# Usability Guidelines for Designing Mobile Learning Portals

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## ABSTRACT
Mobile learning presumes the use of mobile Internet technology to facilitate the learning process. The growth and rapid evolution of the wireless technology have created new opportunities for anytime and anywhere learning paradigm. As a result, numerous mobile learning portals have been developed to gain the advantages of it. Nonetheless, there is little research and exploration has been initiated in proposing usability guidelines in designing mobile learning portals to achieve efficiency, effectiveness and satisfaction of learning. Thus, this paper seeks to present usability guidelines by grounding the user interface on usability theoretical framework, possible constraints, and unique properties of mobile computing. Three categories of usability have been formulated: user analysis, interaction and interface design. Ten golden usability guidelines have been suggested which aims for designing highly efficacious, user friendly and usable mobile interface to support dynamicity of mobile and handheld devices. Moreover, Mobile Learning Course Manager (MLCM) portal has been developed to demonstrate and exemplify the usability guidelines proposed.

## Categories and Subject Descriptors
H.5.2. [**Information Interfaces and Presentation**]: User Interfaces – *benchmarking, graphical user interfaces (GUI), screen design (e.g., text, graphics, colour), standardisation.*
H.1.2 [**Model and Principles**]: User/Machine Systems – *human factors*.

## General Terms
Design, Human Factors, Documentation

## Keywords
Usability, user interface, mobile learning

## 1. INTRODUCTION
The practice of using technology to enhance teaching-learning in higher education has seen a veritable eruption since the emergence of computing and Internet technologies in the last decade.


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Educationalists always positively welcome technologies to transform and indirectly revolutionise the process of learning. The use of technology has not only created new opportunities within the conventional classroom but also served to expand learning experience beyond the popular notion of classroom [1]. This integration of technologies has altered considerably the instructional strategies in our educational institutions and changed the way teachers teach and students learn [2]. Much research has been carried out in evaluating and measuring the learning outcomes with the use of technology in classroom which intend to enhance the learning experience and increase the academic achievement [30, 47]. Some noticeable examples with the use of technologies in educational context are multimedia learning, World Wide Web or web/Internet-based learning, e-Learning, and in recent years, the mobile learning.

## 2. RELATED WORK
### 2.1 Mobile learning
The combination of wireless telecommunication and mobile computing is resulting in escalating transformation of educational world [3]. In addition, the emergence of mobile devices and quick development of wireless communication has opened up another alternative way for higher education institution to employ mobile learning as a mean to transfer knowledge to learners [4]. Mobile learning has been perceived by many educationalists to offer flexibility in learning and present a multitude yet unique educational advantages [5]. The rapid evolving of the wireless communication and demanding for the low-cost of mobile devices potentially direct many researchers and educationalists to move from web-based and e-Learning to mobile learning which promising easy and convenient ways of learning. One distinct feature of mobile learning over e-Learning is mobility [6]. Hence, researchers and scholars are becoming enthusiastically in coining the term 'mobile learning or m-learning', such as 'mobile learning as the point at which mobile computing and e-Learning intersect to produce an anytime, anywhere learning experience [7]. According to Nyiri [8], m-learning is fundamentally e-Learning delivered through mobile computational devices such as Palms, Personal Digital Assistants (PDA), Pocket PCs, smart phone, digital cell phones, and any other handheld devices. The use of mobile devices with the wireless network technology flourishes mobile learners to get convenience, expediency and immediacy of mobile learning in appropriate time and accessing the appropriate learning contents [7]. Additionally, mobile learning is the next generation of e-Learning and important instrument

for lifelong learning [49]. The maturity of mobile Internet technology facilitates the explosion of mobile learning portals' development in order to gain advantages out of it. Some of the significant examples include [9, 10, 11, 12, 13]. The use of Short Messaging Service (SMS) has been seen to be well appreciated as a new communication channel among the adolescents with their tutors for an inexpensive form of communication [14, 15].

## 2.1 Why Usability?

The term usability is defined as by The International Organisation for Standardisation (ISO) ISO 9241-11 [16] as 'the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.' According to Nielsen [17], usability means the measure of the quality the users' experience when interacting interface. Moreover, usability is not a surface gloss which applied at the last minutes or before the releases of the system or product; but it is deeply affected by every stage of the analysis, design, and development [18]. Usable systems are easy to learn (learnability), efficient to use (efficiency), easy to remember (memorability), not error-prone (errors), and satisfactory in use (subjective satisfaction) [17]. The ultimate goal of usability is meeting the needs of to users' satisfaction [17]. Moreover, advantages of usability encompass increased productivity, enhanced quality of work, improved user satisfaction, and reductions in support and training costs [19]. The reduction in costs has attracted many project managers and interface designers to employ the theory of usability when designing the interfaces as reported in [20, 21].

## 2.1 Motivation

Mobile learning appears in any facets of possible variations in context such as locations, environment, conditions, noisy or quiet, weather and so on. Hence, the dynamicity has triggered additional efforts and investigation in order to design highly usable mobile learning portals to cater for different types of users in the global economy. Furthermore, the limitation of screen size, the presentation of mobile contents, and adaptation of the information to the sensitivity of context and devices influence the efficiency and effectiveness when learning via the mobile devices. Hayhoe [23] emphasises that the design criterion of this ubiquitous perspective need to be examined thoroughly and focused as to eliminate boredom and disorientation which involves wide range of users in having variety types of handheld devices. It is perceptible that little research and exploration has been initiated to propose usability guidelines in designing mobile learning portals. Moreover, several extensive experiments conducted from 2002 to 2005 discover substantial amount of severe usability problems pertinent to user behaviour in mobile navigation on mobile Internet portals' design [24]. Therefore, this has set the directions for this paper to explore the usable guidelines when designing mobile learning portals by grounding the user interface on usability theoretical framework, possible constraints, and unique properties of mobile computing.

The next section shortly discusses the concepts of usability and guidelines for designing a usable mobile learning portal. We end with a conclusion and an outlook about future extensions.

**Table 1. Categorisation of usability guidelines**

| Category | Usability Guideline |
|---|---|
| User Analysis | U1 |
| Interaction | U2, U3, U4, U5 and U6 |
| Interface design | U7, U8, U9 and U10 |
| Note: U denotes 'usability' | |

# 3. DESIGN RATIONALE

## 3.1 Usability Guidelines Framework

Guidelines mean 'rules or principles for action, encapsulating some combination of practitioner determined best practices in a domain and research-based insights into factors relevant in that domain [25].' The usability guidelines framework is grounded on the usability theoretical framework discussed in [17], constraints proposed by [22], and understanding of a number of unique properties that are intrinsic to mobile computing as highlighted in [52, 53, 54]. See Figure 1.

(i) Usability theoretical framework:
- Learnability, efficiency, memorability, errors, and satisfaction.

(ii) In order to efficiently achieve usability tailored around; the following factors should be considered:
- Cognitive, perceptual, and motor capabilities and constraints of people in general.
- Unique characteristics of the users' physical and social work environment.
- Unique capabilities and constraints of the chosen software and/or hardware, and platform for the system/product.

(iii) Unique properties:
- Dynamicity:
  - The interaction between the system/product and users is highly fluid.
- Contextual awareness, adaptation and sensitivity:
  - Applications designed are highly related to the contextual use, ability of adaptation and sensitivity to its surrounding.

The usability guidelines are divided into three categories: user analysis, interaction, and interface design. The usability guidelines are associated in each category is shown in Table 1.

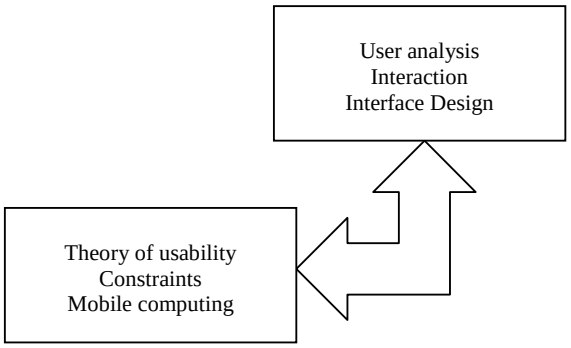


**Figure 1. Mapping of usability categories to the usability guidelines framework.**

### *3.1.1 User Analysis*

**U1: The user/learner**

User, in this case the mobile learners obviously is the most important attribute to be evaluated before other. The importance of users' analysis has been agreed upon by countless researchers to take great effort in defining and understanding the users as the critical factor in the design and development process. Eason [26] has produced taxonomy in analysing users; while Carey [27] has suggested two-dimensional model to classify the users' model. Learners' cognitive styles, motivation, and skills in using mobile technology greatly influence the success and failures of usable mobile learning portals, which apparently affects their academic achievement. For instance, research work that commented in [28, 29, 30] exemplifies the learning outcomes of it. Special attention should be paid in examining the users' characteristics, such as age, nationality (languages used), users' degree of familiarity with mobile devices, and special needs or physical disabilities. Furthermore, cognitive difficulties also are taken into careful considerations as observed by [31].

### *3.1.2 Interaction*

**U2: Human-mobile interaction**

The human-mobile interaction comprises the following:

(i) Human to mobile hardware computing and software architecture:
- The integration of mobile technology should considers the features and appropriateness of the wireless mobile technology such as weight, screen's size, resolution, bandwidth, memory and processing power, input availability and the mobile flexibility. In the aspect of the uncertainty of the wireless network connection, analysis of constructing and establishing the wireless in the outdoor environment should be taken into account. Moreover, functionalities of the learning portals, interface and protocol employed should be compatible to the mobile device with the intention of improving the users' satisfaction.

(ii) Contextual of use, ability of adaptation on learning contents, and sensitivity on its surroundings:
- The location and context-aware informational designed enable users to intelligently interact with the users-based knowledge of their environment. The interaction happens when the context-aware extracts, interpret and use context information and adapt its functionality to the current context and location of use [9, 55, 57]. The special attention should be paid on the context-sensitivity on the learning contents representation for mobile learning [55]. Additionally, the learning contents should be adaptable and independent of the various interaction modes.

(ii) Personalisation on learning contents:
- The characteristics of personalisation signify creativity and flexibility when browsing the portals. Personalisation intends to serve and match the individual learners' preferences and dislike against the services offered in a given situation as implemented in [45, 46].

**U3: Map between mobile learning portals and the real world**

The language of the interaction between mobile learners and the portals should be in terms words, phrases, and concepts familiar to the learners to visualise the abstract representation and the physical understanding, rather than the system-oriented information. The user-oriented dialogue is to aim at good mapping between the mobile display of information and the users' conceptual model of the information. Some relevant studies of possible mapping like [32, 33].

**U4: Help users recognise, diagnose, and recover from errors**

Malfunctions of the learning portals should be expressed in clear or plain language and avoid obscure of programming codes. Error messages should be precise indicated the problems, and constructively suggest a solution for recovery. These would assist the mobile learners to understand the learning portals better as suggested by [17, 34].

**U5: Visibility of the status**

The learning portals should continuously inform the learners about what it is doing on, through appropriate feedback within reasonable time frame. Sufficient indication explains the status and diminishes learners' worries and frustration [17]. In addition, feedback should restate and rephrase the users' input to indicate what is being done with it.

**U6: Minimise human cognitive load**

Miller [35] and Cowan [36] speculate that there is a limit on our capacity to process information, especially information that is loaded into the short-term memory. A comprehensive evaluation of appropriate human model processor should not be neglected. Therefore, the structure of the learning contents should be in small and homogeneous information chunks, and fit well within one screen at a time [50, 51]. Examination of human model processor which includes the understanding of perceptual, motor and cognitive systems provides numerical values for the parameters such as capacity and time to determine human performance when interacting with the interfaces [48]. Hence, interfaces based on recognition are much easier as it is often visually based. The theory of matching the object visibility [37] to fulfil the users need increases the human-mobile interaction and promotes simplicity in interactivity.

### *3.1.3 Mobile Learning Interface Design*

**U7: The small screen display**

The size of a mobile phone decreases over the years. This leads to a problem of displaying and organising efficiently as much information as possible on a small screen display [38]. This limitation has significantly evolved and developed other constraints when designing a usable mobile interface. According to Karkkainen and Laarni [39], small screen display with short lines slow down speed of reading by disrupting the normal pattern of eye movements and indirectly affects human interaction. An empirical research reports on physical text layout affects reading from a screen [40]. The number of line is an important variable which can affect the speed of reading especially text that is displayed on the small screen. In addition, Buchanan et al. [41] comment that too many paging within a screen increase the complexity of the interaction. Long pages should be segmented into smaller chunk and provide effective mechanism to view and jump to the desired page whenever users initiate an action or click on it [42]. Extensive scrolling and the number of clicks should be well thought. The height and width of the display area should not exceed the screen size.

**U8: Do not overuse**
Extraneous information not only risks confusing the mobile novice learners, but slows down the expert learners [43]. Consequently, the 'less is more' rule essentially practical to be applied on the limited display dimension i.e. the mobile phones. The limited capacity of the screen display has restricted not only the relevant information to be displayed at one screen; moreover, the amount of relevancy of the information should be taken into substantial concern. The most important information is placed at the right top corner to ease the readability. Empty and blanks spaces may be designed with great care to avoid misleading and confusion.

**U9: Navigation**
The selection of appropriate navigation structures determines the success and failure of usable and presentable information on a small screen display [42]. Consistency in navigating from one screen to other maintains the learners' pace and simulates the learning interest. It is suggested by [41] that reducing page navigation by using simple hierarchies like the existing phone menus which users are already comfortable with, and decreasing the number of keystrokes made by the users to simplify the navigation and also replacing text input with list selection.

**U10: Consistency**
Consistency claims to be one of the most fundamental usability principles in interface design [17]. The limited screen display has evidently highlighted the importance of consistency in a mobile context. Consistency covers the interface design, tasks and functionality structure of a system [44]. Thus, the similar information and action should be located in the same location to ensure consistency and ease of recognition. This consistency should be maintained for all functions in the learning portals within the same and/or different platform.

## 3.2 Architectural Design

The architecture of the Mobile Learning Course Manager (MLCM) consists of (i) MobileServer runs on a Server which can be directly accessed on the Internet; (ii) MLCM portal connects to the Internet via General Packet Radio Service (GPRS). This architecture is based on the socket connection between mobile phones and the MobileServer. The Transmission Control Protocol (TCP) protocol is employed to maintain the reliability of the data transmission. See Figure 2.

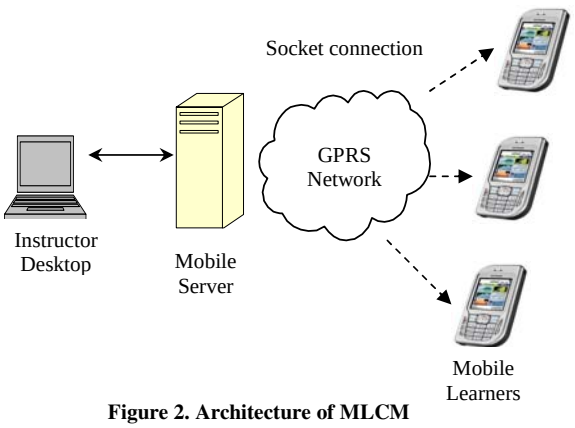


**Figure 2. Architecture of MLCM**

# 4. RESULTS AND DISCUSSIONS

Principally MLCM portal's user interfaces can be perceived usable as the mobile learners or users are considered the most important entity in our design. Much effort has been devoted in analysing and evaluating the mobile learners' need and caters for beginner, fast acting for a more expert learner, provides efficacious support to the learners' working needs and is pleasant to use. Figure 3a to 3e illustrates the flow of a module registered to MLCM which comprise of 3 options such as "Announcement", "Assessment", and "Time Table." The structural design encompasses 4 different portions as follow:

(i) Title bar: describes the portal's title, date and time.
(ii) Module selection: display the options available.
(iii) Narrative description: provides further explanation to guide and assist mobile learners.
(iv) Visited and recall option(s): visualise the option that has been initiated, and enables faster or shortcut access or recall to other options available.

Activation of an option is noticeable when a "folder" is opened, whereby non-activation of an option is typified in a close folder as shown in Figure 3a. The similar design selection and paradigm are adopted in our portals with intention of reducing users' training time and to facilitate the metaphoric understanding and conceptualisation as majority of the Windows application's users are familiar in it. Additionally, the selection of visited and recall options can be notified at the bottom of the interface. This entry aims to promote the visualisation of the visited options. Moreover, the visited link helps in human cognition and memory load whenever users wish to recall the option that has been visited. The visibility of the status is constantly displayed which lessen the anxiety of the mobile learners. The constraint of a small screen dimension and display has guided interface designers to take consideration of the option that is viewed in a folder format in order to decrease the mobile display size. The simplicity of the design and do not overuse the colour and the amount the text advance mobile learners to interact comfortably. The simple hierarchy navigation structure assists the mobile learners to minimise the number keystrokes made when navigating from one page to another. The attribute of consistency is obviously noticeable with the design of the colour used, standard typeface, font style, and size, layout, proportion, and navigation of the fragmented page for every entry of the interfaces designed.

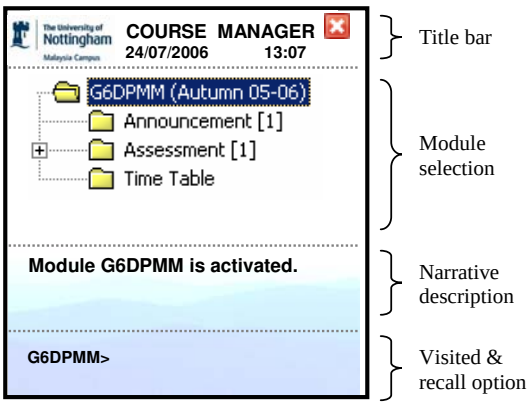


**Figure 3a. Main menu**

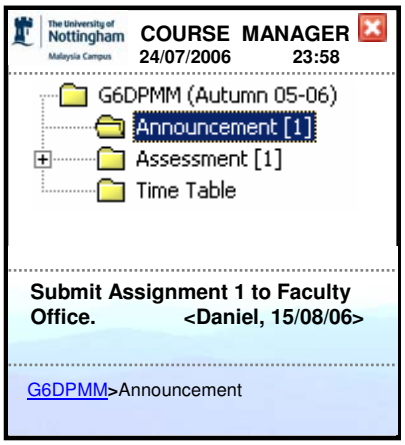


**Figure 3b. Activate "Announcement" option**

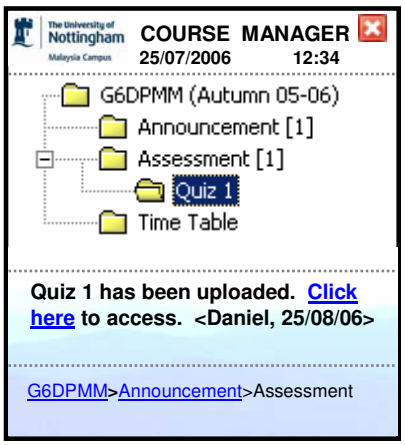


**Figure 3c. Activate "Assessment" option**

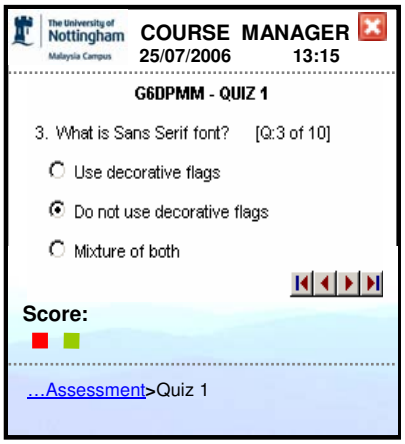


**Figure 3d. Activate "Quiz 1" sub-option**

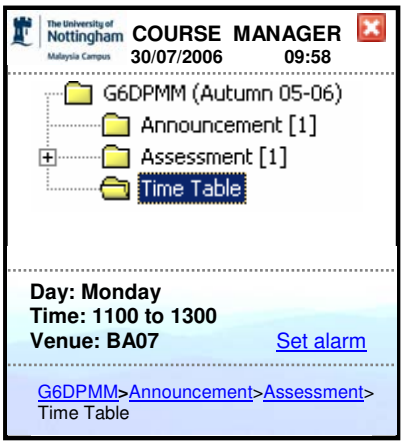


**Figure 3e. Display the time table of a module**

Instructors are freely to make any announcements via MLCM portal by submitting and sending it to the MobileServer which in turn transmitting the messages to the respective mobile learners. Every announcement comes with a format as follows: <Instructor Name, Date Posted> as shown in Figure 3b. This clarifies the mobile learners that they are accessing the up-to-date announcement. Quiz as a part of module's assessment (see Figure 3c) has been designed and embedded into the mobile learning portal which acts to supplement the exercises for the chapters covered. There are 3 option button designed for every question, and the total number of question in a quiz is displayed at the end of the question's title. The use of "green" and "red" colours indicates the "correct" and "wrong" answers attempted by the mobile learners. The use of "next", "previous", "first" and "last" navigation buttons are displayed in the "Quiz 1" in Figure 3d. The time table of a module is viewed by activating the option "Time Table" as typified in Figure 3e. The "Set alarm" option wishes to allow learners to adjust the time as a reminder, for instance 15 minutes before the class commences. In short, the functionalities of the option designed have been taken care by simplifying the task flow and reducing the complexities as possible in order to maximise the beauty of usability.

## 5. CONCLUSIONS

Technological changes and evolution significantly amplifies the demands on the quality and usable user interface and offer the potential to further enhance the task, structure and functionality of mobile devices. The rapidly increased number of mobile learning portals has urged the usability issues to be more transparent when designing the learning portals. This paper contributes ten usability guidelines which envelop user analysis, interaction and user interfaces categories. These usability guidelines empower the effort in creating highly usable and impressive user interface which promote the users' satisfaction and interactivity while learning via the mobile and handheld devices. In addition, the proposed usability guidelines intend to set as benchmark for interface designers to further evaluate the mobile user interfaces to conform to the attributes of usability when designing usable mobile learning portals. Additionally, MLCM has demonstrated and exemplified the use of usability guidelines proposed which aims to increase the users'

satisfaction especially dealing with the diversify and universal mobile learners who comes from different background, culture, race, educational level, learning cognitive and styles. The simplicity design and ease of use, consistency in navigation, structural metaphoric, and standardised iconic design have promote mobile users' cognitive and learning styles in accessing and comprehending MLCM to maximise their learning experiences and increase their learning curve indirectly.

## 6. FUTURE DIRECTIONS

This is a preliminary investigation into outlining the usability guidelines. Therefore, we suggest the following for future extensions:

- Examines the usability guidelines by conducting usability testing/evaluation to measure and quantify the theory of usability such as learnability, memorability, efficiency, effectiveness, and subjective satisfaction. The expected results and outcomes are used to prioritise the importance and plot the ranking of it.
- Further evaluation and experiment will be conducted to assess and determine whether the usability guidelines proposed are appropriate and met the basis of formal instructional design strategies, and the mobile curriculum development.
- Enhances the learning portals by extracting the lecture notes and other relevant digital documents, and transmit them to the respective mobile learners.

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