriptive in terms of pedagogy. It allows the teacher to decide on the teaching style to use in a lecture by providing different tools that may be used in a classroom scenario, such as questions, surveys and assessments.

A prototype, called LiveLearning, was developed as a proof of concept of CIMLA and applied in real classroom scenarios. The prototype was evaluated with learners from Nelson Mandela Metropolitan University. The results of the experiments conducted illustrates that developing a mobile learning application based on proposed architecture for the use mobile devices in the classroom is permissible.

9. REFERENCES

[1] Ah-choo, K., Mohd, A., Harji, M.B. and Kiluwasha, A., 2012. What Probability Students Say About Mobile Learning Through ProbMobile Learning Framework. In *1st International Conference on Mobile Learning, Applications, and Services*. Multimedia University: Selangor, Malaysia, pp. 1–6.

[2] Almstrum, V., Owens, B. and Adams, E., 2005. Building a Sense of History Narratives and Pathways of Women Computing Educators. *SIGCSE Bulletin*, 37(4), pp. 173–189.

[3] Alzaabi, M., Berri, J. and Zemerly, M., 2010. Web based Architecture for Mobile Learning. *International Journal for Infonomics*, 3(1), pp. 207–216.

[4] Attewell, J., 2005. *Mobile Technologies and Learning*, Technology Enhanced Learning Research Centre: London.

[5] Avalos, B., 2011. Teacher Professional Development in Teaching and Teacher Education Over Ten Years. *Teaching and Teacher Education*, 27(1), pp. 10–20.

[6] Bonanno, K., 2005. *Online learning: The Good, the Bad, and the Ugly*, Australian School Library Association: Biennial.

[7] Finstad, K., 2006. The System Usability Scale and Non-Native. *Journal of Usability Studies*, 1(4), pp. 185–188.

[8] Jung, H. and Park, S., 2006. An Architecture for Adaptive Mobile Learning. In *20th International Conference on Advanced Information Networking and Applications - Volume 1 (AINA'06)*. IEEE, pp. 219–223.

[9] Kromer, F., 2010. *SOMA - A Service-Oriented Mobile Learning Architecture*. The Vienna University of Technology: Betreuung.

[10] Magal-Royo, Montañana, I.T. and Alcalde, F.G., 2010. New Educative Methods in the Usage of Audiovisual Content in Mobiles. *Procedia - Social and Behavioral Sciences*, 2(1877), pp. 4492–4496.

[11] Mavengere, N., Ruohonen, M. and Nleya, P., 2011. *E-Learning Using Open Source Software in African Universities*, Finland: University of Tampere.

[12] Mitchell, A., Lane, B.H. and Inchingolo, P., 2006. *Mobile Game-Based Learning to Promote Decision-Making Skills a Pan European Project*, University of Trieste: Trieste, Italy.

[13] Mostakhdemin-Hosseini, A. and Tuimala, J., 2005. Mobile Learning Framework. In *IADIS International Conference Mobile Learning 2005*. Forssa: Helsinki University of Technology, pp. 203–207.

[14] Nielsen, J., 2010. 10 Usability Heuristics for User Interface Design. Available at: http://www.nngroup.com/articles/ten-usability-heuristics/ [Accessed October 26, 2013].

[15] Ojala, T. and Korhonen, J., 2008. Making Technology and Learning Click. In *Mobile Lecture Interaction*. University of Oulu: Oulu, Finland, pp. 119–124.

[16] Ozdamli, F. and Cavus, N., 2011. Basic Elements and Characteristics of Mobile Learning. *Procedia - Social and Behavioral Sciences*, 28(1877), pp. 937–942.

[17] Padiapu, R., 2008. *Towards Mobile Learning A SCORM Player for the Google Android Platform*. University of applied science: Hamburg.

[18] Park, Y., 2011. A Pedagogical Framework for Mobile Learning Categorizing Educational Applications of Mobile Technologies into Four Types. *IRRODL*, 12(2), p. 165. Available at: http://www.irrodl.org/index.php/irrodl/article/view/791/1699.

[19] Savill-smith, C., 2004. *Mobile Learning Anytime Everywhere*, Odescalchi Castle,Bracciano.

[20] Sharp, H., Taylor, J., Löber, A., Frohberg, D., Mwanza, D. and Murelli, E., 2012. *Establishing user requirements for a mobile learning environment*, Milano.

[21] Song, S.M., 2010. *E-learning : Investigating Students' Acceptance of Online Lerning in Hospitality Programs* . Iowa State University: Department of Education.

[22] Tick, A., 2006. *The Choice of eLearning or Blended Learning in Higher Education Concepts of e-Learning and Blended Learning*, Faculty of International Management and Business, Budapest Business School: Budapest.

[23] Tortosa, S., de Marcos Ortega, L., Barchino Plata, R., Jiménez Rodríguez, M. and Ramon, J., 2011. Using M-Learning on Nursing Courses to Improve Learning. *Computers, Informatics, Nursing*, 29(5), pp. 311–317.

[24] Virtič, M.P., 2012. *The Role of Internet in Education*, University of Maribor: Maribor.

[25] Vosloo, S., 2012. *UNESCO's Mobile Learning Guidelines*, UNESCO: Washington.

[26] Wolf, K. and Rummler, K., 2011. Mobile Learning with Videos in Online Communities : The example of draufhaber. *Mobile Learning in Widening Contexts: Concepts and Cases*, 19(1424), p. 13.

[27] Yarandi, M., Jahankhani, H., Dastbaz, M. and Tawil, A.R., 2011. Personalised Mobile Learning System Based on Item Response Theory. In *Advances in Computing and Technology*. London: University of East London, pp. 108–115.