QATAR UNIVERSITY

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A COMPREHENSIVE FRAMEWORK FOR DESIGN AND EVALUATION OF M-LEARNING APPLICATIONS

BY

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ABSTRACT

Human-computer interaction (HCI) communities and Mobile Learning Communities (MLCs) are well aware of the challenges that mobile devices impose when it comes to conducting proper usability and user experience evaluations for M-learning applications. So far there has been limited research on finding appropriate design and evaluation frameworks/methods that can be applied to the usability and user experience of M-learning applications. This thesis proposes a robust framework for mobile learning design and evaluation based on a mobile learning project that developed M-learning apps to train employees in the workplace. Cognitive tests (pre-test/post-test) questionnaires, usage data, and follow-up interviews were used to collect qualitative and quantitative data on learning effectiveness and learner experience with the application. The experimental results and analysis of the collected data demonstrate that the newly proposed framework is a robust framework that can help in designing an efficient, effective and user-friendly M-learning applications that are geared towards creating a better user learning experience.

This thesis is dedicated to my family.

For their endless love, support and encouragement

throughout the years.

رَبَّنَآ ءَاتِنَا فِي ٱلدُّنۡيَا حَسَنَةٗ وَفِي ٱلۡأٓخِرَةِ حَسَنَةٗ وَقِنَا عَذَابَ ٱلنَّارِ

Allahumman fa'nee bi-maa 'allam-ta-nee wa 'allim-nee maa yanfa'u-nee war zuq-nee 'ilman yanfa'u-nee

'O Allah benefit me with what you have taught me, and teach me that which will benefit me, and grant me knowledge which will benefit me.'

DECLARATION

This dissertation is the result of my own work and does not include anything, which is the outcome of work done in collaboration except where specifically indicated in the text. It has not been previously submitted, in part or whole, to any university of institution for any degree, diploma, or other qualification.

Name: Abdulahi Mohamed Hassen

Signature: _____

Date: _____

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"All the praises and thanks be to Allah, Who has guided us to this, and never could we have found guidance, were it not that Allah had guided us!"

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LIST OF ABBREVIATIONS AND ACRONYMS

APP - Application

E-Learning - Electronic Learning

ELAS – English Listening and Speaking application

FRAME - A Model for Framing Mobile Learning

M-learning - Mobile Learning

MLW - Mobile Learning In the Work Place

ISO - International Organization for Standardization

UI - User Interface

UX - User Experience

1 INTRODUCTION

Mobile learning (M-learning) is a relatively new field that is emerging rapidly in the academic world due to the growing of the cell phone and tablet industry [1]. These smart devices offer ever more innovative features and functionalities and are opening new possibilities in our daily lives. Some of these functionalities are

1. **Collaborative tools:** Mobile phones enable users to collaborate. Many applications(apps) take advantage of this medium, such as *Evernote*, *Skype*, and *WhatsApp*, to name a few. Such tools are used by people in their daily activities, meetings, and workplace to communicate and collaborate with each other.
2. **Internet**: Almost all mobile devices these days come with fast internet connections that enable unprecedented access to content on the World Wide Web.
3. **Wearable Computers**: Mobile devices are becoming more integrated with wearable devices, and they are allowing users to monitor and record their daily activities.
4. **Built-In Cameras**: Today mobile devices come with very high-quality cameras that can capture a high-quality images and videos.

These videos and images can be used to document and share information between users.

5. **Head-Mounted Displays**: Google Glass is changing the way we interact with conventional technology and environment. These devices are bringing augmented reality to our daily lives. They are opening new dimensions to the way humans view and interact with technology.

These and many more features are standard in current day smartphones. By exploiting even just the five described above, we can develop teaching and learning that is significantly more effective.

In recent years, mobile learning (M-learning) has become one of the fastest growing educational delivery means for large organizations[1]–[3] and it is expected to continue to grow at a significant rate. A recent statistics released by statista.com predicts the global M-learning market to reach about $37 billion by 2020, as shown in Figure 1 [4].

The expected increase is due to the many educators, higher education institutions, and large corporations that are looking for new ways to deliver educational content to their learners. These organizations are mainly turning to the widespread mobile devices, tablets and PDAs that are owned by most of their organizational members [5]–[7]. These devices are being used by

these organizations to deliver educational contents to a wide range of learners anywhere and anytime. For instance, some of the large organizations that offer Massive Open Online Course (MOOCs) such as Coursera, Khan Academy, Udemy, edX and Udacity are all expanding their delivery methods into the mobile platform.

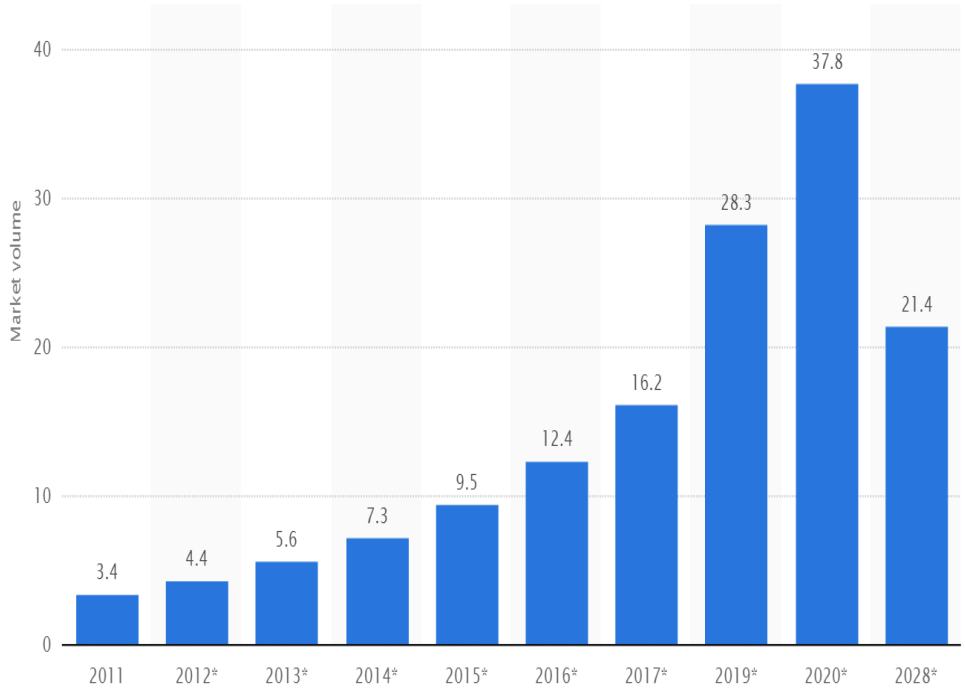


Figure 1: Global mobile education market volume from 2011 to 2020 (in billion U.S. dollars)

As shown above, the M-learning sector has firmly established its position in the global educational market.

1) What is M-learning?

M-learning is defined as “learning across multiple contexts, through social and content interactions, using personal electronic devices”[8]. In another literature [9] M-learning is defined as a function of its facets.

“MLearn = f {t, s, LE, c, IT, MM, m}” where,

- T=learning that happens with continuous time,
- s= in unconfined space,
- LE = freedom of learning environment,
- IT = content delivered, portable technology,
- MM=conglomerate of learners mental ability,
- m =parameters related to the delivery of and interaction with method}”.

Both of these definitions present M-learning as a form of e-learning that does not bound the users to a single location or time, and that merges the capabilities of the mobile devices with the concept of e-learning.

2) How does M-learning differ from e-Learning?

According to the Oxford Dictionary[10], e-learning is defined as “learning conducted via electronic media, typically on the Internet.” This definition is the broader definition but close to that of M-learning. Due to this closeness,

many confuse e-learning with M-learning. Some of the e-learning community argue that M-learning as being just an extension of e-learning, and it should be categorized under, and evaluated with, the existing rich set of heuristic methods for the evaluation of e-learning. However, there is a growing amount of evidence that indicates that this is not the case. Figure 2 and show the differences between M-learning and e-Learning in terms of interaction, device, and portability.

Figure 2: M-learning vs. e-learning devices portability

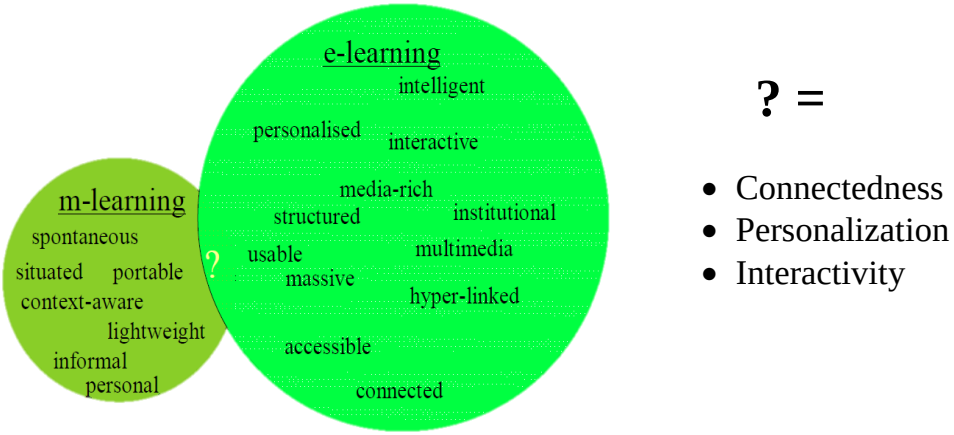


Figure 3: M-learning vs. e-learning attributes

M-leaning comes with a set of challenges that are not directly evaluated by existing e-learning heuristic evaluation methods [11]–[13]. Those challenges are the un-tetheredness of the learning content which means, the learning that is offered in M-learning is more informal and unstructured. Another significant challenge is the lack of context in the environment in M-learning, as M-learning by its nature is not confined to a specific place or ergonomics [11]–[13]. The person could be at any state: walking, jogging, waiting for a bus, in a very noisy place, etc. Thus, there is not any specific way of determining the environment of use as we usually do in the e-learning environment that offers a more tethered educational form.

Furthermore, the mobile interface brings a new set of challenges when it comes to usability evaluation. There are tens of different device sizes, shapes and media supported in mobile devices [11], which make it hard to define one set of usability evaluation metrics. These and many more challenges that are explained in [11], [14]–[16], conclude that M-learning applications cannot be evaluated solely by the existing e-learning evaluation methods

The goal of this thesis is to develop an evaluation framework that is specific to M-learning, by introducing new evaluation parameters and modifying the currently existing robust HCI evaluation methods. The proposed framework will provide M-learning designers and developers with a set of valuable

application design guidelines and evaluation methods developed specifically for mobile learning.

1.1 Background and motivation

Before examining the development of the framework, it is important to define some key terminologies that are necessary for understanding the concepts elaborated in the thesis.

- **Usability:** "Extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use."[17]. It is a fundamental concept that is used in creating applications that are usable.
- **User Experience (UX):** "*A person's perceptions and responses that result from the use and/or anticipated use of a product, system or service*."[17]. The UX is every application developer's end goal. If one can produce an app that has a decent user experience, that means they have done an excellent job in their app design.
- **Pedagogy:** As defined in Oxford Dictionary pedagogy is "*the method and practice of teaching, especially as an academic subject or*

theoretical concept". The core focus of pedagogy is how to deliver learning content to the learner.

- **Pedagogical Usability:** are a set of key criteria and considerations for improving the experience of technology-assisted learning.
- **Context:** the key circumstances and environmental settings needed for M-learning application. The context is mainly comprised of three main components. The learner, the organization and the content. These three entities make up the context of M-learning applications.

In the past two decades, a significant research has been conducted in the M-learning domain, by both the human-computer interaction (HCI) community and the educational community. In the literature, HCI community has mainly focused on solving the problems of the mobile device usability and user experience aspect of M-learning without giving too much attention on the pedagogical usability. On the other hand, the educational communities mainly focused on the pedagogical aspect of M-learning. This has resulted in somewhat disjointed frameworks for evaluating and designing M-learning applications [18], leaving a gap in the literature for people whom would want to have one robust framework that can be used for designing and evaluating their complete M-learning applications. Because M-learning is the nexus between mobile technology and learning, it is desirable to have a framework

that incorporates both the design and evaluation criteria for developing M-learning applications [5], [18].

One of the best framework found in the literature that addressed both the pedagogical and device usability is the FRAME framework [19] which is considered by many as one of the best frameworks in the M-learning evaluation and design. The FRAME framework is the motivation behind the proposed framework. In the early design, the first piloted applications of the thesis were designed using the FRAME framework alone. Two courses were piloted with about 37 students in about 5 different sessions. The two courses that were created were Presentation Skills in English and Agendas & Minutes, for administrative staff, use a blended learning approach.

The experimental group used mobile devices to access course content and practice exercises. Then a Quantitative and Qualitative data was collected that tested the overall learning experience of the learners through pre-test, post-test, questionnaire and follow-up interview.

The majority of the test subjects responded favorably to mobile learning application; however, there were also a significant number of concerns regarding the overall learning experience of the application as shown in chapter 5. With careful analysis of the collected data and literature review,

it was identified that the underlining framework as not being adequate enough for designing and evaluating M-learning applications.

Thus, from the various experiments on the M-learning usability testing and literature review, it was realized the need for a framework on which to develop better mobile learning applications. Due to the findings from the M-learning usability experiments and systematic literature reviews, the thesis proposes a new comprehensive framework that combines the pedagogical usability, user interface usability, and user experience aspects of M-learning. Furthermore, it adds a new dimension that is context. The details of the framework and what each aspect of the framework mean are further discussed in chapter 3.

The proposed framework is a comprehensive learner-centric model that balances learner needs and context with pedagogical and graphic design principles. Thus, the framework will help the M-learning application developers to have a unified robust framework that can be used from the start to end of the M-learning application development. The proposed framework will reduce the time and the cost of both the design and evaluation of M-learning application.

1.2 Research goals and questions

Many researchers have already tried on creating frameworks that can be used as a base for designing M-learning applications as discussed in chapter 2. However, a majority of those studies, do not entirely address the necessary overall criteria for designing and evaluating M-learning application. M-learning, as much as it is about the education, it is also about the technology and context of use. Therefore, it is necessary to find a way to address all of these aspects of the M-learning domain. Thus, the thesis proposes a comprehensive framework that addresses all of those aspects from a usability point of view as discussed in the previous section.

The main research questions that are addressed in this study are as follow.

RQ1: What is the currently (or existing) state of the art HCI M-learning design and evaluation frameworks and are these platforms robust enough to guide the designers in designing and evaluation of M-learning applications?

In this chapter, the thesis focuses on identifying state of the art M-learning evaluation and design frameworks and demonstrate their strengths and weaknesses. In chapter 2, the thesis proves that the existing M-learning frameworks as not been adequate enough for designing and evaluating M-learning applications. The key gaps that exist in these frameworks are discussed and compared to the newly proposed framework.

RQ2: How well does the proposed framework in this thesis perform when compared to another existing frameworks?

In this section, the thesis first test how well the proposed framework performs compared to the other existing rich set of M-learning frameworks. This comparison is done in two stages. First, in chapter 2 by theoretically comparing the different parameters and showing the major features that the new framework offers that the other framework does not. Secondly, in chapter 5 by practically comparing applications that are implemented using the FRAME model [19], a widely used standard for designing M-learning applications and a mobile learning application that represents the newly designed framework. The two models are compared in terms of the usability, user experience, and cognitive gain.

RQ3: How can we design better M-learning applications that can improve the quality of learning?

Based on the analysis of the collected data from users in the form of usability testing and evaluation in Chapter 5, a set of observations and criteria are generated. These generated criteria are some of the best practices and guidelines for designing M-learning applications: the do's and don't's of M-learning design. Finally, a comprehensive checklist is provided as a

framework in chapter 3 that will guide designers and evaluators to design applications that give a better learning experience.

Some of the significant contributions and outcomes of the thesis are as follows:

1) A new comprehensive framework that would help M-learning designers/developers to create effective and efficient mobile learning applications. This framework contains
    a) a list of guidelines and best practices for designing mobile learning applications;
    b) a list of evaluation criteria that would help M-learning creators to evaluate the effectiveness, efficiency and user experience of their systems.
2) A well designed M-learning solution which is built using the proposed framework. This solution will be deployed in the Qatar workplace specifically in Qatar Petroleum and Qatar University to help the instructors and students benefit from the M-learning experience.
    a) During the evaluation and testing of the proposed framework, it was necessary to create an M-learning application that implements the proposed framework guidelines. As part of the system architecture a content authoring tool was needed to be developed. Gladly, Moodle,

which is an open source software, was used as a backend for authoring the M-learning content. However, there were some missing modules that needed to be developed such as: new types of practices in the quiz section, new web services for downloading quizzes and glossary contents, and new web services for uploading student grades and feedback.

Thus, it was necessary to develop these components to meet the M-learning prototype application requirements. Later, it is realized that those newly developed components are highly requested components by the Moodle community. Therefore, as a way of appreciation to the open source community, this thesis will give back all of this newly developed component to the Moodle community for free. Also, a good interface design guideline for minimalistic design is given at the end of the thesis for anyone who would like to modify the Moodle system to be used as a M-learning authoring tool.

2 RELATED WORKS

This chapter discusses some of the important studies related to the proposed framework. The discussed works are the foundation to some of the concepts used in the newly proposed framework which will be explained in chapter 3.

The discussed design and evaluation papers in this chapter are categorized into three main themes. The first set of research papers focuses on the general mobile application evaluation and design. The second set of papers focuses on the pedagogical perspective of M-learning. Those papers focus mainly on creating robust frameworks for M-learning pedagogical design. They also touch on the interface and user experience aspects of the applications. Finally, the third research theme combines the previous two concepts.

2.1 The need for new mobile usability evaluation methods

A very recent and detailed mobile heuristic evaluation survey [20] was able to identify 29 different heuristic sets from the 19 publications. They identified these 19 publications as being the most valuable and informative out of the 2172 papers reviewed by doing a thorough study and filtering techniques. This paper identifies Nielsen and Molich [21] heuristics as being the most widely adopted evaluation methods for mobile usability testing. However

[14], [15], [20], [22][23] show that the classical expert-based evaluation methods fail to capture the contextual, privacy and ergonomics requirement of mobile computing. For that same reason, the discussed research works introduce new sets of heuristic methods that are customized for mobile computing and address the above missing issues. All of the above studies recommend initially using Nielson heuristics [21], followed by theirs as a supportive evaluation method. For instance, in [22] the authors were able to identify more of the usability flaws compared to the Nielson heuristics, but they still failed to identify the cosmetic problems in which Nielson heuristics identified. In [15] they have adopted the complete Neilson heuristics and added 19 extra parameters. We observe that [14], [20], [22] suggest a combination of their method with the Nielsen's, being the best way to identify usability flaws. Although, the thesis agree with the recommendations of the above research [14], [15], [20], [22], the combination of their methods with Nielsen's would still not be able to identify some of the pedagogical usability issues that might arise when designing mobile learning applications.

The same concern is raised in [18], that we need a better framework that addresses the pedagogical usability and user interface usability of M-learning applications. To address the lack of pedagogical usability the M-learning

community has proposed many M-learning frameworks, some of which are robust and well-referenced.

Multiple research works have addressed the gap of pedagogy in mobile learning. In [5], [19], [24], [25] authors discuss the importance of pedagogical usability in M-learning.

The research done by the Futurelab team [24] outlined six broad-based categories of learning activity and the fundamental issues that require attention in M-learning technological usability aspects. Two main characteristics suggested by the team are the need for collaborative tools and the importance of mediums that promote interactivity.

The FRAME model provides a holistic framework for mobile learning[19]. Koole's Venn diagram comprises the Learner aspect, Social aspect, and Device aspect, along with the interaction between these, labeled Device Usability, Interaction, and Social Technology as shown in Figure 4.

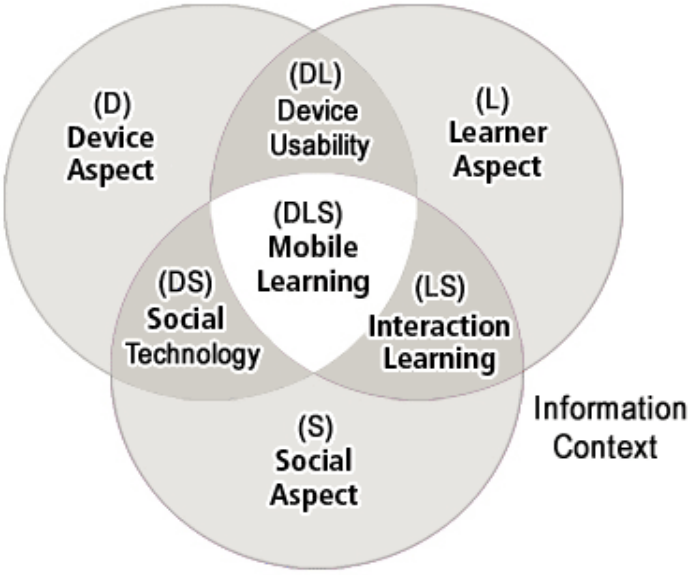


Figure 4: The FRAME Model (source[19])

Koole locates mobile learning at the intersection of these six considerations. This framework touches on the different aspects of the M-learning. However, it still somewhat very generic. For instance, there is no way of knowing how to achieve the user experience aspects of the M-learning application. What specific things we need to evaluate to know the success/failure of our applications. Also, the list of criteria for the design and evaluation are very limited. Nevertheless, it is one of the closest frameworks to the proposed framework for the thesis. And it is the framework that was used as a guideline for designing the early stage of the M-learning application.

2.2 Gaps in related research

There is a significant amount of research being conducted to find better M-learning design and evaluation framework that combine the pedagogical usability and user interface usability [5], [18], [19], [24], [25]. For instance, [18] proposes a new framework that is compiled from 25 selected articles out of the 1085 articles reviewed on mobile and mobile learning usability.

The framework proposed in [18] suggests dividing the M-learning usability into two sub-categories namely pedagogical usability and user interface usability. Then the framework further divides the pedagogical usability into five subcategories and the user interface usability into six major subcategories, each of which contains a total of 28 and 30 sub-criteria respectively. In consequence, the framework identified a total of 58 criteria that were drawn from the 25 identified M-learning evaluation articles, which can be used to evaluate M-learning applications. The framework does a great a job in evaluating M-learning applications compared to any of the previously discussed methods; however, a weakness of the framework is the lack of context of use in the designed M-learning application. The framework blindly evaluates all kind of M-learning applications with the same criteria and hence produces many false-positive usability flaws.

As explained in [16] , M-learning applications can be divided into four major categories as high/low transactional socialized M-learning, high/low transactional individualized. Therefore, it is important to know the context of the designed M-learning application. Even in early days, the HCI and M-learning community clearly new the importance of context in mobile app usability evaluation [26][23].

It is hard to ignore this important concept of context in M-learning as well, as it is an entirely different from the desktop applications. Therefore by identifying the contextual usability such as the type of the learner and organization, it will be easier to understand the requirements of the pedagogical usability and user interface usability and determine which usability criteria should be applied in which context. That way it would be clear where to apply specific usability evaluation criteria.

In summary, this chapter discussed the various related literature to the proposed framework. And in the discussed literature it is very clear that we need improved frameworks that encompass the three core components that make up the M-learning environment; the contextual, pedagogical and user interface usability.

Such a comprehensive framework would allow the M-learning application developers to minimize the number of needed frameworks when designing

and evaluating M-learning applications. It will also minimize the cost of designing and evaluating M-learning applications.

3 PROPOSED FRAMEWORK

As explained in the related works chapter, to the best of our knowledge, there is no framework available that can be used to design/evaluate M-learning applications usability without either ignoring some important criteria or producing false-positive usability flaws. The proposed framework builds on the strengths of all of the discussed frameworks and heuristic methods in the related work in order to offer a more comprehensive framework that can be used for both the design and evaluation of M-learning applications.

While developing any application, it is crucial to consider the context of use and usability [27]. In a recent ISO standards publication [27], usability is categorized into four general stages as shown in Figure 5. Because each phase depends on the other, they should go hand in hand to achieve a better user experience.

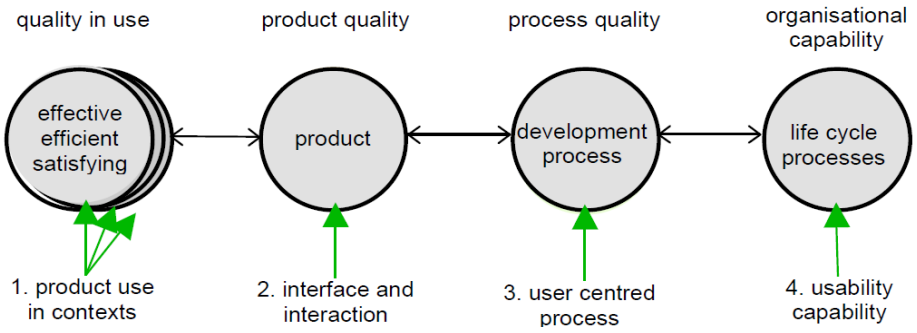


Figure 5: TYPES OF STANDARD FOR HCI (source from [27])

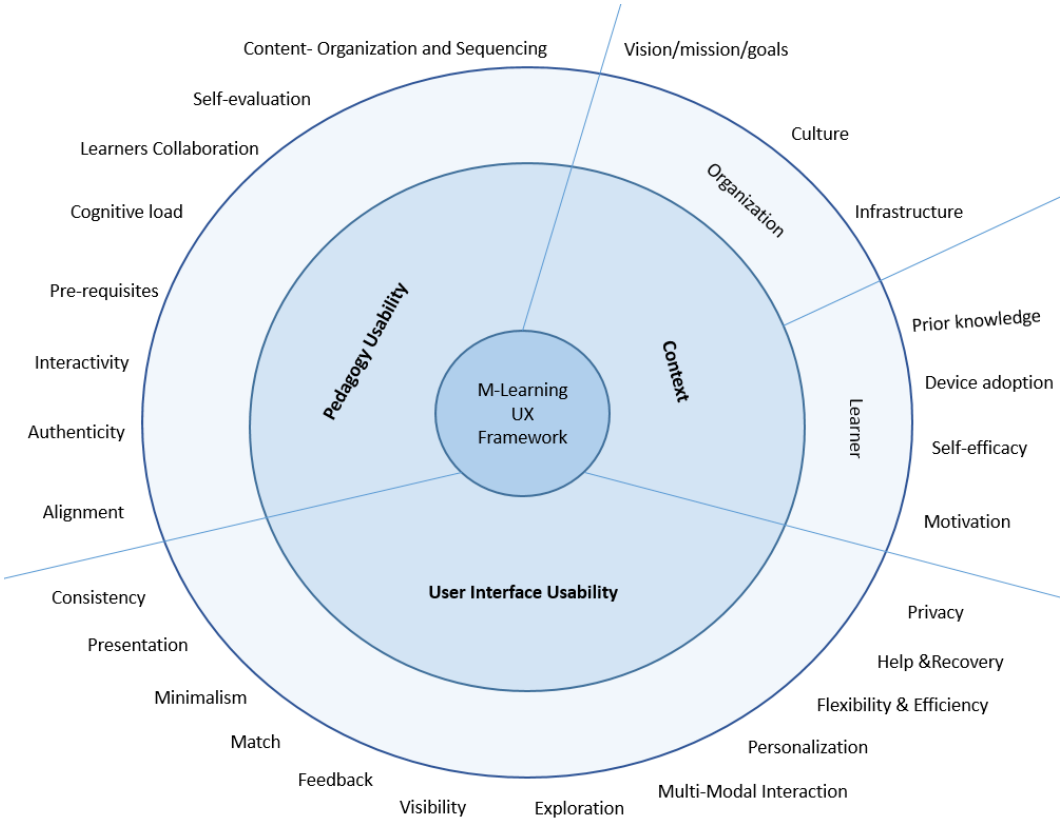


Figure 6: Proposed M-learning Framework

The proposed framework follows similar principle but in a more focused manner. The proposed framework has three main categories named pedagogical usability, user interface usability and context of use as shown in Figure 6. Each of these categories is further divided into subcategories and criteria that specifically help in designing and evaluating M-learning applications. Following sections discuss the details of the listed criteria in Figure 6.

3.1 User Interface Usability

User interface usability is an important aspect of any application development. There are many guidelines and standards such as the *ISO 9241 Parts 12-17* [17], which describe a detail list of user interface usability standards. However, those standards are very general, and they need to be customized for the M-learning.

In this section, the general principles of ISO 9241 standards and the Nielsen's 10 are used to create a group of criteria that are tailored more specifically to the M-learning context.

Nielsen's ten heuristics are considered to be very general principles for usability design guidelines[18], [28], [29]. Thus, it is imperative to refer to them, either directly or indirectly when discussing software design principles. That is why in the proposed framework most of the identified criteria mirror the Jakob Nielsen heuristics[21]. However, they are taken a level up to be from general design principles to very specific criteria that are tailored to the M-learning usability context.

1. Consistency

Five years ago if you asked application designers and developers about consistency, they would unanimously tell you to follow some logical

mapping of your icons and other application artifacts, and to follow the standards of the platform you are working on. Also to keep a consistent look and feel in the overall application. However, these concepts are being challenged due to the sudden growth of applications in the market. There are about 1.2+ million applications in the iTunes app store and 1.43+ million in Google play as of January 2015 [30]. This massive selection of applications creates strong competition in the market. One of the consequences of the competition is every application trying to come up with their own design choice and guidelines.

Most if not all, applications are following their custom made styles, navigations, buttons, menus, mapping, etc. And this confuses users when they move from one application to the other which in turn affects the learnability of the applications. Thus, it is hard to devise an accurate means to measure consistency in mobile.

To fix the issue of consistency without affecting the creativity of application designers, some parts of the consistency requirements needs to be relaxed. This way the M-learning application designers can create a visually compelling application that is easy to learn and use. The issue of consistency can be divided into two categories.

A. **Critical criteria that are good to have:** There are some important platform standards that any application designer needs to follow to have easily learnable apps. For instance, the platform Patterns; Building blocks should be applied to an extent, to keep the application consistency with other apps. Here are some of the major ones we believe should be kept consistent with other applications on the same platform

   a. **Logical Mapping**: The application icons and other artifacts should be grouped logically. The mapping of the logically connected things such as tasks and domain objects should stay consistent over the entire application.

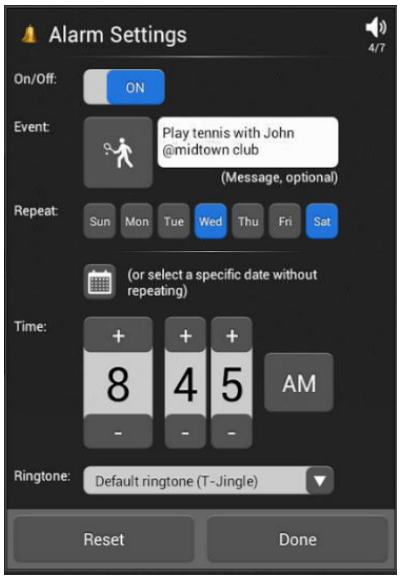


Figure 7: Logically grouped

In Figure 7 we can see that the days of the week are put together at the same place. Also, the alarm icon seems logical as it uses the bell icon that gives the affordance of an alarm. Further guidelines of how to logically map things are discussed in the platform documentations.

b. **Device**: Mobile applications can run on the different types of devices that have different screen sizes as shown in Figure 8. So, for the platform to render the application, properly one needs to follow the standard guidelines given by the platform they are developing for.

Figure 8: Different device types and screen sizes

c. **Patterns**: Makes the application more predictable. So following the guidelines of the platform might be a solution. For instance, in Android the concept of swiping, widgets,

navigation, gesture, etc. have all precise patterns that the Android developer site provides[31].

Also, there are different patterns used when the screen size changes to take advantage of the extra screen space. Following this pattern ensures the developed application will be more consistent on all kind of devices and predictable and hence easily learnable by the users.

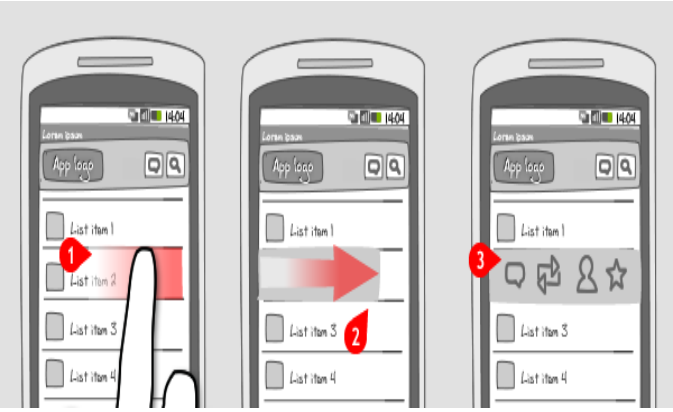


Figure 9: Android swipe pattern (source [47])

B. Criteria that can be relax

1. **Style**: The style of the application could be relaxed. We do not have to be strictly following the style of the platform. So the designer could still decide Themes, Typography, Colors, Writing Styles, etc. of the application and be more creative with them. However, they should always put in mind the pedagogical and contextual usability.

2. **Building blocks**: Tabs, List, Grid, Scrolling, Buttons, Textfields, etc. that are shown in Figure 10 can all be left to the application designer.

A creative designer could make the application more appealing by coming up with icons that suit their application. For instance instead of using the regular platform buttons for a children's educational app, one could decide to use some animated or cartoonish icons that would attract the kids.

Figure 10: Different building blocks of Android platform

2. Multi-Modal Interaction

Mobile devices come with many different input mechanisms like the camera, built-in microphone, touch sensors and so on. Making full use of those input mechanisms is the key to creating a successful M-learning application.

As an input mechanism, the built-in microphone can be used to capture learners speech, make the learner write either using the keyboard or point devices or let learners use their camera to interact with their environment by implementing augmented reality, tag readers, video recording, etc. features. Furthermore, the output that is given back to the learner could be in the form of audio, video, images, vibrations and so on. This way the learners/users of the application will be encouraged to use all of their sensory organs.

The other advantage of the multimodality aspect is to make applications accessible. Learners with disabilities would be able to use the developed application if the concept of multimodality is applied correctly. As a result, the application can attract a larger audience.

3. Presentation

The content that is given to the user should be concise. Due to the small size of the mobile phone, it is not advised to put too much content on a single screen. Also, the clarity in the case of the images used, the text colors, font sizes, and backgrounds should be contrasting enough to be more readable to the user.

The best way to achieve the desired effect is by following the guidelines given by the different platforms such as Android, iOS, Windows and so on. For instance, the Android platform lets you define different image sizes for

different kinds of devices. This way it ensures that the rendering is done correctly when the size of the device changes. Also, the same goes for the size of the text, buttons, and other UI components.

4. Match between system and the real world

The key idea here is the language used to in the app should be the language and terminologies used in the real world. This real world is bound to the learner's real world that is their current working environment. Every learner is familiar with his/her domain. If the application is to teach undergraduate students, then use terminologies that they are familiar with. However, if the application is used in the workplace, then it needs to be designed with the terminologies and concepts utilized in the workplace in mind. This will ensure that the learners understand the different part of the application easily, and hence increase the learnability of the application. Figure 11, for instance, is a medical application; thus, the terminologies used are medical terminologies.

Figure 11: Sample medical application menu

5. Aesthetically appealing and minimalistic design

The look and feel of the application should be pleasing to the eye and should follow some of the guidelines of the platform that is being used. The application designer needs to spend a significant amount of time in the aesthetic design of the application. The first impression is everything for mobile applications for it to succeed or fail. A report by Reuters indicated about 26% of the applications downloaded in 2010 were uninstalled after the users used them for once[32]. The first impression makes the user want to explore more or just leave the application and never open it again [33]. However, if the learning application is designed with the enjoyable look and feels and typographies, then the learner will be motivated to explore more about the content of the application.

On the contrary, it is important not to over- design the application look and feel. If the designer puts too many artistic themes, background colors, fancy text, buttons and so on which make the application look excellent from the creative point of view but limits the usability, then these aesthetic components would eventually cause a negative effect on both the performance and usability of the application.

Therefore, it is necessary to find the balance between too many aesthetic designs versus a dull looking design. One has to use the possible minimal design that is aesthetically appealing for the learner. Avoiding too many graphics that take away the learners attention from the content is crucial. Always it is necessary to keep the learners attention on the content and not on the look and feel of the application. The core purpose of the entire application design should be to facilitate the delivery of the learning content and not compete with the content.

6. Feedback

Feedback is critical in M-learning applications. When learners make mistakes, the application should give appropriate feedback to them. The learner should be able to get alerts when their answer is correct or incorrect. Also, feedback should be carefully designed, as learners can easy get discouraged with kind of feedback they receive. For instance in the initial test

of the MLW application that is shown in section 4.7, the majority of the test subjects complained about a buzzer that was created as a feedback to indicate wrong answers. A sample comment from a test subject was “It was loud and discouraging”. However, on the second pilot of the application, when the buzzer was changed to a less annoying voice with a different kind of feedback that says correct/wrong. This new feedback increased the students’ satisfaction level to a greater extent.

In the second pilot after fixing the buzzer, some learners still had some concerns regarding the feedback. This time, it was related to the lack of diversity and personalization in the feedback. The learners wanted to get more than correct and incorrect feedback. Thus, for the third pilot a more elaborative text and audio feedback with a variety of different accents and gender was added to the practice feedback. From the feedback collected, it is observed that the level of student satisfaction regarding the application comments increased to a much greater level than the previous two pilots. The final application pilot which had about 57 learners, only a single learner made a comment about the feedback, and he requested to add a younger voice.

From the conducted experiments that are discussed in detail in section 5.1.6, we can clearly see the importance of feedback and how much little things

such as diversity in feedback text, audio and feedback personalization affect the learner's satisfaction.

Hence, when designing M-learning applications one needs to care about the feedback given to the learner. It is crucial to provide feedback that is diverse, constructive and encouraging. That way the designed application will result in learners with higher motivation and satisfaction.

7. Visibility of system status

This concept applies to all kinds of application. When the system is busy or doing something, either in the background or foreground, the learner should be informed about what is happening with the application. They learner should be able to see some kind of system feedback that shows what is going on at the moment and what the current status of the system is. If this is not done properly, then it can easily discourage the learners from using the application.

8. Exploration

M-learning by its nature is unstructured and learner-based. So, the application should allow the learners to learn what they want and when they want, by giving them easy navigation that allows skipping to the content they would like to study or practice. Few restriction should be applied to the things they can access at any given time. The learner should have freedom and control

over the system. The content designer should avoid the dependency of lessons/practices as much as possible to make this concept effective.

9. Personalization

Learners should have a means to follow their personal learning track, and they should also be able to customize the application to their needs. Some learners might need a bigger font size, some might want only text feedback, and others might want an audio feedback or both. So the personalization here is both the customization they can do on the application and the way they want to learn to suit their personal needs.

10. Flexibility and Efficiency of use

Regarding flexibility, the users should be able to use the application in different scenarios such as when they are online as well as offline. If the learner wants to download the content they should have the option to do so. Also, the concept of multimodality helps in creating a more flexible application.

The second important criterion is the efficiency of the application in using the device resources. Mobile phones have a very limited resource such as memory, CPU, and battery. Therefore, application develops need to be very conservative with those resources. An example of inefficient application design can be opening multiple services that are not needed at that moment

such as database connections, internet connections, Bluetooth, Wi-Fi, video, audio, etc. all of them which use the memory and battery of the learner device. Therefore, developers need to be cautious with those resources and run tools such as view dumber in Android or 3D view hierarchy inspection in IOS to remove any resource leaks in the application. Also, a detailed code inspection is needed to be made before giving the app to the learners.

11. Help learners recognize, diagnose, and recover from error

When something goes wrong, such as application not responding, unable to do some specific task and so on, the learner should have the means to communicate back those errors to the application developers. Also, a help documentation should be made available inside the applicant that guides the user on how to use the application and how to recover from known errors. When simple mistakes happen such users entering text instead of a number or pressing the wrong button, then the learner needs to receive a proper feedback that tells them what exactly they need to do, like telling them to enter a number instead of a text.

And when a major error happens such as the application crashing then the learners needs to be able to recover from the specified error either through the help of the application or through the application developers [34].

12. Protect learner and organization Privacy

Privacy is a critical issue that needs to be addressed when designing M-learning applications. Many organizations learning materials have a proprietary contents. If such material is leaked, it might cost lots of money to the organization. Thus, the application developer needs to make sure that the applications are well secured by applying security techniques such as password encryption, use of secured ports to exchange data and so on. Also, the majority of the learners do not want to share their private information such as their grades, conversations with their instructors and peers. Therefore, the application developer needs to make sure that the proper privacy environment is assured/implemented before deploying the applications.

3.2 Pedagogical Usability

In pedagogical usability, we mainly focus on the set of key criteria and considerations that we can use to deliver the lessons through the mobile device. A great deal of research has been done into the pedagogical frameworks of M-learning by the M-learning educational community. Many of the proposed frameworks suggest different kinds of criteria. In this M-learning framework, a list of the most important criteria is compiled from a large set of M-learning pedagogical frameworks. The compiled criteria are

then tested on real users and modified depending on the feedback and comments received from the user testing.

Some of the criteria that were identified to be the most crucial ones are:

1. Authenticity

The main idea of authenticity is to make the delivered content relevant and up to date. It ‘‘lies in the learner-perceived relations between the practices they are carrying out and the use value of these practices’’[35]. This means the learners need to see the immediate value of the content there are studying in their current work environment. If learners do not see that whatever they are studying could influence their performance in their professional lives, then the motivation to complete the lessons would decrease drastically. So it is up to the M-learning content developer to focus on the content’s authenticity to create a better learning experience. It's also important when running pedagogical usability evaluation to evaluate how much of the content presented are used in the learner’s current working environment.

2. Learners Collaboration

It is encouraged for learners to collaborate for them to develop critical thinking skills. It helps learners to have better self-esteem and communication skills. Tools such as chat rooms, collaborative whiteboards,

and discussion forums are good mediums to create learner collaboration. This helps to enhance student satisfaction and learning experience.

3. Interactivity

Content should be designed in a way that is more interactive. It is important to know that the application interactivity in M-learning depends greatly on the content. If the presented content is rigid and non-interactive, then that look and feel of the application would not play a big role in the overall learners learning experience. So, the content interactivity and application interactivity should go hand in hand. Information flow should be bi-directional between the learners and the M-learning application. Learners should be able to personalize their learning, able to interact with the content in a more natural way. This interactivity gives learners in-depth learning experience [36].

4. Self-evaluation

The best person to judge how much one knows or learned is oneself. Creating self-assessing practices is a good way to help the learners to set their own goals in order to help them improve their weaknesses, and help them recognize their strength.

For instance, in the application discussed in section 4.7, the students were given self-assessment exercises that allowed them to record video of them

giving presentations. Then the learners were given a checklist to assess their own presentation. This way they could see how well they did in the presentation and in what areas they needed to improve. In another pilot, the same kind of self-assessment was given to the learners where they use the application to record themselves operating on heavy machinery. Later each learner evaluated themselves if they followed the correct safety procedures of the machine.

At the evaluation of the two applications, when learners were asked about the self-assessment feature's importance, they all responded positively saying they liked it, and it helped them to recognize the weaknesses and strength. That is why this thesis believes this criterion to be a good practice that offers the learners a means to assess themselves.

5. Course organization and Sequence

The order and organization of learning activities affect the way information is processed and retained[37]. The main focus here is how we logically organize the presented content in an appropriate sequence. For instance, if we are presenting a course we could divide the content into units/chapters/modules as the first level. Then we can further divide this module into submodules/sections. It is always a good idea to arrange the content in a way that mirrors the real world of the learner. Learners are used

to a particular structure of content; therefore, it is always a good idea to follow the structure they are familiar with.

In the application designed for this thesis, each course content was divided into units. These units were further divided into learning screens and practice. This way it was very easy for the students to understand the content organization.

6. Pre-requisites

This is pretty much self-explanatory. It is important to know the level of our learners. And if the presented content expects a pre-knowledge that needs mastering, then this pre-knowledge need to be made available for the learner or the learner should be informed about the existence of that pre-required knowledge that they need to master before taking this content.

7. Cognitive load

In the late 1980's John Sweller proposed the theory of cognitive load [38]. Since then it has been applied to different fields including human-computer interaction. This theory recognizes the limited working memory of the human mind and recommends that content to be designed accordingly. The mobile phone by its nature has a smaller screen; therefore, it somewhat drives this concept implicitly. For instance, as long as we do not overload the screen,

present a single idea per-screen and avoid scrolled content then we will be presenting content that is somewhat digestible.

8. Alignment

Alignment is the direct correlation between course goals, lesson objectives, learning activities, materials/resources that support success in demonstrating accomplishment of those objectives [39].

If a course teaching is aligned, it means that the stated course goals and learning objectives are in harmony with the activities and assessments given to students. Course alignment helps ensure that both content designer and the learner to have accurate expectations about what will be taught in presented content. This way the learners can be assessed on the stated course goals and objectives[40].

3.3 Context

The context of use is the most overlooked concept in M-learning; even though, it should be the primary criteria that need to be considered at the early stage of the application design. In software engineering, the requirement gathering is all about the stakeholders needs. Therefore, in the requirement gathering the organizations and their customers/employees are surveyed to

discover their needs and requirements. The same strategy needs to be followed when designing M-learning applications.

In the proposed framework, the context is divided into two main categories named learners context and organizational context.

1. Learner-context

If a user-centered application needs to be designed then, it is necessary to do an in depth users/learners study. It is important to know the learner's capabilities, the level of education or prior knowledge they have, age, culture, Self-efficacy and so on. All of this criteria contribute to the design choices that need to be made in the M-learning application development. If this surveying is done correctly, then it will help the application designer to design applications that are targeted to a particular audience and hence will result in a better user learning experience.

2. Organizational context

These are the stakeholders who drive the project such as the sponsors, managers, those purchasing the application and so on. Therefore, it is necessary to study the needs, culture and expectations of those stakeholders.

A simple example that is learned from the piloting of the thesis application was the communication/chatting component that was thought to be a good

way of helping students communicate with one another. This communication component took a long time and effort to be developed; however, due to the culture of the organization/learners, it was later recommended to be removed because of the female/male segregation. Therefore, it is very crucial to do a good organizational study and ask the stakeholders who, where, and when the application is going to be used, for what reason and, what are they expecting to get out of the designed application. In short, more direct communication should be made with the involved organization to make sure the application meets their requirements and expectations.

3.4 User Experience (UX) Goals

The user experience goals are those criteria that would decide the success or failure of the designed M-learning application after usage. These criteria are the emotions and attitudes of the learners towards the M-learning application after using it for some time. Most of the time the application designer have control over the usability of the application; however, the designer has little or no control over the user experience of the application. Thus, as many researchers/developers argue, it is very difficult to design the user experience of the application [41], [42]. There are many criteria that are covered under the UX design, but this thesis will mainly focus on six criteria that are

believed to be the most important criteria for measuring the user experience of M-learning applications [43].

These criteria will allow M-learning application designers to measure the success of their application by studying the user's responses towards the application. And depending on those user responses the application designer can improve the overall UX of their M-learning applications.

Below are the six UX goals that every M-learning application designer needs to strive for to achieve a better M-learning learner experience.

1. Motivational:

The key to learner's motivation is to gain their attention as Gagne explained in his classical publication of the conditions of learning[44]. Unless the learner is motivated, they will not spend their time using the application. To motivate learners, the application content should be created in an attractive way. For instance, the audio/text feedback of the practice exercises should be constructive and encouraging.

For content to be motivational, complex concepts and lessons should be created in a way that encourages the learners to understand them easily. Clear, concrete objectives should be presented to initiate expectancy and motivate the learner to attend to the content. Making learners recall their prior

learning also encourages the learner to associate new information with prior experiences and knowledge, thus stimulating the learning motivation.

2. Satisfying

Content clarity, interface simplicity, and minimalistic design are the key to achieving learners' satisfaction. Navigation should be made simple and straight forward. Unnecessary forms and application components should be removed. The content presented should also be clear and precise to ensure a satisfying learner experience.

3. Helps learners learn new skills

If the content delivered to the learner is something they already know or something they would not use in their current environment, then the probability of them ignoring the content of the application is high. Therefore, as explained in section 3.3 in the context part of the framework, the application designers need to study the learner's background before designing the application content. The content designers should not repeat what learners get from their class. Instead, the M-learning application should act as a provision of extra support materials that help the learners' learn new skills.

4. Engaging / Immersive

The M-learning interface design, as well as the content, should be fun and enjoyable if one wants to achieve immersion/engagement in their application. The images, videos and any other multimedia used in the application should be displayed in a pleasant manner.

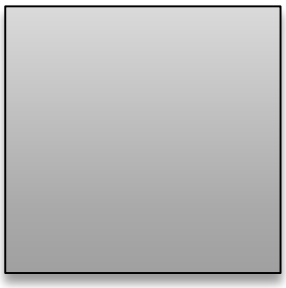
The following are three simple techniques that could be applied to boost this concept.

a) Use visuals whenever possible instead of text.

It is important to differentiate these visuals from the other graphical components of the application like the buttons, styles and so on that are discussed in the minimalistic criteria of the interface usability section.

The visuals suggested in this section are the visuals that are directly related to the content. Mike Parkinson, a graphics designer expert and founder of Billion Dollar Graphics (BDG) explains how we process visuals 60,000 times faster than text[45].

A simple example of this concept is shown in Figure 12.



"A plane figure with four straight sides and four right angles, especially one with unequal adjacent sides, in contrast to a square. "

Figure 12: Description of rectangle using Visual vs. Text

It very clear that it would take a lot longer for someone to process the text than seeing the visual. Therefore, it a good practice in M-learning to use visuals wherever necessary.

b) Create game-like exercise and interactive lessons.

Games are the best way to create an engaging and more immersive application. When created correctly they are one of the most powerful tools for teaching complex contents and still make it fun for the learner[46].

c) Use new technologies that are more exciting to the learner.

It is necessary to stay up to date and provide learners with the latest technologies. The more one integrates new technologies into their M-learning application, the easier it becomes to draw the learner's attention to content. For instance, as of now the use Virtual/Augmented Reality can be considered as an example of the use of new and exciting technology.

5. Aesthetically pleasing

Applications that are not nicely designed do not get good ratings. It is the focal point of attracting learners in using the application. Therefore, the application designers need to design the application aesthetically pleasing without forgetting the minimalistic design.

6. Support learners' creativity

Let the learners contribute to the content. Due to the many interfaces that are provided by the mobile phone, the learner should be able to be part of the M-learning environment. Learners should not be only receivers but also the content creators.

7. Emotionally gives learners sense of accomplishment

After the learners use the application, they should feel more knowledgeable than they were before. Also, when they achieve something like finish a lesson or exercise, they should receive a more encouraging and positive feedback that shows their progress.

In summary, this chapter discussed the main concepts of the proposed framework and showed their importance in designing mobile learning applications. It also explained what each of the specified criteria means and how they can be incorporated into the design process of M-learning

applications. Furthermore, the chapter described the design guidelines that one needs to follow in order to achieve a good mobile learning user experience.

In the next chapter, a prototype sample application that applies the proposed framework concepts is developed. The interface design, system architecture and design choices of the application are all discussed in details.

4 PROTOTYPE IMPLEMENTATION

To test the usability, and user experience of the proposed framework, a prototype application is developed under a project called Mobile Learning at the Workplace (MLW). The implemented application followed all of the proposed framework criteria discussed in Chapter 3. The following sections discuss the general functional, nonfunctional and design of the implemented M-learning system. However, it is necessary to know that this chapter of the thesis will not show the documentation of the details of the functional and non-functional requirements of the application as that is not the aim of the thesis.

Never the less, to explain the implemented M-learning system and its main components, Software description, designed the overall system architecture, the use cases, hardware used are discussed in brief. Then, the majority of the chapter focusses on the designed applications high fidelity prototype interfaces of both the learner's M-learning app and instructor authoring tools applications.

4.1 Software Description

The MLW application developed in this work is intended to train Qatar employees at Qatar Petroleum (QP) and students at Qatar University in English so they can become more effective when communicating in the workplace. The M-learning system demonstrates a novel approach toward understanding how we can better design M-learning applications using comprehensive frameworks that are proven to be effective and efficient. The project uses two frameworks. One which is an already existing M-learning framework called FRAME[19] and another one that is proposed in the thesis chapter 3.

4.2 Project Significance

The developed M-learning System besides being used as a way to prove the effectiveness of the proposed framework, it is also a complete M-learning solution that is going to be used by Qatar University (QU) and Qatar Petroleum (QP) members to help them deliver mobile learning content to their learners.

The fact that the developed M-learning application can be accessed anywhere and anytime provides a highly flexible and simple environment for the trainees/students to study in their spare time, thus being more efficient.

The designed M-learning system also contains a large variety of mediums for learners to learn from such as text, images, videos, games, chatting platform and more. Also, instructors will be able to create a more interactive content that can reach large audiences easily through the interactive authoring tool that is integrated into the M-learning application.

Therefore, the designed M-learning system is a complete solution that is expected to help both the learners and instructors of QU and QP to have a more flexible learning/teaching environment. Furthermore, the project provides a system that proves the robustness of the proposed framework.

4.3 Project Composition

The Project is composed of 3 different components as shown in Figure 13.

Figure 13: Solution Overview

1) **The Client Application** –A client application that allows the learners to learn anywhere anytime by downloading the learning content from the server.
2) **The Authoring Tools** – Which helps instructor create lessons. This authoring tool is a flexible authoring tool that allows the instructors to create interactive M-learning courses. In this project a customized Moodle learning management was used.
3) **The Server** - Which hosts the learning content. Mainly these learning contents are the course contents such as the practices, expositions, and their associated multimedia files. The server content is accessible by both the authoring tool application as well as the client side application.

4.4 Design Choices

There were multiple design choices which have been considered while designing the M-learning application in this work. Major choices are listed below:

1. **Moodle over new authoring tool**: At the beginning of the project, a complete authoring tool was designed; however, later it was dropped due to the multiple functional and nonfunctional concerns from the participating subject organization (QP and QU). Some of the major issues that the Moodle platform addresses are

a. **Security**: Moodle has a very robust and well-tested security framework
b. **User Management:** The Moodle system can support the multimillion concurrent user.
c. **Open Source:** Moodle is free open source software, so it was much easier to extend the system to be used in the M-learning environment. In this project, the Moodle system was customized with the help of the proposed frameworks criteria. Many of the unnecessary components were stripped down, and other new components were added which are discussed in section 4.7.2.

2. **REST over SOAP**: This is chosen because it was lot more efficient and easier ways to implement the restful web services and also maintain. Also, the Rest web service is less redundant and much more efficient way of communication in the mobile application environment. Due to the above benefits for the implementation, it is chosen to go to the direction of the Restful web services.
3. **HTTPS over HTTP:** The HTTPS was preferred over the HTTP protocol because of the REST full service is not as secured as the SOAP service. Thus, it was necessary to take other measures to

secure the content of the application. Both the participating organizations are large organizations; thus, it was necessary to make sure their content be safe and hidden from unwanted eyes.

4. **JSON over XML:** JSON was used over XML because of its modularity. The content that is returned from the server is a lot smaller and modular when used JSON than XML; thus, making it much quicker and easier to parse. Also, the integration of JSON with Android is much better than that of XML. Furthermore, there are multiple JSON libraries that offer robust JSON parsings such as GSON, json2view, ig-json-parser, jackson-jr and many more.
5. **Multitier Architecture:** For better modularity a multitier architecture was used to design the M-learning application.
   - **Client Layer**: There are two client layers.
     - **Moodle**: Client interface that can be accessed through the browser. This is used by the instructors to create courses and the course materials.
     - **Android App**: Used by the learners for accessing the learning materials. They are able to download content and upload their progress back to the server for instructors to grade.

- **Server:** Hosting the content and the Authoring Tool application.

4.5 MLW Use Case

The functional requirements sections show the systems functionality and interaction with users, in particular, situations and to certain actions done by Actors. The use case diagram in Figure 14 shows the main use cases and actors of the entire MLW system. The detailed use case documentation is found in Appendix 0.

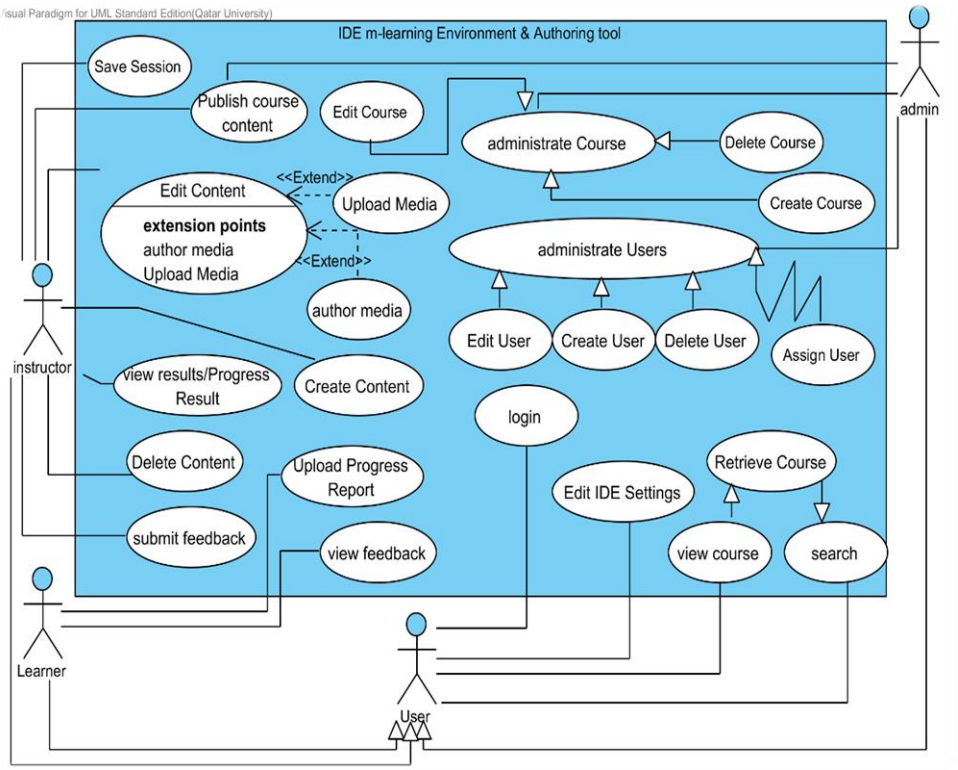


Figure 14: MLW Global Use Case Diagram

4.6 Hardware / Software to Used

The following table summarizes all of the hardware and software used during the implementation and both the learner's Android application as well as the instructors authoring tool.

Table 1 Hardware/Software

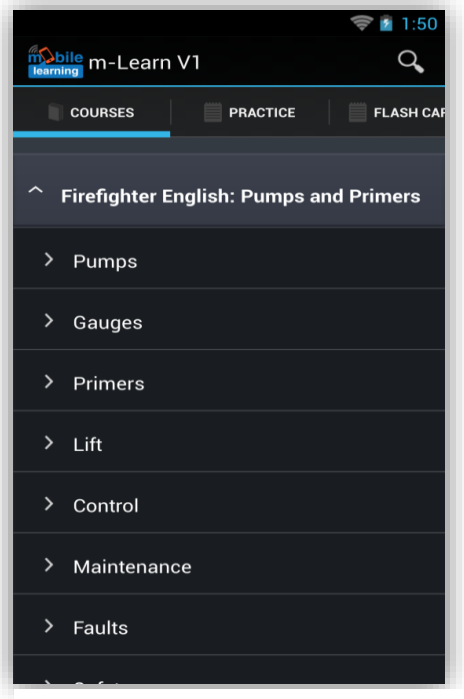
Type	**Item**	**Justification**
Hardware	Laptop	For developing/testing
	Android based mobile devices	For running and testing the application. Also used for piloting the app.
	Server	For hosting the authoring tool
Software	Widows	For client application development
	Apache Web Server	For hosting the authoring tool
	PHP	For the Authoring tool missing components implementation
	MYSQL Database	Backend database for the authoring tool
	MYSQLITE	Backend database for the client android application
	Android SDK	For developing the Android application to develop applications that run on Android-based devices.
	Eclipse IDE	Recommended at the moment of the app development as being the best IDE for Android, However, now the current recommended IDE is android studio.
	Genymotion	A fast Android emulator for app testing and presentation

4.7 MLW System Interfaces

The MLW project as explained above has two major applications. First one the M-learning client application and the second one the authoring tool. The main interfaces of both the applications are shown in the following sections 4.7.1 and 4.7.2 respectively.

4.7.1 Client APP interface

The designed application for the proposed framework followed the criteria's that were discussed in the proposed framework. This application had,



-Easy Navigation,

-Nested lesson menu

-Clean, minimalist design

-Tactile: tap, swipe, pinch, and tilt

-Easy search tool and so on

Figure 15: Application Home Screen

a) **User-friendly navigation:** As shown in **Figure 15**, the navigation of the application was designed to make the users access the application content in an easy and straight forward manner. This design was reached due to many iterations. A low fidelity and high fidelity testing were done. Both of those testing and evaluation can be found in Appendix 0. The result of those evaluations driven by the proposed framework helped to achieve a better-looking app with a high level of user satisfaction.

b) **Pedagogically driven instruction:** During the testing of the application three courses were developed for delivery on Android smartphones. **Presentation Skills in English** and **Agendas & Minutes,** for administrative staff, use a blended learning approach, and **Pumps & Primers** for firefighters was intended for independent learning and as workplace support. All of those were designed with the use of the framework that was proposed in chapter 3 of the Proposed framework and the FRAME framework[19].

All of the designed lesson as shown in Figure 16 had,

- **Clear objectives** and summary for each lesson presented to the learners
- **Chunked content**: separate screens were developed to presents one concept at each screen as suggested in the proposed framework

- **Multi-channel presentations** were used i.e. Text, audio, video, image and animations.

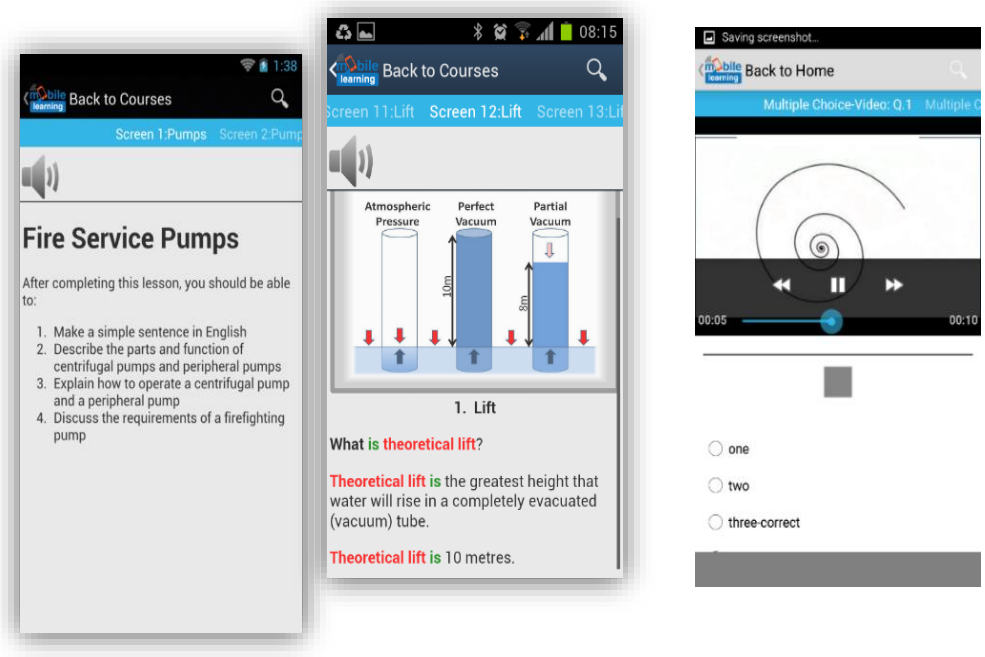


Figure 16: Lesson Screens

- **Searchable glossary**: Allows learners to get a quick access to the definitions of the words they are not familiar with. As shown in the application displayes the translation of the words in both languages. In addition, the student can also create a flashcard out of these words for future access.

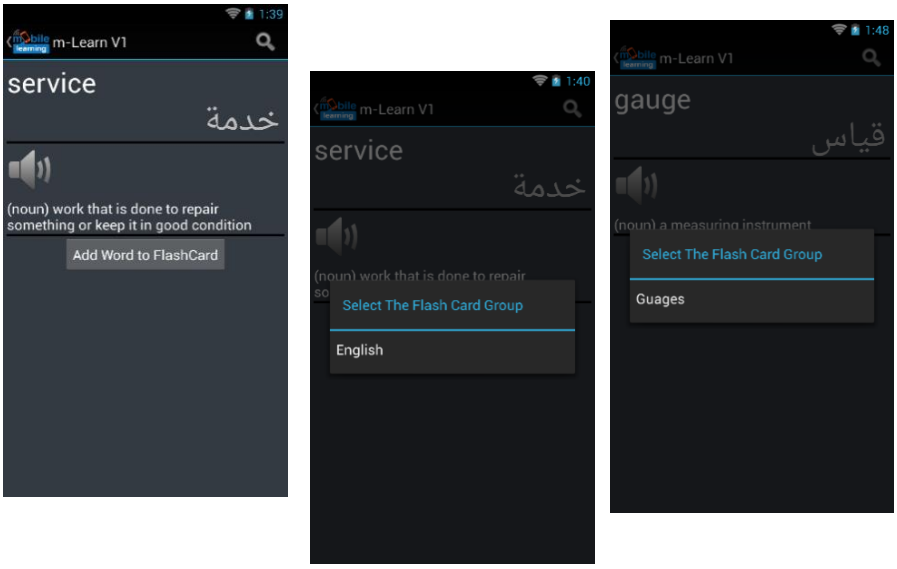


Figure 17 : Glossary

- **Flashcards**: In this kind of exercises learners can create flashcards that they can use to study. These flashcards help learners to create their own drills as shown in Figure 18.

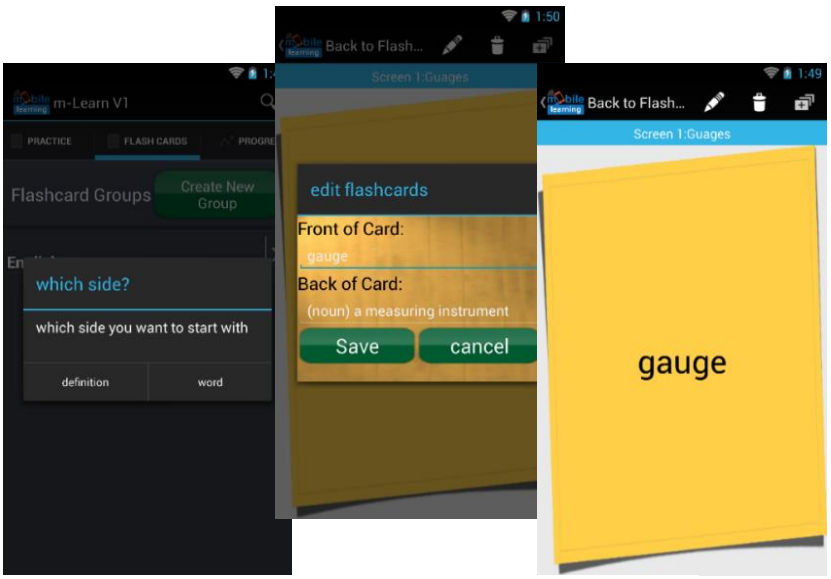


Figure 18: Flashcards

c) **Practices:** Many kinds of practice exercises were created in the MLW application. Some of those practice exercises were,

i) Multiple choice: This type of exercise can have any kind of media. Video/audio/images with multiple choices as shown in Figure 19.

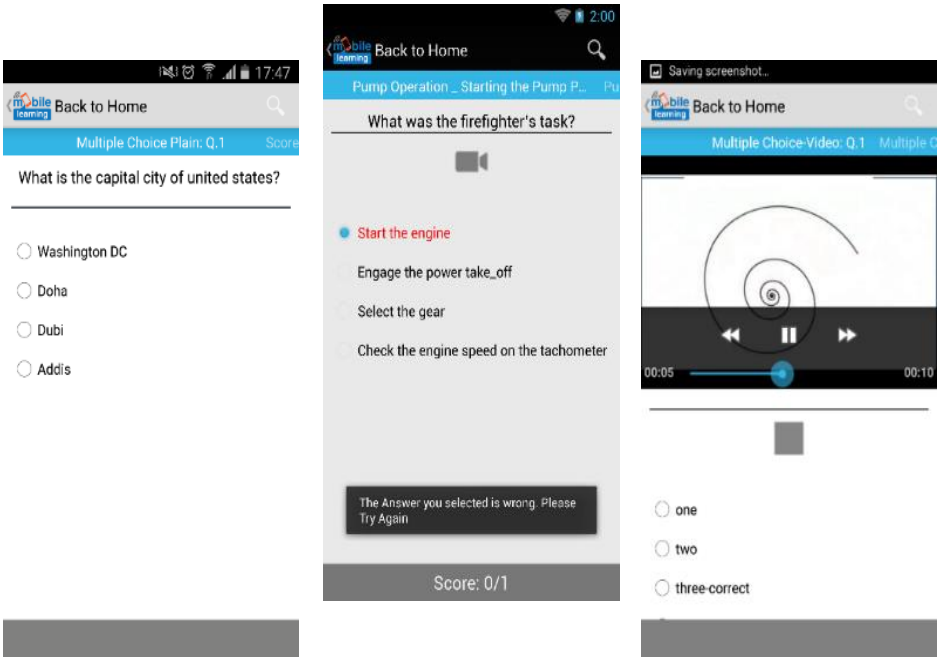


Figure 19: Multiple Choice

ii) Self-Assessment Checklist: This type of exercise was used in the presentation skills course to allow the learners to self-assess themselves. Learners could record themselves presenting and then watch their own presentation and evaluate themselves.

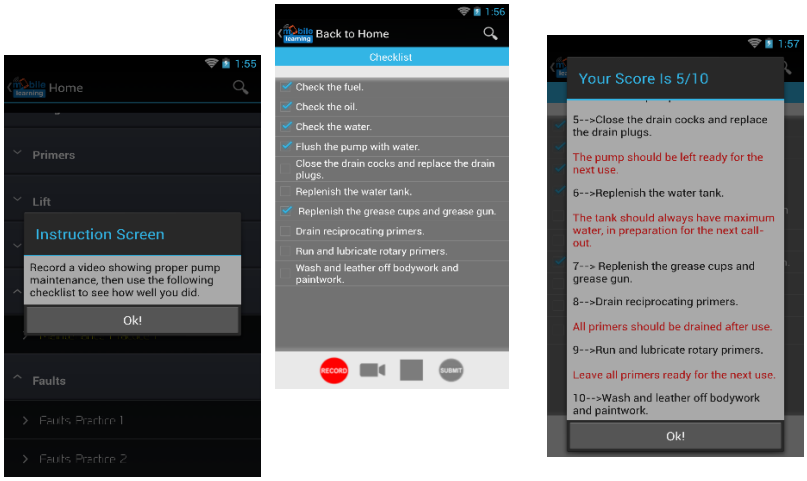


Figure 20: Self-Assessment Practice

iii) Gap fill/ Timed: These type of practice exercises were created to help learners learn while having fun. A time limitation was imposed in each question, and learners are challenged to answer the questions before the time expired as shown in Figure 21. This made the learners read and think faster. The majority of the learners enjoyed this type of exercises compared to the other types were there are no time limits.

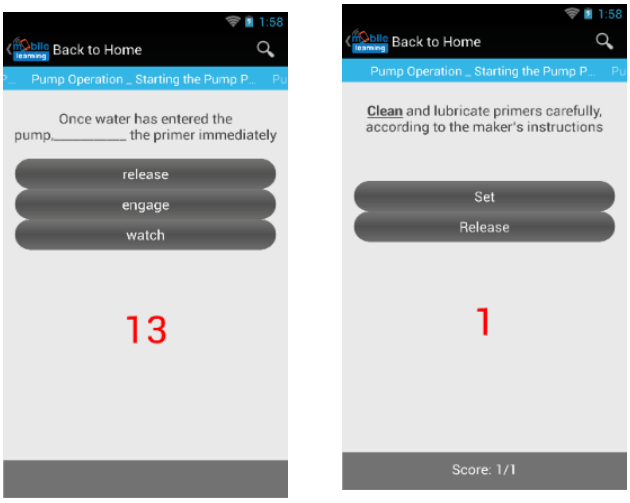


Figure 21: Fill in the gap timed

iv) **Audio and textual feedback:** When students make mistakes, or they answered correctly both an audio and a text feedback is given as shown in Figure 22. Also, the option to disable feedback is offered for the students to give them the control over the system.

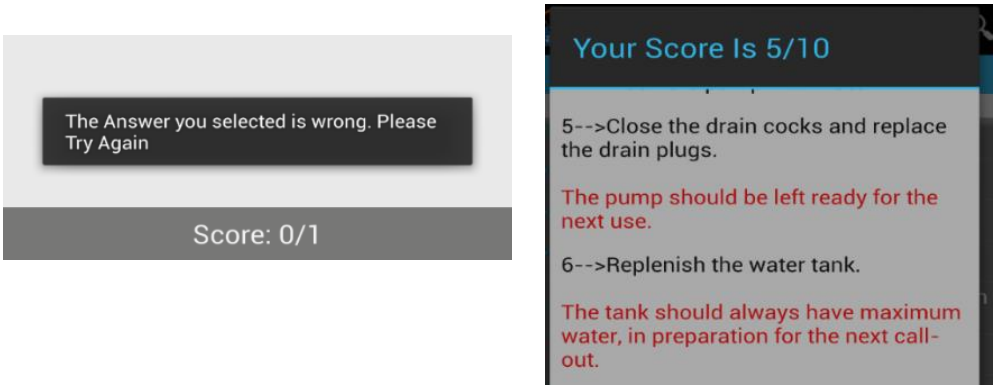


Figure 22: Practice feedbacks

v) **Drag text to the correct corner (Hotspot):** In this type of exercise, the learners are asked to identify the described images. It

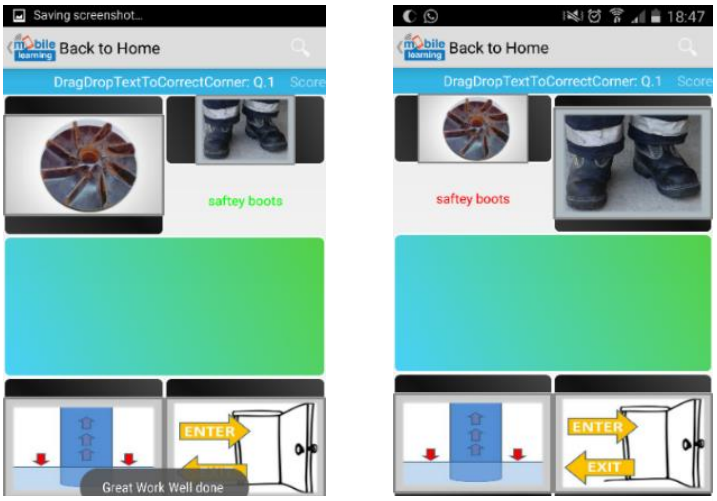


Figure 23: Drag text to the correct corner

was mainly used in the firefighters course were the learners were told to identify the safety equipment by dragging the text to the matching image as shown in Figure 23.

vi) **Drag and Drop/Re-arrange:** In this kind of practice exercises learner are asked to arrange the given words in their correct order as shown in Figure 24.

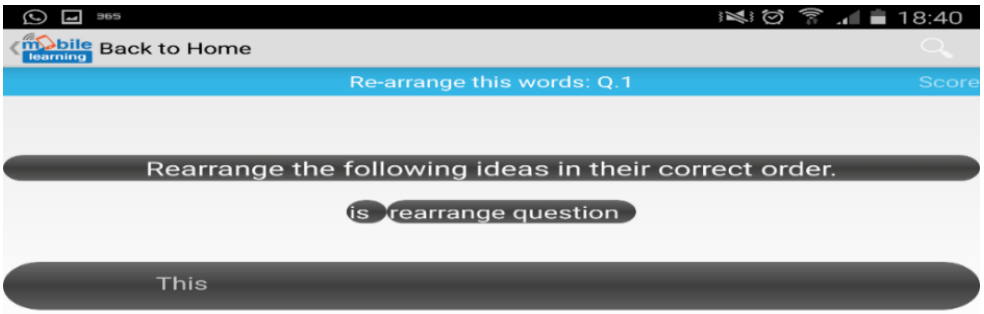


Figure 24: Re-arrange

4.7.2 Authoring tool interface

The M-learning authoring tool is based on an open source M-learning application called Moodle. Moodle is an open-source learning management system which can be tailored to any specific needs.

In this project, the Moodle platform has been modified to be used in the M-learning environment. Also, some new functionalities have been added such as the Quiz web services which Moodle does not implement.

Main authoring tool functionalities include but not limited to:

- View course content and activities.
- Create, Update, Delete courses
- Add learners to class
- View student grades
- Access online course content via hyperlinks when connected to wifi or Wi-Fi data.
- Select or capture an image and record audio or video from their mobile device/laptop and upload to the server

b) **Secured Login:** The authoring tool has a secure login and can only be accessed by authorized users as shown in Figure 25. Mainly this interface is made for the instructors. However, if students would like to use the system they can too by providing their authentication credentials.

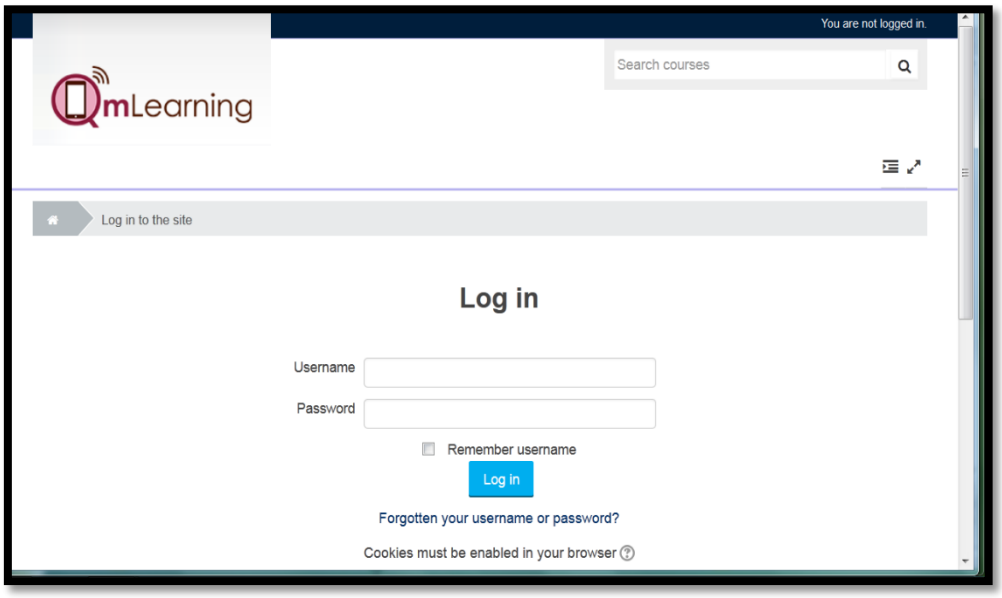


Figure 25: Authoring tool login

c) **Home Screen**: The main page of the authoring tool is designed in a way to show the minimal number of menus/buttons/links and text. As shown in the bellow Figure 26, the screen only shows the necessary courses that the instructor is involved with in a clear and astatically pleasing way.

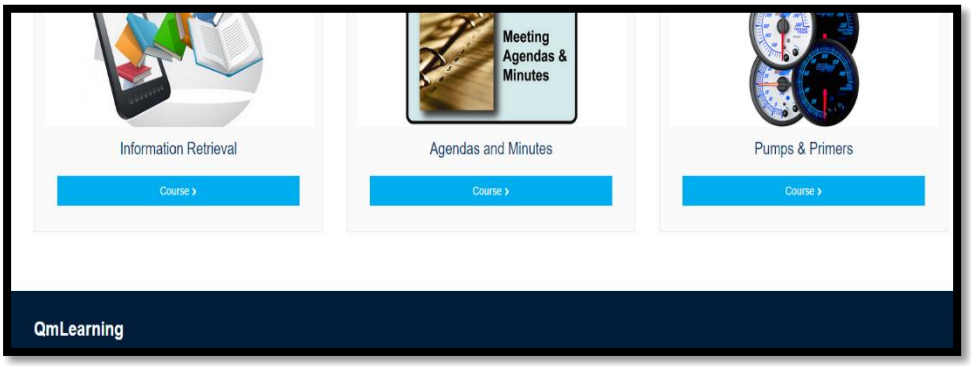


Figure 26: Home Screen

3) **Course content page**: Figure 27 shows the main page where the instructor is able to create the necessary course units/chapters/practice. The instructor can also upload an existing course from their computer or another server.

4) **Practice/Quiz:** The quiz component has been modified to be simpler for the instructors and to accommodate a new type of practices that do not exist in the basic Moodle system. All of the newly added practices are shown in the drop down menu that is shown in

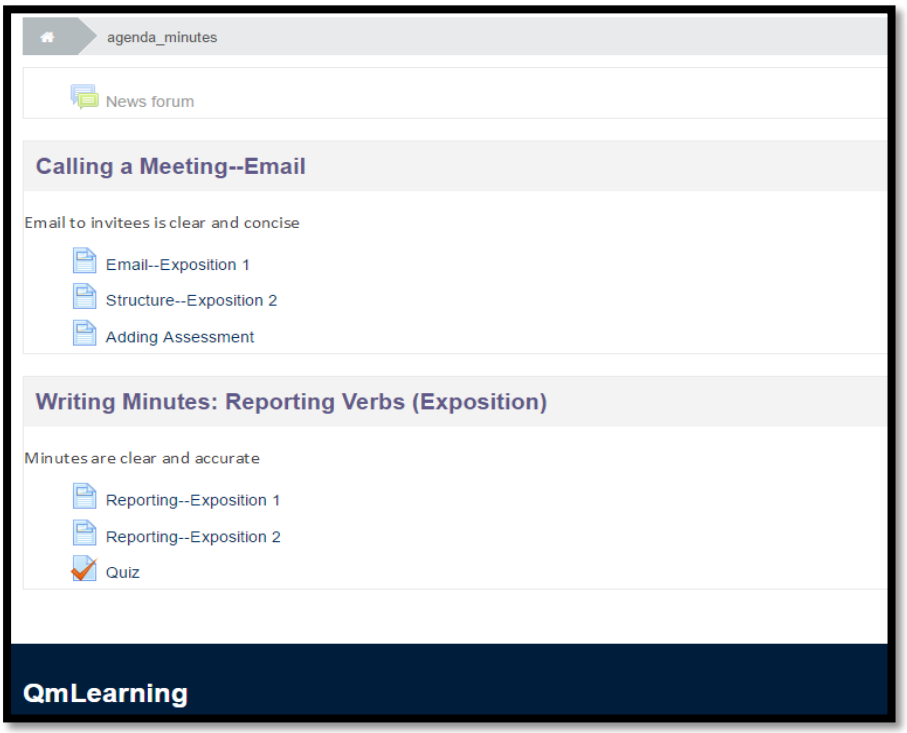


Figure 27: Course content page

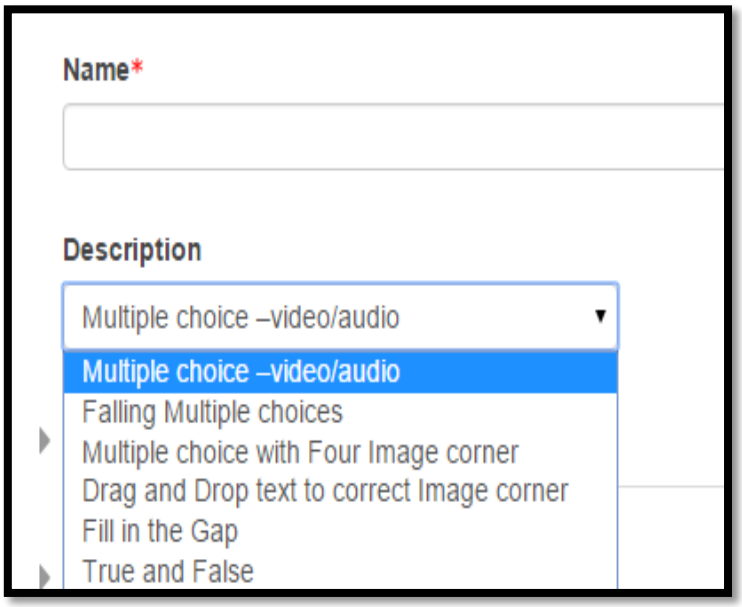


Figure 28: Type of practice/quiz

5) **Minimalistic Design:** In the Authoring tool many of the un-needed components have been removed such as the news, forums, activity results, and blogs and so on. Also, the way course content is created has been limited to "Pages" only. This is done because Moodle is a huge system and there were tons of unnecessary components for the current M-learning system. Also, if those components are kept it violets one the main criteria in M-learning that says M-learning is not an e-learning. The following Figure 29 shows a trimmed version of the new authoring tools activity and resources menu. In the original Moodle, this menu is a lot more complicated, and it has a lot more functionalities.

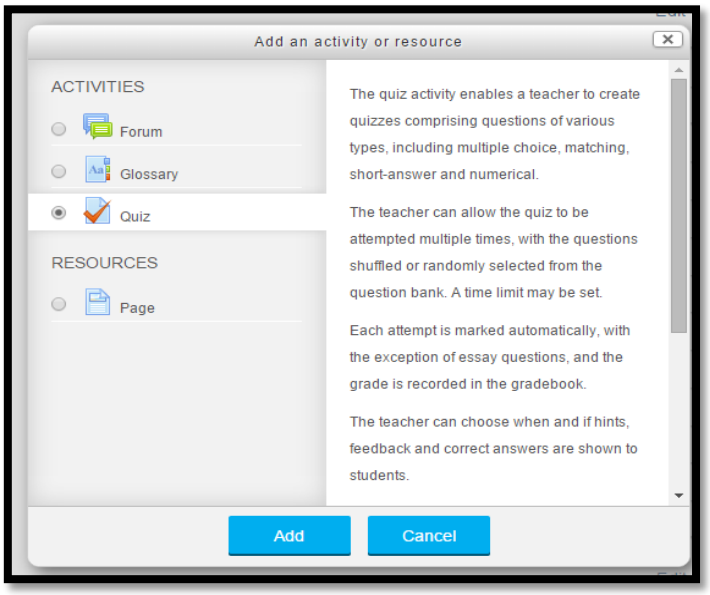


Figure 29: Activity/resources modified menu

In summary, the chapter discussed the major functional, nonfunctional and interfaces designs of the developed applications.

The client side android application is developed from scratch in this project. However, the authoring tool was adopted from an existing learning management system called Moodle. The Moodle system was then modified according to the newly proposed M-learning framework to tailor the M-learning environment.

Also, the new authoring tool offers many some new functionalities specifically in the quiz area. So far in the base Moodle implementation there is no way of downloading quizzes, and also, there is no way of creating all

the listed quiz types in our applications. Therefore, this project also contributes to the Moodle LMS in the area of the quiz and Glossary.

5 RESULTS AND DISCUSSION

The effectiveness of the proposed framework was tested with the use of two experiments. In the first experiment, it was necessary to compare the current framework with the best M-learning framework found in the literature. The FRAME framework[19] which is the highest cited framework in the M-learning community and is also considered one of the best baseline framework for designing and evaluating of M-learning application; was chosen as the best candidate for doing such comparison of the performance. The comparison was done through a carefully designed two experiments.

In the first experiment, two M-learning applications were developed. These two applications were representative applications of the FRAME framework and the newly proposed framework respectively. The two applications were designed with the criteria, concepts and guidelines of their respective frameworks. Then the two Models were compared in terms of usability, user experience, and cognitive gain through those applications. That way it was possible to decide if the newly proposed framework gives a better overall user learning experience or not.

The second kind of experiment conducted was using the same FRAME framework to see if it can identify more usability flaws compared to the

proposed framework. This experiment was necessary because one might say that the previous experiment is biased as the two application are both developed by the same person. Therefore, it was also necessary to evaluate other third party application using the two frameworks and compare how many usability flaws each framework identifies. The following Figure 30 and Figure 31 show the summary of experiment one and two.

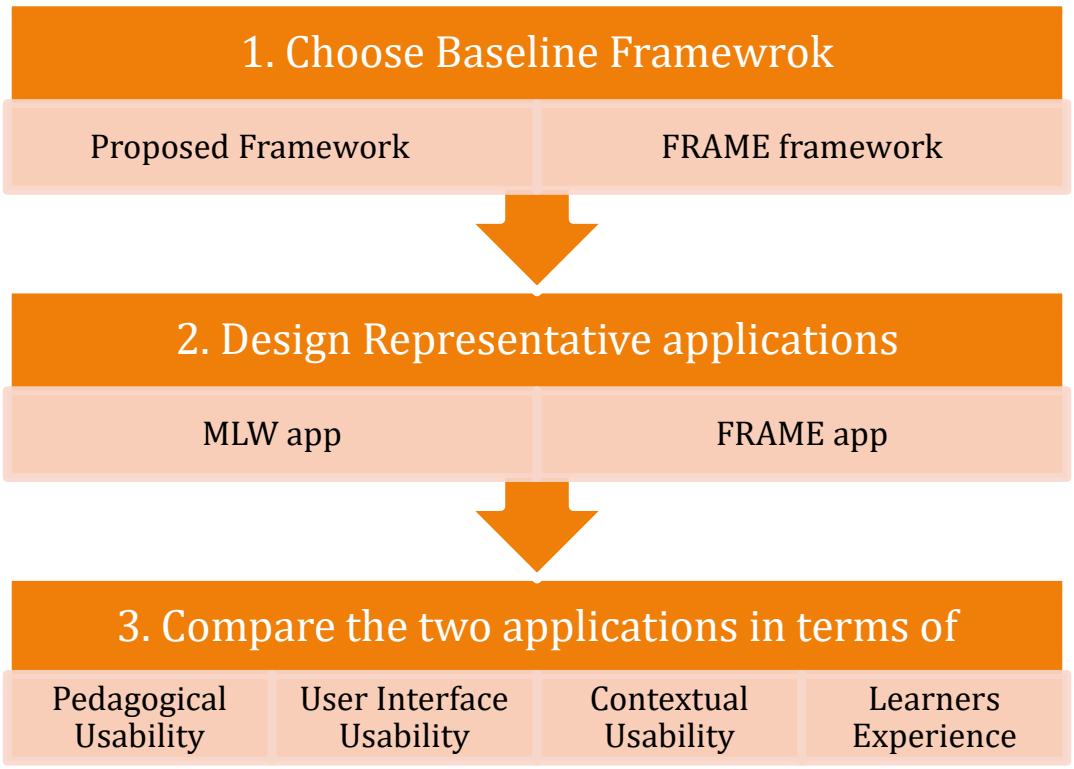


Figure 30: Summary of Experiment #1

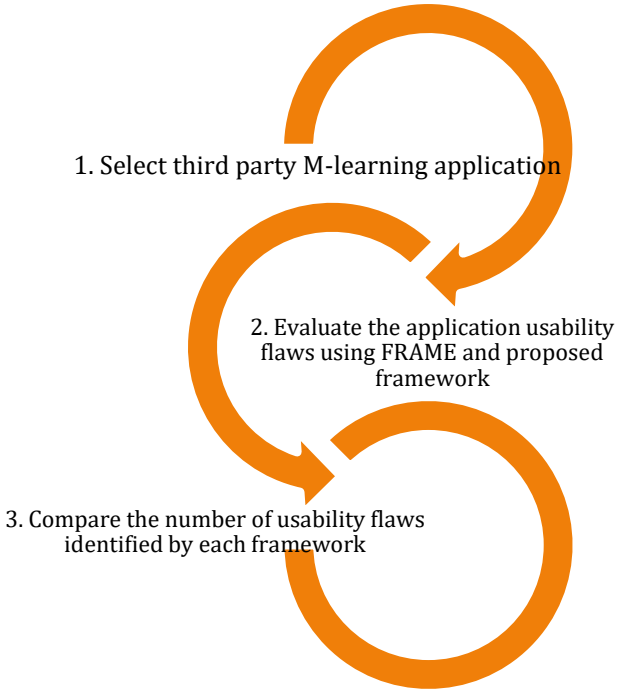


Figure 31: Summary of Experiment #2

5.1 Experiment # 1

In this experiment, a user-based HCI evaluation method is used to evaluate the effectiveness of the proposed framework. The details setup of the experiment and its results are explained in the following sections.

5.1.1 Target User

- Number of Test Subject:

There were about 90 learners who participated in the testing of both applications. These learners are Qatar Petroleum employees who were taking

courses like presentations skills, agenda and minutes and pumps and primers. The following user demographic data is the combined data of both the M-learning applications.

The MLW had about 53 learners, and the FRAME-App had about 37 learners.

- Age Group: The age distribution of the participants is shown in Figure 32.

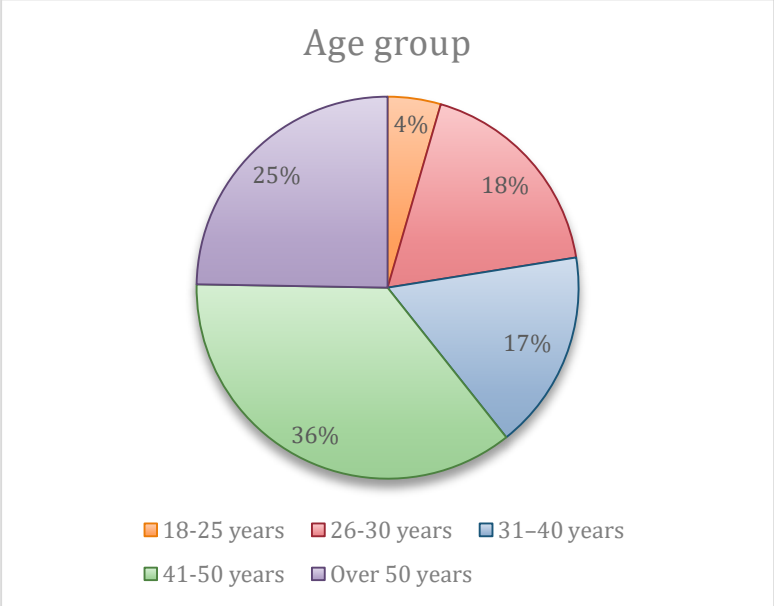


Figure 32: Participants age group

- Gender and Level of Education

Most of the participants were male employees with University and bachelor degrees as illustrated in Figure 33 and Figure 34 respectively.

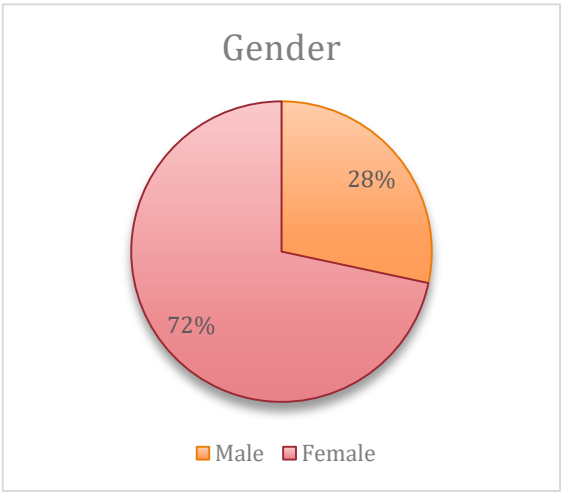


Figure 33: Participants gender

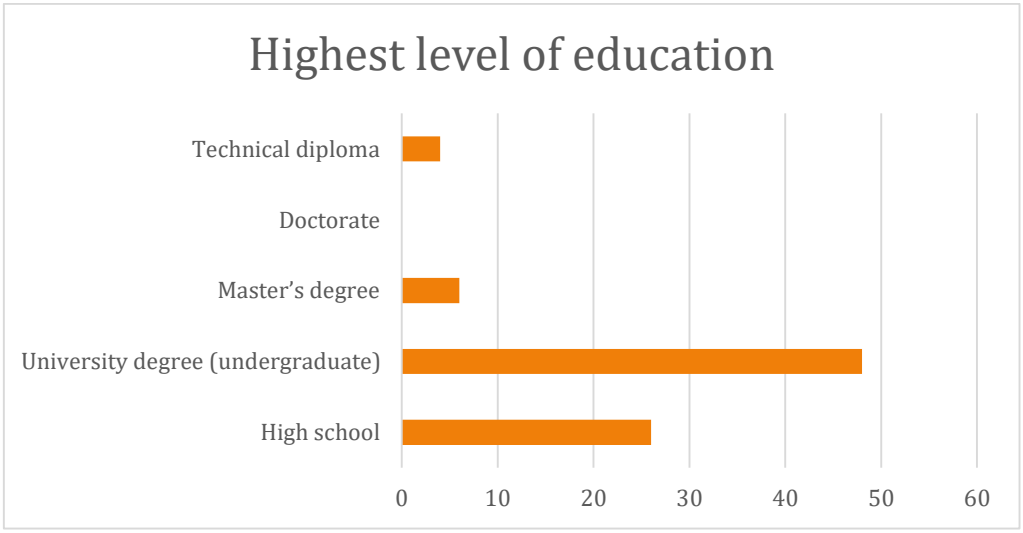


Figure 34: Participants level of education

5.1.2 Applications

Two Android application were developed to test the performance of the proposed framework and the FRAME framework that is the baseline framework for the thesis. We will refer this two applications as the FRAME app and MLW app. MLW applications represent the proposed framework.

5.1.3 Goals of the experiment

The main objective of the experiment was to prove if in fact the proposed framework improves the overall usability and learners learning experience when compared to one of the best M-learning framework, FRAME.

5.1.4 Data gathering

There are fundamental concepts used in collecting the data for the project.

A. **Goal Setting**: It is important to have very clear goals on what kind of data one would like to collect. In this project, the data that needed collecting were of three types.
    1. **Demographic Information**: To study the learner's context.
    2. **User interface usability:** This was done in two stages. The first was during the early design of the application were a low

and high fidelity testing was done as shown in Appendix 0. Secondly, the final applications were tested on the real users. The usability data was collected through questionnaires and post interviews that are shown in Appendices 0, 0 and 0.

3. **Pedagogical Usability**: This is also collected through questionnaires and post interview at the same time of the usability testing. Also to further measure the effectiveness of the pedagogical usability a pre-test post-test was given to the learners.
4. **Overall user learning experience:** A post-interview was conducted to measure the user satisfaction of the designed M-learning applications.
5. **Usage Data:** This data was collected through the application by logging the learner's application usage.

B. Triangulation (Piloting more than once and in different Setting): There were about six sessions that were conducted. In each session, there were two types of groups. One which used the applications and another controlled group that did not use the applications. The controlled group was mainly used to see the cognitive gain of the learners after using the applications.

In each of the testing before the application is given to the student, a pre-test was given to evaluate their knowledge. Then the students used the application for a week. And at the end of the week, they were given a post-test to assess the cognitive change. Also, on the same day they were given a questionnaire that asks about the pedagogical usability, user interface usability and their general experience with the given M-learning application.

Finally, after some time, an interview was conducted with few selected number of students to capture the overall user learning experience of the applications.

5.1.5 Observations

In most of the HCI experiments the user is observed either in a lab setting or their work environment while they use the application. However, both of this cases were not suited for this thesis's M-learning applications. Because M-learning is about learning anywhere anytime; there should be the freedom for the learner to use it whenever they want and wherever they want.

Also, in the M-learning research, it is very important criteria for learners to use the application outside of the class as a supporting device to what they have learned. Therefore, it was not realistic to follow the student while they use the application outside their classrooms. The only time the project used

direct user observation was during the paper prototyping in the design of the application.

However, there was a different kind HCI observation technique used that is an indirect observation of the learner's activity. A particular logging component was developed that logged all of the different usage data and interactions. The application registered the number of time user accessed particular module, the time they spent using the application, the number of exercises they did, the total time it took them to complete the specific module, error logs, grades and so on.

The second kind of HCI observation used was the after use query techniques such as interviews and questionnaires. These interviews and questionnaires were conducted at the end of each week/session of testing the application. The learners were given a pre-test and post-test to see their knowledge/cognitive gain and a questionnaire that mainly focused on the usability and user experience of the applications. Furthermore, an interview was conducted with selected learners that were willing to participate.

5.1.6 Results

The following sections show the overall testing results of the two applications; MLW-APP, which is based on proposed framework and FRAME-APP, which is based on the FRAME framework.

5.1.6.1 Usability Testing: FRAME-APP vs. MLW-APP

There were many questions asked regarding the usability of the applications through a questionnaire and interviews. However, in this section, we mainly focus on the important questionnaire questions that would help us compare the usability between the two frameworks. The flexibility, effectiveness, enjoyability and ease of navigation are compared bellow.

Feedback and Personalization

Two important concepts for M-learning application design, that is, personalization and feedback, are not addressed appropriately in the FRAME framework. These two concepts are important because they influence the learner's usage towards the application.

In the FRAME-APP testing, the application was not given the possibility of disabling the audio in any context of use also it was given very simple audio feedback such as buzzers and simple text feedback. This was done to observe whether the use of personalization and feedback had any effect on the

learner's usage of the application. These simple modifications resulted in negative comments on the usability testing.

When asked the reason during the FRAME-APP usability testing, many students responded with comments like "*I did not need the audio*," "*It was annoying*," "*It was embarrassing*" and so on, all referring to the feedback buzzer. Some other learners had different concerns in the FRAME-APP testing. They requested the feedback to be more precise and personalized instead of saying just giving them the "correct" and "wrong" text and audio feedback.

On the contrary, one of the main criterion in the proposed framework is feedback. Thus, the MLW-APP had been designed with that feedback criterion in mind. Therefore, during the testing of the MLW-APP, the application did not receive any negative comments regarding the application feedback. And the simple reason was the MLW application had diverse, personalized and encouraging feedback, such as "Please, try again", "Better luck next time" and much more with female and male voices. Also, there was personalized feedback on each question. When the learners get the wrong answer besides giving them encouraging and diverse feedback as the ones above they also received a more concrete feedback on the question answered. These feedback were about why something they selected was wrong or why

a particular answer they choose is correct. Also, the feature to choose between text/audio feedback and the ability to enable and disable audio was provided to the learners in the MLW application. This diversity in feedback and personalization helped the MLW-APP not to receive negative comments regarding the application feedback. The following figure shows the number of learners who think the use of personalized feedback as being helpful.

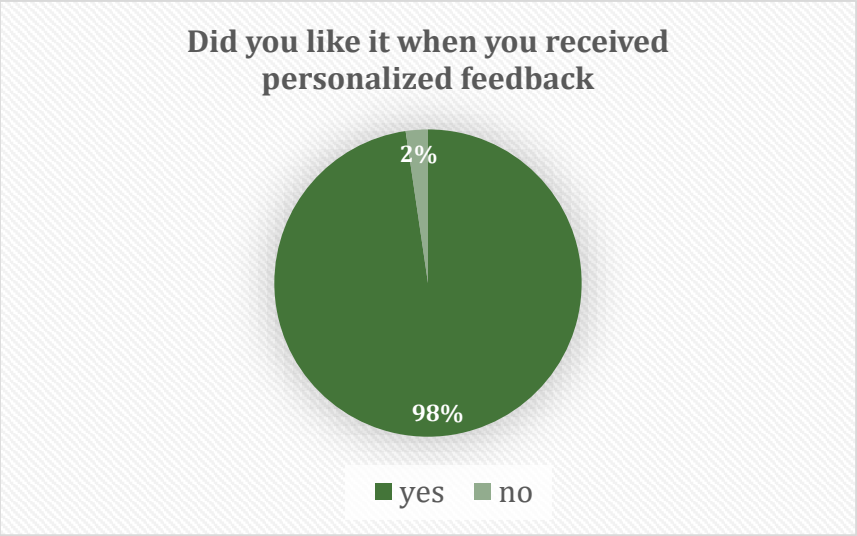


Figure 35: MLW - Learners perception on personalized feedback

Consistency and Ease of Use (MLW vs. FRAME)

Here to test the importance of consistency and the effect it has on the users it was necessary to measure the ease to navigate through the application, clarity of the content displayed, the ease to hear audio/video, etc. Bellow chart shows the summarized results.

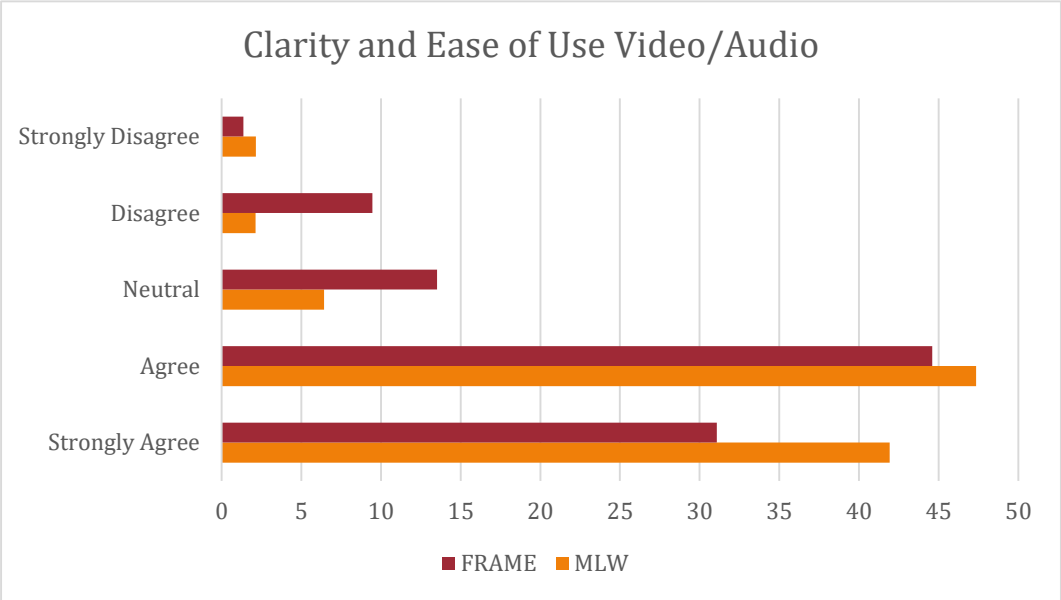


Figure 36: Consistency and Ease of Use

Pedagogical Usability

Here the learners were asked to rate the different ways the content presented to them. The learners rated the animations used, the way the content is presented and chunked, the various dialogues presented and so on. Then the collected user ratings are later combined to give an overall pedagogical usability.

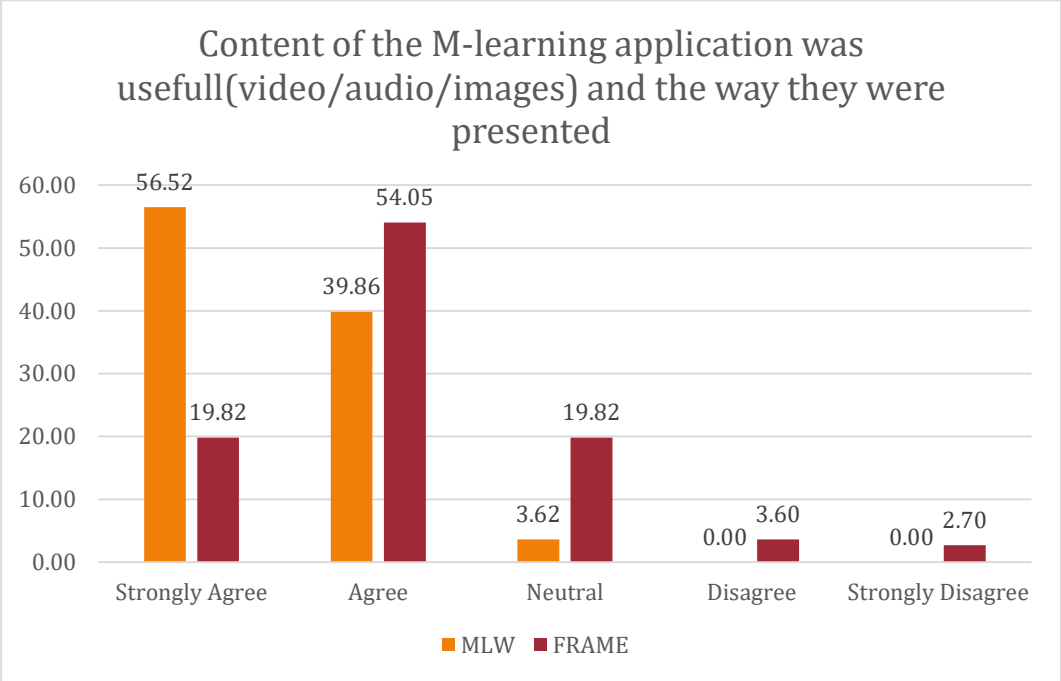


Figure 37: Pedagogical Usability MLW vs. FRAME

As we can see in the MLW application testing more than half strongly agreed that the way the content was presented as being useful and a total of 97% either agree or strongly agree in the way the application presented the content to them.

Learners Immersion and Engagement (MLW vs. FRAME)

The proposed framework features affected the students' usage time of the APP. For instance, in the first FRAME app testing the only about 55% student used the application more than half hour wherein the MLW this number increased to 78%. These criteria of the proposed framework

increased the number of students who used the MLW-APP more than a half-hour by 23% more than the FRAME-APP.

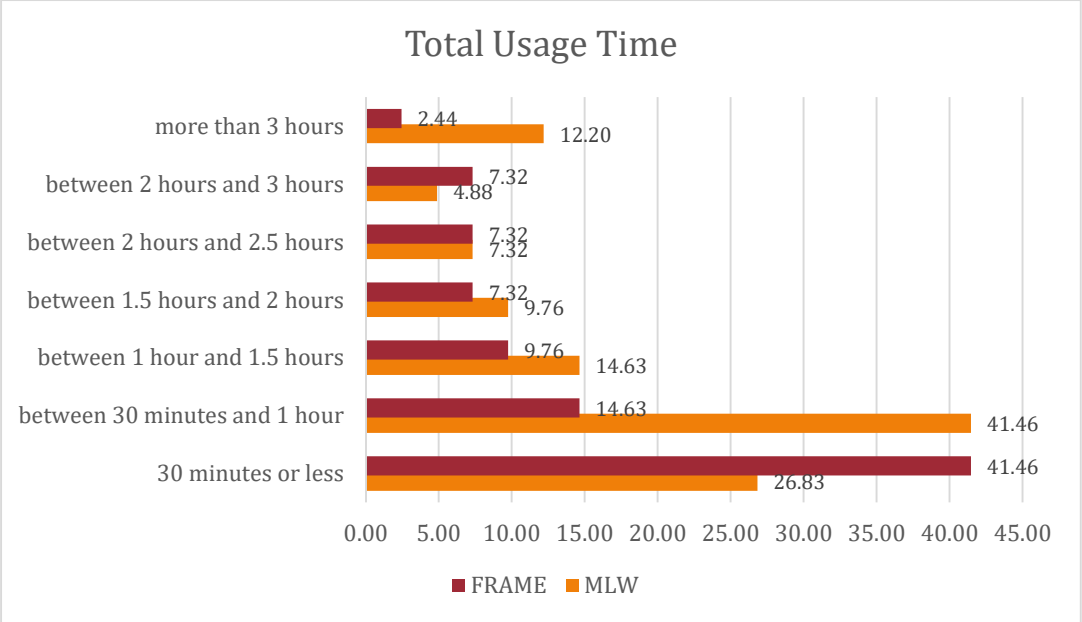


Figure 38: Total Usage Time MLW vs. FRAME

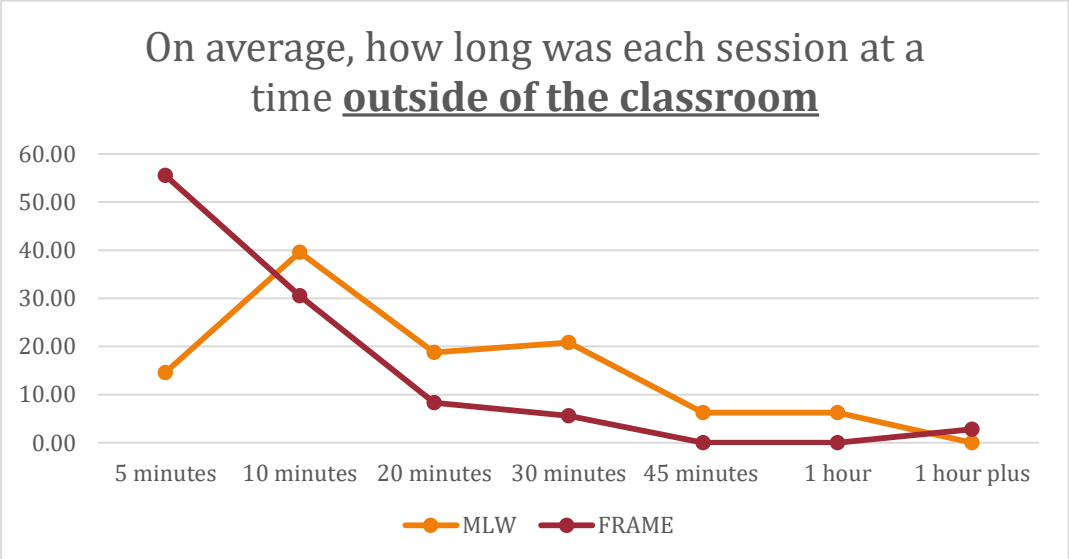


Figure 39: Usage time per session MLW vs. FRAME

To get a better sense of the two graphs. The first graph in Figure 38 describes the overall usage of the application. However, it does not indicate how many times the user accessed the application. Therefore, to estimate the frequency of usage by each user a second data is needed which indicates how long each session lasted which is described in Figure 39.

The aim of M-learning is to give the learners multiple short sessions of about 3 to 10 minutes instead of one long session. Therefore, the ideal M-learning application would be used in multiple short sessions which add up to longer application usage time. That is necessary because it indicates that the learner came back to the application for more content and accessed it more than once.

Therefore, if in the first Figure 38 overall usage time is high and the number of sessions in the second graph is small, then this would translate into a positive outcome.

However, If the majority of the learners say they used the application for more than an hour and their session was more than an hour this translates to the student using the application one or two times which is a negative outcome. But, if the learner used the application for more than an hour but with less session time, that means the learners opened the application more than one time. Now that is good because if the learners do not like the application, they will not use it more than once.

In the thesis experiment, it was expected the learners to spend more than an hour in the overall usage of the entire application's exposition and exercises. But also, it was necessary for the application to be used more than one time. Because the application was given for a week as a support to the course, they were taking in their classrooms.

It is important to know that engagement means, not the learner spending one long session and closing the application and not coming back to it. But, it means the application being used in a number of short sessions for a number of hours. That is why in both graphs the MLW-APP performed better than the FRAME-APP when it comes to learner's engagement.

Flexibility – MLW vs. FRAME

Flexibility was one of the attributes expected to perform the same as both applications gave the learners the freedom to learn anywhere anytime. However, due to the previously discussed usability criteria, the students were a bit hesitant to consider the FRAME-APP as an excellent application that helps them learn anywhere anytime.

Only 10% of the learners strongly agreed that the FRAME-APP provided them to learn anywhere anytime. However, the majority of the learners thought it was a good but not great in terms of flexibility.

One the other hand due to the different pedagogical, user interface and contextual usability criteria applied on the MLW-APP, about 92% of the learners believed that the application provided them the flexibility to learn anywhere anytime.

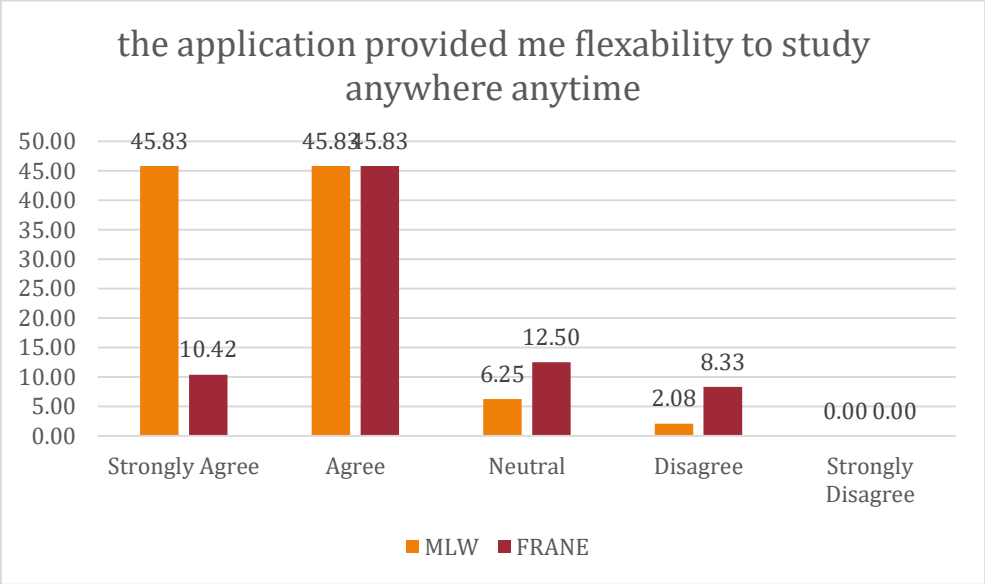


Figure 40: Flexibility MLW vs. FRAME

5.1.6.2 User Experience (UX)

As discussed many times in the previous chapters the UX is the end goal for any application. If the learners did not enjoy the application usage experience and did not find that it added any value to their lives, then this kind of application is considered to be a failure. Therefore, the UX is the decision making single criteria that can decide whether the application was a success or a failure.

Therefore, it was important to evaluate this important aspect of the models. This evaluation was conducted through a questionnaire and a post interview with the learners who used the application. In the questionnaire and interview, the learners were asked their overall experience with the M-learning application.

In general, both the MLW-APP and FRAME-APP users responded positively when they were asked their overall experience with the applications. However, the learners who used the FRAME-APP were not as satisfied as the ones who used the MLW-APP. Appendix 0 describes the compiled comments from the learners about their experience with the mobile learning lessons in the MLW and FRAME-APP application. The collected comments are divided into two main categories namely, positive and negative comments.

5.2 Experiment # 2

In any application design, it is necessary to conduct a proper evaluation to identify any usability and user experience flaws before releasing the application to the users. In HCI, there are well-known methods such as the classical heuristic evaluation method of Nielsen s and ISO standards to conduct general usability evaluation for general purpose applications.

However, as discussed in the literature review section, those classical methods would not be able to identify the pedagogical and contextual usability flaws of M-learning application. Thus, one of the main requirement of the proposed framework is to address the lack of robust evaluation method.

The proposed framework can be used to evaluate M-learning application; however, it is necessary to prove that it can outperform the currently existing M-learning evaluation framework in order to be considered useful. If it cannot identify any new usability flaws than the existing framework, then the proposed framework would not be of much use.

That is why in this section the proposed framework is compared to the FRAME framework which is widely considered as the baseline framework for designing and evaluating M-learning application[19]. The FRAME framework provides a comprehensive checklist that M-learning application developers can use to evaluate their applications. As a result, the FRAME framework is the widely used framework for evaluating of M-learning applications.

In the following section, an experiment is conducted to see if the proposed framework can identify more critical usability and user experience issues than the baseline framework FRAME. The experiment setup is explained bellow.

5.2.1 Application

A third party application was used to avoid any bias towards any of the two frameworks. This application is an M-learning application called English Listening and Speaking by Miracle Funbox (ELAS). It has over 500 thousand downloads, and it is a highly rated M-learning application as shown Figure 41.

Figure 41: English Listening and Speaking M-learning application by Miracle Funbox

5.2.2 Evaluation Method

An expert-based evaluation method is used to conduct this second experiment. Expert based evaluation is an HCI evaluation method where an HCI expert conducts the assessment of a specific application using expert

methods such as Nielsen s' or Cognitive walkthrough. In this experiment, those expert methods are replaced by the proposed frameworks and the FRAME framework as a baseline for evaluation.

In the experiment, two HCI experts were used to identify the usability flaws of the above application that is shown in Figure 41. Each one of the experts was given one framework, either the FRAME framework or the proposed framework as a guideline for evaluation. There were three phases during the evaluation process.

I. **PHASE ONE: Usability flaw identification of ELAS app**

   Each expert was given time to read and study the specific framework that they have been assigned. Then once the experts understood the criteria of each of the framework, then they were given the ELAS app to evaluate and identify as many usability flaws as possible.

II. **PHASE TWO: Categorizing the Usability flaws**

   In phase two, all the identified usability flaws by each of the expert were categorized under one specific criterion of each framework. For instance, all of the font issues, phrases used, issues with inconsistent actions, issues with not following platform standards and so on that are related to the consistency of the application were all categorized under the consistency flaws. Also, others flaws related to the way

content is presented, clarity of the text, images and videos were categorized under presentation flaws. That way, it was straightforward to compare the two frameworks.

III. PHASE THREE Elimination of common usability flaws

After each of the two experts had made their categorization of the type of flaws that they identified, then an elimination process was conducted. If both frameworks identify a particular usability flaw, then that usability flaw is dropped as both identified it. Because the aim of this experiment is to compare the two frameworks, it was important only to focus on their differences. If one identified specific flaw which the other framework did not then, this criterion is reported.

5.2.3 Experiment # 2 Analysis

The main comparison was not the number of usability flaws identified but the number of unique usability flaws identified by one framework but cannot be detected by the other. Even if an expert did not identify that specific usability flaw, but it can be detected by the framework, and then that usability flaw is dropped.

The following are the unique usability flaws that the proposed framework was able to identify, but the FRAME framework was not able to detect in the ELAS application evaluation.

- Consistency: The FRAME framework failed to identify any of the consistency problems even though the ELAS application had many issues of consistency. One of such example was the search bar of the ELAS application was randomly placed at the bottom of the screen even though the Android platform clearly states placing this search bar at the top section of the application action bar.

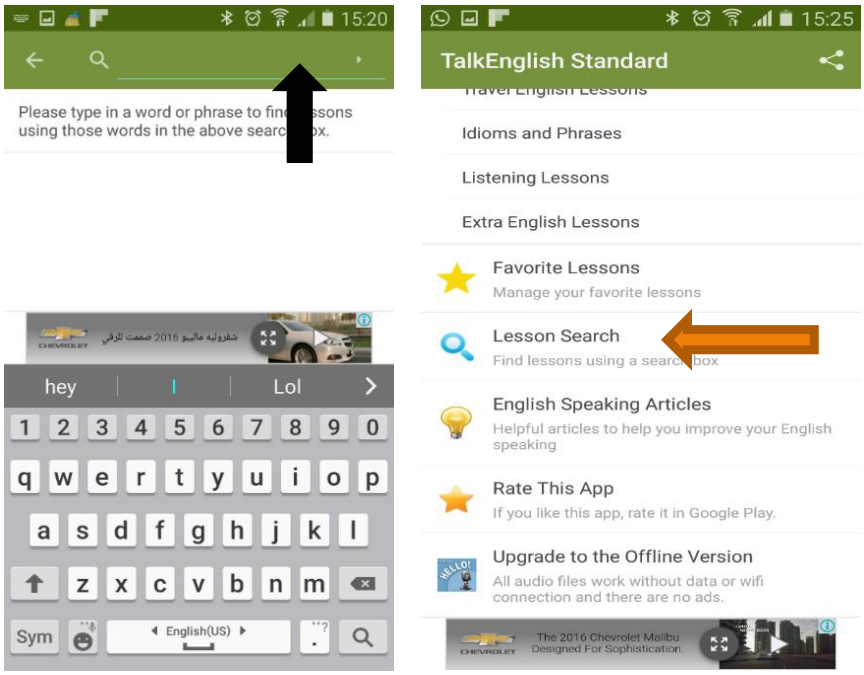


Figure 42: ELAS platform consistency issue

- Navigation: the FRAME framework did not detect all the navigation issues. For instance, in the ELAS application
    - The lessons are presented as a list instead of presenting them in their own activities for ease of navigation.

- The navigation buttons do not tell the user where they would take them to.
- All the scroll bars are hidden from the user which makes hard for the users to detect if a content is hidden or not.
- Some of the menus are not visible and many more issues.

The following Figure 43 shows some of the navigation issues mentioned above.

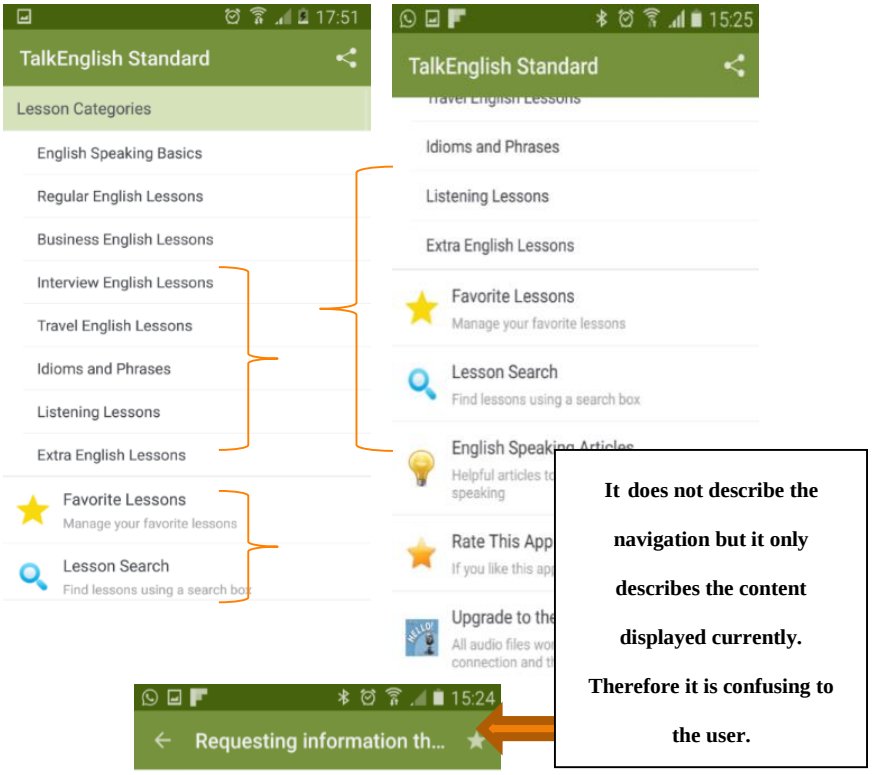


Figure 43 : ESAL app navigation/consistency issues

- Content Presentation: Almost all the content presented had some presentation issue. For instance, some of the content were hard to read

due to the underlining. Also, the spacing between the texts was badly written as shown in Figure 44. Unfortunately, this issues of presentation were not detected by the FRAME framework even though they are very necessary criteria in user interface design.

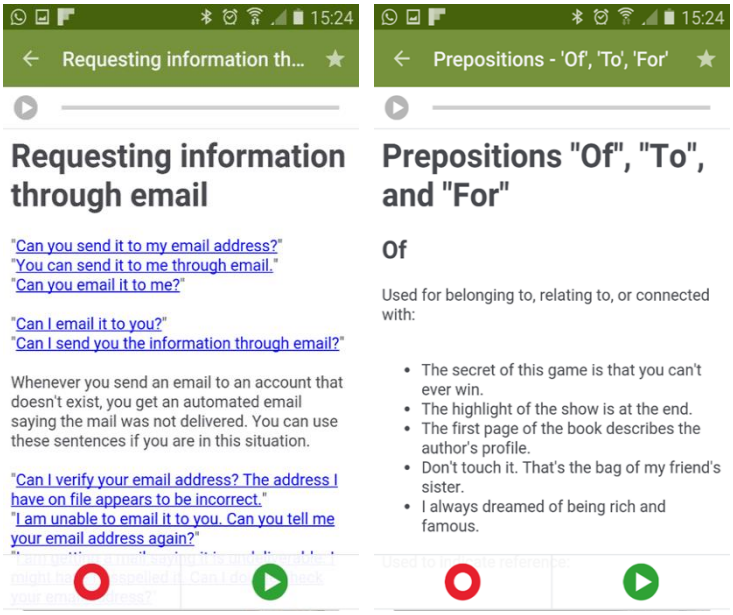


Figure 44: Presentation flaws of ELAS app

As discussed above the FRAME framework fails to address the interface usability issues of M-learning application. However, the FRAME framework was able to identify all the pedagogical usability issues as well as some of the interface usability issues such as user interaction and communication flaws. Also, the FRAME framework was able to identify the contextual usability issues that can arise when developing M-learning applications. These

contextual issues are the learners and organizational cultural and social aspects.

However, one of the biggest issue with the FRAME framework is the lack of any of the user experience criteria discussed in the proposed framework section 3.4 such as the motivation, satisfaction, and engagement and so on. Those are not being considered in the FRAME framework. That by itself is a significant issue when evaluating M-learning applications as the user feelings toward the application are completely ignored by FRAME framework.

In summary, this chapters has shown the performance of the proposed framework through two carefully designed HCI evaluation experiments.

In the first experiment, a user-based HCI evaluation method was used to test if the proposed framework could be used for designing M-learning application. In the experiment, two prototype applications were developed and tested on real users to validate if the proposed framework is effective enough in designing M-learning applications when compared to one of the baseline frameworks in the literature called FRAME. The result collected indicated that the proposed framework as being the better option when designing M-learning application as it has more comprehensive M-learning

user interface and user experience design guidelines. All the test subject favored the application that was designed using the proposed framework.

A second experiment was conducted to determine if the proposed framework could also be used for evaluating M-learning applications. An expert-based HCI evaluation method was carried out to evaluate the effectiveness of the proposed framework. In the experiment a third party application called ELAS was evaluated using the FRAME framework as well as the proposed framework. Then the flaws identified by both framework are compared to see if one of the frameworks can identify application flaws better than the other. The results indicate that the proposed framework as being the better option for evaluating M-learning applications as the FRAME framework ignores critical interface and user experience criteria.

From these two experiments and the literature review, it is concluded that the proposed framework in the thesis as being a robust framework that can be used in both the design and evaluation process of M-learning applications.

6 CONCLUSION

The thesis presented the different frameworks that currently exist for designing and evaluating mobile learning applications. It also presented their strength and their weaknesses. Then, this thesis with the use of practical experiments identified important criteria that are necessary for designing and evaluating M-learning applications. The identified criteria are then combined with M-learning theoretical framework to create a more robust alternative design and evaluation framework for M-learning applications.

The proposed framework is proven to be a robust alternative to the existing M-learning frameworks through multiple experiments and expert study.

6.1 Theoretical Implications

The proposed framework combines many scattered M-learning design and evaluation guidelines with research based new criteria into one comprehensive framework that can be used in creating and evaluating M-learning applications.

Currently, as discussed in the literature review, there are not many comprehensive frameworks that could be used in both the design and evaluation of M-learning applications. Therefore, the proposed framework

will provide both the application developer and content designers, robust guidelines to design and evaluate their M-learning applications. Furthermore, the framework opens the opportunity for researchers in the M-learning and HCI domain that are interested in in creating a more comprehensive framework that combines the best guidelines and practices that are being scattered through the literature.

6.2 Practical Implications

So far the implemented MLW project, is the first of its kind in Qatar and the Middle East. It introduces new ways of delivering learning content to learners for the organizations. Many of the learners especially in the higher education and organizational employees spend much of their time using their mobile devices on a daily basis. Thus, it would be a great idea to take advantage of this incredible device.

Currently, the developed M-learning system will be deployed in Qatar Petroleum and Qatar University to help both the employees and students to experience new ways of learning anywhere anytime.

However, the developed MLW system is a complete solution that can be adopted by any organization that would like to deliver their learning content to their organizational members through mobile devices. It has both a

learner's client application which learners can use and an authoring tool which instructors use to author the learning content.

6.3 Future Work

As a future work, this framework will be made available to the public as a software implementation, where users can evaluate their application and get more visualized scores on the effectiveness and efficacy of their applications.

Currently, the backend application of the MLW system depends on the Moodle framework; however, for future work a complete M-learning environment will be developed that applies all of the mentioned concepts.

Finally, the application as discussed in the practical implication section is only given to two institutions; however, as a future work it would be great to test the M-learning application with elementary and high school students and see the effect it has on their learning. This variation of the context of use would help the proposed framework to be a more inclusive framework that can be used in different context for both education and training.

REFERENCES

[1] C. I. Faculty, "QUEENSLAND UNIVERSITY OF TECHNOLOGY CREATIVE INDUSTRIES FACULTY LITERATURE REVIEW INTO MOBILE LEARNING," no. January, 2006.

[2] T. Maturity, "Mobile learning in the workplace," no. June, 2014.

[3] U. Hq, "UNESCO Mobile Learning Week Report," no. December, 2011.

[4] "• Global mobile education market volume 2011-2020 | Statistic." [Online]. Available: http://www.statista.com/statistics/273960/global-mobile-education-market-volume/. [Accessed: 10-Oct-2015].

[5] H. Beetham and R. Sharpe, *Rethinking Pedagogy for a Digital Age: Designing for 21st Century Learning*. 2013.

[6] C.-C. Hsu and C.-C. Ho, "The design and implementation of a competency-based intelligent mobile learning system," *Expert Syst. Appl.*, vol. 39, no. 9, pp. 8030–8043, 2012.

[7] M. Kearney, S. Schuck, K. Burden, and P. Aubusson, "Viewing mobile learning from a pedagogical perspective," *Res. Learn. Technol.*, vol. 20, no. 0, Feb. 2012.

[8] H. Crompton, "A historical overview of m-learning: Toward learner-centred education," in *Handbook of mobile learning*, 2013, pp. 3–14.

[9] Y. Laouris and N. Eteokleous, “We Need an Educationally Relevant Definition of Mobile,” *Proc mLearn*, no. June, pp. 1–13, 2005.

[10] “e-learning: definition of e-learning in Oxford dictionary (American English) (US).” [Online]. Available: http://www.oxforddictionaries.com/us/definition/american_english/e-learning. [Accessed: 08-Nov-2015].

[11] G. N. Vavoula and M. Sharples, “Challenges in evaluating mobile learning,” in *Mlearn*, 2008, pp. 1–8.

[12] J. Traxler, “Defining mobile learning,” *IADIS Int. Conf. Mob. Learn.*, no. September 2004, pp. 261–266, 2005.

[13] M. Sharples, “Mobile learning: research, practice and challenges,” *Distance Education in China*. 16-May-2013.

[14] G. Vavoula and M. Sharples, “Meeting the Challenges in Evaluating Mobile Learning,” *Int. J. Mob. Blended Learn.*, vol. 1, no. 2, pp. 54–75, 2009.

[15] F. Alshehri and M. Freeman, “Methods of usability evaluations of mobile devices,” in *Australasian Conference on Information Systems*, 2012, pp. 1–10.

[16] Y. Park and V. Tech, “A Pedagogical Framework for Mobile Learning : Categorizing Educational Applications of Mobile Technologies into Four Types,” *Int. Rev. Res. Open Distance Learn.*, vol. 12, no. 2, pp. 78–102, 2011.

[17] "ISO 9241-210:2010(en), Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems." [Online]. Available: https://www.iso.org/obp/ui/#iso:std:iso:9241:-210:ed-1:v1:en. [Accessed: 08-Nov-2015].

[18] C. X. N. Cota, A. I. M. Díaz, and M. Á. R. Duque, "Developing a framework to evaluate usability in m-learning systems," in *Proceedings of the Second International Conference on Technological Ecosystems for Enhancing Multiculturality - TEEM '14*, 2014, pp. 357–364.

[19] M. L. Koole, "A Model for Framing Mobile Learning," *Mob. Learn. Transform. Deliv. Educ. Train.*, p. 39, 2009.

[20] A. de L. Salgado and A. P. Freire, "Heuristic Evaluation of Mobile Usability: A Mapping Study," pp. 178–188, 2014.

[21] J. Nielsen, "Heuristic evaluation," *Usability Insp. methods*, no. April, pp. 249–256, 1994.

[22] E. Bertini, S. Gabrielli, and S. Kimani, "Appropriating and Assessing Heuristics for Mobile Computing," in *Proceedings of the Working Conference on Advanced Visual Interfaces (AVI'06)*, 2006, pp. 119–126.

[23] H. J. K. H. J. Kim, J. K. C. J. K. Choi, and Y. J. Y. Ji, "Usability Evaluation Framework for Ubiquitous Computing Device," *2008 Third Int. Conf. Converg. Hybrid Inf. Technol.*, vol. 1, pp. 164–170, 2008.

[24] L. Naismith, P. Lonsdale, G. Vavoula, and M. Sharples, "Literature Review

in Mobile Technologies and Learning Literature Review in Mobile Technologies and Learning," *Educ. Technol.*, vol. 11, pp. 1–25, 2004.

[25] Y. Park, "A pedagogical framework for mobile learning: categorising educational applications of mobile technologies into four types," in *Perspectives on open and distance learning: increasing access through mobile learning*, 2014, pp. 27–48.

[26] T. Lindroth and S. Nilsson, "Contextual Usability Rigour meets relevance when usability goes mobile," *Proc. 24th Inf. Syst. Res. Semin. Scand.*, pp. 641–654, 2001.

[27] S. U. Services, H. Court, and L. Wcv, "International Standards for HCI," no. May, pp. 1–15, 2006.

[28] L. L. Constantine and L. A. D. Lockwood, *Software for use: a practical guide to the models and methods of usage-centered design*, vol. 32. 1999.

[29] E. Bertini and A. Dix, "Appropriating Heuristic Evaluation for Mobile Computing," vol. 1, no. March, pp. 2002–2004, 2009.

[30] "Report: Google Play's App Store And Developer Community Grew Faster Than Apple's In 2014." [Online]. Available: http://techcrunch.com/2015/01/13/google-plays-app-store-and-developer-community-grew-faster-than-apples-in-2014/. [Accessed: 10-Oct-2015].

[31] "Data formats - Patterns - Google design guidelines." [Online]. Available: https://www.google.com/design/spec/patterns/data-formats.html.

[Accessed: 18-Oct-2015].

[32] “First Impressions Matter! 26% of Apps Downloaded in 2010 Were Used Just Once | Reuters.” [Online]. Available: http://www.reuters.com/article/2011/01/31/idUS202184+31-Jan-2011+BW20110131. [Accessed: 10-Nov-2015].

[33] Mobile Statistics, “Mobile Apps: What Consumers Really Need and Want - A Global Study of Consumers’ Expectations and Experiences of Mobile Applications,” pp. 1–18, 2012.

[34] J. Nielsen, “How to Conduct a Heuristic Evaluation,” *Useitcom*. pp. 1–11, 2002.

[35] S. a Barab, K. D. Squire, and W. Dueber, “A co-evolutionay model for supporting the emergence of authencity,” *Educ. Train. Dev.*, vol. 48, no. 2, pp. 37–62, 2000.

[36] L. Barkhuus and a Dey, “Is context-aware computing taking control away from the user? Three levels of interactivity examined,” *Ubicomp 2003 Ubiquitous Comput.*, vol. 2864, pp. 149–156, 2003.

[37] “Learning Concepts - Sequence of Instruction.” [Online]. Available: http://www.instructionaldesign.org/concepts/sequence-instruction.html. [Accessed: 11-Oct-2015].

[38] J. Sweller, “Cognitive load during problem solving: Effects on learning,” *Cogn. Sci.*, vol. 12, no. 2, pp. 257–285, Jun. 1988.

[39] “Instructional Design Strategy for Achieving Alignment - eLearning Industry.” [Online]. Available: http://elearningindustry.com/instructional-design-strategy-for-achieving-alignment. [Accessed: 11-Oct-2015].

[40] “Course Alignment: Instructional Design.” [Online]. Available: https://canvas.instructure.com/courses/803402/pages/course-alignment. [Accessed: 11-Oct-2015].

[41] Helge Fredheim, “Why User Experience Cannot Be Designed – Smashing Magazine.” [Online]. Available: http://www.smashingmagazine.com/2011/03/why-user-experience-cannot-be-designed/. [Accessed: 12-Oct-2015].

[42] C. Lallemand, G. Gronier, and V. Koenig, “User experience: A concept without consensus? Exploring practitioners’ perspectives through an international survey,” *Comput. Human Behav.*, vol. 43, pp. 35–48, Feb. 2015.

[43] D. Parsons, H. Ryu, and M. Cranshaw, “A Design Requirements Framework for Mobile Learning Environments,” *J. Comput.*, vol. 2, no. 4, pp. 1–8, 2007.

[44] Gagné R, “The conditions of learning,” *Science (80-.).*, vol. 1, no. 34, p. 1993, 1970.

[45] “The Power of Visual Communication.” [Online]. Available: http://billiondollargraphics.com/infographics.html. [Accessed: 16-Nov-2015].

[46] K. Squire, “Video games in education,” *Int. J. Intell. Simulations Gaming*,

vol. 2, no. 1, pp. 49–62, 2003.

APPENDIX A: USE CASE DOCUMENTATIONS

Use case	Brief Description
1. Search	Trainee searches for specific content he needs
2. Practice	Trainee chooses practice tab when browsing for a course to start taking to practices
3. CRUD* Flashcards	Trainee can Create, Review, Update and Delete Flashcards in his account
4. View Courses	Trainer selects a course to view course material
5. Browse Courses	Extension point for Practice, View Course and Download course modules

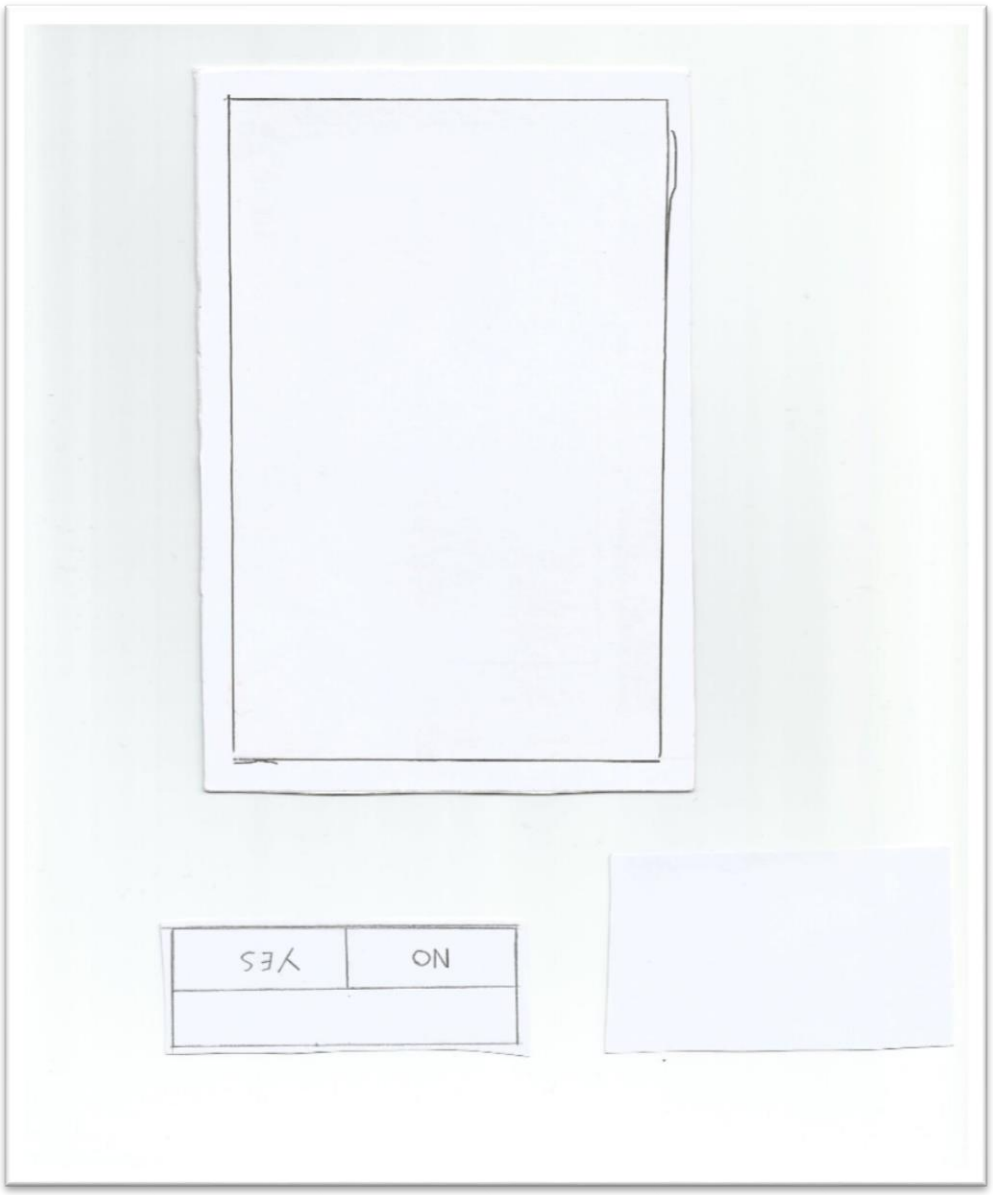
6. Download Course Modules	Trainee requests to download new course module from the content provider
7. View Progress	Trainee checks his progress for his/her registered course.
8. Send Progress Report	Trainee sends progress report to instructor
9. Login	User provides username and password to login to the application
10. Send Progress Feedback	Instructor sends his feedback on Trainee Progress
11. Review Student Assessment	Instructor view practices taken by user
12. CRUD Courses	Instructor can Create, Review, Update, and Delete Courses
13. Post Course	Instructor can post new course to be browsed by Trainees

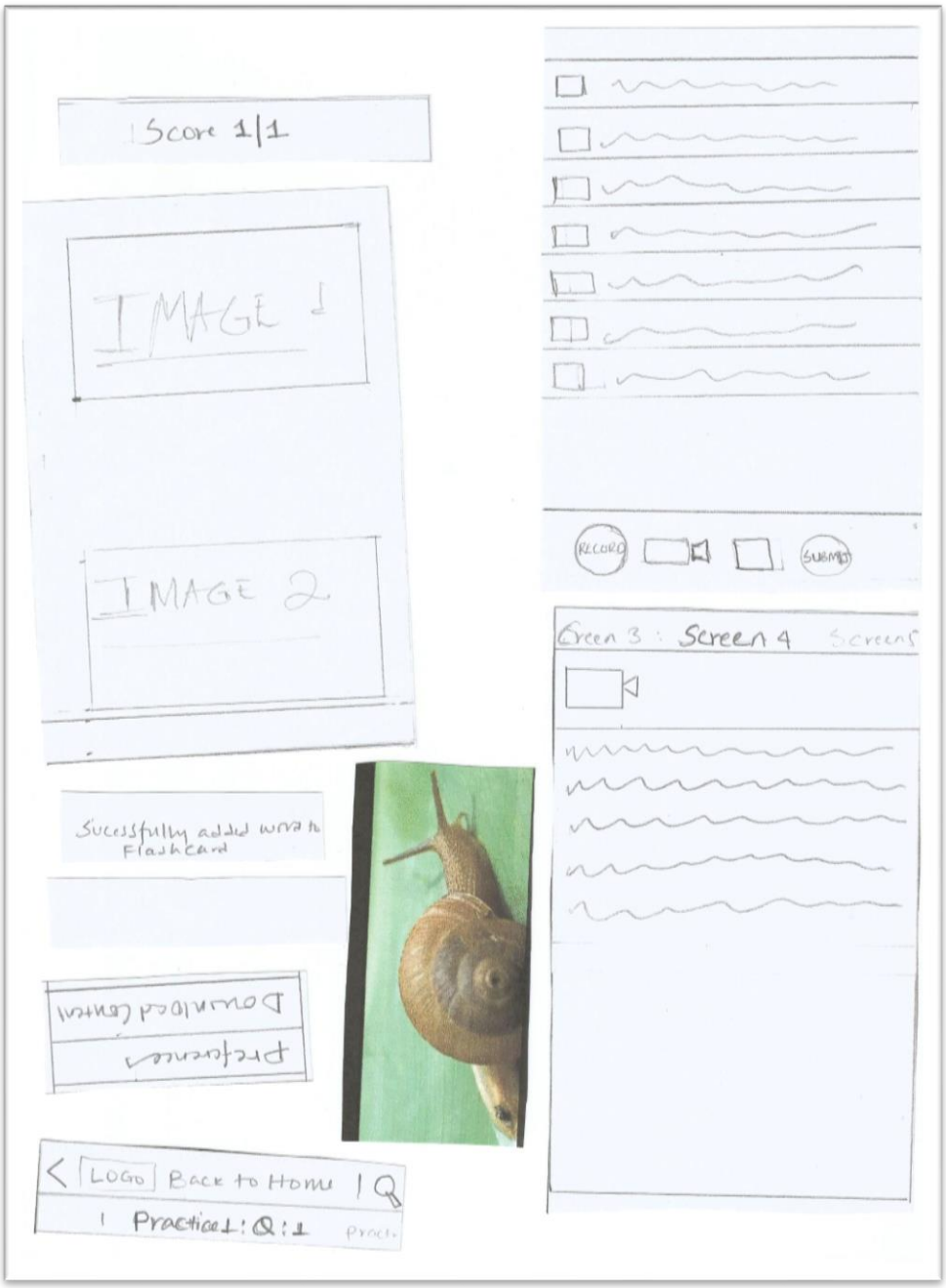
14. CRUD Discussion Board	Instructor can Create, Review, Update, and Delete Discussion Board
15. Check New Learning Objects	
16. Notify Users	Send any new activity happens in the system by other users to the user
17. Manage Sequence of Learning Objects	
18. Send Message	Trainee sends a message to their instructor or to their peers.
19. Check Messages	Trainee clicks on messages to check out new and existing messages in his inbox
20. Follow Trainee	Trainee selects to follow another trainee's account
21. View/Comment Discussion Board	Trainee enters their discussion board to view the available

	discussions and comment on a certain discussion
22. Check Notifications	Trainee checks notifications by the system due to uploading, adding new learning object or announcements from the instructor.
23. CRUD Accounts	Admin Create, Read, Update and Delete Accounts

*CRUD = Create/Review/Update/Delete.

APPENDIX B: MLW-APP LOW FIDELITY PROTOTYPE




Score 1/1
IMAGE 1
IMAGE 2
RECORD
SUBMIT
Screen 3 : Screen 4
Successfully added word to Flashcard
LOGO Back to Home
Practice1: Q: 1

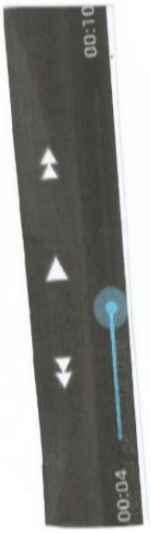

LOGO M-Learn V1
Course
Practice
FLASH CAR
Course One
Course TWO
Course THREE
(adjective)
Add to Flashcard
SEND E MAIL
EMAIL
Gmail
Skype
Printing
BY pressing YES You agree to Send your progress report.!
YES
CANCEL
LOGO M-Learn V1
Disable Sound
Reset Practice to Undone
About the aPP
ON
NO
Are you sure you want to reset all practice to Undone?
Feedback Sound disabled
00:04
00:10

Add New Card

FRONT OF Card

Back OF Card

Save | Cancel



Delete Flashcard

Are You Sure you ?

Yes Cancel

Edit Flashcard Group

Group Name

Save | Cancel

edit flashcard

Front of Card

Back Of Card

Save | Cancel

am

the

I

Man

LOGO Home

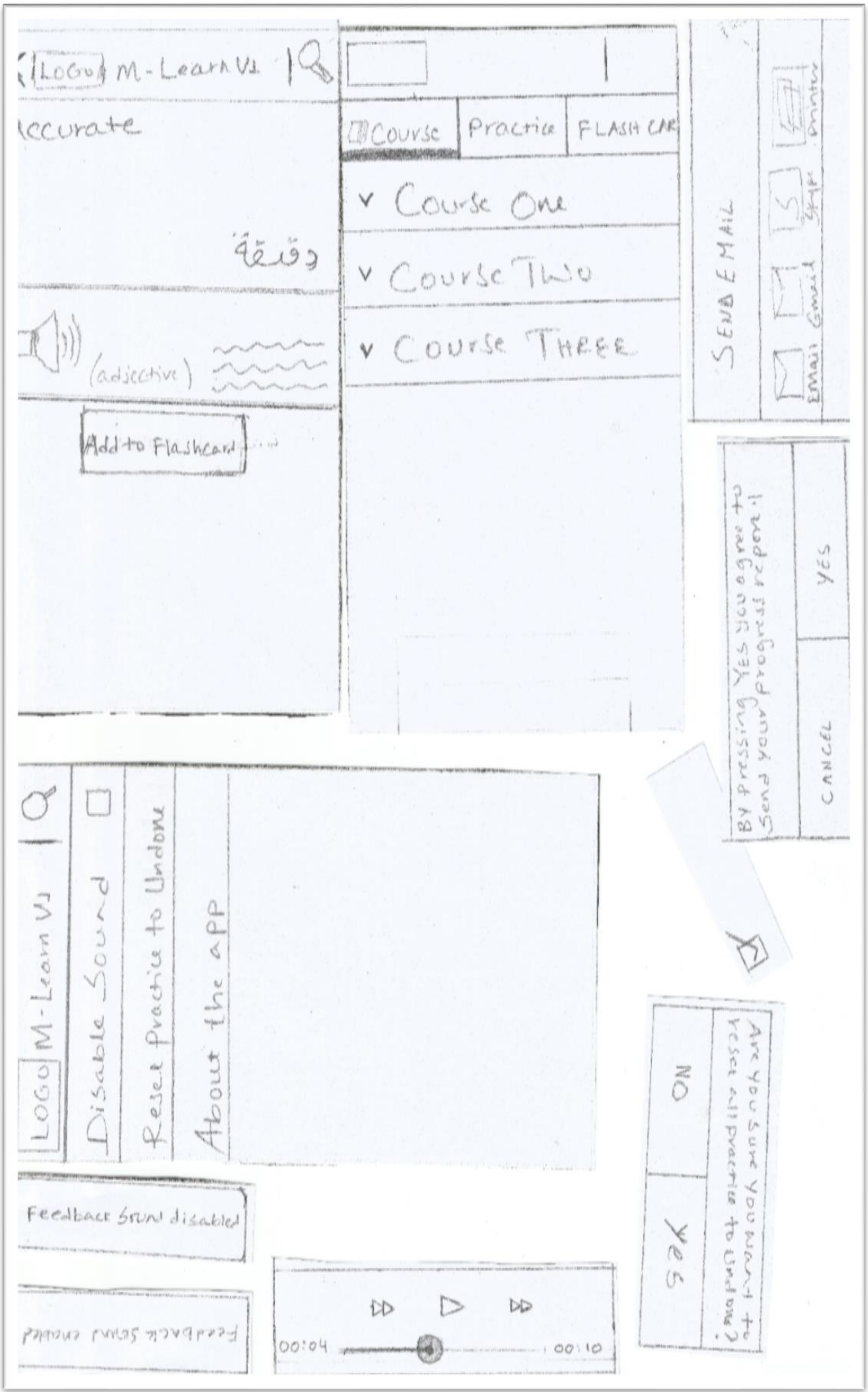
^ Course 1 Practice

> practice 1

> practice 2

Practice Result

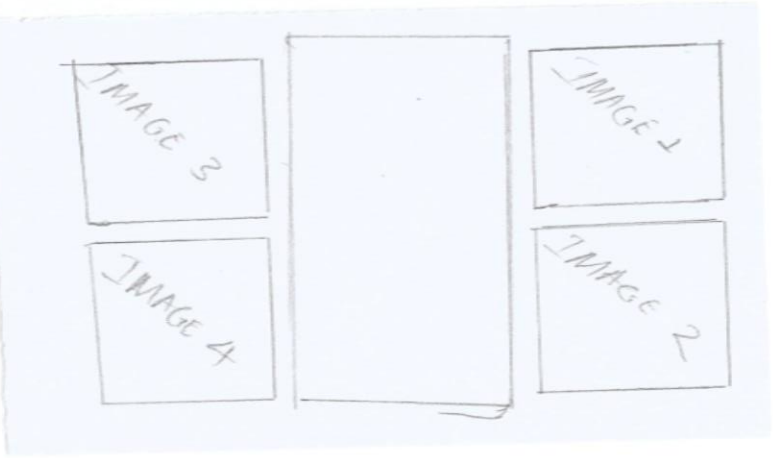
5/10

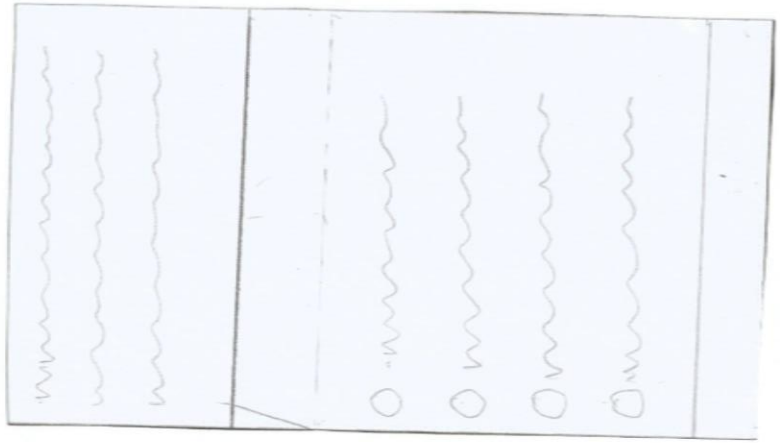

LOGO
M-Learn V1
ccurate
دقيقة
(adjective)
Add to Flashcard
Course
Practice
FLASH CAR
Course One
Course Two
Course Three
SEND EMAIL
Email
Gmail
Skype
Printer
By pressing Yes you agree to Send your progress report!
YES
CANCEL
LOGO
M-Learn V1
Disable Sound
Reset Practice to Undone
About the APP
Feedback Sound disabled
Feedback Sound enabled
00:04
00:10
Are you sure you want to reset all practice to Undone?
NO
Yes

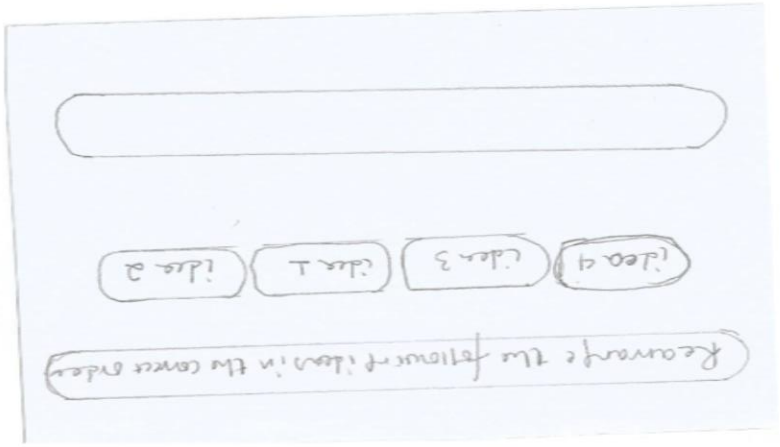

LOGO | Back to Courses
Screen3
Course One
Chapter 1
Chapter 2
Chapter 3
Chapter 4
Flashcard Groups
CREAT
Select Flashcard Group
Delete a group
Are you sure, you want to delete Flashcard?
yes
CANCEL
Select Side
Which side you want to store with ?
definition
word

Click on the word before they reach at the bottom.

WHICH of the following word is the Verb?

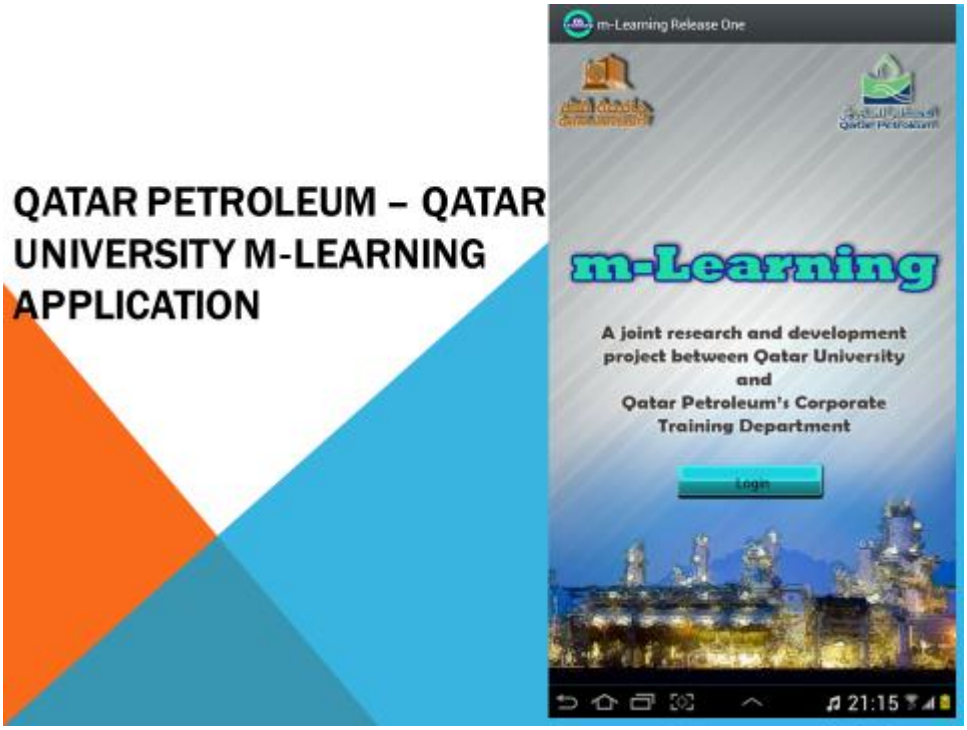


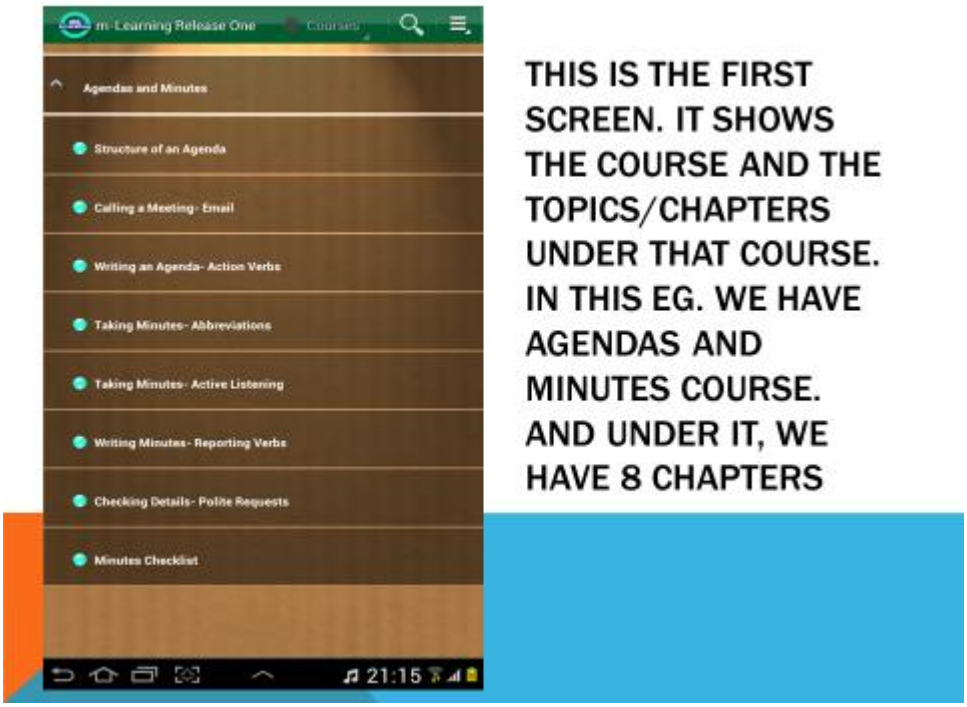


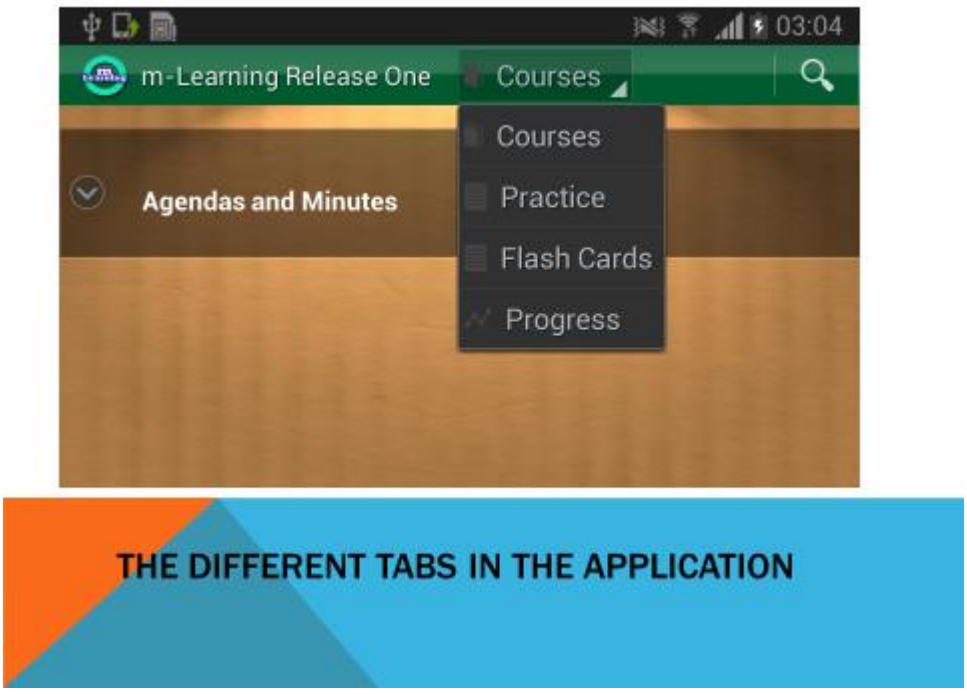


APPENDIX C: FRAME APPLICATION

USER INTERFACE

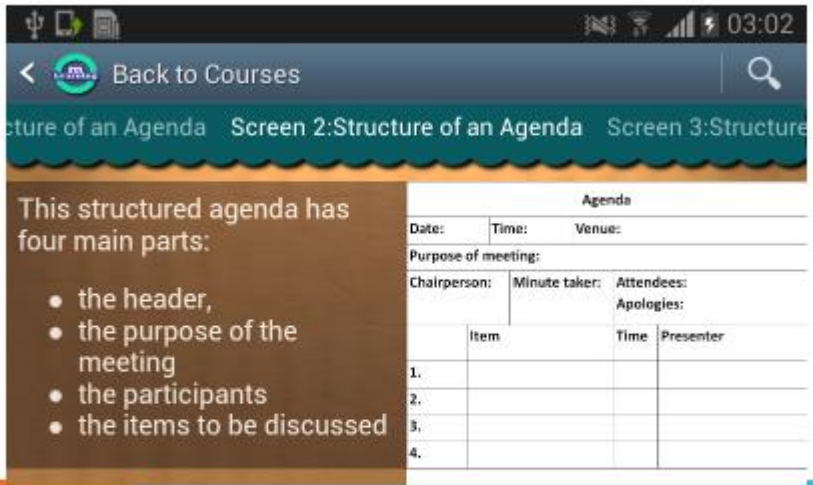



m-Learning Release One
Courses
Agendas and Minutes
Structure of an Agenda
Calling a Meeting- Email
Writing an Agenda- Action Verbs
Taking Minutes- Abbreviations
Taking Minutes- Active Listening
Writing Minutes- Reporting Verbs
Checking Details- Polite Requests
Minutes Checklist
21:15
THIS IS THE FIRST SCREEN. IT SHOWS THE COURSE AND THE TOPICS/CHAPTERS UNDER THAT COURSE. IN THIS EG. WE HAVE AGENDAS AND MINUTES COURSE. AND UNDER IT, WE HAVE 8 CHAPTERS

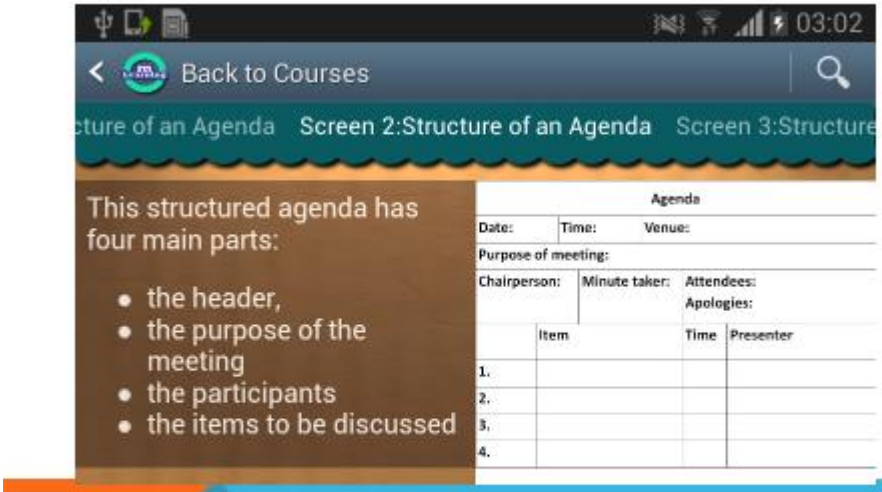

03:04
m-Learning Release One
Courses
Courses
Practice
Flash Cards
Progress
Agendas and Minutes
THE DIFFERENT TABS IN THE APPLICATION

THE DIFFERENT TABS IN THE APPLICATION

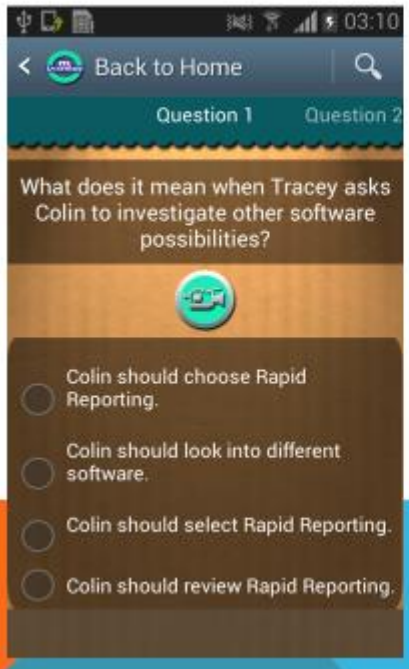
THE DIFFERENT TABS IN THE APPLICATION



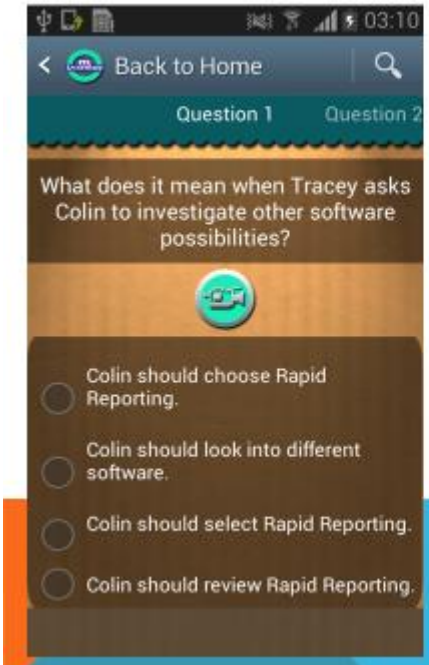
A SINGLE SCREEN OF THE CHAPTER : "STRUCTURE OF AN AGENDA" .



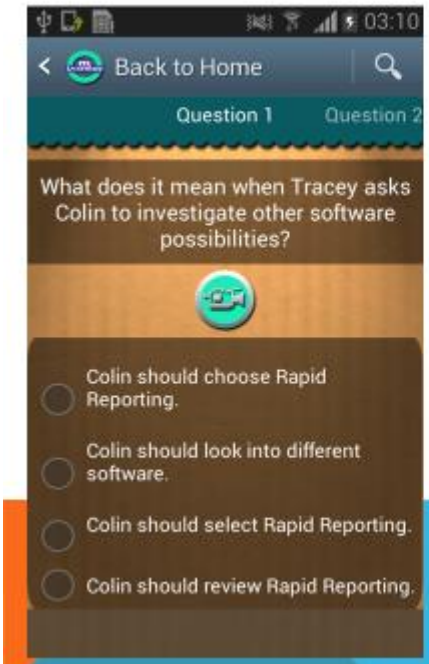
A SINGLE SCREEN OF THE CHAPTER : "STRUCTURE OF AN AGENDA" .



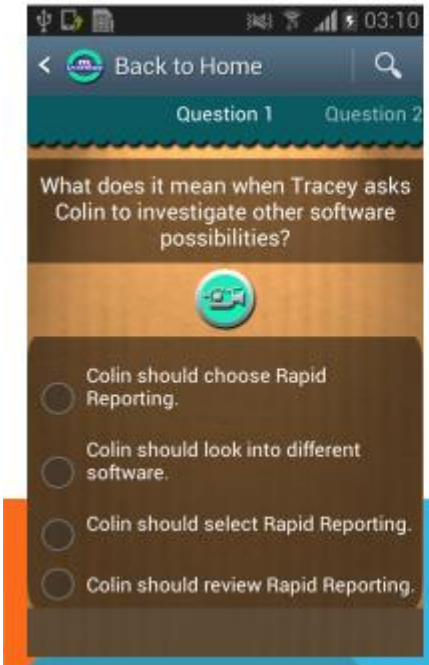
MULTIPLE CHOICE KIND OF QUESTIONS WITH VIDEO .



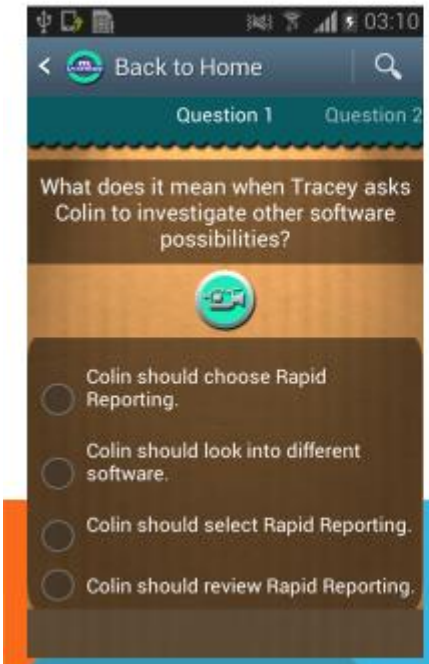
MULTIPLE CHOICE KIND OF QUESTIONS WITH VIDEO .



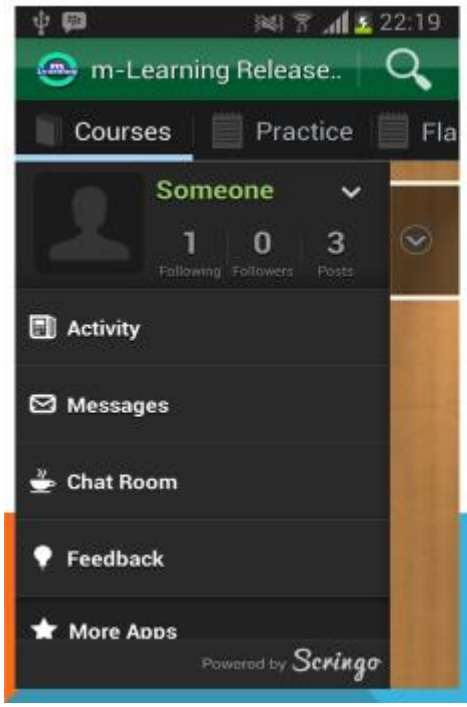
MULTIPLE CHOICE KIND OF QUESTIONS WITH VIDEO .



MULTIPLE CHOICE KIND OF QUESTIONS WITH VIDEO .

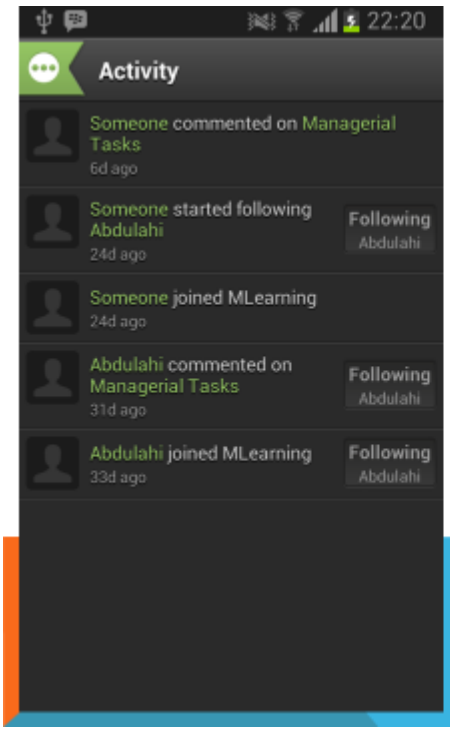


MULTIPLE CHOICE KIND OF QUESTIONS WITH VIDEO .

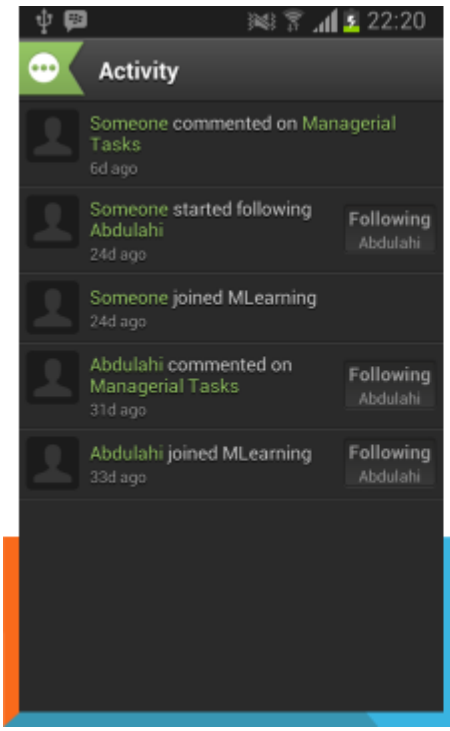


SOCIAL INTERACTION / COMMUNITY IN THE APPLICATION

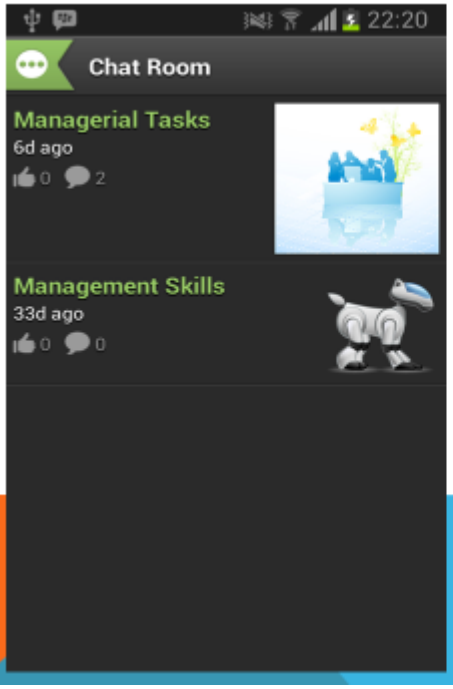
..



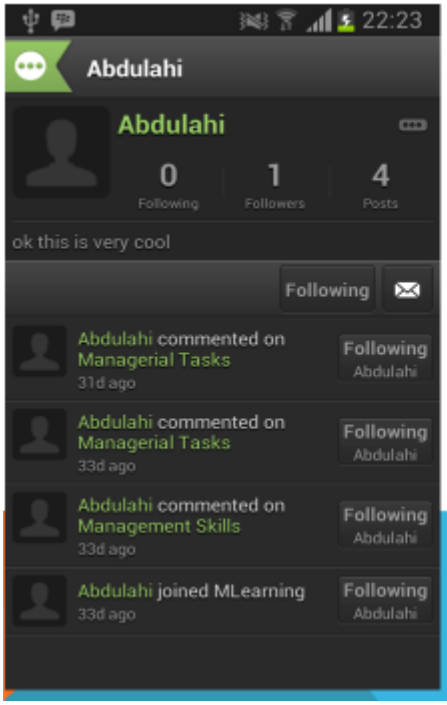
SHOW ALL THE ACTIVITIES OF THE COMMUNITY IN THE APPLICATION



SHOW ALL THE ACTIVITIES OF THE COMMUNITY IN THE APPLICATION



THERE ARE ROOMS FOR LEARNERS TO CHAT AND DISCUSS TOPICS. INSTRUCTOR POST THEM AND THE STUDENTS GET ON THEIR DEVICES AS SOON AS IT IS ADDED.



ANOTHER STUDENT PROFILE

APPENDIX D: USABILITY AND UX QUESTIONNAIRE

QP Questionnaire

Section 1: Background Information

1) What is your age group?

1. 18-25 years
2. 26-30 years
3. 31–40 years
4. 41-50 years
5. Over 50 years

2) What is your gender?

1. Female
2. Male

3)

4) Have you taken courses in English overseas?

1. Yes
2. No

3(b) **Pumps & Primers only** what is your nationality?

1. Qatari
2. Other nationality _____

5) What is the highest level of education that you have completed?
    1. High school
    2. University degree (undergraduate)
    3. Master's degree
    4. Doctorate
    5. Technical diploma
6) Why are you taking the course Presentation Skills/Agendad & Minutes?
    1. To learn a skill necessary for your job in the future.
    2. As part of your development program.

5) (a) **Pumps & Primers only** Where did you receive most of your firefighter training?
    1. Qatar
    2. Other country
7) Have you given a presentation before? (Choose any that are true)

1. Yes, as part of a course. Yes I've written an agenda.
2. Yes, in a work situation. Yes, I've taken minutes.
3. No.

6) (a) **Pumps & Primers only** How many years have you been a firefighter?

1. 0 to 2
2. 3 to 5
3. 5 to 10
4. more than 10 years

7) What is your experience using mobile devices such as smart phones, Blackberry, Samsung, iPhone, etc?

1. Use a mobile device on a daily basis (Specify type: _____)
2. Use a mobile device occasionally (Specify type: _____)
3. Never used a mobile device

7 a) Pumps **& Primers only** what do you normally do with your smart phone or tablet? Tick all that apply.

1. Make and receive telephone calls
2. Send and receive SMS

3. Use social media (Facebook, Twitter, etc)
4. Use WhatsApp, BBM, or other messaging
5. Download apps and music
6. Browse the internet
7. View videos

Section 2: Usage

A. Did you use your own handset or one supplied by Qatar University?

1. my own
2. Qatar University
3. I did not use the application at all

B. If you did not use the application at all, please explain why

1. Could not download it onto my device
2. Could not open it on the Qatar University device
3. I did not have enough time due to other commitments
4. Other. Please explain

8) How many minutes **in total** did you use the M-learning app?

1. 30 minutes or less

2. between 30 minutes and 1 hour
3. between 1 hour and 1.5 hours
4. between 1.5 hours and 2 hours
5. between 2 hours and 2.5 hours
6. between 2.5 hours and 3 hours
7. more than 3 hours

9) On average, how long was each session at a time **outside of the classroom** (approximately)?

1. 5 minutes
2. 10 minutes
3. 20 minutes
4. 30 minutes
5. 45 minutes
6. 1 hour
7. 1 hour plus

10) Did you mainly use headphones when you were listening to the audio exercises?

1. Yes
2. No

11) Did you ever turn the audio off?

1. Yes

2. No

11a) If you answered “yes” to the above question, why did you turn it off? **(You can choose more than one answer)**

1. It was disruptive to others.
2. It was embarrassing when I got something wrong (buzzer, etc.).
3. Other reason (please explain)

   _____

12) Where did you use the app? (you can choose more than one)

1. in the classroom
2. at home
3. while traveling
4. Other (please tell us where)

   _____

5. Other

Section 3: Question Preferences

13) Did you like the timed questions? See *Rhetorical Questions- Exercise one*

1. Yes
2. No

14) Did you like the falling sentences question? See *Making a Mistake-Practice 1*

1. Yes
2. No

14(a) **Pumps & Primers only** I **liked** the following practice activities: (Check all that apply)

1. Multiple choice (Lift Practice 2, Control Practice 1)
2. Hot spot corners (Faults Practice 2 and 3)
3. Fill in the blank questions (Primers Practice 1
4. Rearranging words (Pumps Practice 1)
5. Falling words questions (Faults Practice 1)
6. Video questions (Primers Practice 2, Control Practice 2)
7. Audio questions (Gauges Practice 1 and 2)
8. Picture answers (Pumps Practice 2, Safety Practice 1)
9. Checklist (Maintenance Practice 1)

14)(b) **Pumps & Primers only.** I **did not like** the following practice activities: (Check all that apply)

1. Multiple choice (Lift Practice 2, Control Practice 1)
2. Hot spot corners (Faults Practice 2 and 3)
3. Fill in the blank questions (Primers Practice 1
4. Rearranging words (Pumps Practice 1)
5. Falling words questions (Faults Practice 1)
6. Video questions (Primers Practice 2, Control Practice 2)

7. Audio questions (Gauges Practice 1 and 2)
8. Picture answers (Pumps Practice 2, Safety Practice 1)
9. Checklist (Maintenance Practice 1)

Section 4: Feedback Preferences

15) Did you like the audio comments? For example: "Try again" "Better luck next time" "Well done"

    1. Yes
    2. No

16) Did you like the buzzer noise for an incorrect answer? See *Making a Mistake- Exercise 1*

    1. Yes
    2. No

17) Did you like it when correct answers turned green and incorrect answers turned red? See *Review PowerPoint- Exercise 1*

    1. Yes
    2. No

18) Did you like it when you received personalized feedback (you were given the reason an answer was wrong)? See *Review PowerPoint- Exercise 1*

    1. Yes
    2. No

Section 5: Learning Process

Please draw a circle around the number that describes your experience with the application.

19)The audio was clear and easy to hear.

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

20)The videos were clear and easy to hear.

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

21)The animation was useful. (see *the Introduction* lesson)

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

22)The videos of presentations were useful. (see *the Introduction* lesson)

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree

5	4	3	2	1

23)The audio dialogues were useful. (see *Know Your AUDIENCE* lesson)

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

24)The option to listen to the instructions was useful. (see *the Introduction* lesson)

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

25)Which was the most helpful for you?

1. Listening to the audio
2. Watching the video presentations
3. Watching the animations
4. Doing the practice exercises
5. Making flashcards
6. Reading the lessons on the screen

26)The mobile technology provides flexibility for me to learn anywhere and at any time.

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

27)Navigation (moving) through the lessons was easy.

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

28)Learning with the mobile technology increases my enjoyment of learning.

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

29)I think my presentation skills improved after doing these exercises.

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

30)I would like to take other lessons using mobile technology.

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

30)(a)**Pumps & Primers only.** The best part of this learning experience was _____

30)(b) **Pumps & Primers only.** The worst part of this learning experience was _____

31)In the space below, provide additional comments on your experience using the mobile learning lessons for developing presentation skills. Is there anything you particularly liked, or didn't like?

APPENDIX E: FOLLOW-UP INTERVIEWS

mLearning Application Questions for Follow-up Interviews

Date: _____

Time: _____

Venue: _____

Participants: _____

During the mLearning training:

1. What do you remember about the mobile learning app?
2. What did you particularly like or dislike about using the mobile learning app to improve your English skills?
3. Did you use the application outside of your work shifts? If you did, when and where did you use it, and for what purpose? If you did not, why not?

After the course

4. Have you used the knowledge and skills you learned using the mLearning app on the job? If yes, describe how you have done so. If No, describe why you have not used the knowledge and skills.
5. Would it be useful for you to continue to have access to this app at work? Why or why not?

6. How can the mobile application be improved to help you learn?
7. Should QP expand the use of mobile learning for training? Why and how?

Mobile learning in general

8. What are some benefits or problems when using mobile technology for learning?
9. Any further comments about mobile learning or using learning apps in the workplace?

APPENDIX F COLLECTED DATA-POST INTERVIEW

	Some of the Not Positive Comments FRAME
1	A couple of answers in the “Purpose” exercise were wrong. · In some exercises, the App was not very responsive. · It wasn’t clear to me whether I needed to tap once, repeatedly or drag the answer. The questionnaire is too long.
2	It was a nice trial , but regarding the exercises some of them need to be adjusted (for example a lot of my answers where wrong because by mistake I press another answer instead of the right answer , from my point of view submit button should be their to confirm the answers .
3	it will be better to have material "lessons" in the mobile that is different than those in the handouts so ti will not be boring and will complement the in-class materials
4	it would be easier if we can download to our personal phones and if it can work within other operating systems

5	The idea of using mobile learning should be for areas where research is highly required such as purly technical courses. The idea of the application is fine, but it's been put in a wrong practice or ti might be useful for high school students.
6	It was quite helpful but not much as the course in a classroom setting.
7	to learn more infromation and give us the idea of what we are take to give easy understand with many kind of pratice.
8	In general, the software is so useful BUT, be careful of repeating questions, increase database be careful of sounds in the software and how it noisy, make it gentle.
9	ARABIC (translated by Abdulahi) i wish for it to be in both english and arabic since i have faced difficulties in understanding some of the vocabulary. and wish you all the best.
10	Logo color is frightening!! I knew it's about teaching. The features are good such as, dictionary and lessons. But I didn't like the audio and video!!
11	make it available for all mobile types and easy to be downloaded

12	no creativity
13	maybe more harder question or user can choose which level he wants to begin with
14	installing the app on candidate mobile phones would make M-learning servey success

	All Non-Positive Comments MLW
1	I like learn through elearning
2	about for learning english I am not ferpect tacking english and sometimes hard to undestand the correct sentences
3	Once we answer a particular question, should be closed ;if it open again, it becomes confusing
4	more graphics, more animation, and maybe clear audio because sometimes not clear; verbal comment: younger voice for narration
5	the course better to be in arabic than english
6	(verbal) Used for first days and then stopped until reminded by supervisor; suggest to send weekly email reminder.

	All Positive Comments FRAME
1	love the idea but the user experience should be inproved with better navigation and better graphics
2	I like the idea and it is useful and easy to carry anywhere
3	I like it.
4	new positive experience!
5	This experience assist me to develop my presentation skills it's give an ability to practice my self similar to I am front of a mirror.
6	it would be nice if we have the application on other devices, such as iphon and ipad
7	It would be nice if the application can show me which exercises I tried to answer and which ones I haven't started yet. A "pause" option can be a good addition.
8	It's a useful application and I would like to re-use if it will bw available but only in class or in my workplace. No time for using the application after work.

9	to learn more infromation and give us the idea of what we are take to give easy understand with many kind of pratice.

	Positive Comments of MLW
1	this application is: very practical; very easy; very efficient to improve English and firefighting level at the same time
2	Yes it is big help for my part to improve me for being a firefighter. Because communication is very important in our daily lives.
3	This application is very important to me when my day off. It is fun and exiting and I learn more.
4	the videos are good for more knowledge and working principles. Understand the lessons
5	Need more subjects related with our profession. (verbal) If youhad other courses that would be good. During the bus, traveling, that would be good.
6	Very good

7	It was a very handy, fast, good way of learning that in my own opinion it can be used in other areas of learning also.
8	more become accessable to busy firefighter
9	verbal comment: inquired regarding getting the app onto his own Android when he purchases one.
10	thanks a lot for help and assist
11	verbal comment: inquired regarding **copying** app to laptop to save in case of mobile reformatting
12	I don't know how to [vete]. (verbal comment: Should have other courses like how to work in teams.
13	I'm not using the M-learning aplication last week because I'm sending training at Safety College. That why no time to open. Please allowed me to used this application even they finished the 16 days duration. Thank you