Mi-Learn: An evaluation of an m-learning management system

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Abstract. M-Learning is a novel concept concerned with delivering learning content over mobile devices, which today is being seen as a way to support for conventional and collaborative learning as well as for extending the scope of e-learning. This paper presents the work carried out on a research project named Mi-Learn, whose goal is that of gathering background knowledge within the field of m-learning, identification of related research problems, and creating an environment where solutions to these problems can be identified and evaluated. Pocket SCORM initiatives such as [ADL04] that are working towards a set of standards for m-learning have identified the restricted user interface and the requirement for offline learning sessions as the two major challenges in this area. The work presented in this paper forms part of the first phase of an m-learning research project and concentrates on the first of these challenges. By means of a pilot m-learning management system, an evaluation exercise was carried out in order to assess the impact of a restricted user interface on the learning experience. The evaluation carried out takes both the pedagogical and user interface aspects as the evaluation criteria. Evaluation results show that currently there seems to be a value for m-learning, but more as an extension for exiting e-learning programmes rather than a complete learning management system on its own. The results also helped in clarifying the research area and setting a direction for further research work

1 Background

The *Mi-Learn* project is a research project [BVP03] funded by the University of Malta with an overall objective of building a mobile learning infrastructure for the departments of Computer Science and Manufacturing Engineering at the University of Malta. This would allow students to use their mobile devices (mobile phones, personal digital assistants (PDAs), etc.) to follow courses (or part thereof) online. The project's goal is that of gathering background knowledge within the field of m-learning, identification of related research problems, and creating an environment where solutions to these problems can be identified and evaluated. This paper presents the results from the first phase of the project. In this phase a pilot m-learning environment was developed, with the

aim of analysing its potential value as well as the limitations that such a learning environment may provide.

1.1 M-Learning

A literature review was conducted on the following research areas: Mobile Devices, Mobile Learning Systems, EU Mobile learning projects and the adaptation of the Shareable Content Object Reference Model (SCORM) in m–learning. The main points emerging from this study are the following:

- *User interface adaptation* — Mobile device screens such as the ones found in PDAs to the ones found in smart phones are relatively much smaller compared to screens available in bulkier devices such as personal computers (PCs) and laptops. This reduced screen size in mobile devices creates limitations in creating mobile device user interfaces. Mobile presentation technologies such as the Wireless Markup Language (WML)[3] and later the Compact Hypertext Markup Language (cHTML)[4] address this limitation. User Interface restriction is one of the two main challenges presented in Pocket SCORM proposals such as [ADL04]. Pocket SCORM is a project attempting to adapt the SCORM standard to mobile devices.
- *Memory* — Whilst mobile devices are commonly associated with memory restrictions, the latest generations of mobile devices such as phone enabled PDAs are changing the situation mainly via SD chip technology.
- *Bandwidth* — Whilst bandwidth available for mobile devices has been known to be low and costly (e.g. over GPRS [BMV04]), extended WI-FI coverage [BVP03] [OdM03] and the increasing popularity of PDA devices [DMAM04] are improving the situation.
- *Asynchronous communication* — Bandwidth limitations are favouring asynchronous communication within the field of mobile devices, where due to lack of WI-FI coverage or GPRS costs, mobile device user sessions are carried out off-line with the device being required to be on-line only at the stages where application server synchronization is required. Asynchronous communication is the second main challenge identified by Pocket SCORM within the field of mobile learning.
- *M-Learning as a conventional learning support* — Mobile devices are being used as a support for conventional learning. An example of this is the slideshow exposure system proposed in [WFP05], where the integration of a presentation software, such as Microsoft© PowerPoint, with handheld devices for use in a teaching environment that allows users to selectively download and annotate parts of the slide show using mobile devices. A web application has been developed for use in a lecture theater or classroom environment that allows students to access content from a slide show during a presentation. The website content is extracted into a markup language,

[3] `http://www.wapforum.org`
[4] `http://www.w3.org/TR/1998/NOTE-compactHTML-19980209`

and an HTML version of a PowerPoint slide show is made available via a wireless access point (Figure 1). Another example of mobile devices assisting conventional learning can be found in the iSign [MFA04] project. The iSign project started as a web-based laboratory setting for students of electrical engineering. It has expanded into a heterogeneous learning environment offering learning material, adaptive user settings and access to a simulation tool that can be accessed via the web and also by wireless clients, such as PCs, PDAs and mobile phones (Figure 2).

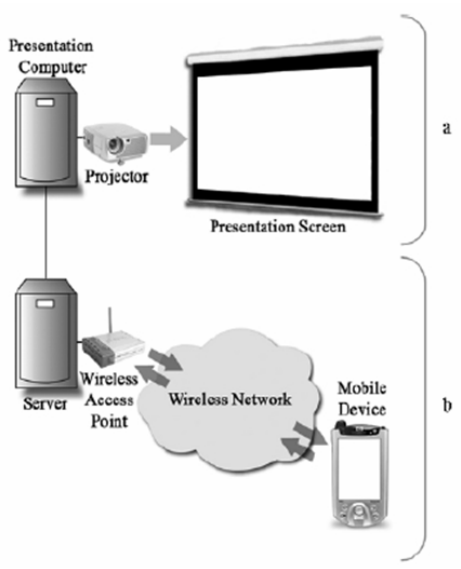

Fig. 1: Slideshow

M-Learning as a collaborative learning support — Mobile devices are also being used as a means of enhancing collaborative learning. One such example is mCLT [AMT04]. The mCLT system is a Java^{TM} Mobile Information Device Profile (MIDP) client for mobile telephones. It introduces an innovative mobile platform for computer-supported collaborative learning, based on 3rd Generation mobile telephones. Students can collect and share live data immediately, anywhere and anytime. This enables them to play an active role in the knowledge-building process.

M-Learning as an adaptation of e-learning systems for mobile devices — The most common m-learning applications could be found identified in this category. Learning Management Systems (LMSs) found in this category are primarily e-learning systems that are either adapted or extended to leverage the use of mobile phone devices. An application in this category is the Intelligent Web Teacher

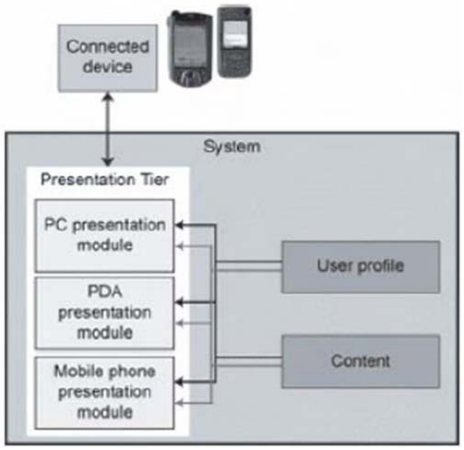

Fig. 2: iSign Modules [MFA04]

(IWT). This project is an extension of a state-of-the-art e-learning system — the Intelligent Web Teacher (IWT) — to support multimodal mobile access [CGMP04]. This work offers a complete set of learning experiences, services and models that are well suited for the complex mobile world. The extended platform offers customized e-learning experiences depending on the type and capabilities of the users' mobile device. Subsets of IWT functionalities can be accessed from HTML-enabled mobile devices, where the content and layout are automatically adapted by the IWT engine that recognizes the type of device used.

1.2 Research Direction

In the light of the literature review's main points, a research decision was taken in the direction of evaluating an m-learning experience *vis--vis* the user interface restrictions posed by mobile devices, as the primary task. This decision was made since this aspect could be considered as a fundamental one affecting all others. In fact, from the results derived from the evaluation of an m-learning experience, it would be possible to identify those learning tasks that could be feasible to carry out via mobile devices in order to extend existing e-learning systems, and those which would not be feasible. In addition, positive results from such an evaluation would give value to research carried out on the area of asynchronous communication in relation to m-learning. With this research direction taken, the deliverables of the first stage of the project were set as follows:

- An m-learning LMS allowing the evaluation of an m-learning experience in respect of a restricted user interface.
- Two sample m-learning courses on which the evaluation is based.
- The results of the evaluation, with a focus on which aspects of a learning experience are well suited for m-learning, and which do not.

2 Mi-Learn LMS — A mobile Learning Management System (LMS)

The Mi-Learn LMS is a pilot application built with the focus of enabling the evaluation of an m-learning experience and as such sophisticated features such as asynchronous communication or the automated adaptation of learning content for use with mobile device profiling was not included in this first phase of research. The LMS can be accessed by any mobile device having a cHTML client and supporting a GPRS or WI-FI connection. The Mi-Learn URL at the time of writing of this paper is http://milearn.cs.um.edu.mt. Figures 3, 4a and 5a display a sample set of screen shots from the mi-learn m-learning portal. Figure 3 shows the main page, figure 4a shows the course list screen, whilst figure 5a shows a sample course content screen. Figure 4b and 5b show the equivalent of the latter screens, in case no mobile device screen adaptation is performed. The difference in the screen layout where no adaptation is carried out can be clearly noted, whilst the other difference that cannot be shown here is the difference in the download time required.

Fig. 3: Mi-Learn portal

2.1 Architecture

Figure 6 shows the architecture of the mi-learn portal in UML Deployment Diagram notation [OMG04]. The main part of the architecture can be found within the Mi-Learn node. The components deployed on this node are:

- a web server (httpd);
- a PHP application server;
- an SQL database (MySQL); and
- the Mi-Learn LMS that compromises of a customized Moodle (*http://moodle.org*) component.
- A repository of SCORM compliant course contents and course images are also deployed on the Mi-Learn node.

The customizations carried out on the Moodle LMS were mainly concerned with compacting the user interface for restricted screen size presentation purposes. Although the cHTML versions of the pages are immediately adapted for mobile device viewing, some Moodle pages were considered to be too cluttered even after conversion to cHTML. The customization activities are as follows:
Removal of the breadcrumb menu from header.html residing in the chosen theme directory; Addition of the *Mi-Learn* logo in the header.html in the chosen theme directory; Addition of the Google© logo in the footer.html in the chosen theme directory; Update of the /course/player.php file in order to display the table of contents at the bottom of the page rather than at the top. Keeping the contents at the top can give rise to cumbersome user navigation due to cHTML page segmentation; Update of the /course/player.php file in order to add a further SCORM navigation bar at the bottom of content screens in order to enhance ease of navigation; Update of the /lib/weblib.php file in order to remove recurring login message; Update of the /login/index_form.html file in order to remove the recurring "Returning to website" and "New user?" header messages; Update of the /lang/en_utf8/moodle.php file by changing "Available courses" string to "Mobile courses" string; Removal of the recurring Moodle image form the print_footer() function in weblib.php; Removal of the recurring Moodle documents link from footer.html found in the chosen theme directory; Removal of the top horizontal break from header.html found in the chosen theme directory.

2.2 Learning Content

The learning content used for the evaluation sessions was adapted from two courses originally created for deployment on an e-learning LMS. The two courses are: Computer Integrated Manufacturing (CIM) and Linux Operating System Principles. Both courses feature the use of diverse media (text, images, sound, and video) and course components (content, assignments, assessment sessions, etc.). The process of adapting these courses for delivery to mobile devices itself resulted in the identification of the necessary adaptation requirements needed to convert an e-learning course content to an m-learning one. The m-learning

experience evaluation could highlight further adaptation requirements. The idea here is that a way for automating the course content adaptation to m-learning environments is researched.

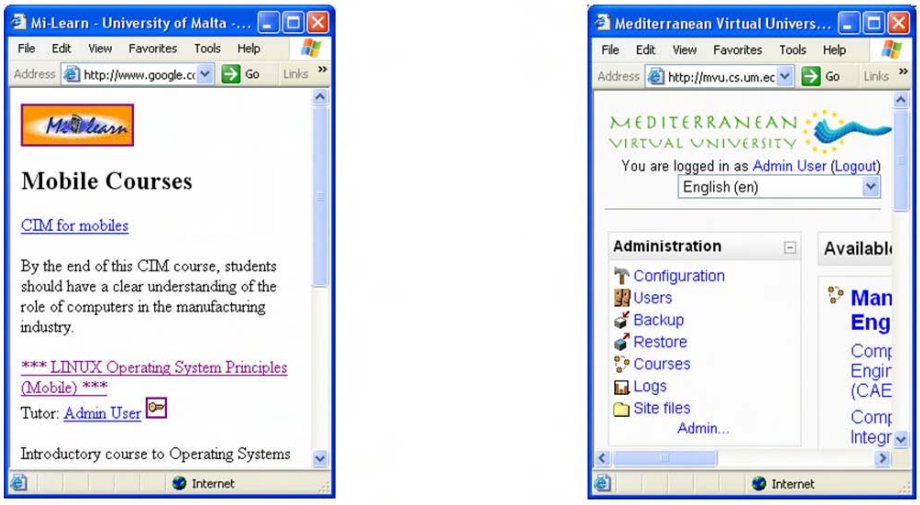

Fig. 4: (a) Mi-Learn course list, and (b) Course list (with no UI adaptation)

This way, course content would need only to be created once, and applied both in e-learning as well as m-learning environments. The main result of the adaptation process was found to be concerning with non-text media. Images and video could be too large in size to transfer, too cumbersome to view, or have detail lost, when viewed on small screens. Sound media could not be adequate in case when a mobile device is used in a quiet environment and no headphones are available. Flash[5] formatted presentations, a popular format for multimedia presentations are not supported as yet by mobile phone devices.
Some devices though do support the Flash-Lite format, which is a sub-set of the full flash format. Still, a flash presentation cannot be converted to Flash-Lite, but rather created from scratch specifically for the lite version. In all of these cases the solution was to have a text equivalent of all the non-text media utilized, in order not to deprive m-learning students from being able to follow certain course contents. A further necessary adaptation, purely from a technical point of view was that images embedded within a SCORM content package are no longer visible once the cHTML version is created by the Google proxy. This technical limitation requires that images forming part of a course content package are uploaded separately in an appropriate web server location. This in turn requires that SCORM HTML files no longer refer to these images as local course resources, but reference the appropriate images repository URL.

[5] `http://www.adobe.com/products/flash`

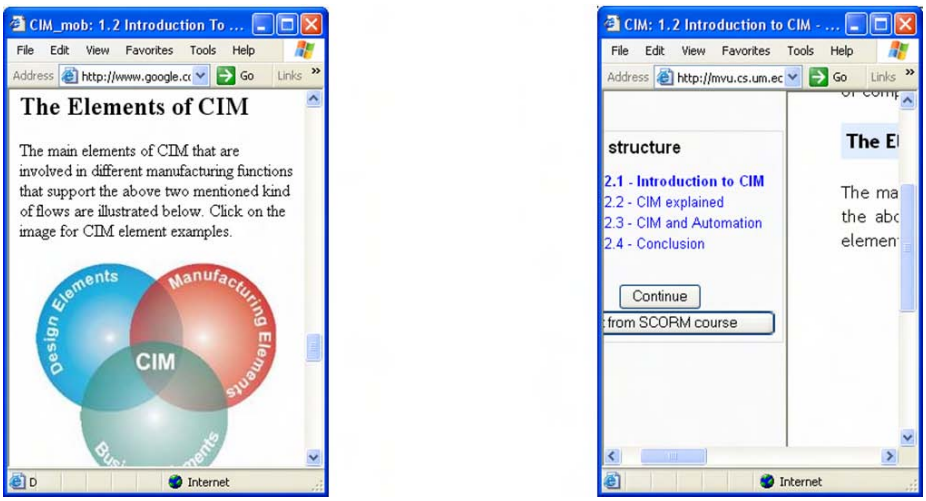

Fig. 5: (a) Mi-Learn course content, and (b) Course content (with no UI adaptation)

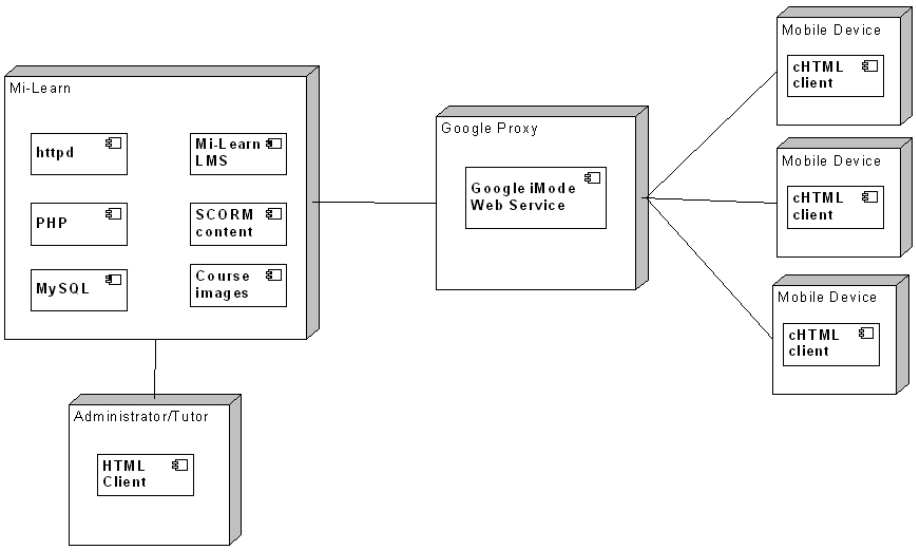

Fig. 6: Mi-Learn portal architecture in UML Deployment Diagram notation

2.3 Evaluation Procedure

The evaluation procedure consists of three parts:

- Virtual Learning Environment (VLE) evaluation;
- User Interface evaluation;
- Critical evaluation.

The VLE evaluation is concerned with evaluating the pedagogical aspects of the Mi-Learn portal and is based on the framework for Pedagogical Evaluation of eLearning Environments by Britain and Liber [BL04]. The User Interface evaluation is concerned specifically with the m-learning portal user interface in regards of the limited screen sized and is based on scientific research carried out by Jeffries *et al.* [JMWU91]. The critical evaluation exercise is concerned with the research process itself — critically appraising the research process so far and setting a research direction for the future.

3 Virtual Learning Environment (VLE) Evaluation

The VLE evaluation is concerned with evaluating the pedagogical aspects of the Mi-Learn portal and is based on the framework for Pedagogical Evaluation of eLearning Environments by Britain and Liber [BL04]. This evaluation framework provides a means by which the pedagogical process underlying VLEs can be reasoned about, and then how a particular VLE under test can be evaluated based on how the VLE encourages or less these pedagogical aspects. Although originally built with e-learning systems in mind, the framework can be utilized with any form of a Virtual Learning Environment due to the fact that it abstracts from the particular user interface being adopted. The framework is built upon two fundamental principles. The first principle is that of evaluating the incorporation of effective teaching and learning practice into a VLE. The second principle assesses the organizational aspect of the VLE, that influences whether the system will facilitate or less the ease with which a pedagogical can be used within that system.

3.1 VLE Evaluation Results

The VLE evaluation exercise was carried out by the research and development team, since an in-depth knowledge of the virtual learning system is required in order to carry out such an evaluation. Being mainly a customisation of Moodle, the starting point for evaluating Mi-Learn's virtual learning environment was the evaluation of Moodle carried out in [BL04]. The main differences between Moodle and Mi-Learn were identified and the evaluation carried out accordingly.

The Module Level — Overall results (Table 1)

Presentation and re-presentation of key concepts and ideas — Mi-Learn allows several tools for tutors and student to express teaching ideas and supplying feedback. These tools, as provided by the underlying Moodle infrastructure are: Resources (content), forums, journals, quizzes, assignments, surveys, chat and workshops. All of these tools are usable both by students and tutors except for resources, which can be used only by tutors. The VLE experience as seen by tutors is exactly the same as the one experience in Moodle, since tutors access Mi-Learn from the same identical Moodle portal. Students access Mi-Learn via the mobile device portal, still having access to the listed tools, but through the restricted mobile device portal.
Coordination of people, resources and activities — The model of teaching and learning interactions was retained as originally provided by Moodle. The system encourages modules to be laid out in a sequential order. A module outline is required. Learners can be organised in a whole group, separate subgroups, visible subgroups or individuals (group of one). Types of learning activities include: Connected discussions with optional peer evaluation, Reflective journals, Reading, Glossary/Encyclopaedia writing (Students can build up a glossary and any of those entries automatically link from any text throughout the system), Chatting, Peer-evaluated assignments and Quizzing.
Resource negotiation and agreement — The 'rules of the module' are expressed and made evident to the student in the same way as it is carried out in Moodle. Essentially this is left to the teacher to express, using the tools provided (e.g. setting an introductory activity containing the instructions to be followed throughout the particular course).
Monitoring and Learning — The facilities required to monitor the learning progress within the context of a module are available for tutors (activity reports and grade books) but not available directly for students. An integrated SMS gateway that sends assessment results to students having phone enabled mobile devices, would be a welcome addition.
Self organization amongst learners — Outside the purview of the teacher, learners are able to both upload files as well as to locate other people, as per Moodle. Student file upload is possible via forums and glossaries, but of course restricted by the capabilities of the mobile device in use. Locating people is possible via a people search allowing the localisation of any visible Mi-Learn user.
Adaptability of module and system — Like in Moodle, module structure can be adapted and assigned to particular groups of students.

The Student Level — Overall Results (Table 2) *Coordination of people and activities* — The concept of programme-level progression is not directly supported by Mi-Learn.
Resource negotiation and agreement — As per Moodle, Mi-Learn does not allow for the specification of programme rules for delivering a module nor does it permit or provide a space for negotiation between programme managers and module tutors on resource questions.

Table 1: Module level evaluation

Evaluation Point	Evaluation Value
Presentation and re-presentation of key concepts and ideas	*****
Coordination of people, resources and activities	*****
Resource negotiation and agreement	****-
Monitoring and Learning	**---
Self organization amongst learners	*----
Adaptability of module and system	*****

Monitoring of modules — The performance of a module can be monitored by the programme manager by means of logging as an administrator, an invisible teacher or an invisible guest. QA examination or peer observation of module activities is not included.
Self organization of teachers — As in Moodle, self-organization of teacher is possible by making a "course" for teachers (who attend as students), where they can coordinate and assist each other.
Adaptability of programme — At a content level, apart from the ability to import SCORM content, courses can be designed and developed. Courses can also be hidden from student allowing development to take place before being "made live". No direct support for validation is present.

Table 2: Student level evaluation results

Evaluation Point	Evaluation Value
Learner-centeredness	***--
Time management / planning	-----
Monitoring own learning	*----
Adaptation / reflection	*****-

The Programme Level — Overall Results (Table 3)

Coordination of people and activities — The concept of programme-level progression is not directly supported by Mi-Learn.
Resource negotiation and agreement — As per Moodle, Mi-Learn does not allow for the specification of programme rules for delivering a module nor does it permit or provide a space for negotiation between programme managers and module tutors on resource questions.

Monitoring of modules — The performance of a module can be monitored by the programme manager by means of logging as an administrator, an invisible teacher or an invisible guest. QA examination or peer observation of module activities is not included.
Self organization of teachers — As in Moodle, self-organization of teacher is possible by making a "course" for teachers (who attend as students), where they can coordinate and assist each other.
Adaptability of programme — At a content level, apart from the ability to import SCORM content, courses can be designed and developed. Courses can also be hidden from student allowing development to take place before being "made live". No direct support for validation is present.

Table 3: Programme level evaluation results

Evaluation Point	Evaluation Value
Coordination of people and activities	*****
Resource negotiation and agreement	*****
Monitoring of modules	*****
Self organization of teachers	****-
Adaptability of programme	****-

The VLE evaluation of Mi-Learn shows that in terms of a virtual learning environment, Mi-Learn is strong on the module level, but lacks both on the student and programme levels. The strong evaluation results on the module level are mainly due to the amount of learning activities than can be deployed and adapted in the learning environment, as well as the way in which learners enrolled in a module can be grouped. Yet, self-monitoring and organization were found to be very limited in this respect. Although the individuality of students is given prominence throughout the m-learning system, Mi-Learn was found to be weakest in respect of the student level. This result is mainly given due to the lack of Personal Development Planning (PDP), time management tools, and the inability of monitoring one's progress. The evaluation results for the programme level aspects of Mi-Learn are only average. Whilst showing a strong implementation of course design, tutor co-ordination and overall module progress monitoring, the concept of a programme of courses is missing.

4 User Interface (UI) Evaluation

The User Interface (UI) evaluation is concerned specifically with the m-learning portal user interface in regards of the limited screen sized and is based on scientific research carried out by Jeffries et al. [JMWU91]. This first phase of the research concentrated on the point that was considered to be the most crucial in

moving from an e-learning to an m-learning environment — the restricted user interface. In [JMWU91] four user interface evaluation techniques are presented and compared, these being: Heuristic Evaluation, Usability Testing, Guidelines and Cognitive Walkthroughs. In Heuristic Evaluation, UI specialists study the interface in depth and look for properties that they know, from experience, will lead to usability problems. In Usability Testing, the interface is studied under real-world or controlled conditions, with evaluators gathering data on problems that arise during its use. The Guidelines technique involves in the publishing of user interface qualities to be observed by developers during development of interfaces. In Cognitive Walkthrough the developers of an interface walk through the interface in the context of core tasks a typical user would need to accomplish, with the actions and feedback of the interface being compare with the user's goals, with any discrepancies arising being noted. According to the comparison study carried out in [JMWU91], the Heuristic Evaluation and Usability Testing guarantee the best results mainly due to the best rate identifies in identifying serious and recurring problems. In this case the choice was made for the Usability Testing approach for the reason of being able to get first hand feedback from potential users of such a system — in this case the students themselves.

4.1 UI Evaluation Results

Table 4: User Interface evaluation results

User Interface Issue	Reports
Textual presentation focus	48%
Continuous navigation required	30%
Low quality technical images	13%
Cumbersome collaboration tools	9%

The usability testing exercise for the Mi-Learn LMS was carried out by a sample of potential end users at the Computer Science and Manufacturing Engineering Departments. Two full courses were setup on Mi-Learn, and students asked to complete one of these, whilst in the meantime pointing out all those issues that in their view undermined the overall learning experience. Table 4 shows the overall UI evaluation results. All the reported issues could be grouped in one of the following four m-learning related UI issue categories:

- Textual presentation focus (48%)
- Continuous navigation required (30%);
- Low quality technical images (13%);
- Cumbersome collaboration tools (9%).

The problems within the 'textual presentation focus' category are concerned with the fact that there is too much textual content in courses, all of which is unjustified. Also related to the issue is the lack of animation in the learning content. Long sections of text make the learning content less interesting, and also difficult to follow on a small screen. Due to cHTML limitations, text justification is not as yet possible, as well the use of varied fonts is limited, making it even harder on the learner to read the text. The lack of animations make course content less interesting. The reported problems within the 'continuous navigation' category are concerned with the facts that learning on a small screen is strenuous and hinders learning experience and the continuous clicking and scrolling through learning content hinder learning experience. Essentially a full course is too bulky to follow on a mobile device screen and it becomes tiresome after a while. Being able to see only a small portion of the screen makes learners feel lost at times and hinders learning. The low quality of technical images stems from the fact that when images are resized to fit mobile device screens and to make them more lightweight for client download, these lose the quality that certain technical images require. The 'cumbersome collaboration tools' is concerned with the use of forums and email to collaborate with tutors and fellow students. Essentially, in several instances the text written in these messages is rather lengthy and detailed. Carrying this out using a mobile device was found to be quite cumbersome. Analysing the overall UI evaluation results, the main deterrent for a learning experience over mobile devices seems to be that of low quality of the presented medium concerning the emphasis on textual presentation and the continuous navigation required due to restricted screen size. These account to nearly 80% of all reported issues.

5 Conclusions and Future Work

Taking the Mi-Learn LMS as a pilot evaluation environment for course delivery within an m-learning environment, one may conclude the following points, both from a pedagogical and user interface aspects. From a pedagogical point of view m-learning seems to be strong in content delivery but weak in creating the supporting environment in which this content is delivered. As shown by the evaluation, this supporting infrastructure consists of tools for helping student achieve overall academic objectives, and tools for helping a teaching institution to organize and monitor a programme of courses. This result hints that m-learning could be a strong addition to an existing e-learning environment, in delivering the additional comfort provided by the use of mobile devices, but difficult to offer a VLE of complete pedagogical quality, on its own. The UI evaluation results back the argument that m-learning would be best suited to complement e-learning (e.g. follow parts of a course whilst on the move, carrying out revisions and quick self-assessment tests etc.) Although from the pedagogical evaluation it resulted that m-learning is strong in content delivery, UI evaluation results show that even though the content is there, this is of lower quality than expected and strenuous to follow for a long periods of time. Content quality in

turn, heavily relies on the technology advances in the mobile device field, both on the transport field (increase in bandwidth) and the content level (the availability of lightweight graphics and animation formats).
Being the first phase of this research project, the main achievement was that of subject immersion and the setting a direction for the rest of the research project. The following is a list of candidate tasks to be carried out during the next phase. Inclusion of asynchronous communication between the LMS and the mobile clients in order to evaluate the additional value this may give to an M-Learning LMS, as per Pocket SCORM proposition; Analysing the possibilities of proposing an e-learning to m-learning content converter, that automates the conversion of existing e-learning content and adapting it for display on a cHTML client; Enhancement of the Mi-Learn LMS with an integrated SMS gateway that enables the delivery of progress reports and assessment results to phone enabled mobile devices; Refine both VLE and UI evaluations in order to make them sensitive to the type of mobile devices being used and investigating whether certain mobile devices are more adequate than others for following an m-learning course; An investigation of what are the m-learning specific strong points in respect to e-learning, and as a consequence analysing the best way that m-learning may complement e-learning.

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