DEVICES AND TECHNOLOGIES FOR MOBILE LEARNING

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INTRODUCTION

The choice of devices and technologies for mobile learning will depend on the definition of mobile learning adopted.

In this presentation mobile learning is defined as 'the provision of education and training on mobile devices: Personal Digital Assistants (PDAs), palmtops and handhelds and on smartphones and mobile phones'.

This definition reflects the tension in the field of mobile learning between functionality and mobility. The devices available may be assembled on a continuum running from the most functional to the most mobile. Because the focus in mobile learning is on mobility this presentation limits the range of mobile learning limits the range of the field to the devices listed, to the exclusion of laptop computers.

There are five dimensions to this presentation:

- Definition of devices to be used
- Definition of technologies to be used
- Development of tools and environments to be used
- The search for a wireless Learning Management System (mLMS) that is the changes that are needed to an LMS to 'mobilise' it
- Listing of courses to be developed.

DEFINITION OF DEVICES TO BE USED

What do we want?

When we look at how our students and teachers are working today, we find good readability to be of great importance. The materials that we offer online as well as answers to assignments and the assignments themselves, are quite extensive and demand a readable screen. The size is also an issue, but we must also take ease of mobility into consideration. If the screen is to be large, the device will inevitability have to be bigger.

The hypothetically perfect device would be small and fit easily into one's pocket. The screen should fold out to A4 paper size and have paper readability. Wireless connectivity should be of high speed, the user should be always online with the possibility to switch seamlessly between wireless zones and phone networks. The device should have an integrated phone and support all the major office formats for reading and writing as well as pdf format. Security should be high, and if the device is lost the data should be made useless with no risk to the owner. The perfect device should render standard web pages perfectly and offer the ability to strip out advertisements etc. and display useful content only. The web pages should be readable offline as well as online. This should facilitate an understandable on-the-fly text-to-voice and voice-to-text feature.

We believe the above would be a close to perfect device, but since a device satisfying these specifications is not presently on the market and will not be within the foreseeable future we need to restrict what we want and tend to what we need.

The following list describes a close-to-perfect handheld device:

- Always online connectivity
- Bluetooth for connection with other devices
- Built-in video cannon for displaying presentations etc.
- Camera for documentation in the field
- Flash support
- Full size keyboard available
- Full WI-FI connectivity
- Large storage capacity (Large is a relative term changing with time)
- Screen of acceptable size and readability
- Large battery capacity
- Messaging client for peer-to-peer communication
- Non-volatile memory for backup
- Phone ability
- Read Adobe Acrobat documents
- Read/write common office formats
- Scanner and printer built in
- Small compact device
- Support multimedia content as well as flash, java and java script etc.
- Synchronize and check e-mail with common mail clients.
- Text-to-voice screen reader and Dictaphone
- … This list could go on forever

What do we need and why?

Our main focus would be on the students' and teachers' needs. These are summed up as; a readable screen, the ability to read courses online as well as offline and be able to communicate with other students and teachers from wherever they are. A Personal Digital Assistant (PDA) with communication possibilities can serve these needs. Students and teachers will have easier access to online services and give the teacher the possibility to answer questions while away from his/her personal computer. We wish to allow our students to be able to study on their own when and where they want to.

Recommended requirements for our device:

- Always online connectivity to facilitate synchronous communication and possibly generate quicker response from teachers on e-mail
- Bluetooth for connection with other devices
- Near to full size keyboard to write papers and answer assignments
- Long lasting battery
- Memory: 64MB RAM + some (32MB?) ROM for non-volatile memory to have enough space for multimedia content and backup of important documents
- Messaging client for peer-to-peer communication (GPRS would enhance this functionality by being always-online compared to logging on by WLAN or dial-up)
- Read Adobe Acrobat documents
- Read/write Microsoft office Word, Excel, PowerPoint
- Readable screen of good quality
- Small and compact device that fit into our pocket
- Support multimedia content as well as flash, java and java script etc.
- Synchronize and check email with Microsoft mail clients.
- WI-FI connectivity

The Devices Chosen for Proof-of-Concept (PDAs)

Based on the list of what we consider to be needed for a good test of the always-online environment, we have chosen to tryout the HP Ipaq with WLAN capability. For testing we will apply both new PDAs with integrated WLAN and the devices used in the previous EU Leonardo m-Learning project. The older versions of PDAs are equipped with a jacket that enables the use of a WLAN CF-Card. We will use a HP Ipaq SilverSlider CF jacket with a WLAN Compact Flash Card. This enables WLAN on the PDAs and will together with a Wireless Cable/DSL Gateway with a DSL connection simulate the always-online environment in the homes of the students who will test the courses and features of the PDA.

Definition of devices to be used (smartphones and mobile phones)

The intention of mobile learning is to utilise the capabilities of existing GSM, GPRS and UMTS mobile telephone handsets and PDAs to increase access to training courses.

Phase 1 of the project proposes to develop and trial mobile learning courses for current mobile telephone handsets. Newer 3G (UMTS) devices on the market at phase 2 of the project will be trialled when readily available.

Specifically, the devices chosen for phase 1 are the SonyEricsson P900 and the SonyEricsson T610.

P900 Specifications

The Sony Ericsson P900 is a triple band mobile phone, an MP3 audio and MPEG4 video player, an advanced handheld device and a mobile video and digital camera. The phone has e-mail access to a network of contacts. The calendar can be updated. The P900 supports a range of messaging types which will be used to monitor progress and test students. Pictures can be taken with the P900 built-in camera which allows pictures to be received and sent. Text input is facilitated by an on-screen keyboard and a large touchscreen.

Some of the more relevant P900 features are listed below.

- 208x320 pixel display
- Colour LCD 65,536
- MMS (Multimedia Messaging)
- MMS Video
- Video player
- Video streaming
- MP3 Audio
- MPEG4 Video
- Email
- Java
- SMS long (Text Messaging)
- WAP 2.0
- WTLS
- CHTML

T610

The T610 is a sophisticated camera phone. It has a quality 65536 color display. It does not, however have as large a screen size as the P900. Extensive picture sharing options and the latest messaging functionality is available. The T610 supports Java™ download of mobile applications.

Some of the more relevant T610 features are listed below.

- Color Display (65536 colors)
- 128x160 pixels display
- e-mail
- GPRS
- Java applications
- Multimedia messaging (MMS)
- WAP 2.0

Further uses

Our target groups are IT auditors and our regular students. The first group is able to purchase the latest devices whether PDA-s or smart-phones which regular students may not always afford. For this latter group mobile phones are more familiar devices than handhelds.

Our assumption is that the common devices suitable for both groups are smartphones. These are not wide-spread today, however, the dynamic development of the market allows us to forecast their spread in the near future. Considering the advance of technology, we chose one of the multi-purpose devices with the most advanced features available today, the Sony Ericsson P900. The functionality of this device is near to the PDAs, the screen size is almost the same and it has Internet-connectivity in contrast to a regular PDA.

Didactic and evaluation use

This development of mobile learning will focus on the Sony Ericsson P900 (smartphone) and the Sony Ericsson T610 (mobile phone).

These devices will be used for two purposes:

- Didactic analysis

- Project evaluation.

For didactic analysis the devices will be used to access and analyse all course materials developed in the project. The analysis will focus on the student userfriendliness of the learning materials developed and feedback will be provided to the course developers on:

- Pedagogical issues

- Screen layouts

- Sequencing of content

- Questioning techniques: SAQs, TMAs, CMAs
- Feedback to the student
- Student to student communication
- Student to tutor communication.

Further analysis will focus on the status of the course materials developed. This is regarded as vital if mobile learning is ever to take off as a viable sector of training provision.

The devices will be used to evaluate the products of the project from four perspectives:

- Student userfriendliness
- Didactic efficiency
- Technical feasibility
- Cost effectiveness.

When assessing these criteria for success the evaluation will take into account the objectives of the Leonardo da Vinci programme, the details of the project proposal, and the needs of mobile learning as a sector of education and training provision.

DEFINITION OF TECHNOLOGIES TO BE USED

How to design for handheld devices?

We will design and develop technology that enables a device independent system. The chosen technology should be well adapted and commonly accepted. Hyper Text Mark-up Language (html) is such a standard and is already used in the NKI Learning Management System (LMS), SESAM. To specify the look and feel of our pages we already use XSL Transformations (xslt) on the server to output the html based on data from Extensible Markup Language (xml) and look and feel from Extensible Stylesheet Language (xsl). We also use Cascading Style Sheets (css) for layout and design. We are also looking into the newer version of Cascading Style Sheets, called css2. The benefit of css2 by the use of @media types gives more control of output to the client. This will give all our courses better readability on small screens.

There is a media-type designed for print that could give us an improved printer-friendly version of our pages and better layout for small screens. When we implement changes on the server-side we know it will benefit all our clients, the only drawback at the moment is the minimal support for css2 by current browsers but support for css2 will certainly increase during the project's lifespan. CSS2 is a World Wide Web Consortium (W3C) standard and they are already working on developing the next generation of CSS.

There are several issues defining the usability of a web page, one of these being download time. This is a crucial issue and should be a concern for every type of web page, whether it is meant for reading online using a traditional screen or a PDA (or smart phone). The limited bandwidth on a mobile network is clearly an issue, but the technology is rapidly advancing. Good and efficient coding will result in better utilization of bandwidth and processing power and the use of css will reduce the amount of mark-up needed for defining look and feel.

Another issue is the use of pictures, illustrations and graphics in courses. Most of the pictures and illustrations used on web pages for educational purposes are there for a defined reason, not only for navigation and a showing pretty pages. This gives us a challenge. How do we display an illustration of a certain size that is needed for the student to understand the learning materials and reach learning objectives? If we keep the size of the picture, the download time will be an issue, but so will screen real estate. The screen is most of the time limited to 3.8 inches for PDAs and even less for smart phones. We feel that to read and work through an extensive amount of learning materials a screen smaller than the PDA is unacceptable. This was also demonstrated in the first m-learning project. For smaller courses and on-demand learning or information collection, it could perhaps be acceptable, but not preferable. Some people also turn off images in their browsers and they should get a good description in text format, at least an idea of what they are missing, alt-text is a tag used for this.

There are some PDAs that have larger screens and some web browsers can use the screen in landscape modus (ThunderHawk) which gives a better feel of the page, ThunderHawk also uses all of the screen real estate for content which further enhances the browsing experience.

Evaluation of use of technologies

All the technologies, standards and specifications used in the project will be evaluated on the four criteria listed above:

- Student userfriendliness
- Didactic efficiency
- Technical feasibility

- Cost effectiveness.

The focus throughout will be pedagogical - the contribution of the technologies, standards and specifications used to the creation of a learning environment which will contribute to successful learning for the student. The rules for the creation of successful learning environments for distance education are well known by now, and will be applied to the products of the project.

Cost effectiveness is another major factor. Mobile learning will never take off if the systems designed are not cost-effective for the student/user and in development time, access time, costs for data and voice transmission - all are required to be controlled by the project.

Technical feasibility, especially from the point of view of the student/user is another important criterion for the success of mobile learning.

Student userfriendliness is vital - from the first mlearning project there is plenty of evidence, both from students and partners questioning the userfriendliness of studying from smartphone and mobile phone screens.

Recommendations by course authors

Course authors are mainly concerned with all aspects related to the course content and a few layout issues like that text explaining a figure has to appear on the same page as the figure itself. Most of them are familiar with only one editor. Authors do not want to spend time with the preparation of their courses for other devices or technologies than the one that the courses were originally created for, but leave this task for technical administrators. The latter prefer simple ‘save-as’ buttons in their automatic conversion software. But all these simple automatic conversion procedures bear the danger of turning a course that is well designed and functional on the one and only platform it was developed for into an unperceivable and useless piece of work on another platform. This is why standards play such a big role in elearning: using widely supported document formats is the only way to reduce the testing work to a reasonable amount.

The two most frequently used platform-independent electronic formats in which documents are presented to recipients nowadays are HTML and PDF (no matter how they are actually stored). For both of them a large amount of authoring and viewing software is available on all PC OS platforms. It is beyond the scope of this project to research into authoring complete courses on handheld devices, but adding personal comments, e.g. texts or sketches, to a document and exchanging these personal comments with others will be subject of the project. The PDF format is often favoured by authors as it supports some kind of DRM: the author can decide what the recipient is allowed to do with the delivered document, i.e. shall it be possible or not to extract text, figures etc., to change the

text, to print the document and so on. On the other hand, it is impossible to add interactive (at least theoretically) elements like JAVA-applets to PDF documents. On the other hand, only the PDF format is prepared for allowing the recipient to add bookmarks, textual remarks and even freehand sketches to the document without any knowledge about the internal document structure; this functionality is provided by the PDF viewer software. Both HTML and PDF documents support some kind of simple question and answer techniques using predefined active form elements.

For both the HTML and the PDF format in their current standards there are means of producing a sophisticated and smart design on PC-monitors and print-outs. Whereas layout is highly integrated in the PDF format, it is added to the mainly structural HTML format by CSS. And exactly from this point on the display device really matters for the HTML format. But why is this? Because early handheld devices had about the same capabilities as PCs some years ago, the manufactures, e.g. Microsoft and Opera, simply based their HTML-viewing software, commonly called browsers, for use on handheld devices on the code of their middle-aged browser versions for PCs. And these versions do not know much of CSS1 and nothing of CSS2. Therefore, it is a subject of the project to analyse which layout features are likely to be correctly displayed on handheld devices and which are not.

Neglecting the active form elements, both HTML and PDF are ‘passive’ document formats, i.e. they were developed to display static information. But from a didactical point of view, involving the recipients by forcing them to interact with the matter presented is likely to increase the learning outcome substantially. The term ‘to interact’ means that a recipient can influence the course of a process embedded in the document; this kind of interactivity, e.g. in the creation of flow or class structure charts in information processing, is often realised by JAVA-applets as well as by interactive FLASH- or SHOCKWAVE animations. Another way frequently used to enhance static documents is using non-static pieces of information like videos and/or sounds, this is often called using multi-media.

It is assumed that courses are developed for use on PCs (including notebooks) and that nearly all course parts should be accessible from two additional device types, i.e. PDAs and Smartphones. It can be stated that the most frequent PDA OSs are PALM OS and MS-Windows PocketPC/Mobile. The smartphone OS market is dominated by SYMBIAN OS, followed by MS-Windows Mobile. Each of these three different major operation systems co-exists in several similar versions in the set of devices in current use.

Concluding, from an author’s point of view this project is going

1) to analyse

- to which extent documents in CSS1-, JAVA-, FLASH-, SHOCKWAVE- and multi-media enhanced HTML as well as in PDF delivery format can be used on handheld devices without any modifications,
- which are proper modifications and transformations when a feature is not available on any of the handheld devices,
- which features cannot or should not be transferred to handheld devices at all.

2) to use
- the introductory course on descriptive statistics as a testing ground for topic 1, which explicitly means to answer the following questions:
  i) which efforts are necessary to produce a smart layout of static course content for the three different media PC screens, PDA/smartphone displays, and print-outs on paper,
  ii) for which interactive media which efforts are necessary to produce a smart representation on the different kinds of handheld devices,
  iii) which efforts are necessary to display multi-media encoded pieces of information on the different kinds of handheld devices, including mobile phones,
- the bachelor of science course on object-oriented programming by as real-world application for topic 1.

DEFINITION OF TECHNOLOGIES, STANDARDS AND SPECIFICATIONS

One of the critical underlying tenets of the 'mlearning – the next generation of learning' project is the promotion of strict conformance with industry standards and specifications as produced by the mobile telephony industry. The leader in the development and promotion of these standards is the Open Mobile Alliance (OMA) (http://www.openmobilealliance.org/).

Ericsson is a key member of this alliance. In the production of standards and specifications the OMA works in tandem with other significant groups of which Ericsson is also a member:
- WorldWide Web Consortium [W3C] – for its Internet content specifications and architectures
- Internet Engineering Task Force [IETF] – for its Internet technologies where appropriate to OMA
- ETSI, 3GPP, 3GPP2, etc – for their work in enabling applications in mobile handsets,
- RIAA, IFPI - for their work in the recording industry

It is the intention of this project to work within the standards and specifications as approved by the OMA and the other relevant bodies as listed above.
OMA was formed in June 2002 by nearly 200 companies including the world's leading mobile operators, device and network suppliers (including Ericsson), information technology companies and content and service providers. The fact

that the whole value chain is represented in OMA marks a change in the way specifications for mobile services are done.

Rather than keeping the traditional approach of organizing activities around "technology silos", with different standards and specifications bodies representing different mobile technologies, working independently, OMA is aiming to consolidate into one organization all specification activities in the service enabler space.

This philosophy is in keeping with a major aim of this mlearning project as it is not intended to develop any proprietary standards or specifications during the lifecyle of the project. Instead it is intended to use and apply the industry standards as specified by the OMA to mobile learning scenarios. This has huge potential for the success of the project as it means that once common industry standards and specification are used in the development and supply of mlearning courseware then the emphasis of the work of the partners can be on the production and testing of mlearning scenarios rather than on the development and testing of standards for educationally focused mobile content.

There is one possible exception to this and that is the integration of mlearning content and the administration and delivery of this content with Learning Management Systems. This is a set of standards and specifications that are not covered by the work of the OMA. However it is envisaged that adherence to current elearning standards in the production of mlearning courseware (as specified in SCORM type models by the work of organisations such as IMS Global Learning Consortium, Ariadne etc) and the supply of this courseware using industry standards for mobile devices (as specified by OMA) will result in efficient of production and supply of mlearning courses.

Principles of the Open Mobile Alliance

This section looks at the principles of the Open Mobile alliance as they affect this mlearning project. The principles encourage competition through innovation and differentiation, while ensuring the interoperability of new and existing mobile services across the entire value chain. As you can imagine, this philosophy has major ramifications for the work of the mlearning project as adherence to OMA approved standards will result in access to the products of this project via any mobile device or system that in turn adheres to the standards of the OMA.

The principles of the OMA are stated as follows:

- Products and services are based on open, global standards, protocols and interfaces and are not locked to proprietary technologies

- The applications layer is bearer agnostic (examples: GSM, GPRS, EDGE, CDMA, UMTS)

- The architecture framework and service enablers are independent of Operating Systems (OS)

- Applications and platforms are interoperable, providing seamless geographic and inter-generational roaming.

The OMA is organized into a number of Working Groups and there are a number of these groups that this project will reference quite closely. The first of these is the Browsing and Content Working Group as this group will define the key specifications that this project will use in content production. The work of a second group, the Messaging Working Group, is also of great importance to the work of this project as this group will define key issues to do with Multimedia Messaging and Instant Messaging which are two key technologies that will be utilized in mlearning scenarios.

Browsing and Content Working Group

BAC is specifically chartered to be responsible for base content types, including the semantics and such user agents, behaviour and programming interfaces as is necessary to use such content types, render them and interact with the browser user agent, with the intention of enabling the creation and use of data services on mobile hand held devices, including mobile telephones, pagers and PDAs.

BAC's scope currently includes the following areas :

- Content types - definition of base content types (syntax and semantics) within OMA, e.g. XHTMLMP, ESMP, WCSS, WML, WMLScript, SMIL, pictograms, download descriptor, Rights expression languages, etc.,

- Rendering – the interpretation and presentation of content,

- Browsing – the processing models and associated behaviour when rendering content in the context of the browser, including the use of the session protocols, and its extensions, e.g. EFI,

- Related HTTP technologies e.g. PUSH, URI schemes, HTTP caching and state management, Download, content optimisation and profiles (WBXML and UAPROF),

- Standard Transcoding interface

- User agents - semantics and processing models to ensure a consistent programming models, e.g. DRM, Download, etc

Messaging Working Group

The OMA Messaging Working Group is responsible for the specification of messaging and related enabling technologies. The goal of Messaging Working Group is to specify a set of basic messaging features that may be used to enable specific messaging paradigms.

Messaging Working Group is also expected to provide clarity of methods by which the messaging enablers are used as a medium for the interaction with different mobile applications.

The scope of Messaging Working Group is the specification of messaging protocols and features for the Open Mobile Alliance as a whole, dependent on work that may be carried out by other workgroups and other organizations. This involves:

- Creation of new specifications including detailed architecture (in conjunction with the OMA Architecture Group), definition of basic messaging features, definition of messaging protocols

- Ensuring interoperability for the messaging enablers

- Ongoing work in Multi Media Messaging

- Ongoing work in Instant Messaging

- Interworking between different messaging services and OMA messaging protocols

The work of both of these working groups will be monitored through the lifecycle of this project to ensure industry standard specifications and technologies are utilized. This will ensure that the end products are available to as large a catchment group as possible.

DEVELOPMENT OF TOOLS AND ENVIRONMENTS TO BE USED

Technology

There are some different technologies we need to examine when we are considering the mobile environment. Some handheld devices may have support for Java and common plug-ins like flash or pdf, but they can rarely display web pages and Java or Flash simultaneously. Pages based purely on plug-ins can therefore be used as supplements in the course, for instance in assignments.

The carrier and bandwidth considerations

4G

- On the drawing board
- 4G will blur the distinction between mobile phone operator and ISP. It will blur the already diminishing distinction between fixed line provider (and their broadband ADSL niche) and mobile provider. Indeed, why should Internet backbone providers use their own networks to carry data when they could use a 4G network?
- A 4G network could use CAT Telecom's IPv6 network to carry IP-based voice instead of laying down their own fibre-optic cable.
- Indeed, with 4G the hardware technology will become less and less relevant. With speeds approaching 100Mbps, why bother with Wi-Fi? Why use Bluetooth?

3G

- 3G is also known as the International Mobile Telecommunications-2000 standard. The ITU defines a 3G network as a data-optimised one which can support a minimum of 144kbps in mobile situations and 2Mbps in fixed (i.e. office or hotspot) installations, in other words, enough for smooth, real-time video
- EDGE (Enhanced Data for GSM Evolution)
- Implemented some places, not widely
- EDGE is an enhancement to the GSM mobile cellular phone system. The name EDGE stands for Enhanced Data for GSM Evolution and it enables data to be sent over a GSM TDMA system at speeds up to 384 kbps. In some instances EDGE systems may also be known as EGPRS, or Enhanced General Packet Radio Service systems.
- 2.5G system
- (http://www.radio-electronics.com/info/cellulartelecomms/edgeinfo/edge.htm)

2G -2.5G (GSM/GPRS)

- Standard of today
- Technologies such as GPRS (effectively, an interim upgrade of the existing GSM infrastructure) and even CDMA 2000 1x fall short of the ITU definition.

Client-sided

- Browsers
  - NetFront v3.0 for Pocket PC
    - Supports Pocket PC
    - Symbian
    - Linux
  - Opera for small screens
  - Pocket Internet Explorer
  - ThunderHawk

- CSS/CSS2
  - Supported or not?

- Javascript
  - Supported or not?

- Flash
  - Is supported with flash version 6.0 as a plug-in for Pocket Internet Explorer

Server-sided

- Xslt (xml + xsl with css)
  - By having the presentation in xsl + css we can utilize different stylesheets on the data to give the users a look and feel based on the client accessing our site. We could use one xsl with different css' for the devices by the use of media types. We could also use different stylesheets (xsl) for each type of client accessing or we could use a combination, which is most likely to be done.

- Push
  - Is used when the server pushes information to the clients. This could be a great way of keeping in touch with contacts by the use of the always-online environment. This is also a way of giving important information to the students, such as their grades, responses to their assignments, forum etc.

- Pull

  This is the traditional way of the web. The client actively selects which information it should download, for instance by clicking a link.

Recommendations by tutors

In Germany, tutors working at universities are usually members of the academic staff and thus subject to all advantages and disadvantages related to working as a civil employee or civil servant. As far as a fast reaction of a tutor to a student's question is concerned, one main disadvantage is the level of inflexibility of the covenanted working hours. Distance universities, in particular, often advertise their study offers by explicitly emphasising that the students are not treated as pupils but can freely decide on when to study during a day or a week. For working people this may be a chance to be educated further, but then they obviously have to work late in the evenings or during the weekends when the tutor is unlikely to be in the office.

Thus, if they publish a possibly urgent question during their studies it is totally left to a tutors personal level of dedication to the tutoring work whether this question is answered shortly after it has been published, which will be appreciated by the student and which also is the only acceptable scenario from an educator's point of view, or whether the answer is delayed until the next office hour, which possibly leads to a severe interruption of the student's learning process and is thus totally unacceptable from both a student's and an educator's point of view.

Thus the invention of handheld devices with outstanding communication capabilities has been celebrated as birth of the saviour who will make all tutoring problems disappear. But in the early euphoria there was neglect of the fact that the widespread use of email in elearning has revealed the real bottleneck in the communication between tutors and students: the limited total amount of time a tutor can spend for tutoring.

Additionally, a very interesting psychological effect has been observed which makes the situation even worse: because sending an email is much easier and cheaper than sending a letter or making a phone call, elearning students have been tented to send an email before and not after they had started to think hard about a problem.

Additionally, German universities experienced both a decrease in the number of staff people available for tutoring services and an increase in the number of students during the last decades, which has led to student to tutor ratios of at best 10 and at worst 500, depending mainly on the subject of study. And because tutors are human beings and not question answering machines, in the subjects with the highest student to tutor ratios often a complete breakdown of the tutoring systems has been observed.

The most sustainable concept to improve the situation has been to distribute the tutoring workload on the shoulders of other students, too, by the invention of news fora and FAQ lists, e.g., and by establishing a binding and hierarchically organised set of rules for the student to tutor communication like 1.) search the FAQs, 2.) search archived fora posts, 3.) select an appropriate forum and write a post and only if all this failed to give an answer than 4.) contact the tutor via

email. Obviously, these rules should not be referred to as ‘good practises’ but as a ‘tutor survival handbook’.

When adding communication via handheld devices to elearning, the old errors have to be avoided, i.e., it does not make sense to advertise tutor phone calls or SMSs, e.g. Instead, to preserve an efficient communication structure between students and the tutor, the rules that have been established in many years of conventional e-learning communication should be obeyed in the m-learning scenario as well, but all existing channels of information exchange should be made accessible for handheld devices, too. This means it is tried to increase the efficiency of tutoring by utilising handheld devices to increase the number of channels through which information can be exchanged and not by increasing the number of tutor contacts.

To give valuable answers depending on own experience and demonstrated knowledge and skills of a student, tutors also need an easy access to student records stored in some kind of database. This database is definitely subject to very strict rules for data privacy and security in order to prevent unauthorised reading from or writing to it.

This leads to a very difficult trade-off decision between the desired level of security and accessibility of all different kinds of information to be stored in the database. Additionally, it has to be fixed which actors in the teaching-learning process are allowed to read or write which kind of information. Usually, a so-called learning management system (LMS) is used to facilitate and guide the process of adding information to the database and recover detailed or summarised information from it.

Because a mobile connection is likely to die suddenly of all reasons rated between “known knowns” and “unknown unknowns”, the LMS and/or database has to support a feature called ‘transactions’. That basically means a read or write process is monitored on both ends of the information flow chain and changes in the database are only allowed if both communicating devices ‘agree’ that the information flow has been correct and complete.

Concluding, from a tutor’s point of view this project is going

3) to analyse
    - which proper modifications and transformations are necessary to make FAQs, news fora, mailing lists, email and other channels of information exchange between tutors and students easily accessible for handheld devices,

    - whether it should be left to tutors (and students) to decide on when and how to use handheld devices in the tutoring process or whether existing elearning LMSs should be enriched by services specifically designed for use with handheld devices,

- which kind of information may be kept in a database accessible by handheld devices and which kind is to be securely stored for intranet access only.

4) to use

- the introductory course on descriptive statistics as testing ground for topic 3, which explicitly means to answer the following questions:

  i) which channels of information exchange established in elearning can be conveniently accessed by current handheld devices,

  ii) is there evidence that frequent usage of handheld devices in the tutoring process demands the creation of tutoring services specifically designed for use with handheld devices,

  iii) which combination of open-source LMS and database can be easily administered, is safe enough, and natively supports transactions;

- the bachelor of science course on object-oriented programming as real-world application for topic 3.

Recommendations by students

In a recent survey (Socrates/Minerva SSS project output 5 FeU, extended German report by Rudolf Schuemer and Georg Ströhlein, to be published as ZIFF PAPIERE 123 in April 04) students mainly demand for an intensive usage of group work and extensive comments in their re-submitted exercises. They want to share questions, answers, written or sketched thoughts, comments in exercises etc. with other students and the tutor. But the sample is strongly biased towards students of information engineering.

From other sources it is known that the use of media strongly depends on the subject of study: students in information engineering try to use electronic media throughout all their work, whereas students of humanities prefer paper for all intermediate stages of work. Most of the students do not own a smartphone or PDA and do not plan to buy one, but this attitude again depends strongly on the subject of study. Nearly each student owns a mobile phone, and most of the phones are equipped with a simple camera. It is thus difficult to extract common wishes or demands of students. But anyway, students of information engineering and related subjects are likely to be the first group who makes intensive use of new electronic devices and media.

None of the existing handheld devices is prepared for using the whole range of powerful group-work functionality provided by leading office software packets. Therefore, it seems questionable whether there is much sense in (developing

and) using software for group-work with handheld devices when people have a much mightier tool in their offices which is used worldwide. It seems more useful to try to promote the exchange of ideas utilising handheld devices and leave the hard work on large documents for the office hours.

But students also demanded (ZIFF PAPIERE 123, to be published) a completely different feature of elearning courses: a clear and comprehensive list of which group the course targets at, a list of the main learning objectives, a list of the prerequisite knowledge and ICT necessary etc. This leads to another important use of standards: those which describe the content of a course, the relationship of its parts, its position in a curriculum and related features. There seems to be one standard that turns out to be the most widely supported one: SCORM. Obviously, the combination of LMS and database used to access the course has to support this standard.

Many students proposed to be informed by SMSs if there are any changes in on-campus events after the schedule has been sent out via email. This seems to be an ideal application for the WAP 2.0 push technology. But most of the students do not know whether they have a GPRS phone, whether their contract supports GPRS access, what are the costs of GPRS and so on. This is true even for students of technical subjects.

Additionally, as most of the FeU students belong to the workforce, they are not allowed to have their phone switched on during the working hours and/or are working in environments physically shielded from mobile networks by buildings made of Ferro-concrete or sheet steel, inside walls fixed on sheet steel pillars etc. Therefore, it does not make much sense to use the WAP push feature, but the students should be trained or even guided to regularly check their private email account utilising their handheld device.

Most students like to play a game on their handheld device when riding the train or bus or when waiting in a station. The present writer even thinks that playing games has become more popular than excessively writing SMSs and therefore is going to develop Java2ME-based edutainment features for his statistics course.

Concluding, from a student's point of view this project is going

5) to analyse

   - which are good practises for using handheld devices to promote group-work,

   - whether mobile phones equipped with digital cameras can be utilised to promote exchange of ideas originally written on a piece of paper, a chalk- or whiteboard etc. via MMS or an email with a picture attachment,

- whether personal comments added to course material in electronic format (mainly PDF is meant here) can be sent to other students and viewed by them in place (!!) to add own comments, depending on the handheld devices.

6) to use

- the introductory course on descriptive statistics as testing ground for topic 3, which explicitly means to answer the following questions:

  i) how can students be supported to make use of the GPRS technology in a manner that prevents them from running out of money after the first connection

  ii) does it really add value to an LMS if its group-work functionality is prepared for access by handheld devices,

  iii) is the resolution of built-in cameras of handheld devices and their screen size respective viewing software suitable to communicate hand-written information to other students or the tutor,

  iv) is there a way to view and/or edit a received file which contains the comments of another user of a course eBook in PDF (or other) format,

  v) are the current GPRS networks of the four main carriers in Germany and open-source LMSs and databases stable enough to reliably offer services that depend on extensive database usage;

- the bachelor of science course on object-oriented programming as real-world application for topic 5.

Development of tools and environments to be used

In the ’mlearning-the next generation of learning’ project, the technologies available on the mobile phones themselves and within the mobile network have greatly increased in number and sophistication.

The course development tools and environments will conform to the specifications of the Open Mobile Alliance (OMA). As mentioned above the OMA works in accordance with other standards bodies.The standards of these other organisations will also be adhered to in this project. In this way, the courses developed will conform to the mobile telephony industry standards and specifications.

MultiMedia messaging (MMS) will be used in the project. Creating the MMS messages can be done by a number of methods:

- Using the messaging option on the P900 or T610

- Multimedia, MMS Home Studio comes with the software pack for the P900. This allows MMS messages to be created on the PC.

- Creating MMS messages to be sent from a Value Added Service Provider (VASP) to be sent either over SMTP or HTTP can be done with SOAP or the JavaMail API. Borland's Jbuilder will be used for any Java development. The Apache web server will be used also.

- The MML (MultiMedia Libray) function of the MMS system will also be examined as a means for students and tutors to manage, send and receive MMS messages in a PC environment.

The Browsing and Content Working Group (BAC) of the OMA is responsible for the standardisation of content types used in the development environment of mobile devices. The technologies used here will be in accordance with the BAC specifications. The course development environment will partly be in XML based languages. Based on the device requesting the service, the application can be tailored to suit the capabilities of the phone.

XSLT (eXtensible Stylesheet Language Transformations) will be examined as a way to do this. This means for application development for this project, the course material can be developed once but will be suitable for use on a range of devices. The devices will also be described in accordance to the specifications of the Browsing and Content Working Group.

This working group's scope also covers content optimisation and profiles which describe a mobile device. The User Agent Profile (UAProf) describes a phone's hardware and software profile. It is based on the internet standard Composite Capabilities/ Preferences Profile (cc/pp). An XML framework, Resource Description Format (rdf) is used to describe these capabilities.

The Ericsson GPRS (General Packet Radio Service) test network will be used to develop and test the course. This is a CGSN 2.1 (Combined GPRS Support Node). This configuration contains SGSN (Serving GPRS Support Node) and GGSN (Gateway GPRS Support Node) functionality in the one cabinet. The SGSN is connected to a BSC (Base Station Controller) which in turn is connected to an RBS (Radio Base Station). An HLR database (Home Location Register) stores the subscriber data. These will proved the radio access for any voice calls made. For WAP requests the Mobile Internet Enabling Proxy

1.0 or 2.0 will be used (MIEP) and MMS traffic will be sent and received via the Ericsson MMC 2.5 and SMS-C.

Evaluation of tools and environments

The evaluation of tools and environments to be used will be based on the principle that the tools that were successful in the distance education and e-learning periods should be developed for mobile learning as well.

In distance education communication between the teacher and the learner and between the learner and the learning group was mediated by technology. These technologies were usually the printed word and written correspondence, augmented by audio and video media.

E-learning added the interactivity of largely typed interaction as students learned at a computer screen and communicated with teachers and fellow students via a keyboard.

In both distance education and e-learning voice communication was unavailable or underdeveloped, but voice communication is the central tool of both face-to-face education and ILT.

As mobile learning uses a telephony technology one of the challenges facing any mobile learning project is the reinstatement of voice communication in education and training contexts.

Successful learning environments were built by both distance education and elearning systems.

In distance education a combination of carefully structured high quality learning materials allied to a rich provision of student support services, as in the Open University of the United Kingdom, proved successful.

In elearning, high quality learning materials, often built around reusable learning objects, are again a prerequisite. High quality student support services are again a feature of academic elearning provision. In corporate elearning such rich student support services, if provided, seem to be little used.

The development of a successful learning environment for PDAs, smartphones and mobile phones will be a central theme of the evaluation of this project.

THE SEARCH FOR A WIRELESS LEARNING MANAGEMENT SYSTEM (MLMS). THE CHANGES THAT ARE NEEDED TO AN LMS TO ‘MOBILISE’ IT

The development of a wireless Learning Management system (mLMS) is important for the success of the project. It is also vital for the development of mobile learning as a viable sector of training provision.

It seems clear that the development should be based on an adaptation of an Open Source LMS. We have proposed Moodle (www.moodle.org). To this have been added:

- Tiny LMS
- PfP LMS
- LRNTM
- Interact
- A Tutor
- Eledge Open LMS.

In spite of certain problems we consider that Moodle is still the leading contender.

The modifications that are needed to an LMS to make it viable as an mLMS need to take into consideration the following:

i) Enrolment and student records

- Student registration. The mLMS will require the functionality for student registration. Basically this will envisage that the registration is by mobile telephones as students contact the institution for the purpose of registration. Other forms of registration need to be considered as well: by post, by email, by telephone.

- Development of student database. The mLMS will need to be able to build a database of students from the registration data received. The categories of data that will be collected and retained need to be agreed upon.

- Passwording. The student database will need to be passworded. Classifications of users with various access rights will need to be established: administrators, tutors, students.

- Payment. If possible, it would be excellent if functionality and be provided for the collection of course fees, especially from mobile phones.

- Recovery of data. Facilities for the recovery of data need to be established. This can be by course group, by tutor group, by individual student. Different levels of permissions for the accessing of this data need to be established.

(ii) Course development

- Course development tools. There should be a facility for assisting developers in the development of courseware for mobile learning.

- Location of courses. The portfolio of courses available should be held by the mLMS.

- Student study. It may be desirable for students to access their study programmes through the mLMS.

- Interactivity. If students are to access their courses via the mLMS it will need to provide the interactivity required for correct course study.

(iii) *Communication.*

- Student to tutor/institution. The mLMS will need to carry functionality for student to tutor or institution communication, especially from mobile phones.

- Student to student(s). The mLMS will need to carry functionality for student to other student(s) communication, especially from mobile phones.

- Voice. The basis of mobile learning in telephony should lead to much greater use of educational voice communication than was the norm in distance education or elearning.

- Data. Facilities for submission of assignments and tutor feedback and other forms of data transmission need to be available.

- SMS. The particular strengths and popularity of SMS should be a feature of the system.

- MMS. The particular strengths and popularity of MMS should be a feature of the system.

(iii) Assessment

- SAQs. Provision for self assessment questions should be included.

- TMAs. Provision for tutor marked assignments should be included.

- CMAs. Provision for computer marked assignments should be included.

- Recording of student data. It should be possible to record in the mLMS database the results of students' TMAs and CMAs.

- Assessment. It should be possible to match student records against assessment criteria for awards and certification.

Specification of mLMS

This project will endeavour to produce mlearning courses that a student can take on his or her mobile device when and where it suits them. That this activity is administered and recorded by a Learning Management System (LMS) is an ambition that the project also hopes to realise. As mentioned previously there are two sets of standards that will be reused to enable such an mlearning scenario. The first set essentially controls the content production and how this is integrated into an LMS.

Today in the elearning world the key standards in this area are produced and defined by such organisations as IMS Global Learning Consortium, Ariadne, AICC, etc and have been widely adopted by the corporate and to a lesser extent the academic elearning world. Reference models such as SCORM are prevalent and both content developers and LMS system developers strive to adhere to such models. This set of standards will be dealt with in more detail later. The second set of standards is related to both content production and supply to wireless mobile devices (as opposed to supply to Internet connected PCs). These standards have been previously considered in the section on 'Definition of Technologies' and are largely defined by the Open Mobile Alliance.

This project will strive to adopt both sets of standards in both the development and supply of mlearning courseware and it is envisaged that the successful integration of both sets of standards holds the key to the widescale use of mlearning as a viable alternative to traditional elearning.

We will now look at the standards that must be present in a LMS in order for it to be mobilized. Firstly, some key requirements on an LMS in mobile learning situations are defined as follows:

- The user (student/teacher/administrator) can access the LMS via his mobile device

- The administrator can carry out rudimentary administrative tasks (add new users,allow access to users to new courseware etc)

- The teacher can conduct basic functions on his mobile (check students progress, check for new assignments, download new assignments etc)

- The student can enroll for and attend courses on his mobile device

- Current technologies such as MMS, SMS can be integrated seamlessly into the LMS

It is envisaged that the use of industry standards in both the content production and supply will result in the above requirements being met. As mentioned, two parallel sets of standards will be adhered to; standards produced by OMA and related bodies for mobile specific situations and standards such as SCORM for LMS related situations.

LMS to be used

The above choice of device relates to the test equipment for the project only, since the most important principle governing the general choice of devices and technology the mLMS should support is, that they should make it accessible to the widest possible potential audience both from the availability and the affordability points of view. This means that the mLMS should be device- and platform-independent. This requirement is satisfied by HTML on which the NKI Learning Management System (LMS) SESAM is based.

An LMS and by consequence an mLMS must involve the following types of authors**:**

- technical experts knowledgeable of the way the mLMS can be made device- and platform-independent using technical standards like HTML, XML, CSS, W3C Device Independence Working Group guidelines, etc…

- usability experts who are knowledgeable about ergonomy and software quality standards like ISO 9241, ISO/IEC 9126,

- learning technology experts who can make the mLMS complient with learning technology standards like SCORM (Sharable Content Object Reference Model), CEN/ISSS WSLT, IEEE LTSC, IMS Global Learning Consortium, etc…

- educational, pedagogical experts knowledgeable of designing appropriate educational processes into the mLMS,

- teachers who actually create the learning content.

The specification of the mLMS should consider all of the above issues.

One of the following would be a satisfactory model:

- Moodle tried but not convincing and not SCORM compliant, (http://moodle.org)

- ATutor good accessibility but SCORM compliance only aimed at, (http://www.atutor.ca)

- TinyLMS states SCORM compliant but not tested yet, the favourite (http://www.randelshofer.ch/tinylms/download.html)

- Interact not tested yet (http://cce-interact.sourceforge.net)

DEFINITION OF COURSES TO BE DEVELOPED

The issues to be addressed under this heading include:

- The status of the course materials in the institution's provision

- The integration of the course materials into the institution's portfolio

- The fees charged to the students for studying the mobile courses

- The level of accreditation awarded by the institution on the successful completion of the course.

Definition of modules (courses) to be developed

In the first phase of the content development process one course will be selected and this course will be used to verify the key functionality requirements both from a content development viewpoint and from an LMS integration viewpoint.
Once this course has been verified in phase 1 of the project, it makes it possible to take any existing or new course in phase 2 and fit it into this diverse mobile learning environment.

The course that has been selected for phase 1 is WCDMA/ UMTS Radio Access Network Overview. Some courses that are being examined for suitability for later phases are are the Introduction to WCDMA course and MMS Overview course. If selected the base content of these courses will be redesigned to allow them to fit into the mobile learning environment following on from the successful verification of the first course and incorporating any lessons that have been learned. The base content of all these courses is both up-to-date and related directly to the technologies used in the project (such as MMS) and matches the Ericsson requirement in the project proposal to produce telecomminication and datacommunications related courses.

The following scenarios are envisaged from a student usability viewpoint:
On signing up for the course, the student will be presented with a number of course options. Option 1 will present the course on a standard web browser on a PC. A second option presents the course to a web enabled mobile terminal eg.

the SonyEricson P900 phone and for PDAs. A possible third option of rendering the material for a more basic phone such as the T610 will also be explored.

Each learning option will present the the following supplementary course materials: Section tests will be in the form of MMS messages or short emails sent to the student upon completion of a section. SMS hints, MMS messages with further notes, more diagrams, ”talking head” video presentations of a related topic, voice sound files, educational games and other useful supplementary information can be sent to the student. These could be at either the request of the student or by a course tutor as he or she sees necessary, or automatically sent at the completion of each learning unit.

The course to be developed in phase 1 of the project is called “WCDMA/ UMTS Radio Access Network Overview” and is based on an existing web based learning Ericsson Education course (LZU 108 5202). This material will be technically updated and then substantially reworked and rendered suitable for a new mobile learning environment. New graphics will be developed and the content modified as appropriate.

Description

This course provides the students with an overview of the WCDMA/UMTS Radio Access Network, with all its components, functions and limitations.

Objectives

After successfully completing this course the student will be able to:
Outline the difference between FDMA, TDMA and WCDMA technologies
Explain the purpose and principles of WCDMA technology. Outline the WCDMA Radio Access Network (WCDMA RAN) nodes and network structure

Prerequisites

The student should be familiar with 2G mobile systems, to at least system survey level.

Course Modules

Course Objectives
Lesson 1 Introduction to WCDMA RAN
Lesson Objectives
Introduction
Section Test
WCDMA RAN Architecture
Section Test
Lesson Summary

Lesson 2 WCDMA RAN Technologies and Modes
Lesson Objectives
Lesson 3 Radio Access
Lesson Objectives
Radio Interface Entites
Section Test
WCDMA Downlink Channels
Section Test
WCDMA Uplink Channels
Section Test
Lesson Summary
Lesson 4 WCDMA RAN Nodes
Lesson Objectives
CPP Common Platform
WCDMA UMTS Spectrum and Duplex techniques
Section Test
Multiple Access Technologies Overview
Section Test
Lesson Summary
Section Test
WCDMA RAN RBS
Section Test
Radio Network Controller (RNC)
Section Test
RXI 820/810
Section Test
Lesson Summary
Course Summary

Courses to be used

As stated above two courses will be used:

- Introduction to Descriptive Statistics

- Object-oriented Programming
-

Parts of the statistics course were developed in a preceding project. The course has four main units and provides exercises as well as simple multiple-choice quizzes. There are versions in WML, HTML, and eBook format. Using the HTML version an attempt will be made to apply the appropriate DC-header-tags (DC means Dublin Core) to each page for preparation of SCORM compliance. Additionally, an attempt will be made to use CSS1 for optimising the output on different media like PC screen, handheld screen and print-out. Additionally, highly interactive, JAVA2-based exercises will be added and research will be done into the question how to achieve minimal parallel development efforts for the different platforms.

The programming course is part of the study offer of the University and will be taken as it is to check how far mobile learning has emerged from a testing ground into the real world.

Target users and definition of courses to be developed

As we have a full distance learning site in operation with hundreds of courses and more than 100 study programmes, it is important that developments for m-learning to a large degree is done on the server side. Thus, we will do an attempt to “mobilise” all the courses and make access to our LMS as device independent as possible. In addition, we will also adapt one of our courses specifically to be studied on the PDA. We have chosen the course “Sales and Services” which is a course that covers theoretical content, knowledge, understanding and skills of a qualifying examination for skilled workers in the sales and services industry. This course is within the agreement with Aetat, Norwegian Employment Service, to deliver courses qualifying unemployed persons to get back into the labour market.

This course is developed in parallel both for the PDA and our “ordinary” learning environment. It consists of 6 study units with a set of interactive features such as self-test assignments using multiple choice, drag-and-drop and audio. These assignments are developed using flash technology and one of the major parts in this project will be to develop these assignments and other multi media elements to the PDA learning environment with a small screen.

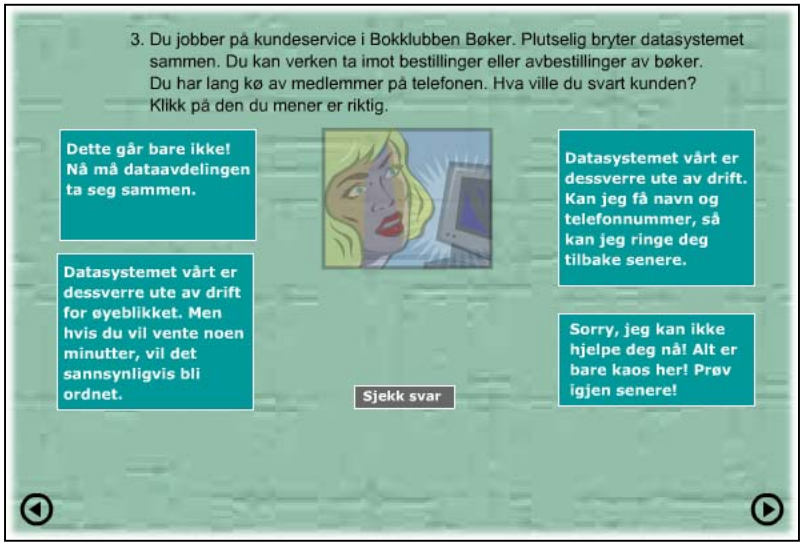

Figure: An example on an assignment from the course “Sales and Services”:

One of the course materials the project plans to develop aims at a relatively small group of people but with the potential to afford a relatively high level of equipment, IT-auditors. These people are able to use the latest technology and they are also interested in it, since it can ease their work. A mobile device, in contrast to a laptop computer, does not disturb the eye-contact between the auditor and the auditee during an interview.

By consequence, our plan related to IT-audit is to develop complementary materials to our normal IT-audit courses. The complementary material aims to refresh the knowledge gathered during the normal courses, and to serve as a summary helping auditors during the actual interviews. The auditors can review the knowledge transferred by the courses in their residual time, during travel for example.

The other planned course material is related to SAP courses. We are currently delivering SAP courses in the framework of regular university education. These courses include knowledge which does not require the direct use of computers at all. These elements of the courses can be ported into mobile form.

As we mentioned in the case of the IT-audit course, a summary of normal courses is a straightforward application for mobile learning. The mobile learning tool can however be useful even in front of an actual computer where the real use of an application is practiced. The parallel display of the summary of the steps to perform and of the actual application is of course feasible with window based operating systems, but it is usually cumbersome and disturbing. One solution in case of presentations for large audiences is the simultaneous use of two computers with two projectors. In case of a single person practicing in front of a single screen, the parallel use of a mobile device for following the steps to perform on the computer makes a lot of sense. It is certainly more space and cost effective than the use of two displays side-by side which can also be managed by graphics cards.

Course evaluation

The role of the evaluation process is to evaluate the courses that are developed by the project against these criteria:

- Student userfriendliness
- Didactic efficiency
- Technical feasibility
- Cost effectiveness
- Conformity to the project proposal

- Contribution to the field of mobile learning.

We certainly support the development of courses in innovative areas, like mobile guides to art galleries.

Factors which are important to the evaluation of the courses, because they are crucial to the development of mobile learning as a field include:

- Pedagogical effectiveness of the courses
- Cost effectiveness of the courses to students
- Status of the courses in the view of the institution
- Role of the courses in the institution's portfolio
- Fees charged by the institution for enrolment in the courses
- Accreditation offered by the institution for successful completion of the courses.

Resources

Media Queries:
http://www.w3.org/TR/css3-mediaqueries/

Netfront:
http://www.netfront.no/

ThunderHawk:
http://www.bitstream.com/wireless/?wireless-web

Missing article:
http://www.bangkokpost.net/171203_Database/17Dec2003_datacol51.html

An Overview of EDGE:
http://www.radio-electronics.com/info/cellulartelecomms/edgeinfo/edge.htm

The World Wide Web Consortium (W3C):
http://www.w3.org/

Komplett.no:
http://www.komplett.no

Idedata:
http://www.idedata.no