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A Model For Designing And Adapting Mobile Learning Content

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By

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نموذج تفويض

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DEDICATION

This is dedicated to my family, for their love and encouragement.

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LIST OF ABBREVIATIONS

BL	Battery Level
BBN	Bayesian Belief Network
CMS	Content Management System
Db	Decibels
EDGE	Enhanced Data Rates for Global Evolution
GPRS	Global Packet Radio Service
GSM	Global System for Mobile Communication
HTML	Hyper Markup Language
IrDa	Infrared Data Association
LCMS	Learning Content Management System
LMS	Learning Management System
LO	Learning Object
LOM	Learning Object Meta Data
LP	Learner Preference
LS	Learner Style
MR	Multiple Representation Approach
PC	Personal Computer
PDA	Personal Digital Assistant
SCORM	Sharable Content Object Reference Model
UMTS	Universal Mobile Telecommunication System
WAP	Wireless Application Protocol
Wi-Fi	Wireless Fidelity Protocol
WML	Wireless Markup Language
WWW	World Wide Web
XML	Extensible Markup Language
3D	Three Dimensions
3G	Third Generation

TERMINOLOGIES

Blended Learning: a combination of e-learning or mobile learning and any traditional learning method.

Content Adaptation: adjusting the learning content with respect to the presentation format, abstraction level, order and the structure of the learning objects in order to fit the learner and the technological contexts.

Content Management System: a system that is used to store and subsequently finds and retrieves large amounts of data.

E-learning: the utilizing of distributed systems, networks, devices and communications technology in order to deliver at most all the activities that are provided by the traditional learning environment in order to facilitate and enhance the learning and the teaching process.

General Packet Radio Service: one of the wireless telecommunication technologies that depends on the packet switched approach in transferring the data with a rate between 30 and 80 Kbps.

Information Objects: isolated single pieces of digital resources such as text paragraphs or web pages that are not related to any particular context or learning objective.

Instructional Design Model: a systematic process that instructional designers must follow in order to achieve the creation of efficient and effective instruction.

Learning Content: a digital content that include learning materials, activities, objectives and assessments.

Learning Content Management System: a system build on the content management system and it is used to manage the higher educational learning content.

Learning Context: any information that can be used to characterize the situation of an entity in a learning activity.

Learning Management System: a system that offers a group of functionalities designed to administrate the learning process, manage students, track the student's progress and deliver the learning content.

Learning Objects: Any entity digital or non-digital which can be used, re-used or referenced during a learning process supported by technology.

Learning Process: an organized process of acquiring a body of knowledge that is found in a defined educational course or learning material.

Mobile Devices: any device that is small, autonomous, and unobtrusive enough to accompany us in every moment of our every-day life, and that can be used in learning such as PDAs, smart phones and cell phones.

Mobile Learning: a new stage of e-learning that support the learners' mobility by enabling them to access the learning content via mobile devices and wireless technologies.

Wireless Application Protocol: a protocol that was designed to allow the users to browse the Internet from their mobile device rather than browsing the Internet from a desktop computer.

Wireless Fidelity Protocol Technology: a collection of standards that has been developed by the IEEE LAN/MAN Standards Committee and it is used for wireless local area networks the most recent version of Wi-Fi technology (802.11g) offers 54 Mbps data transfer rates.

ABSTRACT

Since mobile learning was emerged in the educational community, many researches have been done to conceptualize this new learning form. This thesis are going to solve a significant problem, which is designing and adapting the learning content in mobile learning application to fit both the learners and mobile devices. In order to attack the main problem, we have explored the field of electronic learning (E-learning) because there are many important and similar connections and issues between e-learning and mobile learning. We have also introduced the mobile learning field and the core aspects that are playing major roles in enhancing the learning experience that is provided by these devices. The focus has been on mobile learning content design which becomes more complex as a result of the sophisticated relationship between the learning content and the learning context. Through our investigations we found that current technological devices used in mobile learning such as mobile devices and wireless technologies enforce critical constraints on the learning process considering screen size and other technological constraints. To solve this issue, and to make the learning process ubiquitous, we have introduced a detailed approach to design the learning content and proposed some of the design guidelines that can be applied to effectively design the content. Furthermore, we have successfully design a model to adapt the learning content in mobile learning applications in order to conform the learner context, preferences and the educational objectives. Success

Key Words: *Mobile Learning, Learning Content, Content Design, Content Adaptation, Learner Context, Technological Context.*

الملخص باللغة العربية

منذ ظهور التعلم عن طريق الأجهزة النقالة في المجتمع التعليمي, تم إنجاز العديد من الأبحاث لتحديد مفاهيم هذا الأسلوب التعليمي الجديد. هذه الرسالة ستقوم بحل مشكلة هامة ألا وهي تصميم و تعديل المحتوى التعليمي في تطبيقات التعلم عن طريق الأجهزة النقالة لتناسب كلاً من المتعلمين و الأجهزة النقالة. و من أجل مهاجمة المشكلة الرئيسية قمنا باستكشاف حقل التعلم الإلكتروني لأن هناك العديد من الروابط و القضايا المهمة و المتشابهة بين التعلم الإلكتروني و التعلم عن طريق الأجهزة النقالة. و أيضاً قمنا بتقديم حقل التعلم عن طريق الأجهزة النقالة و السّمات الجوهرية التي تلعب أدواراً رئيسية في تحسين التجربة التعليمية المقدّمة من خلال هذه الأجهزة. التركيز كان على تصميم المحتوى التعليمي الذي أصبح أكثر تعقيداً نتيجة العلاقة المعقدة بين المحتوى التعليمي و المحيط التعليمي. من خلال تحرّياتنا وجدنا أنّ الأجهزة التقنية الحالية التي تستخدم في التعلم عن طريق الأجهزة النقالة مثل الأجهزة النقالة و التقنيات اللاسلكية فرضت قيوداً حرجة على العملية التعليمية آخذين بعين الإعتبار حجم الشاشة و القيود التقنية الأخرى. لمعالجة هذه القضية و لجعل عملية التعلم متاحة في كلّ مكان, قمنا بتقديم أسلوب مفصل لتصميم المحتوى التعليمي و قمنا بطرح بعض التوجيهات التي تتعلق بالتصميم و التي يمكن أن تطبق لتصميم المحتوى بفعالية. بالإضافة إلى ذلك, قمنا بنجاح بتصميم نموذج لتعديل المحتوى التعليمي في تطبيقات التعلم عن طريق الأجهزة النقالة ليطابق محيط المتعلم, رغباته و الأهداف التعليمية.

CHAPTER 1

1. INTRODUCTION

Learning is a charming phenomenon that takes place continuously throughout human's lifetime. It is considered the foundation stone of the economic development in any modern society. In this thesis, learning process is defined as an organized process of acquiring a body of knowledge that is found in a defined educational course or learning material. The learning process is related to two important factors. First is the student learning style, where each student has a preference to certain learning style that guides his learning process. For example, some students prefer the visual style such as pictures or diagrams while other students prefer the aural style such as sounds or music.

Second, the technology which has a great affect on the learning process. First of all, technology has an influence on how people can learn. For example, technology offers several tools that facilitate the learning process such as calculators, computers, Internet and many other means that make it easy for learners to be engaged in their learning experience. Furthermore, technology plays a vital role in determining why people learn; each person has some reasons that inspire him to learn and educate himself. Currently, one of the most important reasons that motivate people to learn is to go along with the technological advances. There is also an important impact of technology on what people can learn. It has to be said that any major modification in the educational curriculum is a result of significant technological changes [53]. Finally, the recent proliferation of some technologies such as mobile devices increases the technological impact on the learning process; these technologies can give the learner the freedom to choose when and where to learn.

In the past, formal education was presented in a classroom where the tutor and learners interact with each other directly and the technology acts as an extra tool to support the tutor. This traditional form of learning characterized by face-to-face provision between tutor and learners in the learning group and it based on interpersonal communications [23]. As a result, this form has some physical presence restrictions.

Distance learning appeared into use as a consequence of the technological developments associated with the Industrial Revolution to overcome the traditional classroom restrictions and to provide a new type of learning in which students are not in the physical presence of the tutor. The first form of distance learning based on two main characteristics which are: separating the tutor from learners and separating the learner from the learning group [23]. Mainly, the communication between the

tutor and learners was via mail. In the seventies, great advances were made with the foundation of the European open universities that was formed by Royal Charter initiative to "open-up" education. At first, they use correspondence as the main way of communication between tutors and students. Later, they were pioneers by linking themselves to other national institutions like the British Broadcasting Corporation (BBC) to deliver a high quality learning materials. Later, the eighties, some technologies including audio-visual aids, cable and satellite expand the distance learning experience and facilitate the group-based learning via linking several geographical locations simultaneously [23].

The electronic revolution in the eighties had a profound impact in the technological advancements especially on personal computers. Ever since, we have observed a rapid development and deployment in computing power. The size and the price of personal computers were reduced and there was a significant increasing in the personal computers capacity.

As the World Wide Web (WWW) evolved in early nineties, the electronic learning came into light to describe a new way of managing the learning process and delivering the learning materials via Internet or any e-media. It is characterized by [23]: first, the separation of tutors and learners that will release the learner from the traditional classrooms stress. Second, the influence of educational organizations, which distinguish self-study from private tutoring. Third, the use of computer networks to deliver the learning content. Finally, the provision of two-way communication through computer networks to enable the learner to communicate with fellow classmates and with his tutors. However, e-learning is not intended to replace the classroom learning. It could be used in conjunction with more than one traditional learning method; in this case the term blended learning is used.

While many predicted that e-learning is the final and most effective solution for providing learning services, there have been significant developments in mobile and wireless technologies which were the main factor for expanding the mobile usage habit among different communities and escalating the number of mobile Internet subscribers. At this point, the educational community starts to think in investing the mobile usage habit as well as the wireless technologies to introduce a new learning form that can extend e-learning services and can support the traditional learning techniques.

Mobile learning is a natural flowering of e-learning. There is a large similarity between e-learning and mobile learning. In [32], the author defines e-learning as "learning supported by digital “electronic” tools and media", and he defines mobile learning as "e-Learning that uses mobile devices and wireless transmission". However, mobile learning extends the benefits of e-learning by

offering a new degree of freedom to support mobile learners. And just as the relationship between e-learning and the traditional learning methods, mobile learning can not replace the traditional classrooms. Mobile learning is a supported learning technique that can be presented with conjunction of other learning forms.

Finally, it has to be said that technology in all forms is the driving force of the learning process. Each technology participates in transmitting us from one learning form to another. Now, it seems that learning is getting ready to make another shift forward the era of mobile learning as shown in Figure 1.1.

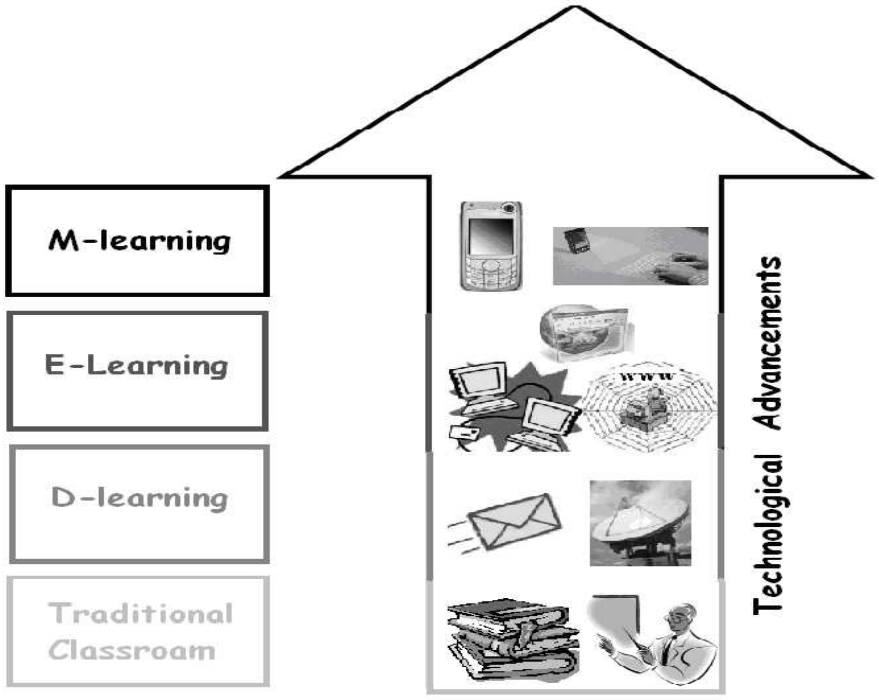


Figure 1.1: Technology Impact on Learning

1.1 CONTENT IN THE NEW LEARNING FORMS

E-learning and mobile learning platforms provide several services. Some of these services are common and have grown since computers were first used in education, the other services can vary from one platform to another [40]. One of the most important services is the learning content and content presentation. The learning content in the new forms of learning is a digital content that is used by the tutors to present the learning materials to the students. Much effort has been devoted for the reuse of the learning material, and the result was introducing the term Learning Object (LO), which are defined as "any entity digital or non-digital which can be used,

re-used or referenced during technology supported learning" [28]. Moreover the learning content has a lifecycle which include a number of phases. The content pass through these phases before the learner can interact with it. Each phase has a specific purpose that enhances the learning content in certain way. Learning content lifecycle includes the following phases [14]:

1. Analysis phase: is the foundation that helps in understanding the learning content, building the logical model and preparing the content to be designed.

2. Design phase: is one of the most critical phases in creating content which includes applying some instructional design model or guidelines and identifying the technologies and tools that will be used to deliver the content.

3. Authoring phase: in this phase the content is created and written from the scratch.

4. Assembly phase: this phase includes joining the existing contents into rational presentation. It may also include methods for personalizing the learning content; identify content for different learners, so different learners can view different versions of the content.

5. Transport phase: is responsible of transporting the learning content from one system to another. Beside, it is also responsible of storing and retrieving the content through a search engine.

6. Delivery phase: finally the learning content is ready to be delivered to the learner. The way in which the learner uses the content can be monitored to gain a history of interactions between the learner and the system.

In this thesis we will explore the mobile learning content design phase which is a critical phase that focuses on building content blueprints that support the subject matter, the learning styles and the technological requirements.

1.2 STATEMENT OF PROBLEM

The problem we focus on is the one of designing the learning content to be compatible with the capabilities and limitations of the mobile devices. Most of today e-learning content is developed in large sections and designed to be displayed on relatively large screens such as laptop and desktop computers screens which have at least 800 x 600 pixels resolution. This resolution is larger than the

available mobile screen area. As a result, the presentation of most e-learning content is unsuitable on the small mobile devices. Moreover, mobile learning has the interesting aspect from the idea of learning anytime and anywhere. But on the other hand, the mobility of mobile learning scenarios defines a new relation between the learning content and the learning context. This relationship should be taken into consideration when designing the mobile learning content. The learning content must be adapted in order to fit the different scenarios on the learning context which changes frequently for the same learner and from one learner to another.

1.3 THESIS MOTIVATION

Our motivation is based on the following fact: mobile telephone usage is now concerned as a habit among students' community. This habit can be a large investment that enhances the educational level and helps in releasing the students from being taught with cutting-edge technologies. Mobile learning can extend the e-learning benefits by releasing the last technology from its minimal requirement which is a personal computer (PC) and open new horizons for the educational community to achieve the idea of learning at anytime and anywhere. And because content design is a hot topic that enhances the learning process in any learning form we would like to propose a model for designing and adapting the learning content for mobile learning applications.

1.4 GOALS

In this thesis we aim to:

- Introduce a new model for designing and adapting the learning content in a way that go well with the learner's preferences, support the learning context (location, noise level, device type, availability of resources, network,) and finally it should be compatible with the learning objectives.
- Define most of the possible scenarios of context that can take place in the mobile learning environment and how the learning content can be adapted to support each scenario.

1.5 CONTRIBUTION OF THE THESIS

In this thesis we analyzed different mobile design guidelines to introduce a detailed top-down approach for designing the learning content for mobile learning applications. Furthermore, we determine most of the possible context scenarios that could occur while the learner is using his

mobile device to engage in a meaningful learning process and finally we propose a model that can adapt the mobile learning content to fit the learner, environment, device and wireless connectivity contexts.

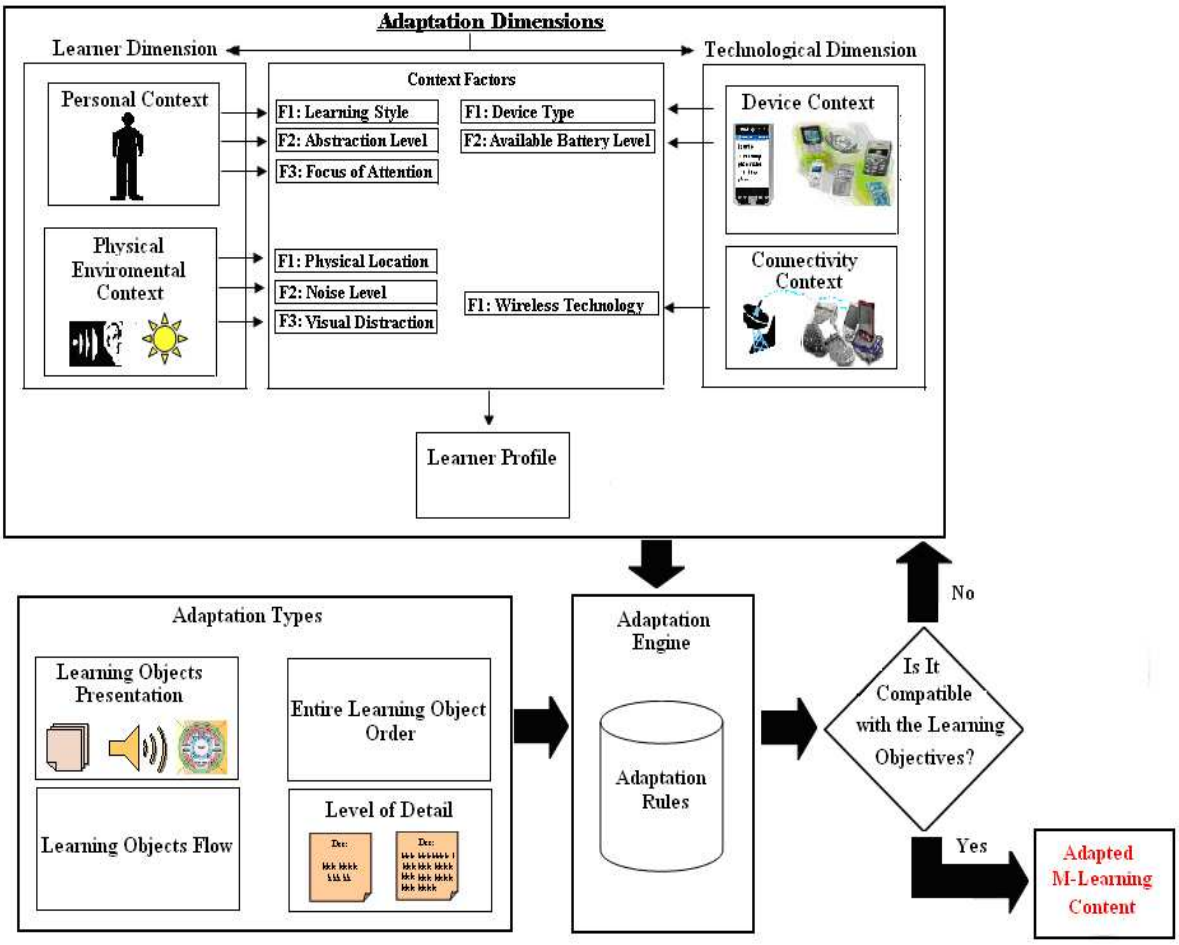


Figure 1.2: Our Model for Adapting Mobile Learning Content

As shown in Figure 1.2, our model takes into account several factors from four context categories specified according to two dimensions which are the learner and technological dimensions. The learner profile contains the type of content presentation that is preferred by the learner as well as the context factors that are almost stable. The information that will be provided by the learner profile and the values of contexts' factors will be used as an input on the adaptation engine. The adaptation engine specifies which type of content adaptation is needed according to predefined rules. The model involves four types of adaptation that can be applied on the learning content which are: adaptation on the learning objects presentation, entire order, flow and level of details. We used this model to cover most of the possible scenarios that can take place in the mobile learning environment and we found out the most appropriate learning content that fit each scenario.

1.6 RELATED WORK

Designing the learning content to fit the capabilities of mobile devices is a remarkable problem. Unfortunately, most of learning materials are designed for displaying on desktop computers that lead to unlikable presentation of most web pages on the small devices. In [19], the author introduced significant suggestions that can be used to overcome the hardware and software challenges in mobile learning systems. Moreover, the author proposed some guidelines for the mobile learning designers relating to users environments and the tasks that should be performed by the users such as:

- When designing mobile learning content we should realize that reading online at low resolution significantly reduces the reading comprehension.
- When designing the content we should think in terms of nuggets or specks rather than chunks.
- When designing web pages for reading on mobile devices we have to remember that the screen orientation is portrait not landscape, and that the screen width is very narrow.
- Before designing mobile learning content we have to analysis the learners, their tasks and their environments. Then, we have to apply the results of the analysis to the design, and be cautious of the wide range contexts.
- Minimize file sizes to help in quick loading of the learning content and to save the memory of the device.
- The amount of interactivity and scrolling should be also minimized to avoid the learner frustration.
- Recognize that these devices are almost always held in one hand, so the user has only one hand free for interaction with the device.

In [24], the authors illustrated the concept of Multiple Representation (MR) approach and its application in mobile adaptation. As a starting point, they reviewed several techniques for web page level content adaptation. Next, they proposed MR approach to solve the gabs in the previous techniques, which are generic and lake of the pedagogy guidelines, by providing new guidelines for content adaptation in e-learning and m-learning applications. The MR approach deal with the

presentation of content in three ways which are: First, the appropriate selection of multimedia objects. The authors claimed that this can be done by applying some recommendations such as:

- Selecting the learning objects on the basis of the task specificity and learner's competence.
- Taking into account the expectations of the learner.
- Selecting the learning objects that attract the learner senses.
- Selecting the most suitable object for the learner context.

Second, navigational objects selection. The MR approach, determine six types of navigational links that will help the learner to reach different types of learning content without deviating the learner attention while he is doing the learning activity. These links are: direct successor links, parallel concept links, fine grained links, glossary links, excursion links and problem links.

Finally, the third way that handles the learning content presentation is the integration of multimedia objects. The authors stated some suggestions on how a multiple multimedia objects can be combined such as: the objects that will be integrated must be complimentary to each other and synchronized.

A work that is also related to this research described ongoing work to build a mobile learning environment that based on probabilistic adaptivity for content adaptation [30]. This environment consists of three major components: a granule generation, a distributed mobile environment, and the probabilistic adaptivity component. The design suggests designing the learning content in small chunks of information that will be adapted via probabilistic adaptivty component to support the learning processes. Adapting the content is done according to the Bayesian Belief Networks (BBNs) and four main categories are considered for adaptation: device limitations, connectivity, learner's profile and content types. The user can interact with the learning environment with lightweight java interface or by requesting to receive the learning content over SMS or MMS because they are considered as cost effective techniques to receive the information.

However, the described framework only considers the supporting learning materials, for example: quizzes, news or exams schedules, but it can be applied to the other categories of the learning content.

In [40], the authors study the parameters that could help in adapting the learning content for a specific mobile learning context which is the offline delivery periods. This work presents a new

strategy with three main modules context discovery, mobile content management and presentation adaptation and packaging and synchronization. The new strategy will allow the offline usage by taking into account additional parameters, extracted automatically by the system. Moreover, the authors proposed some guidelines and instructional design tips which based on the nature of mobile devices, with their small screens and poor input capabilities as follows:

- Mobile Learning lessons should be short, and last no more than 5-10 minutes in order to enable the learner to use their small waiting or free time to read small learning content, to do small assessments or to use forums or chat.

- Mobile learning content should be designed to be simple, funny and added learning value because mobile devices capabilities make it difficult to use complex learning content, but on the other hand mobile devices capabilities are used for entertainment with great commercial success. For that reason, the experience of learning with the help of mobile devices should be interesting and engaging for the learners.

- Finally, area/domain specific content should be delivered just in time/place. The mobility should be able and support learners and tutors in new the learning situations when and where it is necessary.

In addition, some of the most important mobile learning content design guidelines were proposed in [3]. The authors introduced two broad designs. The first design focuses on producing the learning contents in the form of objects; each of that objects should have a specific goal. These objects must be organized in a tree form that has nodes and levels. The nodes represent the objects, while the levels represent the goals. The tree structure has many interesting features such as: each object may be assigned certain attributes such as goal. The learner can sit his contexts as well as his preference or priority.

Accordingly, the system gives weight for each context. The selection of the objects sequence is determined based on the objects' attributes and the weighted contexts. The sequence of objects may be changed, according to the learner's context. Algorithms from graph theory such as shortest path may be applied to obtain the optimum sequence as shown in Figure 1.3. The second design is for the developer of the mobile learning application. The authors claim that the developer must be up to date with the provided services, either by available services or future services.

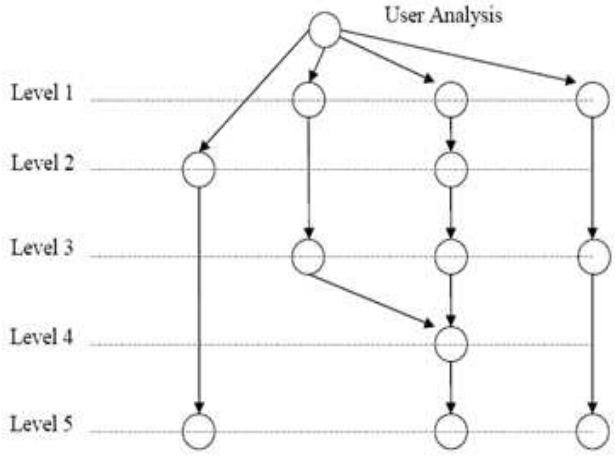


Figure 1.3: Objects Structure, Bayoumi [3]

Another interesting research in mobile learning content design is described in [33]. The authors discussed the most important design issues in mobile learning field from the following perspectives: generic mobile environment issues, learning contexts, learning experiences and learning objectives. The authors analyzed the interaction between the four design issues, incorporated best practices in designing mobile learning and finally they developed a practical framework of mobile learning design requirements as shown in Figure 1.4. Their framework was then applied as an analytical tool to validate three successful mobile learning systems. It was also used as an analysis framework for the requirements phase of a mobile learning project.

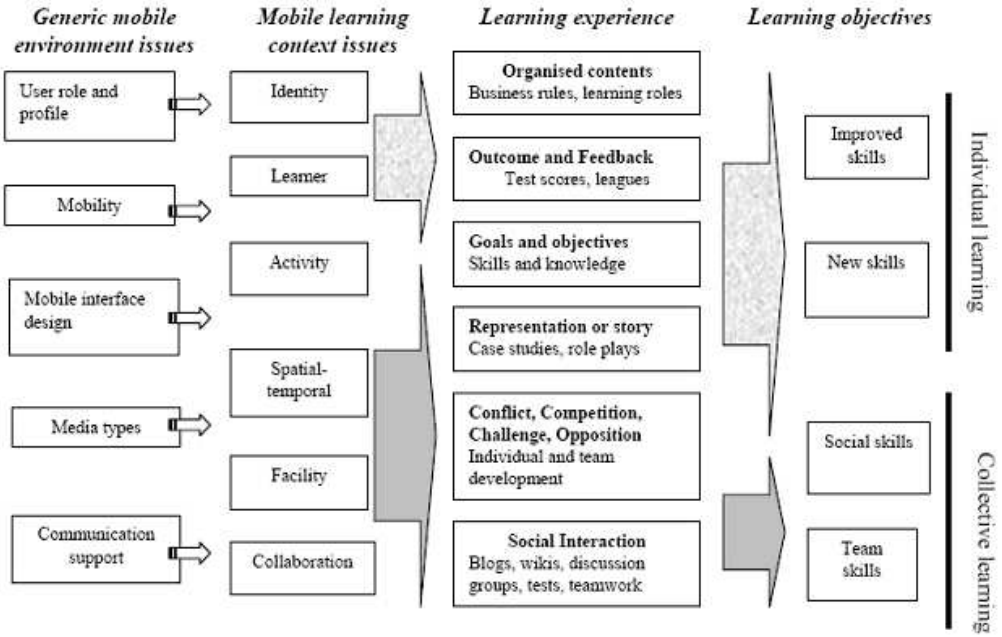


Figure 1.4: A Framework for M-learning Design Requirements, Parsons [33]

Finally, this thesis are going to handle the issue of designing mobile learning content to fit the area of the small mobile devices and it will introduce a model to adapt the learning content in order to support the mobility of mobile learning learners.

1.7 METHODOLOGY

This thesis was mainly based on studies of relevant books in order to investigate the transformation from e-learning to mobile learning field. The main sources of information in both the e-learning and mobile learning chapters originated from exploring core projects in mobile learning such as: From E-learning to Mobile learning project that was organized by Ericsson Education and Dublin. However, most of the underlying design guidelines behind the model were taken from online papers and guidebooks related to the effective content design in mobile learning applications. Subsequently, we stated all the possible scenarios that can occur as a result of combining the different learning contexts with the learner preferences and we have formulated five sets of rules that can be applied to adapt the learning content. Finally we have developed a prototype for a specific mobile learning lecture and utilized a group of our presentation adaptation rules on it to provide an example on how our model can be used and implemented.

1.8 THESIS ORGANIZATION

Chapter 2 (the following section) will summarize the e-learning domain because there are significant connections and many similar issues between e-learning and mobile learning. The chapter will present the definitions that were proposed for e-learning, e-learning types and expansion. Also, the most important aspects in the e-learning field, which are: technology, services and content, will be discussed and the main focus will be on the last aspect. The chapter will introduce the design issues that should be consider when developing e-learning content.

Chapter 3 of this thesis will focus on mobile learning. It will present the definition, projects and main characteristics of mobile learning. Moreover it will discuss the core three aspects in this field which are: the technologies that are used to develop deliver and access the learning content, the learning context and the learning content. The focus will be on the learning content aspect. The chapter will introduce the different categories of the learning content, comparison between the learning content in mobile learning and e-learning application and finally the design of the mobile learning content.

Chapter 4: is dedicated to present our model for designing and adapting the learning content in mobile learning application. As a start point, the chapter will introduce a top-down approach that include nine steps to design the learning content and some guidelines to be applied on the learning content. Next, our model to adapt the learning content will be presented and each module on the model will be explained in details.

Chapter 5: is dedicated to the conclusions and gives some ideas for the future work, based on the currently proposed model.

CHAPTER 2

2. E-LEARNING CONCEPTS

2.1 WHAT IS E-LEARNING?

Since the term *"e-learning"* emerged, many definitions came into light to describe exactly the e-learning systems. In some definitions e-learning is a system that uses the Internet to distribute the learning materials and offers most of the traditional learning activities such as students' assessment and guidance online. For example, in [18] the authors define e-learning as "the process of learning via computers over the Internet and intranets". Other definitions, such as in [42], tend to view e-learning as a system that deliver the learning content via any electronic media including satellite broadcast and interactive TV, Internet, intranet and CD-ROMS.

However, e-learning is the utilizing of distributed systems, networks, devices and communication technologies in order to deliver, at most, all the activities that are provided by the traditional learning environment including the delivery of the learning content, exams, tutor guidance, assessment and communication in order to facilitate and enhance the learning and the teaching process.

Effective e-learning as the name indicates must support the activities that are provided by the learning field such as: presenting knowledge, monitoring of students progress and guiding the students in a timely manner with the attributes that are provided by the "e", which stands for electronic, such as: the delivery of the content through network, on-demand delivery of the content, communicating and capturing the knowledge and connecting students with each other and with teachers [21]. E-learning can be represented as shown in Figure 2.1 [23].

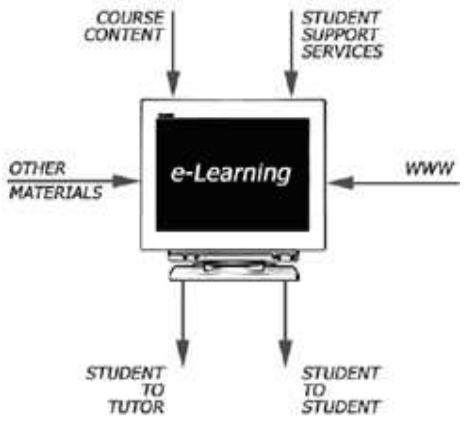


Figure 2.1: Wireless Virtual Environment, Keegan [23]

The previous figure represents the traditional classroom with computer screen that will supply the students with the learning content. Student support services in the figure point to any electronic support or feedback between the teacher and the students. The access to the WWW is provided for other electronic resources. Other materials can be CD ROMs, floppy discs, audio or video. Moreover, the figure confirms that students will be able to interact with their classmates and the teacher will be able to communicate with his students.

2.2 E-LEARNING TYPES

E-learning is a flexible term that can be classified into many types. Each type can be as effective as other types as long as it has a proper learning environment and objectives. In the following, we will determine three major types of e-learning according to three factors: pureness, configuration and class structure.

2.2.1 ONLINE VERSUS BLENDED LEARNING

E-learning can be pure online system with no face-to-face communication or it can be a combination of online and any traditional learning method. This type is referred to as "blended learning". Blended learning involves classroom learning activities and online learning activities. This method is very useful because it merges two learning forms in order to take the best from each approach. Blended learners can improve their interpersonal communication skills at the traditional classrooms and they will also be able to use the tools and services that are provided by the e-learning system [60].

2.2.2 SYNCHRONOUS VERSUS ASYNCHRONOUS

E-learning system has many configurations [31]. According to these configurations we can classify e-learning into two types that can overlap. The common type is the online version in which the Internet is used to deliver the learning materials and implement testing online. This type is considered asynchronous learning and it is on-demand which means that it enables the learner to control his time and place. The second type is real-time interaction between the learning process parties. This type is referred to as synchronous learning.

2.2.3 SELF-PACE VERSUS INSTRUCTOR-LED

Based on the class structure, e-learning can be classified into three types. E-learning can be self-paced learning in which the learner will be able to control what, when and how to learn.

Courses in self-paced learning are appropriate for busy learners and are usually designed to be taken in small chunks or lectures. Contrary, instructor-led learning depends on the tautor or instructor to control the learning process by giving the learners a guide to complete the learning materials. The third type is a mixture of self-paced and instructor-led learning.

2.3 E-LEARNING EXPANSION

In the mid of eighties, there was some institutions that provide on-line learning such as New York Institute of Technology and Western Behavioral Sciences Institute but the term e-learning only emerged in the nineties when a number of universities and specialist organizations started to benefit from the advent of the WWW, email, web browsers and many other technologies to provide a new way of delivering and managing the learning content. In the last few years, e-learning has grown very fast as the result of the new technological advancements including the advanced websites design and the high bandwidth access that led to a significant rises in the online population as shown in Table 2.1 [58].

World Regions	**Internet Usage**
Africa	44,234,240
Asia	461,703,143
Europe	343,787,434
Middle East	33,510,500
North America	237,168,545
Latin America/ Caribbean	122,348,914
Oceania/Australia	19,243,921
World Total	**1,262,032,697**

Table 2.1: World Internet Usage, 2007, [58]

According to [2], in 2002 the United States alone reports about more than 1.6 million students enrolled in one online course at least. In 2003 and 2004, 360000 new students enrolled in the online courses to increase the overall number to 1.9 million students. During 2005, higher education institutions taught nearly 3.2 million online students. This rapid growing in the online enrollment for the past few years is a clear evident that e-learning is becoming a popular approach for learning. Also, in the United Kingdom, e-learning is quite common in the university sector. The government, institutions, and faculty members are working together to develop content in the universities [34].

However, Arab world are the latecomers in this field but e-learning began to grow in our countries. Now, there are some projects that are supporting the e-learning field such as the African Virtual University [44], the Virtual Arab University [45] and the Syrian Virtual University [61] and we believe that in the following few years e-learning will take place in our educational community.

2.4 E-LEARNING TECHNOLOGIES

E-learning requires technologies in three different categories to be successful. These categories are technologies for creating and managing the learning content, technologies for delivering the learning content and finally technologies for accessing the learning content [20] as shown in Figure 2.2.

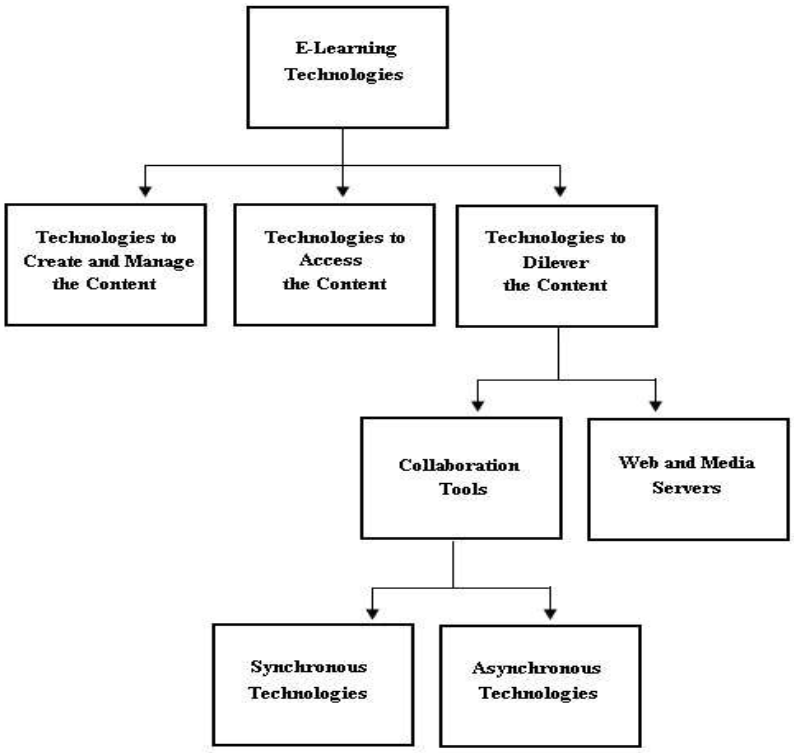


Figure 2.2: E-learning Technologies

2.4.1 CREATING AND MANAGING THE LEARNING CONTENT

Authoring tools are the most important e-learning tools that are used to assemble and create the course as a whole. It is the tool you would use to place all your course elements such as text, graphics or questions [62]. Authoring tools can be classified into different classification as the following:

1. Web Authoring Tools

An e-learning course is a type of website or web page [62]. Thus we can use the web authoring tools to create the e-learning content such as Hyper Text Markup Language (HTML) editors or Media editors.

2. Course Authoring Tools

Course authoring tools are used to create e-learning courses. The market offers hundreds of these tools that varied from advanced course authoring tools to end user tools. The advanced tools have large design flexibility while end users content authoring tools enable non programmer users to build courses via form-based or templates.

3. Content Converters

Content converters are tools that automatically transform any traditional content format including Word documents, PowerPoint presentations or graphics into e-learning courses on the web.

Moreover, there are different technologies that can be use to manage the learning content and the learning process itself such as:

1. Learning Management System (LMS)

Because learning process need to be managed, learning management system is a critical part of e-learning. It is a system that offers a group of functionalities designed to administrate the learning process. “The first learning management systems (LMS) offered off-the-shelf platforms for front-end registration and course cataloging, and they tracked skills management and reporting on the back-end” [22].

However, the market offers hundreds of these products that varied from simple learning management systems that can provide some functions such as: enable the learner to access the course and launch it, detect who has completed the courses and who has passed the tests [62] to advanced learning management systems that can manage complex registration issues and certifications, create assessments, offer advanced reporting on completions, provide resource and administration management and provide all the features of the synchronous tools.

2. Learning Content Management System (LCMS)

As stated in [13], content management system (CMS) is defined in [56] as "a system that is used to store and subsequently finds and retrieves large amounts of data". However, LCMS is a system build on the CMS and it is used to manage, create and store the higher educational learning content. In fact, there is confusion between the difference of LMS and LCMS. Based on [35] and [11], we summarized the differences and similarities between the two terms as shown in table 2.2.

	Similarities	**Differences**
1. Goals	Both LMS and LCMS have the same top goal which is to enhance the quality of e-learning services.	▪ The particular goal of LMS is to administrate the learning process. ▪ The particular goal of LCMS is to manage the learning content.
2. Functions	- Deliver the education content. - Support collaboration among learners. - Track learners' results.	▪ LMS: - Deliver the content on a high level which is the course level by providing access to online courses. - High level tracking of learners' progress such as: detect who complete the courses and what are their courses' results. - Manage registration matters. - Manage certification matters. - Scheduling the learning events. ▪ LCMS: - Support creating and managing reusable learning objects which are small and coherent learning units as we will show in section (2.6.1). - Deliver the content on a level of learning objects - Tracking the learners on the learning object levels. For example check if the learner was able to accomplish the learning objects successfully. - Track the learner interaction with the system in order to offer him a personalized content.
3-Beneficiaries	Learners will benefit from the services that are provided by both systems.	▪ LMS: - The educational institution as a whole ▪ LCMS: - Content developers
4. Learning forms	Both systems support online learning.	LMS can support traditional learning and blended learning while LCMS can only support online learning.

Table 2.2: Comparison between LMS and LCMS

2.4.2 DELIVERING THE LEARNING CONTENT

The second set of technologies that are provided by e-learning is the content delivery technologies. E-learning offers synchronous and asynchronous collaboration tools that make it possible for learners to communicate with each other and with the tutor and it also offers other common tools to deliver the learning content as web server and media server:

1. Collaboration Tools

Because collaboration is a necessary element in any learning process, collaboration tools are making significant impact on e-learning. These tools provide medium for sharing information and transferring knowledge either synchronously or asynchronously.

- Synchronous technologies support the synchronous learning which refers to the learning process in which the tutor and students interact at the same time but they are not together in the same location. These technologies enable many important features that should be supported by any e-learning platform such as: real-time interaction among learners, remote presentations from teachers and virtual classrooms. Synchronous technologies are like:

  - Virtual Classroom: it is an online private classroom that mimics the traditional classroom and provides a virtual place for the teachers to support the students. It offers many activities, for example, group and individual learning activities, interaction with students, quizzes, homework activities and assessments.

.

  - Chat: chat is a real-time delivery method that is used to send and receive comments for the tutor or between the students.

  - Audio and Video Conferencing: audio and video conferencing technology can be used to support the synchronous e-learning. Audio and video conferencing is a method of electronic communication that allows the transmission of sound and video to hold the communication among people located at different locations. Audio conference can be implemented in two ways, either phone conference in which the tutor will teach through phone or via the Internet in which the tutor would teach through a microphone attached to a computer that is connected to the Internet. Video conferencing can also be done either by digital cameras attached to computer that is connected to the Internet or by special video conferencing devices.

- Shared Whiteboard: shard whiteboard is also considered one of the important technologies that presents and edits documents. It can be used for typing, highlighting and pointing any comments. For example the tutor can attract the student attention to a certain sentence in the document by drawing a circle around it or highlighting it.

- Application Sharing: this tool is used for teaching software applications for remote students. The students can watch what ever the teacher does with the software or they can take the control of the application and practice on it.

- Online Meeting Tools: online meeting tools are web and Internet tools that are used to share meetings or presentations.

▪ Asynchronous technologies support learning where the teacher and students are not online at the same time. These technologies hold up the self-paced e-learning as well as asynchronous e-learning and they include:-

- Electronic Mail (E-mail): e-mail which is usually short text messages sent from one person to another via computer and it can be used as a communication method between the teachers and students in the learning process.

- Listserv: Is an automatic email service that students subscribe to in order to receive mailings. Students must be a member of the list to receive mail, and can choose to unsubscribe at anytime [50].

- Weblog: is a public website where users can post their thoughts ideas and comments. Most weblogs are textual and they include links to other weblogs and websites. One of its most important features is enabling the weblog readers to leave comments in an interactive format.

- Electronic Bulletin Boards (Discussion Forums): electronic bulletin boards are used by most of e-learning platforms in order to carry on discussions, upload and download files and any other online services. Bulletin boards allow many-to-many communication where one can share or discuss information on any subject.

2. Web Servers and Media Servers

Finally learning materials that are requested by a web browser can be delivered by web servers and the media servers is used to deliver the media rich content such as delivering video, audio and other active media.

2.4.3 ACCESSING THE LEARNING CONTENT

Tools that allow the users to access the learning materials are like: web browsers and media players. Web browser is software that allows the users to display and interact with HTML documents that are located on a web page and it is used to request the learning materials that are located in a web server. Media player is a software application that plays and control dynamic media, such as video and audio.

2.5 E-LEARNING SERVICES

As mentioned in [40], the functionalities offered by e-learning platforms can be grouped in four categories: e-learning resources, specific e-learning services, common services, and presentation.

2.5.1 E-LEARNING RESOURCES

E-learning provides electronic access to multimedia and hypermedia learning materials and resources which can be managed by e-learning tools; some systems allow authenticated users to have their own workspace or to upload personal resources [40]. Furthermore, Most of the e-learning tools such as LMS and LCMS have the ability to create online tests that are used to examine the e-learners knowledge. In addition, e-learning offers metadata repositories which refer to data dictionaries that provide a data about each data element.

2.5.2 SPECIFIC E-LEARNING SERVICES

E-learning offers many tools such as LCMS to support content management services. This kind of services are responsible of organizing the learning content that is usually arranged in components such as courses, lectures and classes and subcomponents such as course syllabus, lecture presentation section, exercise section and additional material section [40]. Most of these components should be organized and accessed through a proper engine. Moreover, e-learning offers automated self-assessment that automatically checks the results of the online tests and

evaluate the student progress. Most of these services considered specific services should be provided by the e-learning industry.

2.5.3 COMMON SERVICES

E-learning, as any system, must fulfill the different actors' needs. Mainly, e-learning actors are administrators, learners and tutors that can be either teachers, communication masters or informatics. Besides satisfying the major actors' needs, e-learning provides some extra services for the actors such as informing them about the learning events through an event management system which is an online calendar or scheduler. Also, e-learning offers tools that support synchronous and asynchronous collaboration between learners and with tutors.

2.5.4 CONTENT PRESENTATION

The presentation of the e-learning content is one of the most important services provided by e-learning and it has a common requirement that is e-learning system must be accessible from a single point by using a normal browser. Recent version of major browser must work correctly with the system [40].

2.6 E-LEARNING CONTENT

The highly growth industry of e-learning has three important aspects which are: tools, services and content. In the previous sections we explored e-learning tools as well as e-learning services. Now we are going to examine a critical part in the e-learning industry which is e-learning content. E-learning content is a digital content that include learning materials, activities, objectives and assessments. The first wave of e-learning content was a computerized version of traditional learning content and it did not extract the learner's attention. The second wave of e-learning content was more dynamic and it was a mixture between content and multimedia technology that excites learners and therefore motivates them to participate in the knowledge transfer experience. Finally the third wave of e-learning offers an interesting learning content that combine the learning content with multimedia and three dimension (3D) technology to improve the effectiveness of the learning experience [48].

However, e-learning content is more visible than the traditional learning content because of the absence of learning mediators. In the traditional classrooms the content is hidden behind the teacher or instructor who mediates the learning while in e-learning the content that will be displayed in the learners' screens is fully visible [52]. E-learning content visibility has both positive and negative

sides. On the positive side, the content is clear and with no ambiguity. This can help the learner to be convenient in his learning process. On the other hand, the visibility of the learning content can have a negative impact; any error in the learning material will be easily found and it can be seen by the learner as a reason for dismissing the course [52].

2.6.1 LEARNING OBJECTS

The object-oriented paradigm of computer science discipline which focuses on reusing some parts of the computer code in more than one software applications was the key factor for the learning object emergence. Learning object is defined by the Institute of Electrical and Electronics Engineers as "any entity digital or non-digital which can be used, re-used, or referenced during technology supported learning" [28]. These objects are characterized by being self-contained which means that each learning object is a coherent unit that can be taken independently and it has its own learning objective. Besides, learning objects can be aggregated to larger sets, can be decomposed to smaller ones and finally they can be reused by the learning developers when the same learning objectives come in other learning contexts or circumstances.

2.6.1.1 LEARNING OBJECT STRUCTURE

Each learning object must consist of a learning objective which is a particular understanding level that should be achieved after completing a learning object. In addition to the learning objective, the learning object include one or more information objects which are isolated single pieces of digital resources such as text paragraphs or web pages that are not related to any particular context or learning objective. Finally, informative learning objects should include summary of the learning object content and a form of assessment to enable the learner to evaluate his understanding level at the completion of each learning object.. The structure of the learning object is shown in Figure 2.3. Moreover, each learning object can be attached with metadata which are data about the learning object itself such as the author of the learning object, the description, the date and much other useful information.

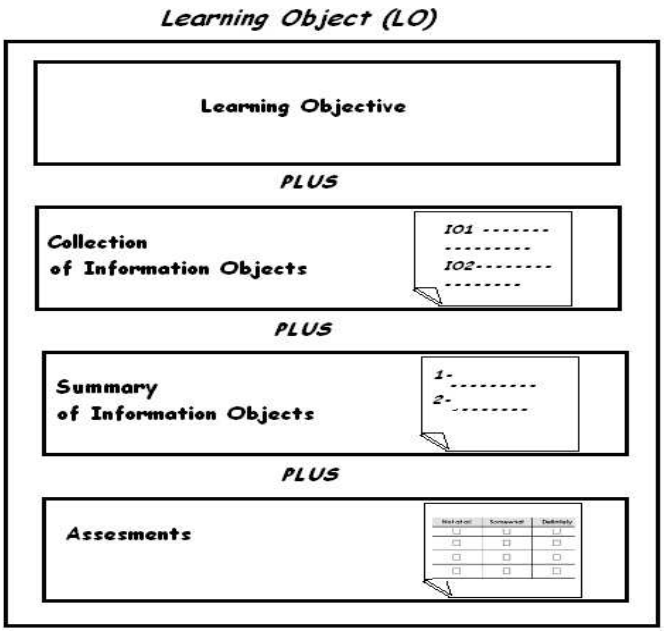


Figure 2.3: The Structure of the Learning Object

2.6.1.2 LEARNING OBJECTS LEVELS

Usually, learning objects referred to small chunks of digital learning resources but the size of these chunks is not universally accepted yet and it depends on the type and objective of the learning process. Aggregation level is a term used in IEEE Learning Object Metadata (LOM) [28] to describe the levels of the learning objects as following.

- The smallest level of aggregation, e.g., raw media data or fragments.
- A collection of learning objects, e.g., a lesson.
- A larger collection of learning objects, e.g., a course.
- The largest level of granularity, e.g., a set of courses that lead to a certificate

Each of the previous levels has a different ability to be decomposed as shown in Table 2.3

AGGREGATION LEVELS	DECOMPOSITION
LEVEL 0	Indecomposable
LEVEL 1	Decomposable → Level 0
LEVEL 2	Decomposable → Level 1
LEVEL 3	Decomposable → Level 2

Table 2.3: Decomposing Different Aggregation Levels

2.6.2 DESIGNING E-LEARNING CONTENT

E-learning content has a lifecycle with sex phases which are the analysis phase, design phase, authoring phase, assembly phase, transport phase and delivery phase. As we mentioned before, each of these phases is playing a major role in transforming the learning content to acceptable form that can be used in a learning process. However, e-learning content must be effectively designed to offer blueprints that reflect the needed quality of the content and to assist the achievement of the learning objectives for the learners. "The design of e-learning content requires understandings in education, multimedia content, resource publication, and electronic technologies" [5]. For that we will divide the process of designing the e-learning content into a number of steps as shown in Figure 2.4.

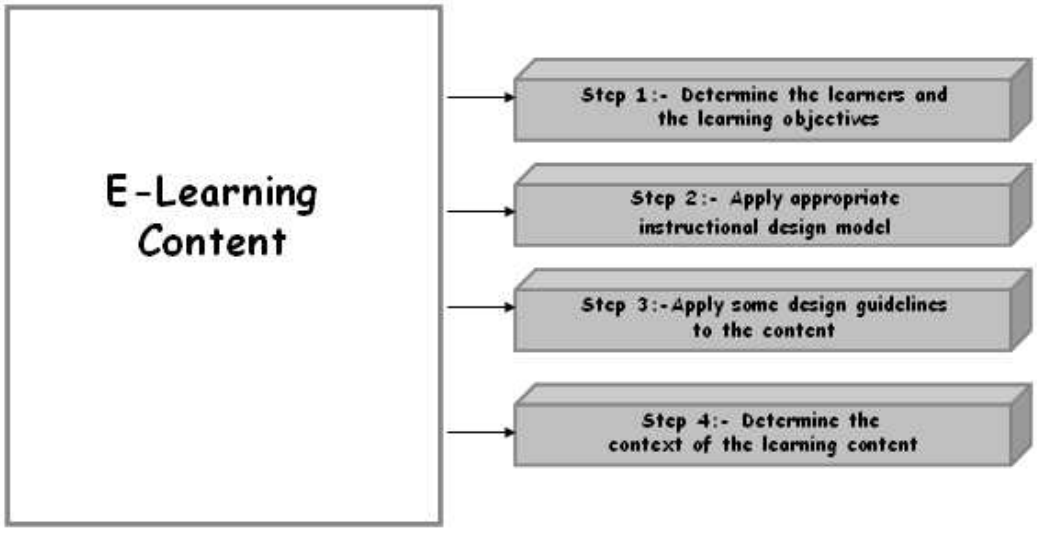


Figure 2.4: E-learning Content Design

Step 1: Determine the Learners and the Learning Objectives

Effective design e-learning content requires determining who will be the e-learners that will use the content and what is their age or their knowledge level. Moreover we have to find out the learning objectives for each learning objects level. For example, in the course level you have to imagine the generic content or skills that will be involved in the course while in the lesson level you have to define the main concepts that will be demonstrated at the lesson and determine the tasks that should be accomplished at the end of the lesson and how it will be evaluated.

Step 2: Apply Appropriate Instructional Design Model

The second step is to adopt one or a hybrid of instructional design models that is appropriate to your content type. Instructional design model is a systematic process that instructional designers

must follow in order to achieve the creation of efficient and effective instruction [22]. A learning object will not effectively support the learning process unless basic instructional design model are applied. However, there are a large number of instructional design models (more than sixty) and each has its own advantages and disadvantages. One of the most used models is Robert Gagné's Instructional Design Model that serves as "a major vehicle for incorporating the conditions of learning into an instructional situation, and as a framework for the design of lessons"[37]. Gagné model has nine events of instruction and we linked them to some simple ideas that can be implemented in e-learning systems:

1. Gain Attention: In e-learning, you can gain the attention of the learners in many ways such as: displaying images, introducing an interesting video or scenario that is related to the subject or asking a puzzling question.

2. Inform learners of objectives: You have to inform e-learners, specially self-paced learners, of the learning objectives that should be achieved after completing the learning content. Of course, the learning objectives will depend on the learning object level that will be displayed for the learner.

3. Stimulate recall of prior learning: Recall some previous related learning materials or objects to make it easy for the e-learners to understand the new learning materials.

4. Present the content: The e-learning content should be presented in one of the learning styles that fit the learner's preferences.

5. Provide learning guidance: In instructor-led e-learning, the tutor can provide guidance for the e-learners while in self-paced e-learning the system can alert the learner if he selects an incorrect path of learning objects to guide him to the correct path.

6. Elicit performance: Present the procedural content, which focuses on the procedures, practical application and processes, to enable the learners to practice what they have studied by using some tools such as application sharing tool.

7. Provide feedback: The tutor will send individualized feedback to answer the e-learners' questions. E-learning can offer different types of feedback, as mentioned in [10]. The first type of e-learning feedback is answer-specific feedback which means that the learner submits an answer to a question, and the tutor provides feedback specific to the chosen answer. The second type is question-level feedback which means that the learner submits an answer to a

question, and the tutor provides generic feedback on that question. The third type is test-level feedback, after a learner completes a test, the tutor can presents a summary report of the test results, test score, a review of chosen answers, feedback on the answers and a pass or fail result. The last type can be semi-automated response to students' work.

8. Assess performance: Many e-learning tools such as LMS and LCMS can create assessments and quizzes to measure the learners' performance.

9. Enhance retention and transfer to the job: Finally e-learning should provide parallel applications of the content, give the learners opportunities to try it out and finally summarize the content that was presented [52].

Step 3: Apply Some of the Design Guidelines to the Content

Many guidelines were proposed to direct the design process of the e-learning content. Sharable Content Object Reference Model (SCORM) is a collection of standards and specifications of e-learning systems. The most significant standards for SCROM are [1]:

1. Accessibility: learning content can be identified and accessed when it is needed.

2. Interoperability: learning content should function in multiple applications, environment and software/hardware configurations regardless of the tools and platform used to create it.

3. Reusability: content is independent of learning context

4. Durability: no modification required for the learning content to operate even if the software systems are changed.

5. Affordability: it shouldn’t cost very much.

Besides, there is some other guidelines focus on the visual appearance of the learning content such as the content type and color; by using different colors for different sections in the learning materials you can attract the learner attention. The choice of font style and size will influence both the visual appearance and effectiveness of your design [51].Moreover, while designing the learning content you should keep the visual style of materials consistent and it is not preferred to create a new design for every screen or page this will lead to confusion [51]. The learning content also should be rich with diagrams, flowcharts and extra explanation to cover what can be managed

by the teacher at the traditional learning. However, there are a large number of design guidelines and we have to select the ones that fit the type and style of the e-learning content.

Step 4: Determine the Context of the Learning Content

While designing the learning objects, we have to take into consideration some aspects related to the context. The context for e-learning content can be determined by defining the type of e-learning environment, technical environment, learning strategy, e-learning strategy and finally the content accessibility [5]. According to the previous elements, the e-learning content should be adapted to fit the leaning context. However, even if the e-learner context is wider than the traditional learner context but it still limited. It has to be said that e-learners are restricted to a specific context in which a personal computer and an Internet connection should be available.

2.7 ADVANTAGES OF E-LEARNING

There are several advantages offered for both the learners and tutors. Bellow is a list of these benefits:

2.7.1 ADVANTAGES OF E-LEARNING TO LEARNERS

- Learners are unbounded by time and place. Taking class anytime is a major advantage of e-learning. The accessibility of 24 hours a day, 7 days a week enable the learners, especially in asynchronous communication, to access the learning session at the time that go well with there schedule, preferences and concentration periods. Moreover, the learner can take time as much as he needs to acquire knowledge regardless to the period that is determined for the traditional learning courses. However, in synchronous communication, the learner still has to be online at the same time of the course session. Moreover, E-learning does not need physical attendance. For that learners are not constrained by their geographic location and they will be able to learn from any place where a personal computer and internet connection is available

- E-learning supports diversity of learning styles. Learners can learn by performing some activities that suit different learning styles such as: visual, oral, reflective and many other styles in order to improve the quality and speed of the learning experience.

- E-learning is flexible for many reasons; the learner can select a certain type of courses that goes well with his preferences. For example he can choose self-study or instructor-led courses. In addition the learner can use any collaboration tool that is suitable to him. Moreover, he can

customize and adapt the learning materials to any level that meet his knowledge level which referred to adaptive learning.

- E-learning provides access to wide information and knowledge resources the learner may never see in a traditional classroom and allows the learner to use his own initiative to find these resources. Moreover, the e-learning will help the learner to develop a beneficial knowledge of the internet, the new technologies ,technical skills and non technical skills

2.7.2 ADVANTAGES OF E-LEARNING TO TUTORS AND LEARNING PROVIDERS

- The tutor will have more flexible role. He will not be constrained by the classroom location. He will also have a flexible time schedule. In addition, e-learning reduces his responsibilities by increasing the e-learner responsibilities.

- It is ease to update the information of any program or course after the first implementation**.**

- At first, e-learning seems to be very expensive for the educational institutions. But in fact, e-learning is more cost effective than traditional learning; by time, many costs will be reduced including the tutors' salaries and more profits will be gained since the e-learners segment, that is not limited to any geographic barriers, is bigger than the traditional learner segment.

- E-learning can increase the quality of learning in any educational institution because it offer what can be difficult to be offered by any tutor or instructor such as supporting various learning styles that can fit at most all the students.

2.8 DISADVANTAGES OF E-LEARNING

Of course, e-learning as any learning approach has some drawbacks. Next we list some of e-learning disadvantages:

2.8.1 DISADVANTAGES OF E-LEARNING TO LEARNERS

- Lack of face to face interaction. E-Learners will miss out the social interaction that is an element of traditional classrooms. Also, e-learners can find some difficulties as the tutor will not always be available. Moreover, they must have good writing and communication skills. When tutors and other learners aren't meeting face-to-face it is possible to misinterpret what was meant [22].

- Actually, even if e-learning release the learner from the physical attendance restriction, it can't offer the learner the ability to learn in anywhere only if there is a personal computer and a connection to the internet.

2.8.2 DISADVANTAGES OF E-LEARNING TO TUTORS AND LEARNING PROVIDERS

- It will be difficult and time consuming for tutors to shift the traditional learning content into e-content**.**
- The tutor must provide distinct feedback for each e-learner**.**
- The educational institution should have a huge technology infrastructure.
- It's hard to address the ethical issues for the e-learners especially when it comes to testing.

CHAPTER 3

3. MOBILE LEARNING (M-LEARNING)

3.1 FROM E-LEARNING TO M-LEARNING

In the past decade, e-learning was the state of the art for many universities and institutions. While many predicted that e-learning is the final solution for corporate training and university programs [23], there has been a continuous evolution in wireless and mobile technologies. We have observed a proliferation in mobile devices capabilities aligned with a decrease in their prices which makes them more cost effective than desktop computers.

In the mid of 2005, the number of cellular phones per person, were more three times than PCs, and most of sophisticated phones have the processing power of a mid-1990s PC, and it is increasing [17]. As the result, the number of mobile users increased rapidly and nowadays they are estimated to be 2 billion users. Beside, the advancements in wireless technologies play a major role in escalating the number worldwide mobile Internet subscribers who have a wireless access to various online recourses through mobile devices as shown in Figure 3.1 [46].

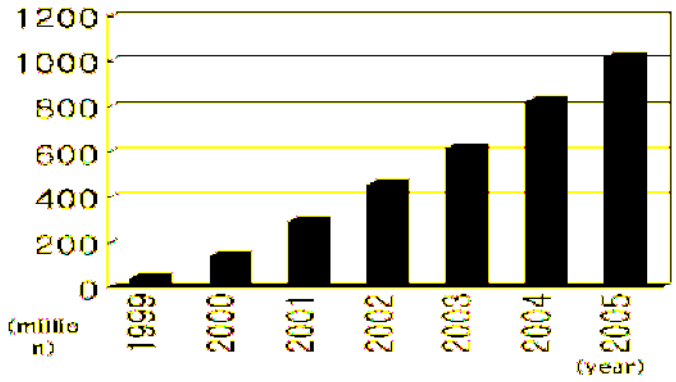


Figure 3.1: The Number of Mobile Internet Subscribers [46]

However, such indicators reveal the need for a new learning form that can serve the educational community by utilizing wireless and mobile technologies. At this point, mobile learning emerged.

Mobile learning describes a new form of learning that merges e-learning with mobility. However, there is a common agreement between most of the authors and researchers that mobile learning is a new dimension of e-learning. For example, in [32], the author defines e-learning as "learning supported by digital “electronic” tools and media", and he defines mobile learning as "e-learning

that uses mobile devices and wireless transmission". According to this, many similarities can be found when comparing mobile learning with e-learning.

First of all, it is obvious that both applications came to support and enhance the learning experience by utilizing technology. Moreover, both of them provide common services such as the delivery of the learning content, supporting learners and providing quizzes and assessments.

On the other hand, there are some differences between the two learning forms. Mobile learning is more flexible than e-learning; Mobile learning supports the learners mobility by offering really anytime and anywhere access to the learning content while in e-learning the mobility is constrained to the weight and the size of desktop or laptop computers. Furthermore, transport mobile devices have some capabilities that can be delivered with greater ease than any other electronic devices [7]. For instance, audio synchronous communication can be simply delivered via mobile devices and with inexpensive costs. Mobile phones have some facility that makes them better than most personal computers. It has been designed to deliver voice. You can listen to, or even talk with, a real person. The mixture of both audio and text facilitates the delivery of certain types of learning content [36]. In contrast of e-learning, mobile learning is always blended and it can not be used as the main technique for learning but it can be an effective form that can be used in conjunction with the other learning forms to enhance and facilitate the learning process.

Finally, we believe that mobile learning takes the power from investing a common habit in our life, which is the mobile usage habit. Such investment makes the learning experience more effective, interesting and convenience. Therefore, this new form of learning is a heterogeneously experience that emerged as a result of social and technological forces; Mobile learning is formed by many social forces including the desire of individuals to choose when and where they learn and technological factors which are the driving force towards the adoption of mobile learning [26]. However, to demonstrate the potential of mobile learning, we are going to present some of the large projects in the mobile learning field.

3.1.1 M-LEARNING PROJECTS

Over the past few years, many projects have been conducted to explore the effectiveness of mobile learning as a new learning form. These projects varies from small projects that test the use of mobile devices to support learning at schools and universities, to large projects that are trying to build an integrated mobile learning environments which take into account the learners context. The following list introduces some of the interesting projects in the mobile learning field:

- M-learning project [45]: An European project that takes place in the United Kingdom (UK), Italy and Sweden and it aims to explore the effect of using mobile devices for learning especially for the young adults that have drooped out of the traditional learning classrooms because of social and educational problems. Jill Attewell, the coordinator of the m-learning project and the manager at the UK's learning and skills development agency, pointed out that " It is not to replace normal education but to re-engage those who have dropped out of learning and help them find out that learning is fun and can be a help in life rather than just something they are forced to do" [47]. This project developed prototype products to provide learning materials via inexpensive mobile technologies which are already owned by the majority of European young adults.

- MOBIlearn project: As mentioned in [23], there are three projects with the title MOBIlearn. One project is in Sweden and it aims to give the workers of organizations the opportunity to develop their competence anytime and anywhere using the third generation cellular networks (3G). The second one is MOBIlearn (Mobile Computing in Learning Environments). It is a German/Brazilian partnership project that aims to allow students to interact through a computer supported learning environment from their mobile devices with low speed wireless connections by integrating the appropriate mobile computing capabilities with the learning environment. The third MOBIlearn project is in Italy and it is funded by European Commission's IST program. This project investigates new methods to use mobile environments to meet the needs of learners, working by themselves and with others.

- Two projects organized by Ericsson Education and Dublin: The first project is: From E-learning to Mobile learning project [23], which aimed to enable the students to read and interact with the learning content easily via small mobile devices. Moreover, they developed courseware for mobile phones. The second project is: Mobile Learning: The Next Generation of Learning [25], which developed a courseware for the personal digital assistant (PDA).

- University of Birmingham HandLeR project [63]: A group of students at Birmingham University developed the HandLeR project to develop mobile technologies that support the learning process and the interaction between the learner and the learning materials.

- Introducing Language Enhancement Techniques (INLET) project [57]: This project based on a great idea that aimed to propose the principles of the Greek language via mobile phones during the Olympic Games.

3.2 DEFINING M-LEARNING

To understand exactly what mobile learning stands for, we are going to describe two terms: *"mobile"* and *"learning"*. We prefer to begin with defining the learning process since it is the base for the new applications that emerged recently such as e-learning and mobile learning. Learning is an organized process of acquiring a body of knowledge that is found in a defined educational course or learning material. However, this organized process does not simply extract the knowledge from a source and download it directly to learners' minds; it includes many learning activities that are used to engage learners in the learning process and to facilitate transferring the knowledge such as: collaborations activities, quizzes to examine the learners' understanding level and self assessments.

The second term *"mobile"* is a key aspect that differentiates mobile learning from e-learning and from any other learning forms and it refers to two main components; First, the mobility of learners and users who can learn while they are moving; Second, the mobility of technologies that are utilized in mobile learning such as mobile and handheld wireless devices.

However, since the term mobile learning emerged, many definitions have been proposed to explain exactly what the term indicates. In [27], the authors reviewed the current definitions of mobile learning and they clarified that the term varies from one author to other. For example, some authors over simplify the term mobile learning by defining it as learning using mobile phones while others like to take a broad techno centric view such as in [39] which defines mobile learning as “any educational provision where the sole or dominant technologies are handheld or palmtop devices”. Furthermore, there are a common agreement that mobile learning is a new dimension inherited from e-learning as a consequence of the recent advancements in wireless communications and mobile devices. For example, in [16] mobile learning is defined as “a new stage of the development of e-learning". However, mobile learning seeks to put in place a new virtual learning environment and it can be represented diagrammatically as shown in Figure 3.2 [23]:

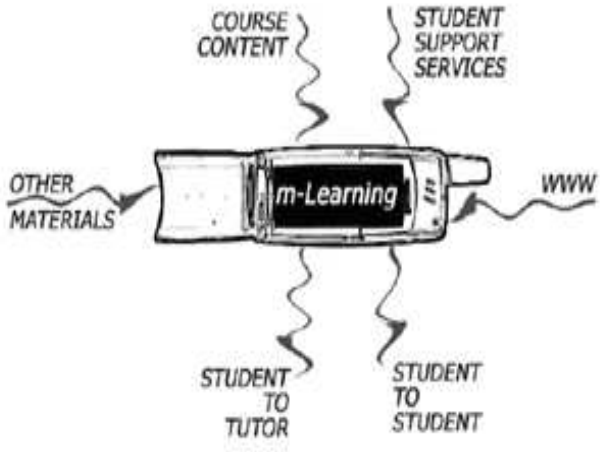


Figure 3.2: Wireless Virtual Learning Environment of Tomorrow, Keegan [23]

In the previous figure, the author represents the classroom as a small mobile that can be connected to the Internet to deliver the course content and any other learning materials to learners. Beside, learners can receive student support services and access the WWW to benefit from extra learning sources. Moreover, the figure confirms that students will be able to interact with their classmates and the teacher will be able to communicate with his students.

3.3 M-LEARNING CHARACTERISTICS

As mentioned in section 3.1, mobile learning discriminates itself from the other learning forms by several characteristics. Next, we are going to list the major characteristics of mobile learning. In [9], the author presents sex unique characteristics of mobile learning which are:

1. Urgency of learning need: mobile learning can be used for an urgent matter of learning.

2. Initiative of knowledge acquisition: the learner can access the learning materials on-demand and the wireless application will provide the information to the learners upon his request.

3. Mobility of learning: the large coverage of the wireless networks enabled the learning process to be performed at anytime and anywhere.

4. Interactivity of the learning process: learner can easily communicate with his tutors, classmates, or other materials using the mobile devices.

5. Situating of instructional activity: the learning activities can be adapted to fit the learner context.

6. Integration of instructional content: integrating many information resources.

Moreover, mobile learning has some other characteristics such as:

1. Mobile learning is usually blended; Mobile learning doesn't intend to replace the other learning forms. It can be used as a supporting learning technique that increases the efficiency of the learning process in traditional learning or even in e-learning.

2. Mobile learning is related to many ethical issues such as: the learning material ownership and the student honesty.

3. Mobile learning technologies are friendly, cost effective and common among all of us.

4. Mobile learning raises the learners' esteem by giving him the responsibility of managing his learning process.

However mobile learning is a promising field that takes into account three main aspects that will be explored in the following sections of this chapter, which are:

- Technology
- Learning context
- Learning content

3.4 M-LEARNING TECHNOLOGY

Some significant technologies should be utilized to manage the learning experience for mobile learners. As shown in Figure 3.3, these technologies can be divided into three categories. First, mobile devices. Second, technologies to deliver the learning content which are the wireless technologies that permit the connectivity of mobile devices to enable the learner to access any content on the Internet and some other communication technologies. Third, technologies to develop the learning content.

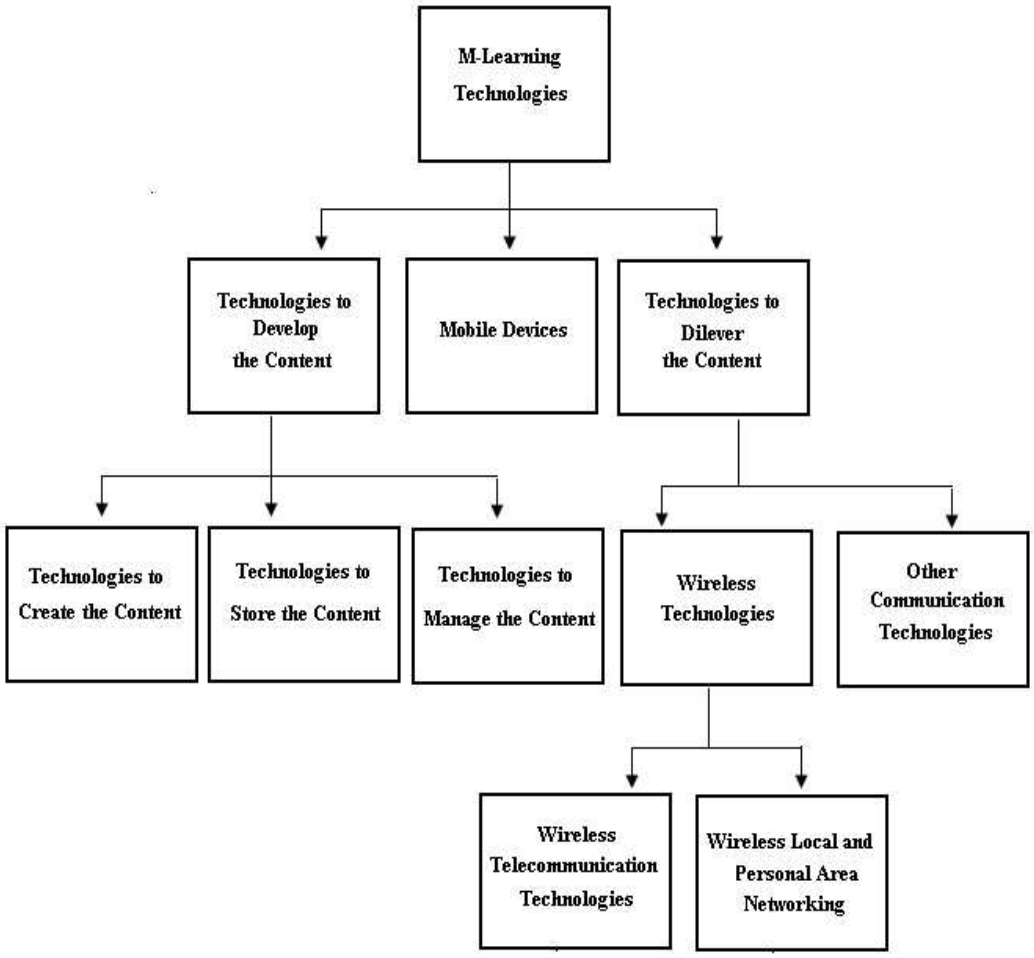


Figure 3.3: Mobile Learning Technologies

3.4.1 MOBILE DEVICES

Devices that can be used in mobile learning must attain two key requirements which are: the ability to deliver the learning content and the ability to support the learner mobility. According to these requirements, mobile devices can be the best technologies that can be used in mobile learning. In [40], the author define mobile devices as "PDA, digital cell phone and generally mobile devices can be any device that is small, autonomous, and unobtrusive enough to accompany us in every moment of our every-day life, and that can be used in learning". Moreover, mobile devices should be small enough to fit in the user pocket and they should be carried by the user in a habitual way. For that, laptops and notebook computers are not included in mobile devices because they are portable but they are not mobile [8]. However, we are going to consider the main categories of mobile devices which are: PDA, cellular phones, smartphones and non-telephony mobile devices.

- Personal Digital Assistant (PDA)

PDAs are small handheld devices which have some of the personal computers capabilities as well as telephone capabilities. PDAs offer many interesting functionalities such as: organizing personal schedules, playing multimedia files, recognizing text and voice input and they offer the user the ability to connect the internet to check an e-mail or to search the web. PDAs have 64 Mb of memory size, 8 hours power capacity and 240x 320 pixel screen resolution as typical parameters [16]. These devices run on two important operating systems which are PocketPC from Microsoft and Palm operating system.

- Cellular Phones

In the last few years, cellular phones such as Sony Ericsson, Nokia, Motorola and many others, scattered all over the world. Cellular phones range from devices with limited functionalities that are used for voice and short text message communications to advanced devices, third generation phones (3G), that enable the user to connect to the Internet to send or check e-mails and to open small web pages. However, cell phones have 10 hours power capacity and 120x160 pixel screen resolution [16]. For that, the flexibility of these devices is less than the flexibility of PDAs.

- SmartPhones

SmartPhones are hybrid devices that take some abilities from PDAs and other abilities from cellular phones [16]. Smartphones can be used for text and voice communication, e-mail and web access and finally media or video player. These devices have 8 Mb, 10 hours power capacity, 200x300 pixel screen resolution [16] and they run on different operating systems such as: Symbian, Palm, Blackberry and Windows Mobile.

- Non-Telephony Mobile Devices

Non-telephony devices, such as Mp3 and Ipod, are mobile devices which are used to play and store MP3 music but it can not be used for voice communication.

3.4.2 TECHNOLOGIES TO DELIVER THE LEARNING CONTENT

1. Wireless Technologies

Regardless of the mobile device's capabilities, no mobile device can deliver learning material to learners if it does not have an access to online learning materials. Over the past years, Internet has

been considered an effective tool that can be used for education purposes. For that reason, next we will list some of the important wireless communication technologies that are used to allow mobile devices to connect to the Internet in mobile learning environment and they can be categorized into wireless telecommunication technologies and wireless local and personal area networking.

- In the following list, we are going to generally describe some of the main wireless telecommunication technologies such as GSM, GPRS/EDGE, UMTS and WAP.

  - Global System for Mobile Communication (GSM) [54]: GSM is a widespread standard that is used for the digital cellular phone communication. GSM has a 9.6 Kbps data transfer rate. Moreover, it offers many advantages to the cellular phone users such as enhancing the quality of voice and offering the short message service (SMS) which is an inexpensive way that allow the users to communicate with each other. In addition, through GSM the user can use his own phone all over the world using the roaming services.

  - General Packet Radio Service (GPRS)/ Enhanced Data Rates for Global Evolution (EDGE) [55]: GPRS is a technology that allows a ubiquitous mobile data service which has a higher data transfer rate than GSM, approximately between 30 and 80 Kbps. GPRS as the name indicates depends on the packet switched approach in transferring the data and it is the most commonly used and available wireless technology. It offers the user the ability to browse the Internet and check e-mail on the move. However some users are able to obtain faster internet connectivity speeds using the EDGE technology, which also called E-GPRS, because it upgrades the GPRS technology [29].

  - Universal Mobile Telecommunications System (UMTS): UMTS is communication technology that based on GSM and was first proposed in Europe. The high data transfer rate of UMTS, which is 2 Mbps, makes this technology suitable for transferring large amounts of data, movie downloads and video conferencing. As GPRS, UMTS depends on the packet switched approach in transferring the data but it is more expensive than GPRS.

  - Wireless Application Protocol (WAP): WAP is a protocol that was designed to allow the users to browse the Internet from their mobile device rather than browsing the Internet from a desktop computer. Moreover, this protocol can view the information that is written by Wireless Markup Language (WML) [16] which is actually derived from the Extensible Markup Language (XML).

- IrDA, Bluetooth and 802.11 are the most familiar wireless local and personal area networking technologies.

  - Infrared Data Association (IrDa) Protocols: A set of protocols that are designed to exchange data in small areas, not more than 2 meters, and with a transmission speed of 16Mbps through the ordinary infrared specification and 100Mbps through ultra infrared specification [16].

  - Bluetooth Technology: Bluetooth is a wireless technology that use radio frequency to connect different devices with each other within a limited area, maximum 100 meters. Bluetooth makes it possible to send and receive signals between mobile devices, computers and other devices and thereby simplify communication and synchronization between devices [16]

  - 802.11 (802.11 LEGACY) [68]: Is the formal name of the wireless fidelity protocol (Wi-Fi) which is a collection of standards that has been developed by the IEEE LAN/MAN Standards Committee and it is used for wireless local area networks. The 802.11 standard has evolved over time to provide higher data rates. The first version provided 2 Mbps while the second version, called 802.11b, provides 11 Mbps. The most recent version of this technology (802.11g) provides 54 Mbps.

2. Other Communication Technologies

- Short Message System (SMS)

SMS is the facility to send and receive small amounts of alphanumeric messages that can include numbers or symbols from one mobile device to another. In mobile learning, SMS can play a role in transmitting limited important information for the learners and the tutors such as announcing the exams schedule or the assignments deadlines.

- Multimedia Message System (MMS)

MMS that is descendant of SMS is used to enable the users to send and receive one or more multimedia messages such as digital photos, graphics, video clips and sounds through mobile devices. In mobile learning, MMS can be used for example to transmit graphs and figures that can summarize some basic ideas that were illustrated in the learning materials for the learners.

3.4.3 TECHNOLOGIES TO DEVELOP THE LEARNING CONTENT

We divide the technologies that are used to develop the learning content into three categories which are: technologies to create the content, technologies to store the content and technologies that are used to manage the content.

1. Technologies to Create the Content

In chapter 2, we have mentioned the major technologies that can be used to create the learning content which is usually written by the HTML such as the web authoring tools ,course authoring tools, content converters and many other technologies. In mobile learning the content can be written by different markup language such as XML and WML and as a result there are many authoring tools that are developed especially for theses languages such as XML authoring tools.

2. Technologies to Store the Content

As in e-learning, mobile learning content is stored as elements in the database or files in a file-structure that can be static with no functions or dynamic with functions such as automating indexing, classification and filtering. Moreover there are some effective solutions as Microsoft Content Management Server that provide database and file structure storage with some useful functionalities including filtering, indexing, classification, search-routines, and content streaming facilities.

3. Technologies to Manage the Content

The learning content in mobile learning is managed by the same tools that are used to manage the e-learning content including:

- Content Management System (CMS) which is an integrated system that are used to create manage and deliver the learning content.
- Learning Management System (LMS) (as mentioned in section 2.4.1) offers several functionalities designed to administrate the learning process by managing the students' information, tracking students' progress and delivering the learning content.
- Learning Content Management System (LCMS) (as mentioned in section 2.4.1) are used to manage the higher educational learning content itself. It enables the tutor to create a different format of the learning content. Moreover, it provides functionalities such as storing, searching,

retrieving and reusing the learning content. Finally, it can hold up asynchronous collaborative learning and it can be used to customize the leaning process to fit the learner's preferences.

3.5 THE LEARNING CONTEXT

Since the learning process is a dynamic process that does not occur in vacuum [6] several aspects can have some bearing on this process. The learning context that is defined as any information that can be used to characterize the situation of an entity in a learning activity [12] will be the central aspect that contributes in shaping the learning process in mobile learning. According to it, we can define the design and delivery of content that fit each learner. Usually, the situation that is described by the learning context is influenced by the learners' mobility; the leaning context variation expands when the learner mobility increases. As a result, in mobile learning the learning context can easily be changed over time and it is difficult to be predicted.

However, many researchers and authors introduce different classifications for the learning context in mobile learning environment. In [43] the author proposed a detailed classification of the possible contexts that can occur in mobile learning which are:

1. Identity Dimension: this includes a unique identifier of each learner.

2. Spatio-Temporal Dimension: this dimension includes the learner location and the time in which the learning process is taking place.

3. Facility Dimension: this takes into account the type of the mobile device and its capabilities and limitations.

4. Activity Dimension: the type of the appropriate set of activities that must be in the learning process.

5. Learner Dimension: the psychological properties and the intrinsic characteristics of a learner are used to describe this dimension.

6. Community Dimension: finally social context of the learner will be used to define the community dimension.

Moreover, an interesting classification of the learning context was proposed in [38]. The author has developed a broad context model as shown in Figure 3.4.

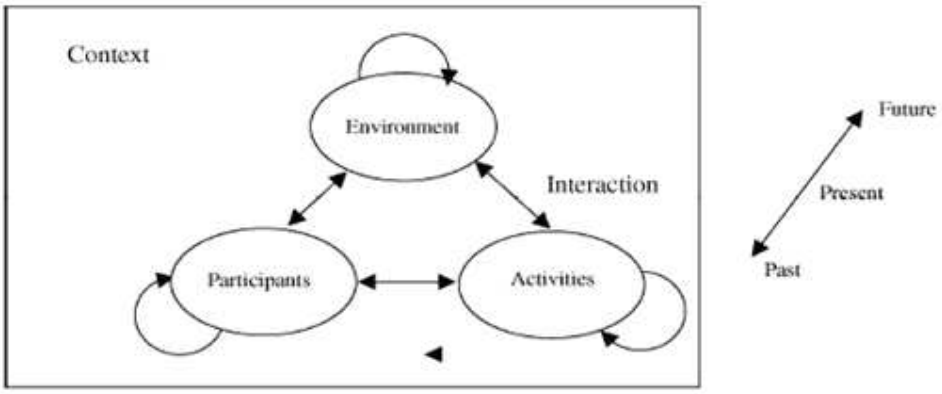


Figure 3.4: Context Model, Tarasewich [38]

The context model includes three context classifications: environment, participants and activities. Environment describes the context within the physical environment. Participant's category is considered with the participants in the environment and their personal characteristics. Finally the activities category includes the participant and the environmental activities. Moreover, the model indicates that there are interactions between the three categories and they are considered over a timeline of past, present and future in order to allow for a context history that is used for predicting the future context of each category.

Based on the previous classification, in chapter 4 we are going to introduce our context classification and the different factors that will be used to describe each context.

3.6 M-LEARNING CONTENT

The learning content is a central feature in mobile learning because it can determine wither the learner will deeply engaged in the learning experience or not. Mobile learning is a digital content, in the form of learning objects that must include the learning materials, activities, objectives and assessment.

3.6.1 M-LEARNING CONTENT CATEGORIES

Mobile learning content can be categorized into three main categories. These are: none interactive learning materials, collaborative learning activities and quizzes:

1. Non-Interactive Learning Materials

This type of content includes all the learning resources that present the information in a linear fashion [52] such as:

- Document: it usually a text-based learning materials with complementary diagrams, charts or graphics. However this type of content may have learning materials abstracts, summaries, indexes and other helpful characteristics, but they are basically linear texts [52].
- Multimedia content: such as audio, animation and video content. Multimedia content is considered a useful supplementary way to deliver the learning materials but it is usually associated with text-based content as an alternative option.

2. Collaborative Learning Activities

Mobile learning should offer collaborative content to enable the learners to collaborate and share information with each other and with the tutor. As in e-learning, collaboration can be synchronous which provides real time content or asynchronous which provides non real time content and there is many tools that can be used to deliver each kind of collaboration content such as SMS, MMS, instant messaging and e-mail.

3. Quizzes and Self Assessments

In this thesis, quizzes and self assessments are referred to the content that allows the learner to exercise the non-interactive learning material content without grading.

3.6.2 M-LEARNING CONTENT VERSUS E-LEARNING CONTENT

With both e-learning and mobile learning content, it is possible to see some similarities. Most obviously, the content in both of them is a digital content that has several advantages over the traditional content such as: the ability to be presented in different format including graphics, audio and video to fit the preferences and styles for each learner. However, by contrast of the traditional content, which is hidden behind the tutor or who mediates the learning, the digital content in mobile learning and in e-learning is exposed and uncovered; there is nothing more than what you see, hear and do via the screen: the learning content is all that there is [52]. Besides, as in e-learning, mobile learning content should be in the form of learning objects to allow the aggregation, decomposition and reuse of the learning content whenever it is needed.

On the other hand, there are real differences between the designs of instructional content for both applications. E-learning content is unsuitable to be displayed on the screens of mobile devices. E-learning content was developed in large sections and designed to be displayed on relatively large screens such as the desktop computers and laptop screens which have at least 800 x 600 resolution; Which mean that it is 4 times larger than the available mobile screen area, making direct presentation of most e-learning content on the small devices un-pleasant, un-navigable, and even illegible [40].

Finally table 3.1 will summarize the general similarities and differences between the e-learning content and mobile learning content.

	Mobile leaning content	**E-learning content**
1. Digital Content	Yes	Yes
2. Fully visible (exposed)	Yes	Yes
3.Designed as learning objects	Yes	Yes
4. The size of the learning objects	large sections of information	Must be designed as small chunks of information

Table 3.1: Comparison between Mobile learning and E-learning content

3.6.3 M-LEARNING CONTENT DESIGN

Designing mobile learning content is a difficult task that requires incorporation of tutors, educators and designers. In addition, the impossibility of separating the learner and the learning content from the context in which the learning occurs specially in mobile learning environments [41] complicates the design task much more. In other words, mobile learning content must be adapted in a way that is suitable to the learning context of each learner and it must serve the learning process. Adapting content means that it is adjusted with respect to the presentation format, abstraction level, order and the structure of the learning objects. For example, the learner can determine his preferences and context and he will only receive the content that fulfill his preferences and context.

However, there are a common agreement between the researchers that mobile learning content should be designed in the form of small learning objects that are self-contained and simple enough to be delivered via simple technologies as simple as SMS [30]. Designing the learning content in the form of small learning objects increases the flexibility of delivering the learning content in away that can accommodate the learners' needs and contexts. Each learning object must be associated to a

learning objective or outcome so that when the learner complete the learning object learners can get a sense of attainment. Besides, if learning objects are developed and stored in a suitable way, this could help tutors by automating the assembly of learning content from one or more repositories for mobile delivery [3].

As well as the learning object guideline, there are other guidelines for designing the learning content such as: when designing mobile learning content we should realize that reading online at low resolution significantly reduces the reading comprehension [19], we should design the learning lessons to be displayed in small amount of time, we have to take the mobile screen orientation into account, minimize the scrolling to avoid the learner frustration and many other interesting guidelines that will be the basis of our thesis.

CHAPTER 4

4. OUR PROPOSED MODEL

We have clearly shown by now that our thesis has the main goal of designing and adapting the learning content in mobile learning application. In our opinion, to effectively design the mobile learning content we should apply a top-down approach for each educational course. This approach includes the following steps:-

Step 1: Define the Overall Course Objectives

This step includes determining and sequencing the core objectives that must be achieved at the end of the course as shown in Figure 4.1. These objectives describe the major elements of content that should be provided to the learner in a specific course. For example, the main objectives for a database course are: explaining basic database concepts and types, illustrating relational model concepts and constraints, describing relational algebra operations and so on.

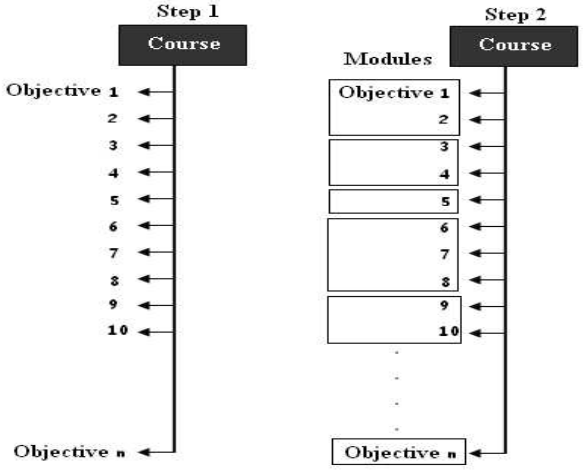


Figure 4.1: The First Two Steps in Designing Mobile Learning Content

Step 2: Define the Course Modules

Course objectives should be assigned to modules as shown in the previous figure. Mainly, at the end of each module more than one course objective must be achieved. The modules of a specific course will be presented to the learner as a menu of hyperlinks to minimize the learner need to scroll the content horizontally as much as possible. Furthermore, we have to reduce the number of

the graphical content in the interfaces because it can increase the time that are needed to download the content and it will take a large space of the small mobile devices' screens. Yahoo News website is a good example that demonstrates the importance of increasing the hyperlinks and reducing the graphics in order to effectively presenting the content in mobile devices. Figure 4.2 and Figure 4.3 for desktop browsers and mobile devices shows the difference between optimized device content and non optimized device content [49].

Figure 4.2: Non Optimized Device Content

Figure 4.3: Device Optimized Content

Step 3: Specify a Number of Lectures for Each Module

Each learning module will include a number of lectures. We recommend that each module should include from 8-10 lectures. Each lecture should last no more than 5-10 minutes in order to enable the learner to use their small waiting or free time to read small learning content or to do small quizzes. Certainly, for each lecture there will be a set of objectives which are:

- Defining concepts
- Presenting facts
- Demonstrating facts
- Describing procedures or models
- Providing examples

However, the module will be presented to the learner as a menu of lectures' hyperlinks and the same guidelines that were used in step 2 will be also applied in this step as shown in Figure 4.4.

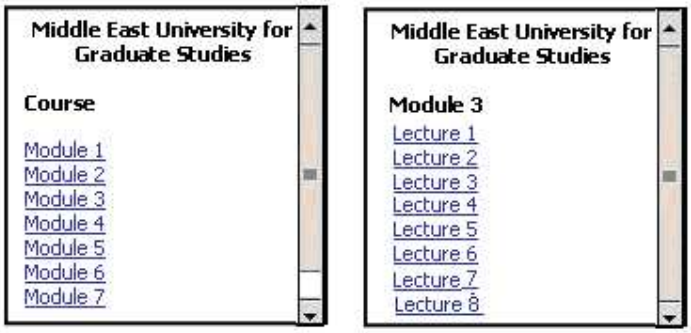


Figure 4.4: Optimized Device Course and Module Menus

Step 4: Decomposing Each Lecture Objective to Sub Objectives

To control the process of achieving the lecture's objectives, and to deal with the limitations of mobile devices' capabilities we have to decompose the general lecture's objectives into smaller objectives with a very limited scopes as shown in Figure 4.5.

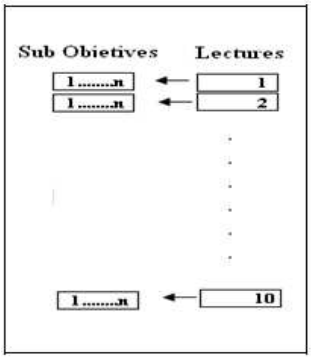


Figure 4.5: Decomposition of the Lecture Objectives into Sub Objectives

For example, describing a procedure is one of the common objectives that can be found in many lectures. Describing each step in the procedure can be considered as a sub objective. However, we do not have to decompose the objectives that already have a limited scope, such as presenting a fact, or the objectives that can lose some of there meaning while dividing them such as defining a concept.

Step 5: Determine Learning Object for Each Sub objective

For every lecture sub objective, which was specified in the previous step, a learning object must be created. However, each lecture, according to our design approach, can include 20 learning object as a maximum number.

In this thesis we are going to consider three main learning object formats. These are: text-based learning object, multimedia learning object and finally graphics learning object.

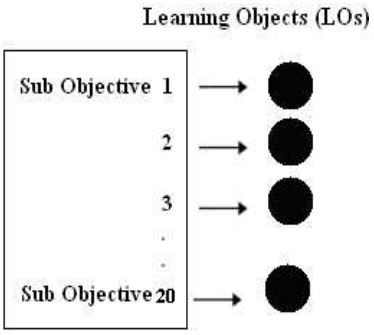


Figure 4.6: Determining Learning Objects for Each Sub Objective

1. Text-based learning object must be small and meaningful. The content in each informative learning object must be organized as following: Small set of information objects, summary of the learning object content and a multiple choice question to enable the learner to evaluate his understanding level at the completion of each learning object.

We claim that text-based learning objects should be maximum 5 kilobyte. Beside, texts should be presented in a small font type that is compatible with the mobile devices standards. Windows™ Mobile standards for font type, size, weight and color as stated in [49] appear in table 4.1.

Class	Font	Size	Weight	Color
Heading	Tahoma	8	Bold	COLOR_HIGHLIGHT
Body text	Tahoma	8	Normal	COLOR_WINDOWTEXT
Subheading	Tahoma	8	Bold	COLOR_WINDOWTEXT
Hyperlink	Tahoma	8	Normal, Underlined	COLOR_HIGHLIGHT

Table 4.1: device optimized content

2. Multimedia learning objects: Offering multimedia on the mobile is recommended to overcome limitations due to the lack of output screens [4]. Multimedia learning objects includes two main sets of objects which are:

- Audio learning objects: For each text-based learning object there will be an audio learning object that provides a spoken version to the same content that is offered by it. In other words, each audio object will have the same structure of the text-based learning object. In addition, the audio content should be presented by different speakers, one speaker for module or lecture headings and other speaker for the text flow [25]. Moreover, certain sounds like ringing a bell can be used for emphasis on some parts of the content [25]. Finally, we claim that the maximum size of each audio object is 30 kilobyte.

- Animation learning objects: This is a learning content that are used to transcribe the text that are found on some of the text-based learning objects. Some of these are essential learning objects that highly contribute in achieving the lecture objectives. Thus, we have to determine which learning objects are essential to accomplish the learning objective and the rest will be considered as supplementary objects. Moreover, we have to classify the animation learning objects into three classifications: animation learning objects less than 240x320 pixels, animation learning objects less than 120x160 and finally learning objects less than 320x480 pixels. This classification can support the screen resolutions of different types of mobile devices.

- Graphic Learning Objects: For some learning objectives, a graphic should be presented to visualize the text content. For example, providing a text explanation of a certain model can not be enough to understand the model. As a result, some of the text-based learning objects should be related to graphical learning objects that include an image or it may include in some cases a screenshot for the first part of an animation learning object. However, we have to keep the image size small, maximum 40, kilobyte for quick loading. Beside, as in animation learning objects, we have to determine which of these objects are essential and the rest will be considered as supplementary objects and we have to classify them into three classifications which are: graphic learning objects less than 240x320 pixels, graphic learning objects less than 120x160 and finally graphic learning objects less than 320x480 pixels

Each learning objects, regardless to its category, must be tagged to a metadata that is a data that describe each learning object. It can include data such as what the object contain, the object rank (essential or supplementary), the date of creating the object and what are the requirements for using the object. This will be useful in making the information available for searching.

Step 6: Adopt an Instructional Design Model

Instructional design model is a systematic process that instructional designers must follow in order to achieve the creation of efficient and effective instruction [22]. As a result, we have to adopt an instructional design model that fit the mobile learning content and it should be applied to each lecture. We claim that the simplified version of Robert Gagné's [37] instructional design model is appropriate to be applied on each lecture in mobile learning content. The simplified version of this model includes the following steps:-

1. Get attention: define a small part of content that can gain the attention of the learner such as: shocking fact, statistics or an interesting scenario. However, in our point of view this part of content shouldn't last more than10-15 seconds.

2. Set the scene: determine the main objective of the lecture. In mobile learning, this part of content should be direct, simple and short which mean that it also shouldn't last more than 10-15 seconds.

3. Present core content: after gaining the learner attention and clarifying the main objective of the lecture, core content will be presented in a way that is compatible with the learning objective. However, we recommend that core content, which will be delivered to the learner through his mobile device, should not last more than 5-10 minutes to enable the learner to use their small waiting or free time to read small learning content.

4. Provide a practice or a question: for each part of content that are presented to achieve a sub objective, some kind of practice or question should be presented to the learner to ensure that he get the idea of the content.

5. Summarize key point: the main key points should be presented in a way that can easily be remembered by the learner.

6. Call for action and signal support: after finishing the learning lecture, the learner can have the choice to do a quiz on the lesson or to participate in a collaborative learning activity to share information with the other peers and with the tutor.

Step 7: Determine Learning Object for Each Instructional Event

Learning objects without a summary or a specific type of self assessment should be created to get the learner's attention, to set the scene and to call for action as shown in Figure 4.7. Moreover, these learning objects will be on the form of text-based or audio content and they will follow the same guidelines of designing the learning objects that were mentioned previously. However, the rest of the instructional events in the simplified version of Gagné model will be already created after creating learning objects for each sub objective as we clarify in step 5 and as shown in Figure 4.7

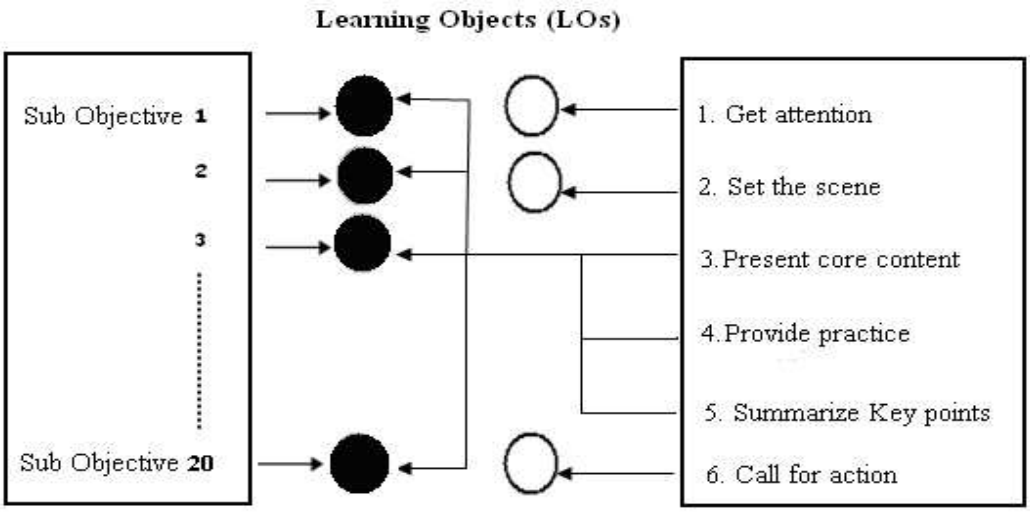


Figure 4.7: Learning Objects for Both Sub Objectives and Instructional Events

Step 8: Structuring All of the Learning Objects

Learning objects must be related to each other in a tree hierarchy structure as shown in Figure 4.8. Each line represents a learning objective. The first and second objectives will be the first two events of the Gagné model. Next, different lecture sub objectives will take place in the hierarchy. As we mention previously, these sub objectives can be defining concepts, presenting facts, demonstrating facts or concepts, describing procedures or models and providing examples. Finally the last objective will be to call for action.

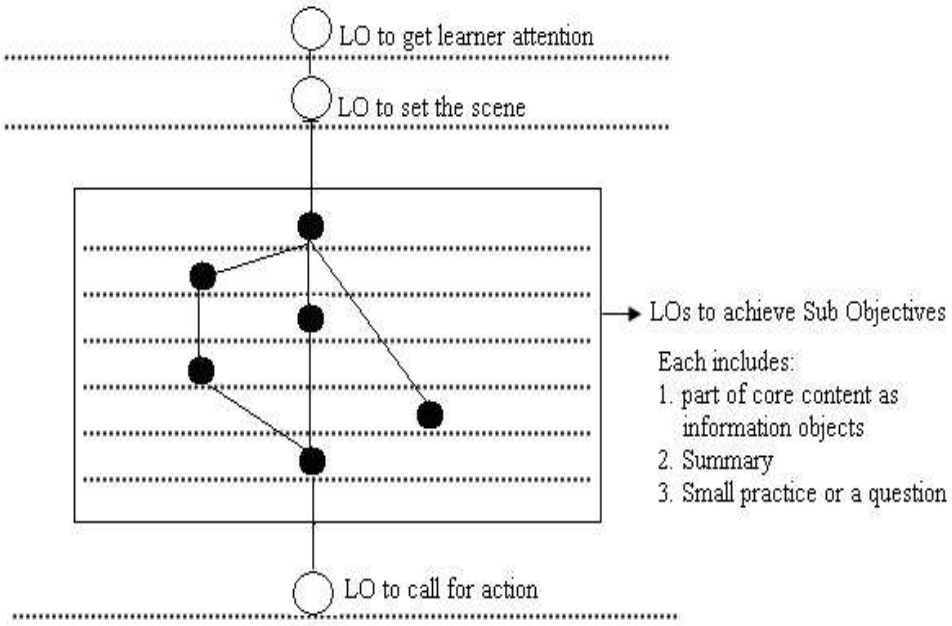


Figure 4.8: Learning Objects Structure

The previous structure of learning objects is the standard sequence of objects that should be followed in order to accomplish the lecture's learning objective. However, this sequence can be adapted based on the learner selection and his learning context, as we will show later in this chapter.

Step 9: Adapt the learning Content According To the Context

It is impossible to separate the learning content from the context in which the learning occurs especially in mobile learning environments [41]. As a result, we have to define the learner context and to adapt the content according to it. In this thesis, we are going to propose a model that demonstrates how the content should be adapted with respect to the content presentation type, sequence, level of detail and entire order of the learning content to meet the learner context, device capabilities and to be compatible with the learning objectives. Finally Figure 3.9 summarizes our top-down approach for designing the learning content in mobile learning application.

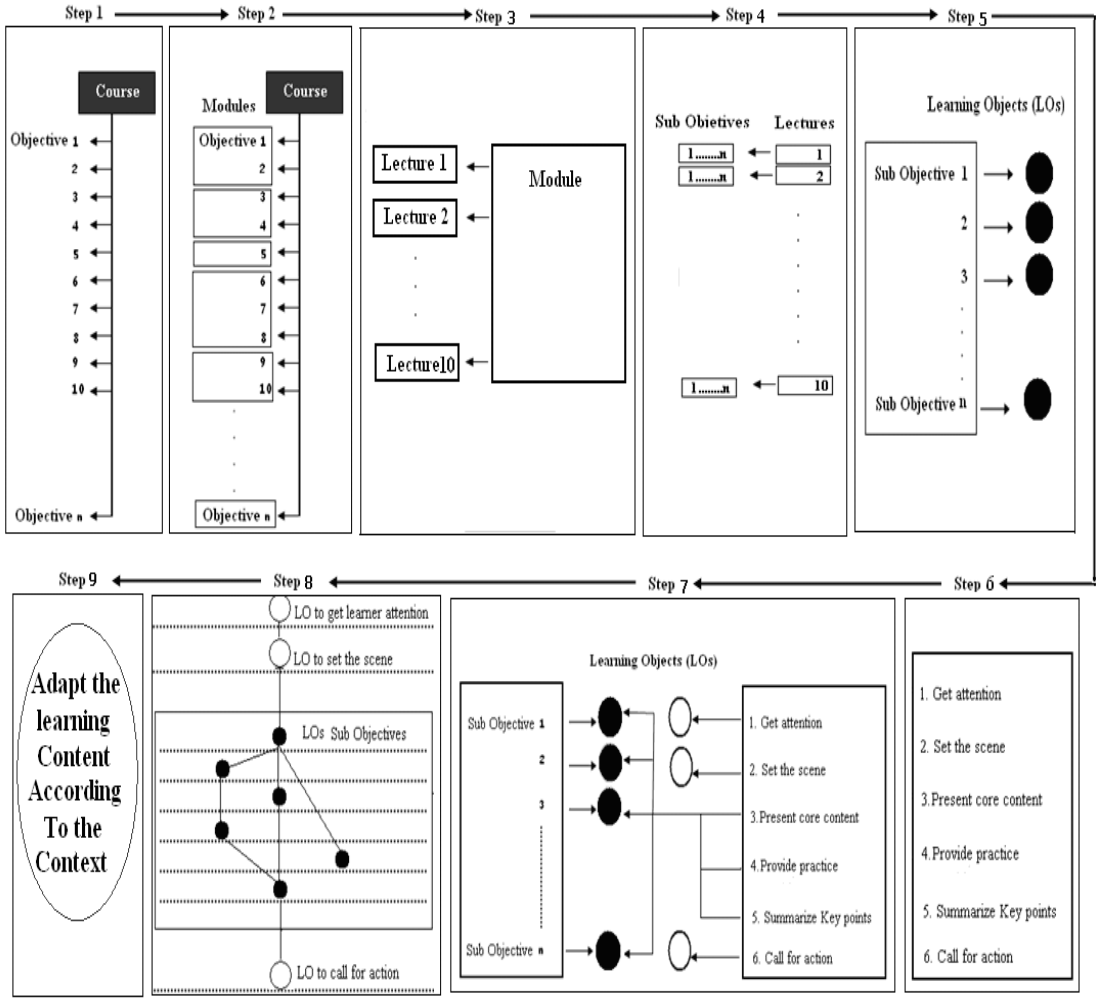


Figure 4.9: Top-Down Approach to Design Mobile Learning Content

4.1 OVERVIEW OF OUR MODEL

Content adaptation is a key part in the process of designing the learning content especially in mobile learning industry. Figure 4.10 shows an overview of our model that is designed to adapt the content in mobile learning application.

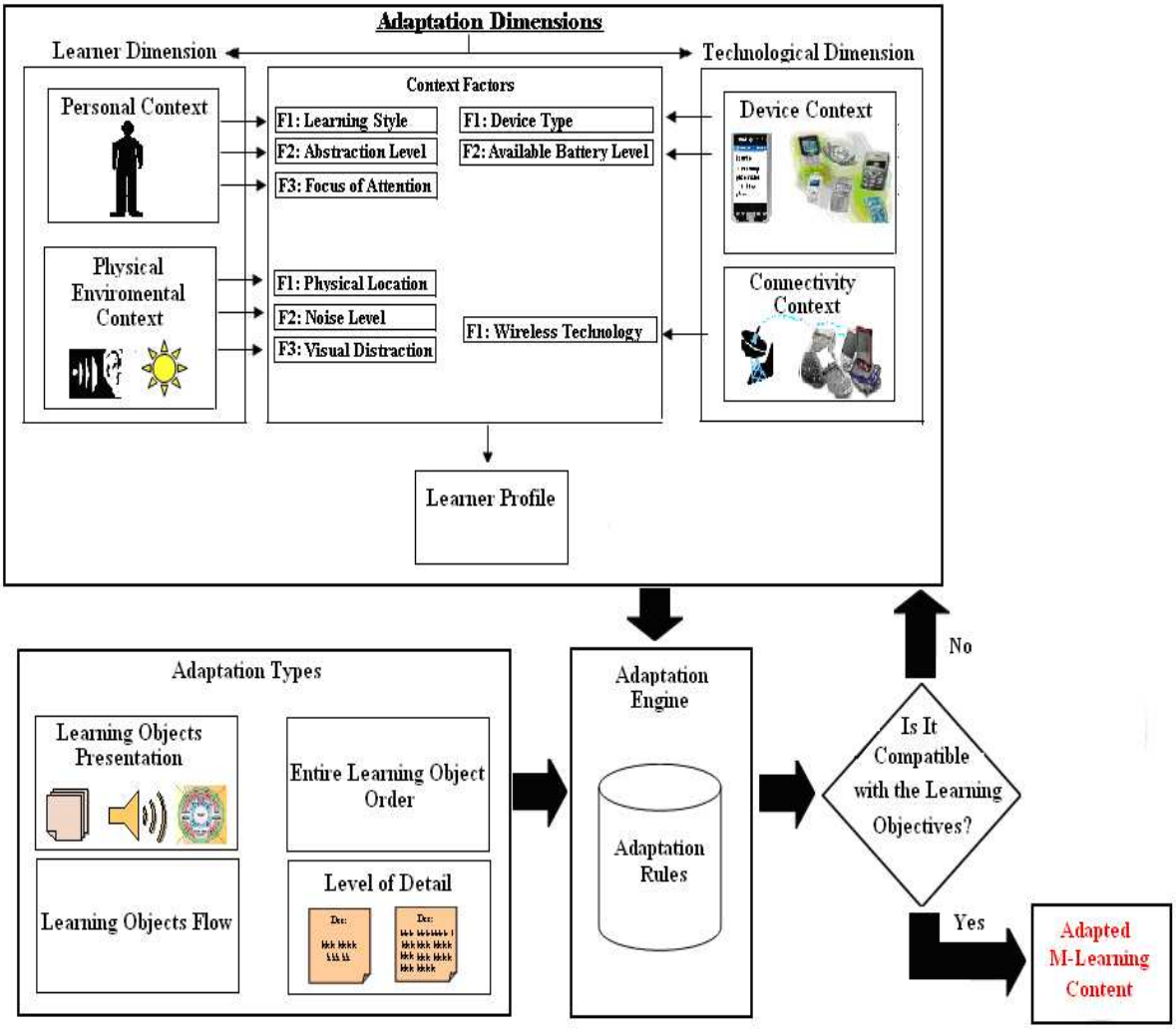


Figure 4.10: Our Model for Adapting Mobile Learning Content

Our model includes three main modules which are:

- Adaptation Dimensions Module
- Adaptation Types Module
- Adaptation Engine Module

Generally, the adaptation dimensions module will describe all the dimensions of adaptation. Each dimension will include several contexts. These are characterized by different factors that will provide the bases for adapting the content. The transformation of the learning content will be with respect of four types of adaptation which are: adaptation on the content presentation type, entire order, level of detail, and finally on the learning objects flow. The adaptation engine will include several rules that conceptualize the different relationships between the context factors and the available types of adaptation and it will define the appropriate content that should be presented to the learner. However, this content must be compatible with the learning objectives as well as with the learner context and preferences.

4.1.1 ADAPTATION DIMENSIONS MODULE

Adaptation dimensions module includes two main dimensions that are provoked by the mobility of the mobile learning learners and devices. These are mainly: learner dimension and technological dimension. Both dimensions include different types of contexts that can take place in the learning process and according to them the type of content adaptation will be determined. Moreover, several factors are used to specify each of the previous contexts and they should be determined by the learner. We have predicted the possible values for these factors in order to minimize the amount of text data entry required by the learner. Therefore, the learner can select one of the possible values that will be displayed to him for each factor. Besides, this module contains a learner profile to hold some of the learner information that is mainly consistent.

4.1.1.1 THE LEARNER DIMENSION

In our model, the learner dimension covers two main contexts as shown in figure 4.11:

- The personal context which takes into account all the contextual concerns which are associated to the learner itself.

- The environmental context which consider the physical surrounding environment of the learner.

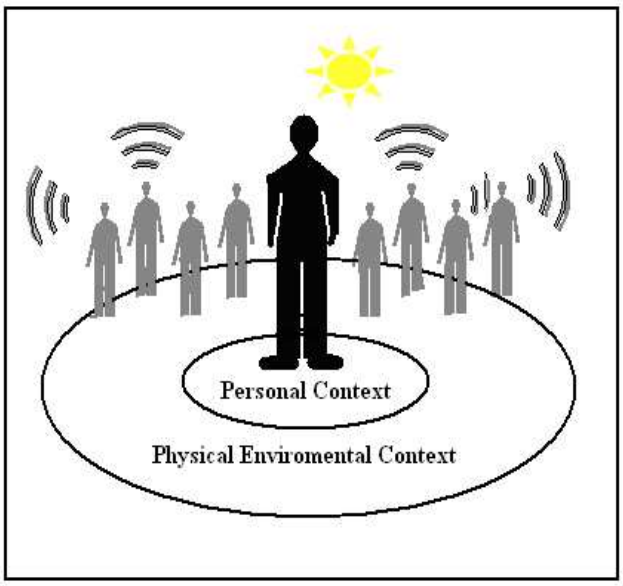


Figure 4.11: Contexts according to the learner dimension

1. Personal Context

First of all, personal context is any information that is used to describe the personal matters that are associated to mobile learning learner. In our model three factors will be used to determine the learner personal context. The learner must select the value of each factor. These factors are:

- **Factor 1**: Learning style. Each learner has his own learning style and preferences that can help him to improve and accelerate his learning process. In our work we are going to base on Felder and Silverman learning style model [15]. The authors classify the learning style in the light of the following four dimensions:

1. Active and Reflective
2. Sensing and Intuitive
3. Visual and Verbal
4. Sequential and Global

The learner must select one of the learning styles that are available in Felder and Silverman learning style model and as a result the value of the first factor in the personal context will be one of the following [15]:

- Active style: the learner prefers to actively process the information in the learning content. For example testing the information or doing an assignment on it.

- Reflective style: the learner has a preference to read and think about the information that is found in the learning content.
- Sensing style: the learner prefers to read concrete materials for example facts, data.
- Intuitive style: the learner prefers to read abstract material such as theories and concepts.
- Visual style: the learner learns easily using pictures and images.
- Verbal style: the learner prefers to learn by reading texts or listing to a speech.
- Global style (Top-down style): the learner finds it easier to learn by having the overall picture and slowly getting into details.
- Sequential style (Bottom-up style): the learner learns better when he focuses on the narrow details first and brings them together to develop the large picture.

- **Factor 2**: Knowledge abstraction level. Different learners need different level of knowledge abstraction. For example, some learners need to only review the key points in the learning materials while other students want to read more detailed level of knowledge and a deep explanation of the key points that are available in the learning materials. In our opinion, the level of abstraction from the learner point of view can be one of the following two possibilities that will be displayed to him:

  - High level of abstraction: shallow knowledge or abstract knowledge that can be a summary of the learning content in a specific learning materials.
  - Low level of abstraction: deep knowledge or a detailed knowledge that are not abstracted.

- **Factor 3**: Focus of attention. The learner attention and concentration level can provide further context. As in factor 2, According to his attention level, he can require a high or low level of knowledge abstraction. However, this factor can take one of the following two values based on the learner status:

  - Full attention: the learner is only concentrating on the learning activity.
  - Partial attention: the learner concentration is not fully dedicated to the learning process. This can be as a result of doing another activity such as running or driving while he is using his mobile device to learn.

Finally, Table 4.2 summarizes all the factors that are used to describe the personal context in the first adaptation dimension.

A D A P T A T I O N D I M E N S I O N S		
P E R S O N A L C O N T E X T		
Factors	**Value**	**Meaning**
1. Learning Style	Active	Learner prefers to actively process the information in the learning content.
	Reflective	Learner has a preference to read and think about the information that is found in the learning content
	Sensing	Learner prefers to read concrete materials
	Intuitive	Learner prefers to read abstract material
	Verbal	The learner prefers to learn by reading texts or listing to a speech.
	Visual	The learner learns easily using pictures and images.
	Bottom-up	The learner learns better when he focuses on the narrow details first and brings them together to develop the large picture.
	Top-down	Learner finds it easier to learn by having the overall picture and slowly getting into details.
2. knowledge abstraction level	High level	Shallow knowledge or abstract knowledge that can be a summary of the learning content in a specific learning materials
	Low level	Deep knowledge or a detailed knowledge that are not abstracted.
3. Focus of Attention	Full	The learner concentration level is high.
	Partial	The learner concentration level is low.

Table 4.2: Personal Context Factors

2. Environmental Context

The surrounding learner's environment can have a great influence on the way in which the content will be adapted. The learner must determine the value of each factor by selecting one of the possible choices that will appear on his device screen.

- **Factor 1**: Physical location. The location of the learner can affect his learning experience. In our model, the value of this factor can be one of the following two possibilities which are:

  - On move learner: we refer to on move learner to the learner whose legs are moving such as walking, running and so on.
  - Stationary learner: the learner is in a specific location. We will describe the environment of this location by factor2 and factor3 as shown next. However, each of these learner

circumstances has different contexts that should be supported with different kind of learning content.

- **Factor 2**: Noise level or auditory distraction. The noise in the surrounding environment can have an affect on the type of learning that should be provided to the learner. Generally, noise levels are measured in decibels (dB). The basic tool to measure the noise level is the sound level meter that almost responds in the same way as the human ear and gives estimation of sound pressure level. Standards for noise levels in some general locations are measured as following [59]:

  - Library: 35 dB
  - Office: 60- 65 dB
  - traffic noise: 70 - 80 dB
  - Airport where planes take off: 120 dB

  In spite of this, the noise levels from the learner point of view who mostly does not aware of the noise level measurement and determines the noise level according to his ear, noise can be divided into three levels which are high, medium and low noise level. However in our model we will take into account only two levels which are high level and low level while medium level will not be included because it does not have any influence on the content that will be adapted. Thus the possible values of this factor are:

  - High noise level: according to learner, he is studying in a noisy place.
  - Low noise level: according to learner, he is studying in a quite place.

  Beside, it has to be said that the noise level is a heraldic issue that can vary from one person to other. For example, to some learners, the normal traffic noise is a large auditory distraction that can affect there ability to interact with the audio learning content while other learners consider the normal traffic noise as a medium noise level that does not abbreviate their ability to go on with the learning activity even if the content was presented as an audio content.

- **Factor 3**: Visual distraction. This can affect the learner's ability to read the learning content through his mobile device. The learner must determine the visual distraction in his surrounding by selecting from the following two values:

  - High visual distraction: there is a great amount of brightness in the learner's surrounding.
  - Low visual distraction: the learner's surrounding is dark.

As shown bellow, Table 4.3 describes all the factors that are used to specify both the social and physical environments for mobile learning learners.

A D A P T A T I O N D I M E N S I O N S		
E N V I R O M E N T A L C O N T E X T		
Factors	**value**	**Meaning**
1. Physical Location	On Move	The learner is moving such as walking, running and so on.
	Stationary	The learner is not moving and he is at a specific physical location.
2. Noise Level	High	According to learner, he is studying in a noisy place.
	Low	According to learner, he is studying in a quite place.
3. Visual Distraction	High	According to learner, there is a great amount of brightness in his surrounding.
	Low	According to learner, his surrounding is dark.

Table 4.3: Environmental Context Factors

4.1.1.2 THE TECHNOLOGICAL DIMENSION

The technological dimension includes contexts that are associated to mobile devices which are used to access the learning content in mobile learning application and the connectivity which are used to deliver the learning content. According to this dimension the context can be classified into two main classifications which are: The device context and the connectivity context.

1. Device Context

It is a crucial issue to specify the learner device capabilities in mobile learning application because they can have a big impact on what content is appropriate and meaningful to be delivered to the learner. The parameters that characterize mobile devices are the main factors that will be used to characterize this context. These factors are:

- **Factor 1**: Device type. Specifying the device type which will be used by the learner to access the learning content is very important factor specially for determining in which the resolution the learning content will be displayed. In general, resolution refers to the clearness and sharpness of a specific image. Screen resolution indicates the number of dots or pixels on the entire device's screen. The typical screen resolution parameter in PDAs is 240x320 pixels, in

cellular phones is 120x160 pixels, in smartphones is 200x300 pixels and finally in touch Ipod is 320 x 480 pixels. The learner must enter his device's screen resolution in pixels.

- PDA and SmartPhones.
- Cellular Phones.
- Ipod (Non-Telephony Device).

- **Factor 2**: Available battery level. Each device has different power capacity. Generally, when device battery is fully charged PDAs have 8 hours power capacity while cellular phones and smart phones have 10 hours power capacity and finally in touch Ipod the power capacity is up to 22 hours of audio playback and 5 hours of video playback. However, the learner must determine the value of this factor by selecting one of the following values which describe the percentage of the total battery power remaining in his device.

- 5-20 %: low battery power remaining in the learner device.
- 20-50%: medium battery power remaining in the learner device.
- Over 50%: high battery power remaining in the learner device.

2. Connectivity Context

Nowadays mobile devices can be connected to Internet through different wireless technologies, as we mention in section 3.4.2. Each of them has different data transfer rate and can be used either for wide or limited coverage. In this work we are going to determine this context by specifying the type of the wireless technology that will be used by the learner to connect his device to the Internet.

- **Factor 1**: Connection technology. Mainly, GPRS, WAP and Wi-Fi are the most common technologies that are used to connect to the Internet via PDAs, smartphones and cellular phones while Ipod devices can only connect to the Internet through Wi-Fi technology. As a result, the learner must specify the type of his wireless connection from the following three types of technologies:

- WAP: WAP technology is used for Internet connection and it has typical data transfer rates 9kbps.
- GPRS: GPRS technology is used for Internet connection and it has typical data transfer rates from 30 to 100kbps.

- Wi-Fi (802.11g): this is the most recent version of Wi-Fi technology and it provides 54 Mbps data transfer rate.

Finally, Table 4.4 goes over the main factors that are used to identify the device and the connectivity context.

A D A P T A T I O N D I M E N S I O N S		
D E V I C E C O N T E X T		
Factors	**Value**	**Meaning**
1.Device Type	PDA	The learner is using a personal digital assistant, with typical screen resolution 240x320, to access the learning content.
	Cellular Phone	The learner is using a cellular phone, with typical screen resolution 120x160, to access the learning content
	Smart Phone	The learner is using a SmartPhone, with typical screen resolution 200x300, to access the learning content
	Non-Telephony Device (Ipod)	The learner is using Ipod, with typical screen resolution 320x480to access the learning content.
3. Available Battery Level	5-20%	Low battery power remaining in the learner device
	20-50%	Medium battery power remaining in the learner device
	50-100%	High battery power remaining in the learner device
C O N N E C T I V I T Y C O N T E X T		
1. Connection Technology	WAP	WAP technology is used for Internet connection and it has typical data transfer rates 9kbps
	GPRS	GPRS technology is used for Internet connection and it has typical data transfer rates from 30 to 100kbps
	Wi -Fi	Wi-Fi technology is used for Internet connection and it has typical data transfer rates 54Mbps

Table 4.4: Device and Connectivity Context Factors

4.1.1.3 LEARNER PROFILE

Learner profile is a record of specific variables that depict the learner preferences and it is considered as a part of the adaptation dimensions module because according to it we can adapt the

learning content to fit the learner needs. The learner profile includes: learner first name, last name, identification number (ID) and the learner learning area which referrers to the courses enrolled by the learner. In the previous section, we have defined several factors that will be used to describe the various learning contexts. However, asking the learner to determine all of these factors each time he would like to access a learning content can be an irritating process. For that reason, the learner profile will also include the factors with the values that do not change frequently such as: learner learning style, device type and finally the connection technology. None of the environmental factors will be included in the learner profile since all of their values, as shown in Table 4.3, will regularly be changed. In addition, the learner preference (LP) to a specific type of presentation will also be involved in the learner profile. Each learner can select his favorite presentation format from the following four LP classes:

- Class 1: Text content
- Class 2: Audio content
- Class3: Visual content (Graphics and Animations)
- Class 4: Compound content (Text, Audio and Visual content)

However, the learner will be able to review his profile in order to change any of his old setting.

4.1.2 ADAPTATION TYPES MODULE

This module includes four different types of adaptation that can be applied on the learning content in mobile learning application. These types are:

- Learning objects flow adaptation: we mentioned earlier, that each learning object has an objective that is identical to one of the lecture's sub objectives such as: defining concepts, presenting facts, describing procedures or models and so on. The flow of learning objects for each lecture can be altered. For instance, some learners may prefer to see a fact or an example before a definition, whereas others prefer it the other way around. Therefore, the learning path in each lecture must be dynamic and the learning objects sequence will be adapted according to the learner style or to the navigation selection.

- Level of detail adaptation: this type involves presenting the learning content to the learner either in high level of detail by displaying the whole content in each learning object or in a low level of detail by presenting the summary part only from each learning object.

- Learning object entire order adaptation: informative learning objects includes three main parts, which are: small set of information objects, followed by a summary of the learning object content and finally a multiple-choice question to enable the learner to evaluate his understanding level at the completion of each learning object. The learning object entire order adaptation focuses on adapting the order of these parts in a way that fit the learner style.

- Learning object presentation adaptation: earlier in this chapter, we have pointed out that the learning objects will be in a text-based form and for each of these objects there is an equivalence audio learning object. Moreover, for some of the text-based objects there are animations or graphics objects that transcribe the learning content. Thus, this type of adaptation specify how to present the learning content in a manner that best suits the learner, as and when required, according to the learner context and preferences.

4.1.3 ADAPTATION ENGINE MODULE

Adaptation engine is responsible for performing the adaptation on the mobile learning content according to a set of predefined rules. Adaptation rules form the connection between the learner context factors and the learner preferences, which will be taken as inputs, and the adaptation type that should be generated. As shown in Figure 4.12, we partition the rules into five groups according to which type of adaptation will be produced. These are:

- Generic adaptation rules.
- Learning objects flow adaptation rules.
- Detail level adaptation rules.
- Entire order adaptation rules.
- Presentation type adaptation rules.

Moreover, all the rules are in the form of:
IF <condition> THEN <action>

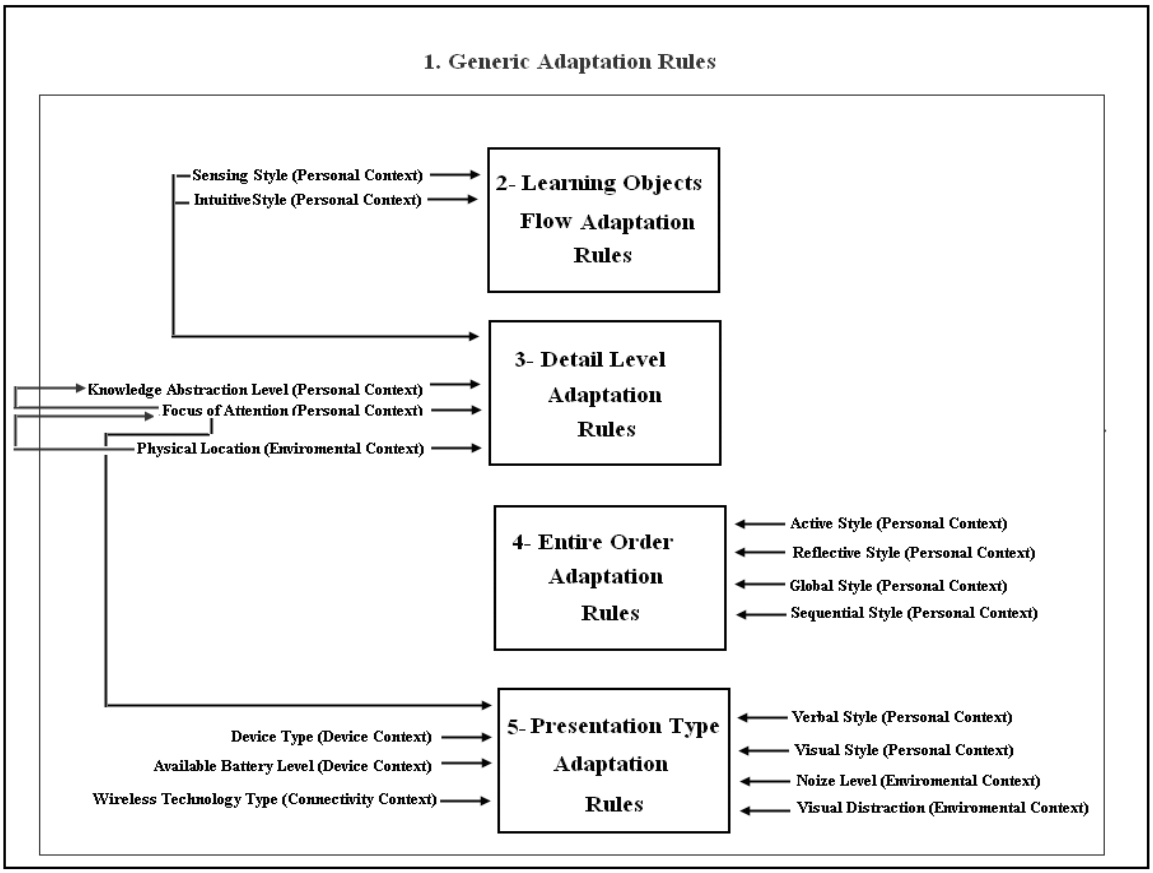


Figure 4.12: Adaptation Rules Groups

4.1.3.1 GENERIC RULES

There are two general rules describe the relationships between some of the factors in the adaptation dimensions module as shown in Figure 4.12. Rule 1 illustrates the relationship between the focus of attention factor and the knowledge abstraction level factor from the personal context while rule 2 describes the relationship between the physical location factor from the environmental context and the focus of attention factor.

- **Rule 1**

IF the learner Location ="On Move"
Then the learner Focus of Attention="Partial"
End IF

- **Rule 2**

IF the learner Focus of Attention ="Partial"
Then Abstraction Level = "High"
End IF

4.1.3.2 LEARNING OBJECTS FLOW ADAPTATION RULES

The sequence of the learning objects can be adapted according to the learner selection or to the value of his learning style. However, only the sensing and intuitive styles require adaptation on the flow of the learning objects while the other learning styles do not have an impact on this type of adaptation as shown in Figure 4.12. Thus we will adapt the learning object flow according to the following rule.

[IF Learning Style ="Sensing"
Then present facts learning objects first followed by example learning objects
Else
[IF Learning Style ="Intuitive"
Then present concept learning objects first followed by theory learning objects
End IF]
Else keep the standard order of the learning objects.
End IF]

Figure 4.13 is an activity diagram that represents the learning object flow adaptation rule.

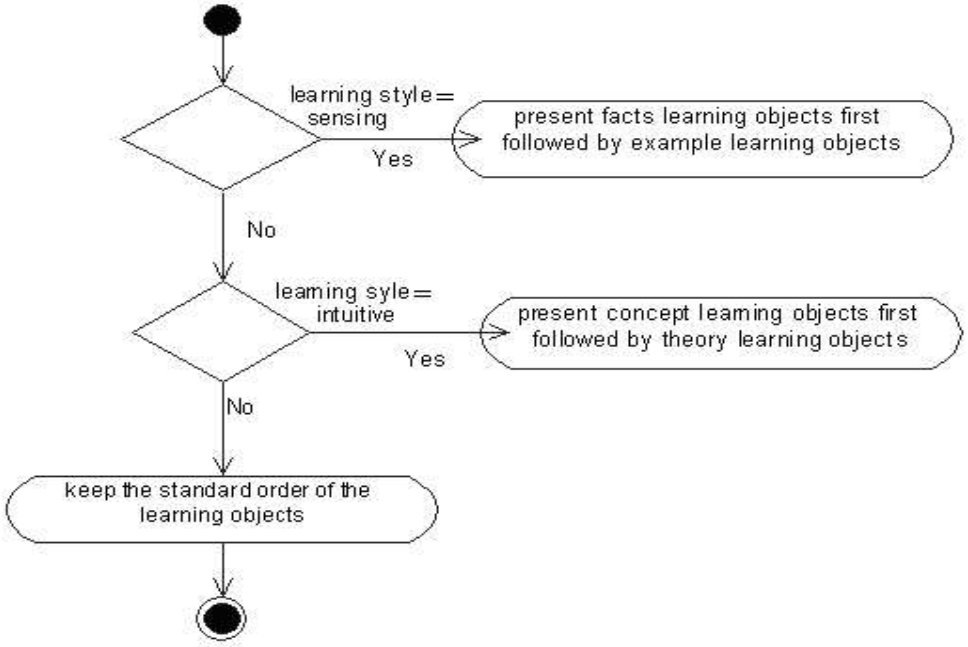


Figure 4.13: Learning Object Flow Adaptation Rule Activity Diagram

4.1.3.3 DETAIL LEVEL ADAPTATION RULE

The following rule determines which level of detail should be presented to the learner according to two factors which are the: learning style factor and the abstraction level factor.

[IF Learning Style ="Intuitive"
Then present learning objects in low level of detail
Else
[IF Learning Style ="Global" or "Sequential"
Then Present learning objects in both levels of details
End IF]
Else
[IF the Abstraction level="High"
Then present learning objects in low level of detail
End IF]
Else present learning objects in high level of detail
End IF]

Figure 4.14 describes the detail level adaptation rule.

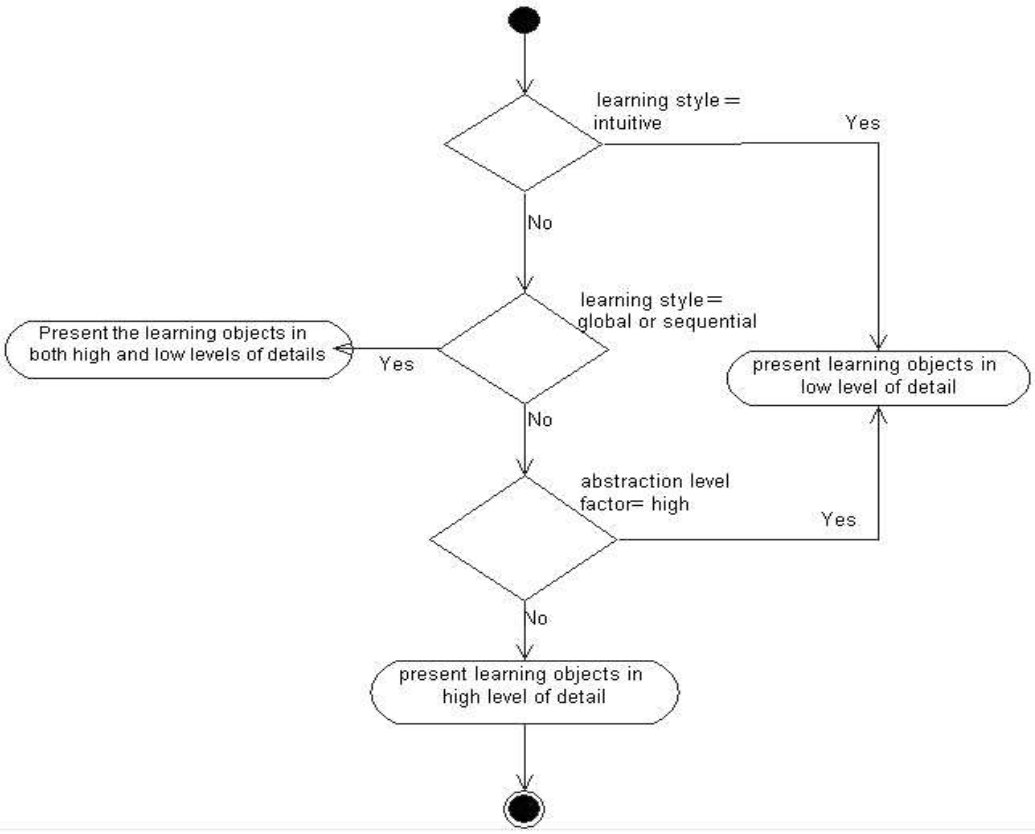


Figure 4.14: Detail Level Adaptation Rule Activity Diagram

4.1.3.4 ENTIRE ORDER ADAPTATION RULE

As shown in Figure 4.12, some learning styles such as global and sequential styles require adapting the entire order of each learning object. This kind of adaptation can be done according to the following rule.

IF Learning Style ="Global"
Then for each lecture present the summaries of learning objects first followed by the information objects

Else IF Learning Style ="Sequential"
Then for each lecture present the information objects of learning objects first followed by the summaries.
End IF

Figure 4.15 describes the entire order adaptation rule.

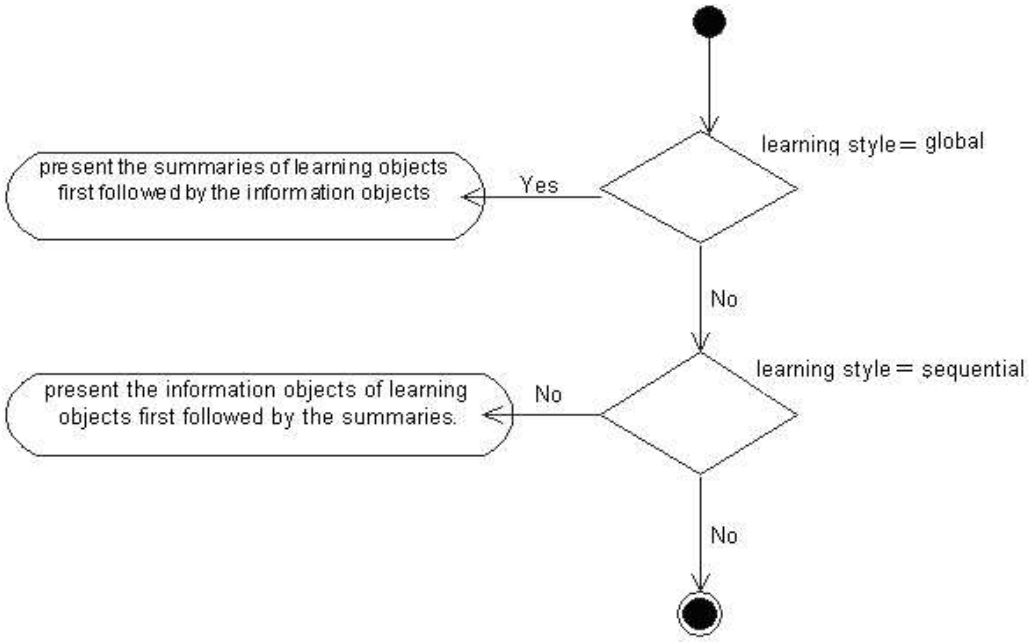


Figure 4.15: Entire Order Adaptation Rule Activity Diagram

4.1.3.5 PRESENTATION TYPE ADAPTATION RULES

Different scenarios can take place while the learner is using his mobile device to present the learning content. These scenarios are combination of the different values of the context factors and

the learner preferences. In this set of rules, we are going to specify the appropriate presentation type of content for each scenario.

However, to handle the large amount of probabilities that can occur while trying to determine the learning scenarios, we identify 12 cases that will be the starting pointes for different rules. Each case will depend on:

- Battery level factor (BL) from the device context which can have the following values.

- 5-20%
- 20-50%
- Over 50%

- Learning style factor (LS) from the personal factor. According to the purpose of this set of rules, which is to adapt the presentation type of the learning content, this factor can have the following three values:

- Not verbal or visual
- Verbal
- Visual

- Learner preferences (LP) from learner profile. As we mentioned in section 4.1.3 the learner preference can be one of the following classes:

- Class 1: Text Learning Objects
- Class 2: Audio Learning Objects
- Class3: Visual Learning Objects (graphics and animations)
- Class 4: Compound Learning Objects (Text, Audio and Visual content)

As a result, the learning cases are:

CASE # 1: *BL ="5-20%"*. In this case there is no need to know what learning style or class the learner prefer because his device available battery level can only support text content.
CASE # 2: *BL ="20-50%" and LS ≠ ("Visual" or "Verbal") and LP="Class1"*
CASE # 3: *BL ="20-50%" and LS ≠ ("Visual" or "Verbal") and LP="Class2"*
CASE # 4: *BL ="20-50%" and LS ≠ ("Visual" or "Verbal") and LP="Class3"*
CASE # 5: *BL ="20-50%" and LS ≠ ("Visual" or "Verbal") and LP="Class4"*

CASE # 6: *BL ="Over 50%" and LS ≠ ("Visual" or "Verbal") and LP="Class1"*

CASE # 7: *BL ="Over 50%" and LS ≠ ("Visual" or "Verbal") and LP="Class2"*

CASE # 8: *BL ="Over 50%" and LS ≠ ("Visual" or "Verbal") and LP="Class3"*

CASE # 9: *BL ="Over 50%" and LS ≠ ("Visual" or "Verbal") and LP="Class4"*

CASE # 10: *BL = ("20-50%" or Over 50 %) and LS = "Verbal"*

CASE # 11: *BL ="20-50%" and LS ="Visual"*

CASE # 12: *BL ="Over 50 %" and LS ="Visual"*

Now, for each case we are going to define the rules that will be used to cover the probable scenario or scenarios in each case.

CASE # 1

IF BL ="5-20%"
THEN apply Rule 1
Else apply Case 2

- **Rule1:**

IF Location = "Stationary" and Visual Distraction= "Low"
Then present text LOs
Else
[Display notification message = "Text content is not compatible with your context" and apply Rule 1.1]
End IF

Figure 4.16 is an activity diagram that describes the first rule in the presentation type adaptation rules.

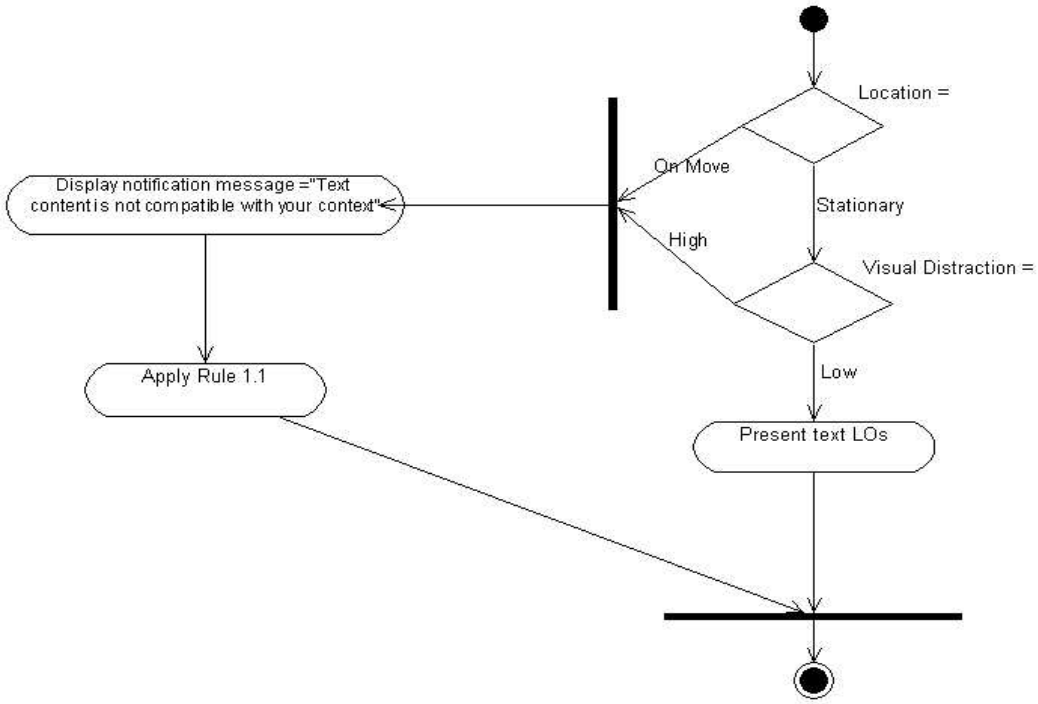


Figure 4.16: Activity Diagram for Rule1

- **Rule 1.1**

[IF Noise Level ="Low"

Then play audio LOs

Else display verification message = "can you use your device headphones?"

[IF yes play audio LOs

Else display notification message="We recommend you to access the learning content later]"

End IF]

End IF]

CASE # 2

IF BL ="20-50%" and LS ≠ ("Visual" or "Verbal") and LP="Class1"
THEN apply Rule 1
Else apply Case 3

CASE # 3

IF BL ="20-50%" and LS ≠ ("Visual" or "Verbal") and LP="Class2"
THEN apply Rule 2
Else apply Case 4

- **Rule2:**

[IF Noise Level = "Low"

Then present audio LOs

Else display notification message = "Audio content is not compatible *with your context, would you like to have other type of content?"*

[IF learner selects text content

Then apply Rule 2.1

Else

[IF learner selects visual content

Then go through Rule 3, Rule 4, Rule5, Rule 6, Rule 7, Rule 8

End IF]

End IF]

End IF]

- **Rule 2.1**

IF Location = "Stationary" and Visual Distraction= "Low"

Then present text LOs

Else display notification message = "We recommend you to access the learning content later"

End IF

CASE # 4

IF BL ="20-50%" and LS ≠ ("Visual" or "Verbal") and LP="Class3"

THEN go through Rule 3, Rule4, Rule 5, Rule 6, Rule 7, Rule 8

Else apply Case 5

- **Rule 3:**

[IF Connection Type = "WAP"

Then

[Display notification message = "Your wireless connection and battery level can not support visual content." and

[IF Location = "Stationary" and Visual Distraction = "Low"

Then present text LOs

Else apply Rule 1.1

End IF]]

End IF]

- **Rule 4:**

[IF Device Type = ("PDA" or "Smartphone") and Connection Type = "GPRS"

Then

[IF Location = "Stationary" and Visual Distraction = "Low"

Then present essential graphic and animation LOs less than 240x320 pixels

Else

[Display notification message = "Visual content is not compatible with your context" and apply Rule 1.1]

End IF]

End IF]

Figure 4.17 is an activity diagram that describes rule5

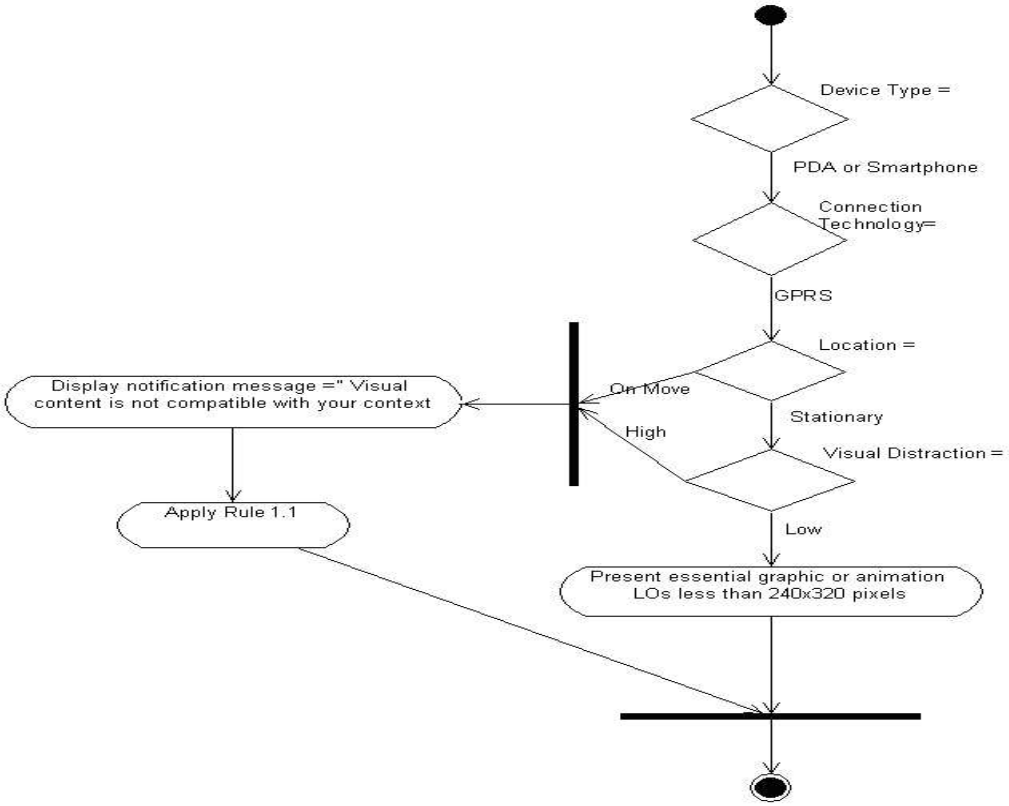


Figure 4.17: Activity Diagram for Rule5

- **Rule 5:**

[IF Device Type = ("PDA" or "Smartphone") and Connection Type = "Wi-Fi"

Then

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present graphic and animation LOs less than 240x320 pixels

Else

[Display notification message = "Visual content is not compatible with your context" and apply Rule 1.1]

End IF]

End IF]

- **Rule 6:**

[IF Device Type = "Cellular Phone" and Connection Type = "GPRS" Then

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present essential graphic and animation LOs less than 120x160 pixels

Else

[Display notification message = "Visual content is not compatible with your context" and apply Rule 1.1]

End IF]

End IF]

- **Rule 7:**

[IF Device Type = "Cellular Phone" and Connection Type = "Wi-Fi"

Then

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present graphic and animation LOs less than 120x160 pixels

Else

[Display notification message = "Visual content is not compatible with your context" and apply Rule 1.1]

End IF]

End IF]

- **Rule 8:**

[IF Device Type = "Ipod"

Then

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present graphic and animation LOs less than 320x480 pixels

Else

[Display notification message = "Visual content is not compatible with your context" and apply Rule 1.1]

End IF]

End IF]

CASE # 5

IF BL ="20-50%" and LS ≠ ("Visual" or "Verbal") and LP="Class4"
THEN go through Rule 9, Rule10, Rule 11, Rule 12, Rule 13, Rule 14
Else apply Case 6

- **Rule 9:**

IF Connection Type = "WAP"

Then apply Rule 3

End IF

- **Rule 10:**

[IF Device Type = ("PDA" or "Smartphone") and Connection Type = "GPRS"

Then

[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"

Then present text LOs, audio LOs and essential graphic and animation LOs less than 240x320 pixels.

Else

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present text LOs and essential graphic and animation LOs less than 240x320 pixels

Else apply Rule 1.1

End IF]

End IF]

End IF]

- **Rule 11:**

[IF Device Type = ("PDA" or "Smartphone") and Connection Type = "Wi-Fi"

Then

[IF Location = "Stationary" and Noise Level = "Low" and Visual Distraction = "Low"

Then present text LOs, audio LOs and graphic and animation LOs less than 240x320 pixels.

Else

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present text LOs and graphic and animation LOs less than 240x320 pixels

Else apply Rule 1.1

End IF]

End IF]

End IF]

- **Rule 12:**

[IF Device Type = "Cellular Phone" and Connection Type = "GPRS"

Then

[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"

Then present text LOs, audio LOs and essential graphic and animation LOs less than 120x160 pixels.

Else

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present text LOs and graphic and animation LOs less than 120x160 pixels

Else apply Rule 1.1

End IF]

End IF]

End IF]

- **Rule 13:**

[IF Device Type = "Cellular Phone" and Connection Type = "Wi-Fi"

Then

[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"

Then present text LOs, audio LOs and graphic and animation LOs less than 120x160 pixels

Else

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present text LOs and graphic and animation LOs less than 120x160pixels

Else apply Rule 1.1

End IF]

End IF]

End IF]

- **Rule 14:**

[IF Device Type = "Ipod"

Then

[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"

Then present text LOs, audio LOs and graphic and animation LOs less than 320x480 pixels

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present text LOs and graphic and animation LOs less than 320x480 pixels

Else apply Rule 1.1

End IF]

End IF]

End IF]

CASE # 6

IF BL ="Over 50%" and LS ≠ ("Visual" or "Verbal") and LP="Class1"

Then apply Rule 1

Else apply Case 7

CASE # 7

IF BL ="Over 50%" and LS ≠ ("Visual" or "Verbal") and LP="Class2"

Then apply Rule 2

Else apply Case 8

CASE # 8

IF BL ="Over 50%" and LS ≠ ("Visual" or "Verbal") and LP="Class3"

Then go through Rule 15, Rule16, Rule 17, Rule 18, Rule 19

Else apply Case 9

- **Rule15:**

[IF Device Type = ("PDA" or "Smartphone") and Connection Type = "WAP"

Then

[IF Location = "Stationary" and Visual Distraction = "Low"

Then present essential graphic and animation LOs less than 240x320 pixels

Else

[Display notification message = "Visual content is not compatible with your context" and apply Rule 1.1]

End IF]

End IF]

- **Rule 16:**

[IF Device Type = "Cellular Phone" and Connection Type = "WAP" Then

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present essential graphic and animation LOs less than 120x160 pixels

Else

[Display notification message = "Visual content is not compatible with your context" and apply Rule 1.1]

End IF]

End IF]

- **Rule17:**

[IF Device Type = ("PDA"or "Smartphone") and Connection Type = ("GPRS" or "Wi-Fi")

Then

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present graphic and animation LOs less than 240x320 pixels

Else

[Display notification message = "Visual content is not compatible with your context" and apply Rule 1.1]

End IF]

End IF]

- **Rule18:**

[IF Device Type = "Cellular Phone" and Connection Type = ("GPRS" or "Wi-Fi") Then

[IF Location ="Stationary" and Visual Distraction ="Low"

Then present graphic and animation LOs less than 120x160 pixels

Else

[Display notification message = "Visual content is not compatible with your context" and apply Rule 1.]

End IF]

End IF]

- **Rule 19:**

IF Device Type ="Ipod"

Then apply Rule 8

End IF

CASE # 9

IF BL ="Over 50%" and LS ≠ ("Visual" or "Verbal") and LP="Class4"
Then go through Rule 20, Rule 21, Rule 22, Rule 23, Rule 24
Else go to Case 10

- **Rule 20:**

[IF Device Type = ("PDA" or "Smartphone") and Connection Type = "WAP"
Then
[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text LOs, audio LOs and essential graphic and animation less than 240x320 pixels.
Else
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs and essential graphic and animation LOs less than 240x320 pixels
Else apply Rule 1.1
End IF]
End IF]
End IF]

- **Rule 21:**

[IF Device Type = "Cellular Phone" and Connection Type = "WAP"
Then
[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text LOs, audio LOs and essential graphic and animation LOs less than 120x160 pixels
Else
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs, essential graphic and animation LOs less than 120x160 pixels
Else apply Rule 1.1
End IF]
End IF]
End IF]

- **Rule 22:**

[IF Device Type = ("PDA"or "Smartphone") and Connection Type = "GPRS or Wi-Fi")
Then

[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text LOs, audio LOs and graphic and animation LOs less than 240x320 pixels.
Else
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs and graphic and animation LOs less than 240x320 pixels
Else apply Rule 1.1
End IF]
End IF]
End IF]

- **Rule 23:**

[IF Device Type = "Cellular Phone" and Connection Type = ("GPRS" or "Wi-Fi")
Then
[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text LOs, audio LOs and graphic and animation LOs less than 120x160 pixels
Else
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs, graphic and animation LOs less than 120x160 pixels
Else apply Rule 1.1
End IF]
End IF]
End IF]

- **Rule 24:**

IF Device Type ="Ipod"
Then apply Rule 14
End IF

All of the previous cases include the learning style that is neither verbal nor visual styles. The cases that include a visual or verbal style are presented as Appendix on page 103.

4.2 MODEL IMPLEMENTATION

We have successfully implemented a small prototype to provide an example on how a learning lesson can be designed according to our design approach and we applied some of the previous presentation type rules on the lesson to illustrate how these rules can adapt the learning content. The lesson will provide basic understanding about the Internet. We have divided the learning content into small learning objects with limited objectives. The first learning object in the Internet basics lesson will include a content that gain the learner attention by providing an interesting fact about the lesson as shown in Figure 4.18.

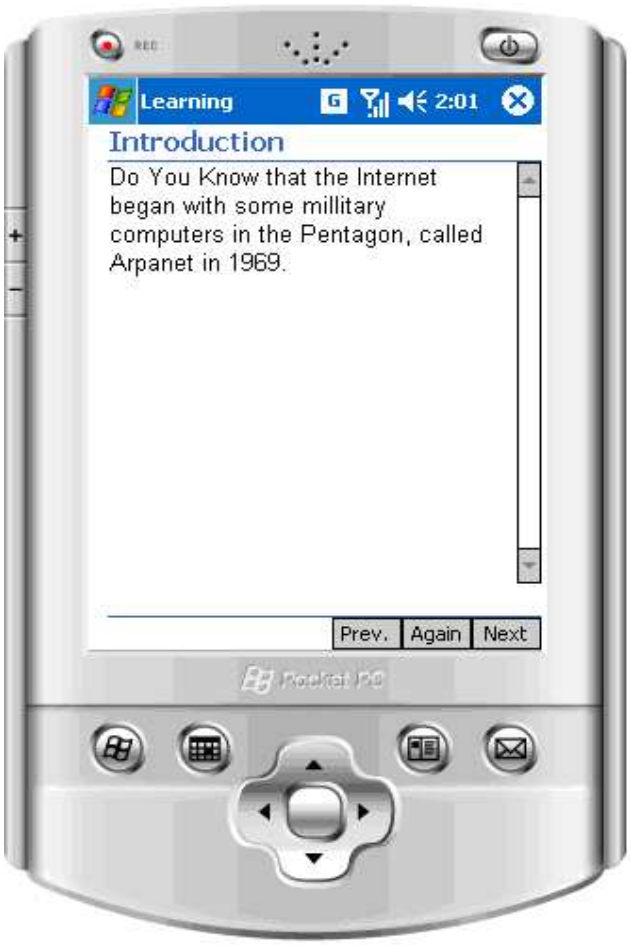


Figure 4.18: Gain Learner Attention Learning Object

The next learning object states the main objective of the lesson. This will be the second event in the Gagne instructional design model as shown in Figure 4.19.

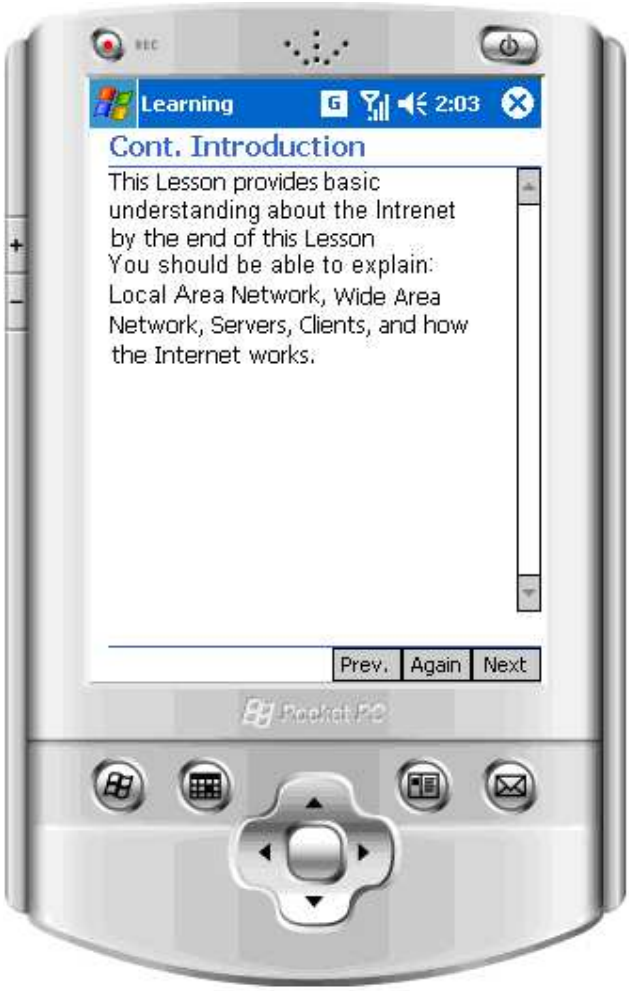


Figure 4.19: Set the Scene Learning Object

After that, the sequence of the core learning objects will be presented to the learner. The objects will be in a text-based form. For each text object, there should be an equivalence audio object. Some of the learning objects will be also associated to visual objects that can be a graphic or animation objects. However, the presentation of the visual object should not be on the same screen of the text object to avoid distracting the learner with two observable objects as shown in Figure 4.20. The first screen in the figure includes a text learning object responsible of achieving one of the lesson's objectives which is defining the Local Area Network (LAN). The visual object that transcribes the text will be displayed on a separated screen if the learner clicks on the image link.

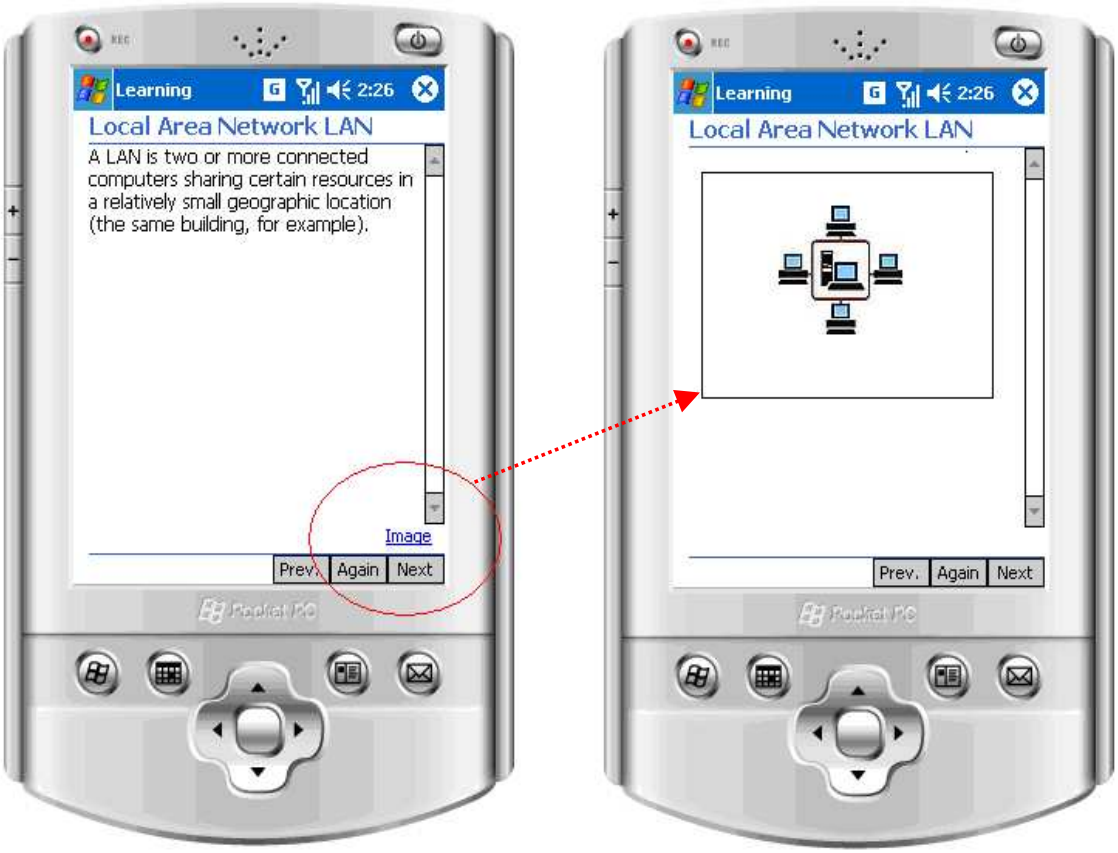


Figure 4.20: Text and Visual Objects Defining the Local Area Network

All of the core learning objects for the Internet basics lesson will be displayed in the same way as presented in the Appendix on page 106.

Reviewing Figure 4.8, the last object will call for the learner action. In our lesson, this will be by asking the learner if he would like to examine his understanding level by taking a small quiz.

As we mentioned several time before, the learning content should be adapted to fit the learning context and the learner preferences. In our prototype we applied a small set of the presentation adaptation rules on the Internet basics lesson to provide an example of how our rules can be implemented. As shown in Figure 4.21, we assume that the learner has the following information on his profile:

- Learning style = Reflective
- Learner Preference = Class 4
- Device Type= PDA
- Connection Type= GPRS

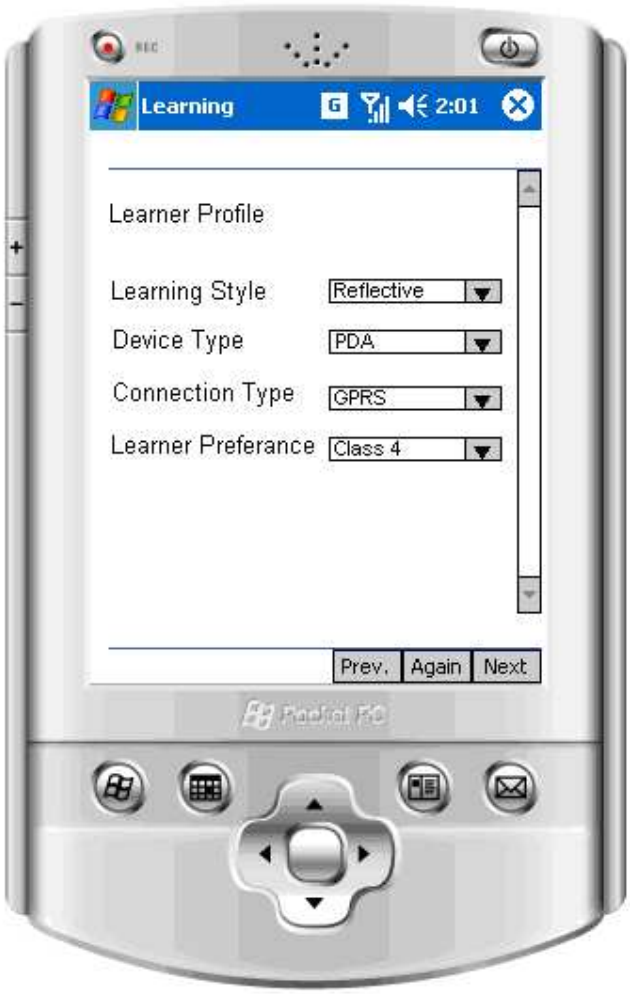


Figure 4.21: Learner Profile Screen

Then we will ask the learner to determine the factors that describe his learning contexts. First of all he will have to select the value of his device battery level as shown in Figure 4.22.

- If the learner selects the first choice, which is 5-20% battery power remaining, then regardless to the value of the learner preference we will only display text learning objects to save his device battery power. In other words, we will have to apply the first rule on the presentation type adaptation rules:

- **Rule1:**

IF Location = "Stationary" and Visual Distraction= "Low"

Then present text LOs

Else

[Display notification message = "Text content is not compatible with your context" and apply Rule 1.1]

End IF

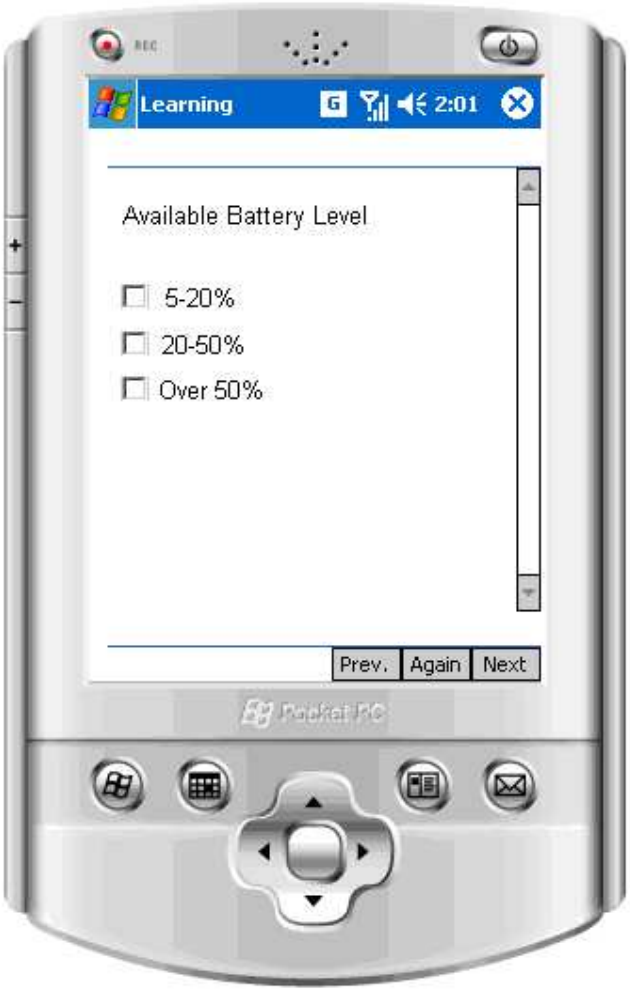


Figure 4.22: Device Battery Level Screen

To apply rule 1, the learner must determine his location and the visual distraction in his surrounding environment. If the learner is a stationary learner and the visual distraction is low then text learning objects will be displayed, as shown in Figure 4.23 and Figure 4.24.

Figure 4.23: A True Statement for the First Part of Rule 1

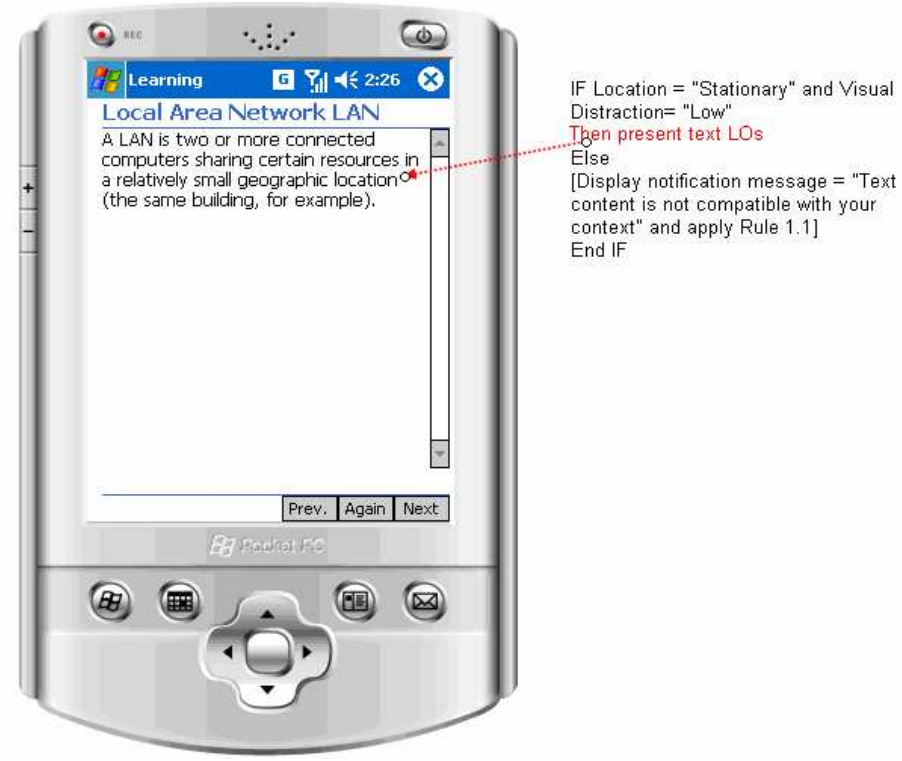


Figure 4.24: Presenting Text Learning Objects According to Rule 1

However, if the learner is on move or the visual distraction is high, then a notification message will be displayed to inform the learner that text content is not compatible with his context as shown in figure 4.25.

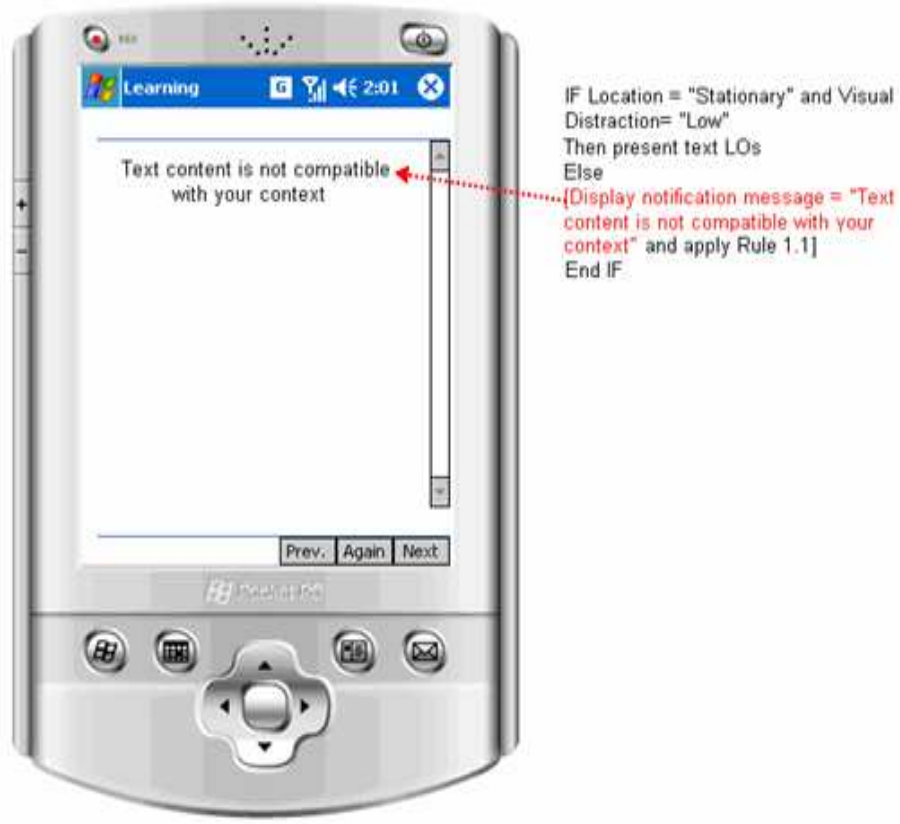


Figure 4.25: Presenting the Notification Message

And finally we will apply rule 1.1 as shown in Figure 4.26, Figure 4.27, Figure 4.28 and Figure 4.29

- **Rule 1.1**

[IF Noise Level ="Low"

Then play audio LOs

Else display verification message = "can you use your device headphones?"

[IF yes play audio LOs

Else display notification message="We recommend you to access the learning content later]"

End IF]

End IF]

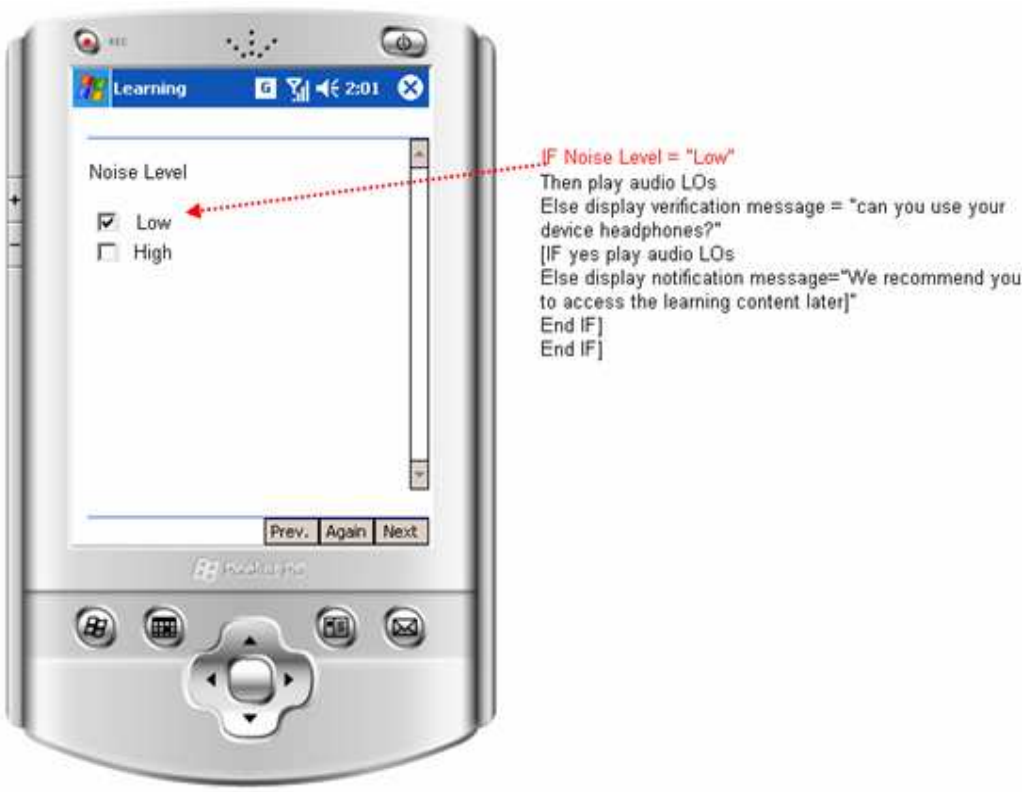


Figure 4.26: A True Statement for the First Part of Rule 1.1

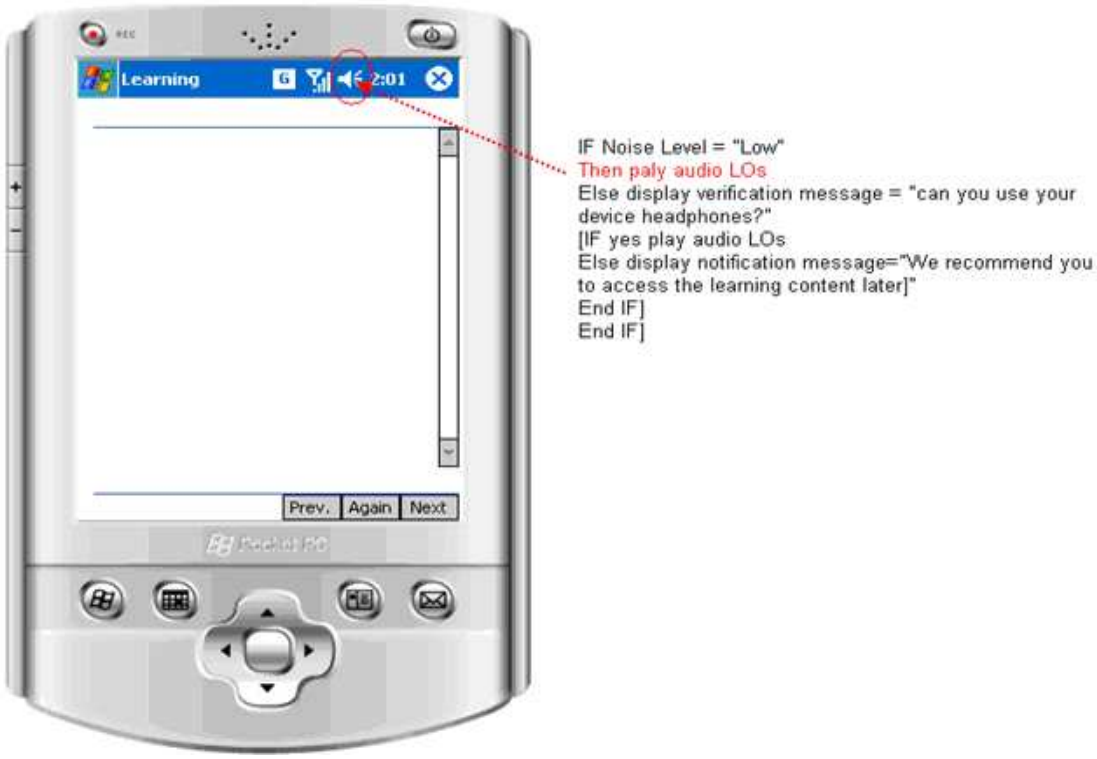


Figure 4.27: Playing Audio Learning Objects According to Rule 1.1

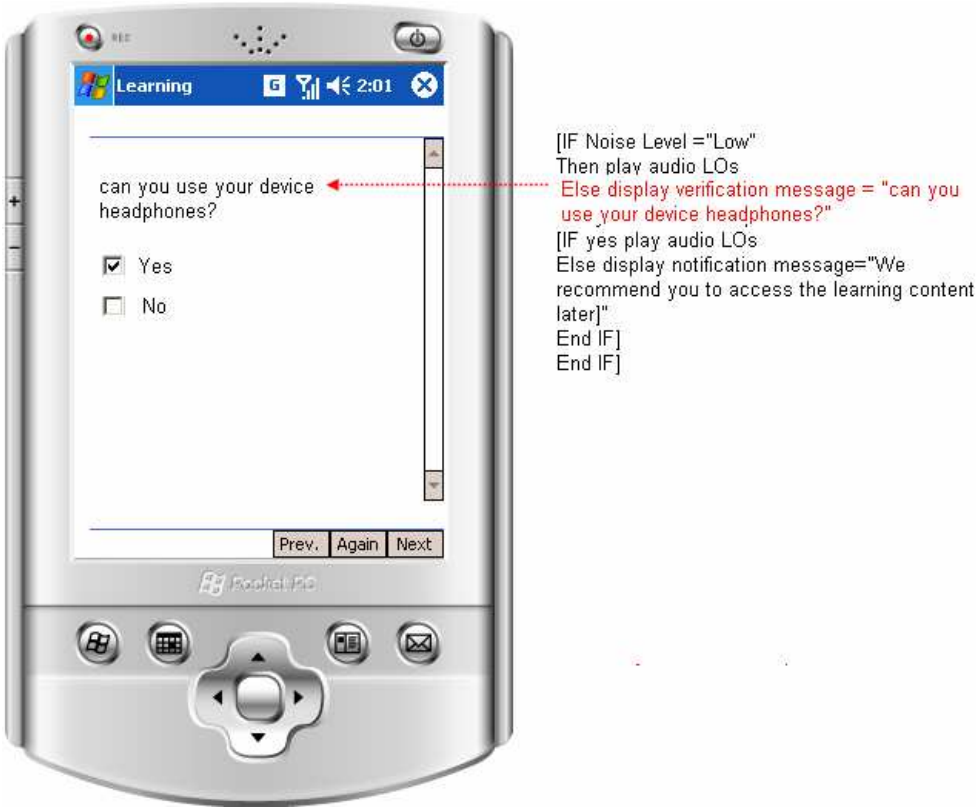


Figure 4.28: Presenting Verification Message

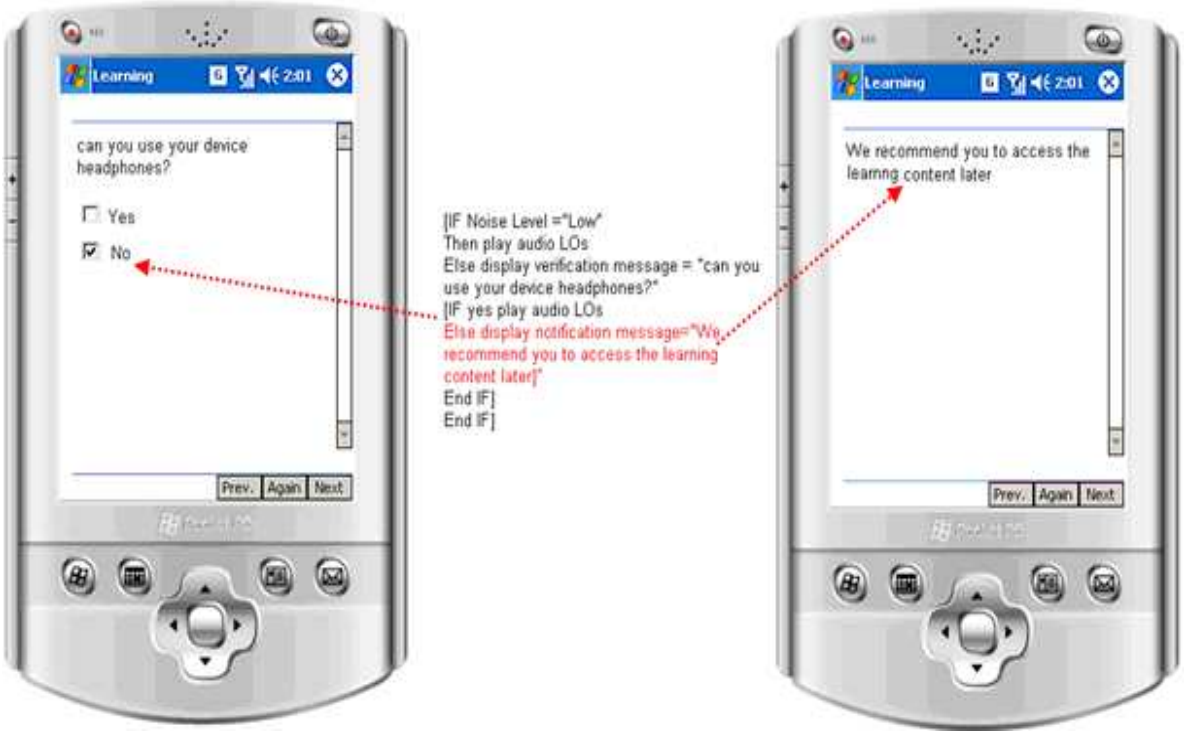


Figure 4.29: Displaying Rule 1.1 Notification Message

- If the learner selects the value of his device battery power 20-50% or Over 50%, rule 10 must be applied, which is:

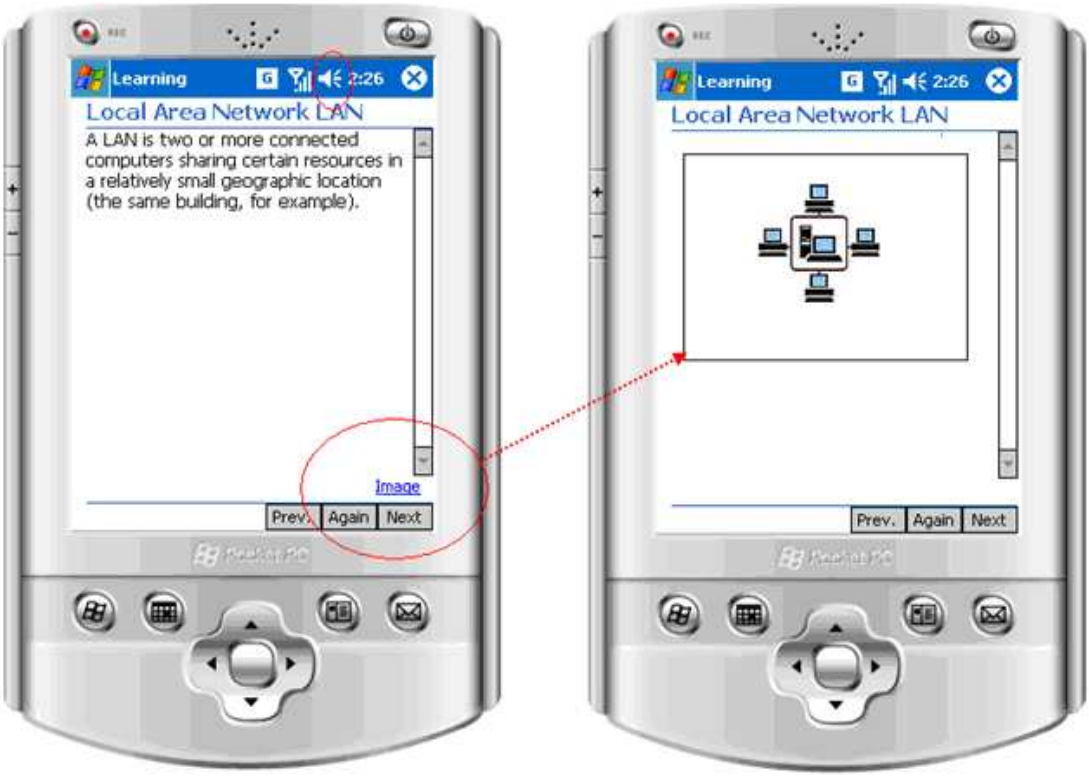
- **Rule 10**

[IF Device Type = ("PDA" or "Smartphone") and Connection Type = "GPRS"
Then
[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text LOs, audio LOs and essential graphic and animation LOs less than 240x320 pixels.
Else
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs and essential graphic and animation LOs less than 240x320 pixels
Else apply Rule 1.1
End IF]
End IF]
End IF]

As shown in Figure 4.30 and Figure 4.31, if the learner is stationary and both, the visual distraction and noise level are low, then we can fulfill the learner preference by successfully applying class 4 and presenting the learning content in all presentation formats.

[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text LOs, audio LOs and essential graphic and animation LOs less than 240x320 pixels.
Else
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs and essential graphic and animation LOs less than 240x320 pixels
Else apply Rule 1.1
End IF]
End IF]
End IF]

Figure 4.30: True Statement for the First Part of Rule 10



[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text LOs, audio LOs and essential graphic and animation LOs less than 240x320 pixels.
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs and essential graphic and animation LOs less than 240x320 pixels
Else apply Rule 1.1
End IF]
End IF]

Figure 4.31: Effective Presentation of class 4

However, if the learner is stationary and the visual distraction is low, only text and visual learning objects can be displayed as shown in Figure 4.32 and Figure 4.33.

[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text LOs, audio LOs and essential graphic and animation LOs less
than 240x320 pixels.
Else
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs and essential graphic and animation LOs less than
240x320 pixels
Else apply Rule 1.1
End IF]
End IF]

Figure 4.32: True Statement for the Second Part of Rule 10

[IF Location ="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text LOs, audio LOs and essential graphic and animation LOs less than 240x320 pixels.
Else
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs and essential graphic and animation LOs less than 240x320 pixels
Else apply Rule 1.1
End IF]
End IF]

Figure 4.33: Presentation of Text and Visual Content

Finally, if the learner is on move or the visual distraction is high, rule 1.1 must be applied, as we have shown in Figure 4.26, Figure 4.27, Figure 4.28 and Figure 4.29**.**

CHAPTER 5

5. CONCLUSIONS AND FUTURE WORKS

5.1 SUMMARY

Mobile learning is a new form of learning that emerged as a result of the technological advancements in mobile and wireless technologies. This thesis handled a significant issue in mobile learning which is the design and adaptation of the learning content in mobile learning application to fit both the mobile learners and devices. To solve this issue, and to make the learning process ubiquitous in mobile learning, first of all we have introduced the impact of technology on the learning process and clarified the statement of problems, our goals and motivations, the previous related work and the methodology in chapter 1. In chapter 2 we have reviewed the most important e-learning field aspects which are: technology, services and content. Moreover, we have discussed the core three aspects in the mobile learning field in chapter 3, which are: the technologies that are used to develop, deliver and access the learning content, the learning context and the learning content. The focus was on the learning content aspect. In chapter 4 we introduced our top-down approach to design the learning content and produced some of the design guidelines to be applied on the approach. Furthermore, we have successfully designed a model that is responsible for adapting the learning content by applying different sets of adaptation rules.

5.2 CONCLUSIONS

Although mobile learning is a new learning form, it can improve and support the learning process if we effectively handle the mobile content design and adaptation issues. In our thesis, we have introduced a top-down content design approach that guarantees an effective displaying and downloading of the learning content on mobile devices. The approach focuses on splitting the learning content into small learning objects each with limited objectives. Each learning object must be available in two main forms which are: text and audio. For some learning objectives, visual object should be also available to transcribe the main learning objects. We found that to fit the limitation of mobile devices we have to classify the visual learning objects according to different resolutions that are compatible with the real mobile devices screen resolutions. In our work, we classify the visual learning objects into three classifications depending on the screen resolutions of the most common types of mobile devices which are: PDAs and smartphones, cell phones and Ipod

devices. Thus we recommend classifying the visual learning objects as following: objects less than 240x320 pixels, objects less than 120x160 pixels and objects less than 320x480 pixels. Finally, the learning objects should be organized according to an instructional design model, they should be related to each other in a tree hierarchy structure and they must be adapted to fit the learner preferences and contexts.

Furthermore, while implementing the prototype, we found that the integration of text and visual learning objects on the same screen can distract the learner so we recommend viewing each of these objects in a separated screen

To accomplish the last step in our design approach, we have proposed a model that is responsible for adapting the learning content. Our content adaptation model considers different factors that characterize four learning contexts which are: the personal, environmental, device and connectivity contexts. We have suggested some possible values for each factor. We find that different values will have an influence on different types of content transformation. Therefore we determined four types of adaptation which are: adaptation on the content presentation type, entire order, level of detail, and finally on the learning objects flow. We observe that adapting the learning content according to the four types in the same time is a complex process and it will be easier to specify which values carry out adaptation and what type of adaptation is needed. Thus we define five sets of adaptation rules that will be applied on the adaptation engine model and each of them will be responsible of one type of adaptation.

The first set of rules, which is the generic rules, take into account the relationships between the different values of factors and we noticed that according to these rules we will adapt the level of detail in the learning content indirectly. However, the learning object flow and entire order adaptation rules are only influenced by certain values of the learning style factor while the presentation type adaptation rules are affected by many factors especially from the environmental context.

5.3 FUTURE WORKS

We would like to suggest some interesting issues and ideas that could not be reached because of the time, resources and other constraints and they will aid as an improvement on the proposed model. As future work, we mention:

- Full implementation of the proposed model for designing and adapting mobile learning content. This can be done by designing a whole educational course according to our design approach, implementing the adaptation model on the course and finally applying an experimental test by allowing a group of learners to try out the system and assess the learning experience and the effectiveness of the adaptation criteria in fulfilling their desires.

- Comparing our model for designing and adapting the learning content with some other models such as: the Multiple Representation (MR) approach and its application in mobile adaptation [24] and the Implementing and Evaluating Probabilistic Adaptivity Framework [30], to measure and affirm the efficiency and effectiveness of the model adaptation performance on respect with the learning contexts, objectives and the learner's preferences. Furthermore, we should compare our factors that are used to characterize the different contexts and their values with the context factors that are used in the existed models.

- Adjusting the suggested model and enhancing its features by adding a mobile learning quality evaluation at the end of each design iterations.

- Studying the influence of the social matters on the learning activity and adding them as a further context on the model.

- Another interesting direction would be to analyze if and how possible is to define all the context factors as well as the learner preferences automatically.

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APPENDICES

APPENDIX A

The presentation adaptation rules for:

CASE # 10: *BL = ("20-50%" or Over 50 %) and LS = "Verbal"*

CASE # 11: *BL ="20-50%" and LS ="Visual"*

CASE # 12: *BL ="Over 50 %" and LS ="Visual"*

CASE # 10

IF BL = ("20-50%" or Over 50 %) and LS = "Verbal"
Then apply Rule 25
Else apply Case 11

- **Rule 25:**

IF L="Stationary" and Noise Level ="Low" and Visual Distraction ="Low"
Then present text and audio LOs
Else
[IF Location ="Stationary" and Visual Distraction ="Low"
Then present text LOs
Else apply Rule 1.1
End IF]
End IF]
End IF]

CASE # 11

IF BL ="20-50%" and LS ="Visual"
THEN go through Rule 26, Rule27, Rule28, Rule 29, Rule 30, Rule 31
Else apply Case 12

- **Rule 26:**

IF Connection Type = "WAP"
Then apply Rule 3
End IF

- **Rule 27:**

IF Device Type = ("PDA"or "Smartphone") and Connection Type = "GPRS"

Then apply Rule 4

End IF

- **Rule 28:**

IF Device Type = ("PDA"or "Smartphone") and Connection Type = "Wi-Fi" Then

Then apply Rule 5

End IF

- **Rule 29:**

IF Device Type = "Cellular Phone" and Connection Type = "GPRS" Then

Then apply Rule 6

End IF

- **Rule 30:**

IF Device Type = "Cellular Phone" and Connection Type = "Wi-Fi" Then

Then apply Rule 7

End IF

- **Rule 31:**

IF Device Type = "Ipod"

Then apply Rule 8

End IF

CASE # 12

IF BL ="Over 50 %" and LS ="Visual"

Then go through Rule 32, Rule33, Rule34, Rule 35, Rule 36

- **Rule 32:**

IF Device Type = ("PDA" or "Smartphone") and Connection Type = "WAP"

Then apply Rule 15

End IF

- **Rule 33:**

IF Device Type = "Cellular phone" and Connection Type = "WAP"

Then apply Rule 16

End IF

- **Rule 34:**

IF Device Type = ("PDA"or "Smartphone") and Connection Type = ("GPRS" or "Wi-Fi") Then

Then apply Rule 17

End IF

- **Rule 35:**

IF Device Type = "Cellular Phone" and Connection Type = ("GPRS" or "Wi-Fi") Then

Then apply Rule 18

End IF

- **Rule 36:**

IF Device Type ="Ipod"

Then apply Rule 8

End IF

APPENDIX B

Screens that include the core content for Internet Basics lesson:

Figure B.1: Text and Animation Content Describes the Internet

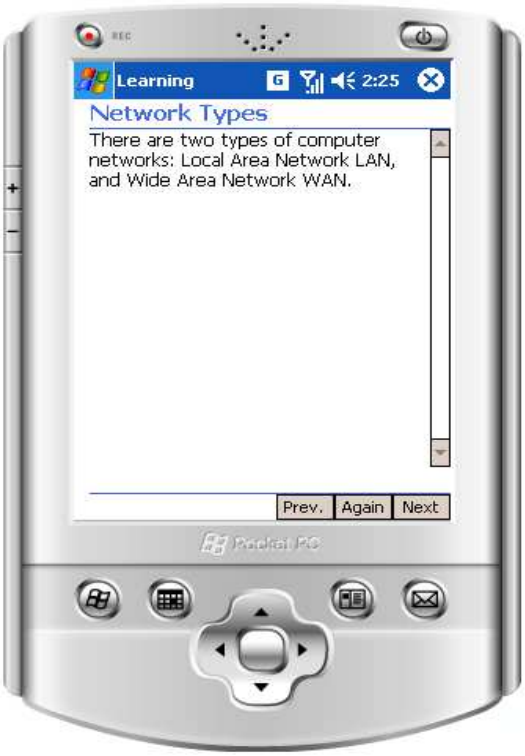

Figure B.2: Text Content Describes Network Types

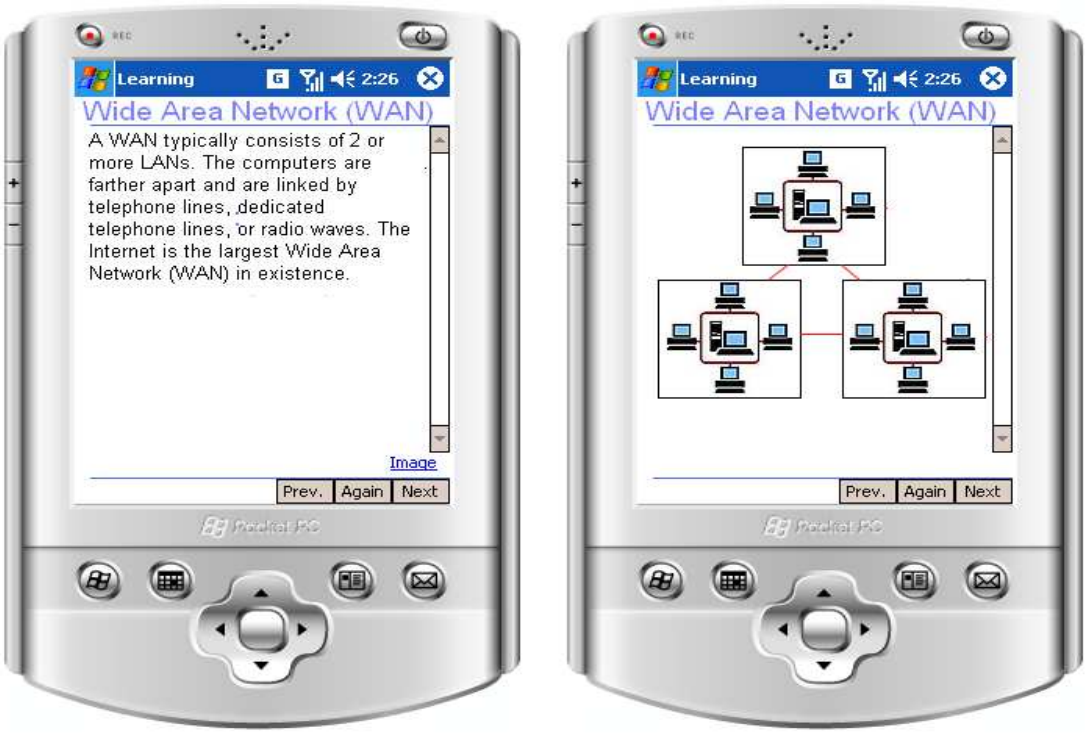

Figure B.3: Presentation of Text and Visual Content about WAN

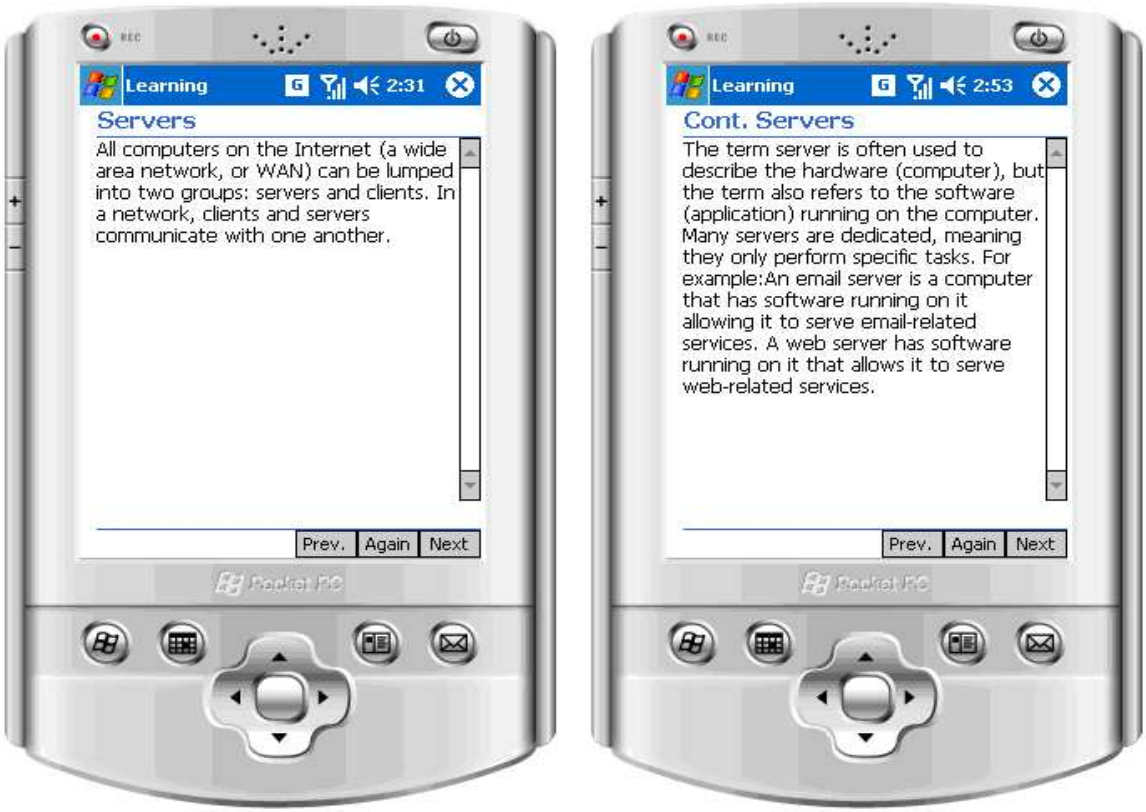

Figure B.4: Presentation of Text Content about Servers

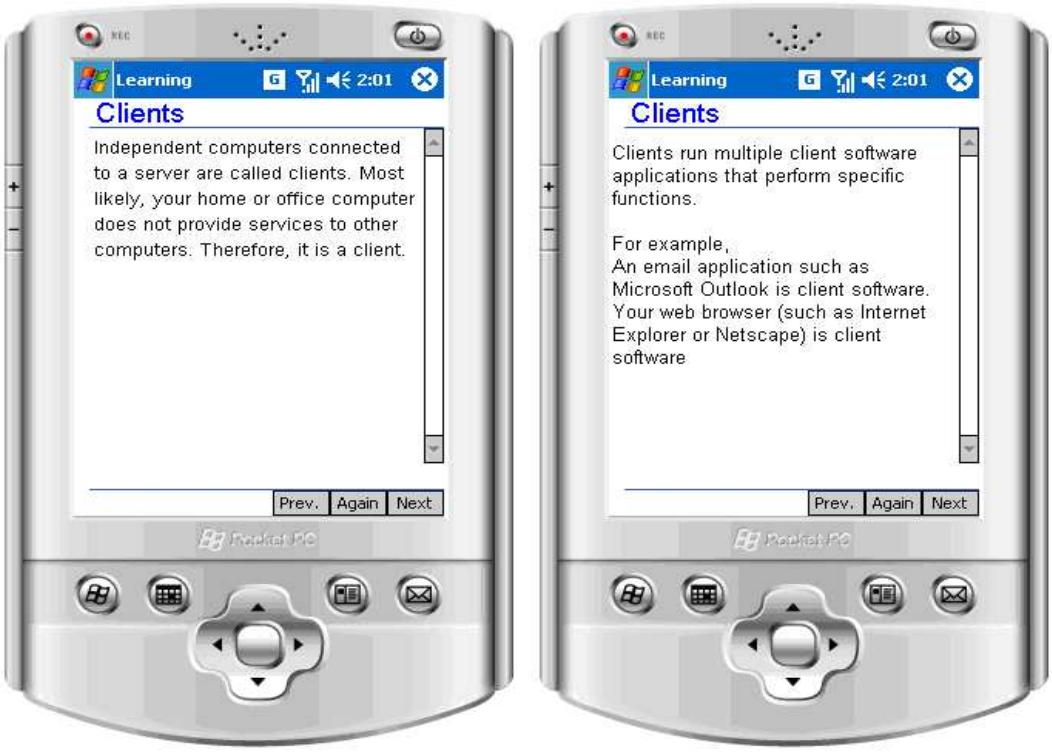

Figure B.5: Presentation of Text Content about Clients

Figure B.6: Presentation of Text and Visual Content about how the Internet Works

APPENDIX C

Curriculum Vitae

Zaina Abdel Hamid Hamdan

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Personal Information

Material Status: Single
Nationality: Jordanian
Date of Birth: May 9, 1982

Academic Qualifications:

2007/2008 Middle East University for Graduate Studies Amman, Jordan.
M.Sc degree in Computer Information System, from the faculty of Information Technology.

2004/2005 Al Ahliyya Amman University Amman, Jordan
B.Sc. degree in Computer Information System, from the faculty of Information Technology with an average of 81.0 % (rating: Very Good)

2000/2001 Al-Etihad High School Amman, Jordan
Scientific Stream

Additional Qualifications:

1. Successfully pass the TOEFL IBT (Test of English as a Foreign Language) with a score 80 of 120.
2. Successfully complete High Intermediate (A) Level, (Listening & Speaking), ALC, American Embassy Amman English Teaching Program.
3. Successfully complete High Intermediate (A) Level, (Reading & Writing), ALC, American Embassy Amman English Teaching Program.
4. Successfully complete High Intermediate (B) Level, (Listening & Speaking),

ALC, American Embassy Amman English Teaching Program.

5. Successfully complete High Intermediate (B) Level, (Reading & Writing), ALC, American Embassy Amman English Teaching Program..

Training Courses:

1. Microsoft Visual VB.Net Architecture
2. ActiveX Server Page.Net-ASP +
2. Microsoft SQL Server 7.0
3. ASP.Net Web Service using Microsoft VB.Net Architecture
4. Smart Device Application using Microsoft VB.Net
5. Programming in Java

Computer Skills:

1. IT skills (MS-office, Excel, Word, Power Point ...)
2. Internet knowledge and research skills
3. Familiar with Rational Rose software for system analysis and design
4. Familiar with Microsoft Office Project Management

Other Skills:

1. Communication & Interpersonal skills
2. Strong Analytical & Problem Solving skills

Publications:

***Conferences**:-*

Hassan, M.; Fayoumi, M.; Hamdan, Z.: "A Framework for Learning Content Design", Six International Internet Education Conference (ICT-Learn), Cairo, Egypt, (2007).

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