Designing Models and Services for Learning Management Systems in Mobile Settings

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Abstract. The paper presents the guidelines of a project of three Italian Universities (Bologna, Siena, Trento) which aim is to investigate the use of mobile computing technologies to support the learning processes in a University context. The project covers three main areas. The first area is concerned with finding effective models for mobile learning. The second regards the evaluation of learning processes in mobile learning environments. The third focuses on the technological aspects of mobile learning, and on their integration with e-Learning systems, and more generally, with the information systems of the academic institutions. The project has its foundations in the availability of significant experience on e-learning real processes, and on the availability of the source code of an e-learning system developed in previous projects and currently used by different faculties, and of the newer platform that gathers the experience obtained in the past.

1 Introduction

Mobile learning is a field which combines two very promising areas – mobile computing and e-learning. Mobile learning could be considered any form of learning (studying) and teaching that occurs in a mobile environment or through a mobile device, like cellular phones, Personal Digital Assistants (PDA), smartphones, tablet PC etc. On the other side of mobile learning, we have e-learning, i.e., every educational process assisted by computers through the networks, and Internet in particular. M-learning has been considered as the future of learning or as an integral part of any other form of educational process in the future.

As m-learning is quite a new domain, there is a lot of work and research that is presently going on. Specifically, people are trying to understand:

- which learning models can help obtaining better learning processes when communication is mediated by mobile devices, and how the student mobility affects her/his learning process.

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- how it is possible to evaluate efficiency and effectiveness of learning processes based upon mobile technologies, given the physical limitation of mobile devices.
- which services are useful for mobile devices, which is the enabling technology that can affect the wide diffusion of mobile learning.

A mobile learning educational process can be considered as any learning and teaching activity that is possible through mobile tools, or in settings where mobile equipment is available. National and international researches in the m-learning field are geared towards some lines that we shall here overview. Different devices that exist and all the devices that are coming up on the market, with their limitations and advancements, provoke different ideas for applying them on learning, thus any device can mean different m-learning. Among the open problems, some are relative to the pedagogical use of mobile devices. Since the m-learning term appeared for the first time, some research has been done to investigate the cognitive and pedagogical aspects.

Investigation had been done also on how useful mobile computing devices could be for reading or for workplace activities [1], on the basis of studying activity theory. Some authors [2] try to give directions to application designers for the areas, where the mobile devices should be most useful. Others [3] are trying to achieve conclusions by analyzing the theories of adult informal learning. In a few papers some interesting positive sides of using new technologies are underlined i.e. the participants are excited and want to try "new" things.

Some findings show that introducing new forms of teaching (even if this means just using a standard tool for drawing on a PDA) make students spend more time in working on that subject, comparing to the other subjects.[4] The currently evaluations and analyses of m-learning projects show many positive results. On the other hand there are some doubts if this excitement is, or is not, a temporary side effect. Most of the researchers think ([5][6]) that PDAs and other mobile devices should be seen more like extension, rather than replace the existing learning tools. Moreover not all kinds of learning content and/or learning activities are appropriate for mobile devices [7].

The paper will present our view regarding the topic on mobile computing. In particular, we'll present a project of our three Universities in which we want to use an existing Learning Management System and adapt it to the needs of mobility, having the source code of the system available. This mobile platform will be used to test principally new models for learning in mobile settings and tools for assessment of learning process through the use of mobile technologies. These objectives will be pursued through:

- Adoption of a well tested e-learning platform adapted to the usage of mobile devices
- Implementation mobile computing services in a University setting
- Study of learning models linked to mobile technologies
- Study of learning evaluation models based in an m-learning environment
- Design and development of Learning Objects suited to mobile learning, together with services for evaluating their effectiveness
- Experimentation of prototypes built in real learning processes

The paper is organized as follows: first we will present the state of the art in mobile learning, then we will briefly present the three elements that in our opinion help to build a mobile learning environment, i.e., models, evaluation systems, back-office

tools. Next we will present the guidelines for studying new models for learning processes in mobile settings, and one approach for the evaluation of these processes. Finally, the problems faced and choices made regarding the adaptation of a Learning Management System to mobile needs will be outlined.

2 State of the Art in Mobile Learning

The state-of-the-art in mobile learning research is heavily conditioned by the features of the devices available on the market. Different user interfaces, capabilities and connectivity may generate different ideas for possible learning applications: each single device can mean a different way to "m-learn". We shall here review the main trends and indicate some of the relevant papers in the field, with special attention to the themes that are more closely related with the aim of the present paper. A more extensive analysis of the state of the art can be found in [8][9].

Among the open problems, some are relative to the pedagogical use of mobile devices. Some research has investigated the cognitive and pedagogical aspects. Investigation had been done also on how useful mobile computing devices could be for reading or for workplace activities [1], on the basis of studying activity theory. Some authors [2] try to give directions to application designers for the areas, where the mobile devices should be most useful. Others [3] are trying to achieve conclusions by analyzing the theories of adult informal learning. In a few papers some interesting positive sides of using new technologies are underlined i.e. the participants are excited and want to try "new" things. Some findings show that introducing new forms of teaching (even if this means just using a standard tool for drawing on a PDA) make students spend more time in working on that subject, comparing to the other subjects.[4] The current evolution and the analyses of m-learning projects show many positive results. On the other hand there are some doubts if this excitement is, or is not, a temporary side effect. Most of the researchers think ([5][6]) that PDAs and other mobile devices should not be seen as a replacement of existing learning tools, but rather as a new and different opportunity. Moreover not all kinds of learning content and/or learning activities are appropriate for mobile devices [7].

People are experimenting with the application of m-learning to different fields: a promising one is language learning. At Stanford Learning Lab [10] an exploration of mobile learning has been done by developing prototypes that integrate practicing new words, taking a quiz, accessing word and phrase translations, working with a live coach, and saving vocabulary to a notebook. They envisioned that a good approach would be to fill the gaps of time by short (from 30 seconds to 10 minutes) learning modules in order to use the highly fragmented attention of the user while on the move. The research indicates some very useful directions, like the length of the learning materials, the personalization of interaction and the frustration of the user and the decreasing of the perception of the learning materials because of the poor technological implementation. In the same field an ongoing project [11] aims at porting to mobile systems an ad-hoc language-learning system developed for the special needs of an Italian bilingual region, where every public officer is supposed to be fluent in Italian and German. One problem investigated in this context is the one of anticipating user's need and pre-caching the needed content when a cheap and fast connection (such as a direct connection via cradle) is available, since the whole material is too large to fit in a small palmtop device.

Many authors approach m-learning in the context of life-long learning. One of the biggest initiatives in such domain is the *HandLeR* project [12] (University of Birmingham). The project attempts to understand in depth the process of learning in different contexts and to explore the lifelong learning. The stress is on communication and on human-centred systems design. Similar in some concepts to *HandLeR* is the project undertaken at the Tampere University of Technology (Finland) [13], where PDAs are used for mathematical education of children. The study-content is presented in the form of a game where the pupils can communicate and help each others and the electronic device is used to measure the average students' knowledge level and to adapt the speed of presenting new material to the learners' ability.

One of the most straightforward application of the usage of mobile devices as educational supporting tool is messaging. At Kingston University (UK) an experiment was undertaken to research the effectiveness of a two-way SMS campaign in the university environment [14,15]. The team has developed a system that sends SMS to students, registered to the service, about their schedule, changes in it, examinations dates and places, student's marks and etc. The conclusions of the experiment were that the students in certain scenarios where a certain type of response is required preferred SMS as a medium to e-mail or web-based announces. SMS could be efficiently used in education (m-learning) as a complementary media. As the technology improves (i.e. EMS and MMS, potential more user-friendly interface) the potential increases too. For this reason, as explained in the next sections, we decided to include in our experimentation the management of SMS from teachers / administrative staff to students as one of the approaches to info-mobility. Also at the University of Helsinki the *LIVE* (*Learning In Virtual Environment*) experiments, made with SMS system and with WAP phones, were very positive [16]. The project went on by introducing digital imaging and sharing photos between the participants (teachers). The conclusions were that it is very possible that the introduction of MMS and the other 3G services in the large scene will lead to more and more possibilities for m-learning. Another project [17] on evaluation of a Short Messaging System (SMS) to support undergraduate students was done at Sheffield Hallam University. The implemented system was again not for learning, but for managing learning activities (to guide, prompt and support the students in their learning). The findings were overwhelmingly positive, with students perceiving the system to be 'immediate, convenient and personal'. Positive results were underlined and after the outcomes from a survey in Norway - almost 100% of the students in that University have cell phones and SMS system would be widely accepted [18]. Once again an SMS system was considered to be used to spread information about lectures and classes, corrections in the schedule and etc. In certain cases students find it more convenient than e-mail or WWW as the information always comes on time. These projects open some very important issues to be considered in doing further research in the mobile learning domain. One is that the current technology gives enough powerful instruments to support some new forms of auxiliary learning tools. They also show the enthusiasm of the students to accept such new technologies.

Several m-learning projects focus on of how to apply e-learning techniques and content on mobile platforms. The UniWap project ([19][20][21][22]) concentrated on testing the use of WAP technology in higher education, by exploring the process of creating an operating environment for studying and teaching through smart-phones and WAP phones. One phase of the project was to create some working prototypes

(courses modules) and to investigate the problems and the value of such courses. The positive results they encountered (easy to develop, willingly accepted and widely used modules) encourage them to continue investigating the new coming technologies – digital imaging with mobile devices, 3G, etc. At Ultralab *M-Learning* project the team is producing m-learning materials for people with literacy and numeracy problems [23],[24]. A great potential is encountered from the cognitive and pedagogical point of view, even by using simple development tools (Macromedia Flash).

"From E-learning to M-Learning" [7] is a long-time project that aims at creating a learning environment for wireless technologies by developing course materials for range of mobile devices. The authors discuss the devices characteristics that are proper for learning and highlight analogies and differentiation between e-learning, d-learning (distance learning) and m-learning. They also try to predict which methods and technologies should be used for successful m-learning.

Tourist and museum guides are often considered to be applications in mobile learning domain. They usually refer to newest technologies as location-discovery via GPRS, radio frequency or etc. However we rather consider them as a separate applicative field and therefore we will not discuss them in this context. Also, due to space constraints we cannot discuss the very interesting approach of using mobile devices in the framework of collaborative and problem-based learning. The interested reader can find indications and a short discussion of this topics in [9].

In conclusion, the overall view on the existing research work and projects in the m-learning domain shows that it most probably applies best to processes, where specific knowledge should be retrieved/accessed in a certain moment, where discussions in distributed groups (i.e. brainstorming) appear, where data is collected or utilized "on the field", and where context-information is strongly related to the learning content. The nature of mobile devices, with their small screens and poor input capabilities leads to the assumption that they can not replace the standard desktop computers or laptops. However, the same properties can make them efficient in learning domain, if certain constraints are kept ([7][17][25][26]):

- Short modules (max 5-10 minutes). Users should be able to use their small fragments of waiting time (i.e. waiting for a meeting or while travelling in a train) for learning, like reading small pieces of data, doing quizzes or using forums or chat for finding answers to "on field" questions.
- Simple, funny and added value functionality. The limited computational power and the other properties of mobile devices (as they are today) make it difficult to use complex and multimedia content. One should find it more interesting or necessary and useful (or at least equally) to study using this m-learning system in his/her 5 min. break than playing a game on the same device.
- Area/Domain specific content, delivered just in time/place. The mobility should bring the ability to guideline and support students and teachers in new learning situations when and where it is necessary. The dependency of the content can be relative to *location* context (i.e. the system knows the location where the learner resides and adjusts to it), *temporal* context (i.e. the system is aware of time dependent data), *behavioural* context (i.e. the system monitors the activities performed by the learner and responds to them adjusting its behaviour) and interest specific context (i.e. the system modifies its behaviour according to the user's preferences). Of course a mix of the contextual dependencies is possible and likely.

3 The Three Elements of Building a Mobile Learning Environment

As said in the introduction, the aim of the project has three key elements. Firstly, we are interested into analyzing and viewing the system as whole and thus researching, whenever it would be possible, models that would allow us to individuate the relationships that connect those elements, as well as their knowledge value and reach. Therefore, the concept of model becomes the basis to connect the learning process with the languages, the methods, and the tools that are employed to implement and experiment the Virtual-Real Learning Communities. Such communities should deliver evaluations of the result of learning process and objective measurements parameters, which are (possibly) independent from the teaching contents.

A second but not secondary issue is concerned with how to evaluate the m-learning tools and their model as a function of the induced quality in the learning processes. Talking about good quality in distance learning is undoubtedly a not easy task. Not easy for various reasons, first among everybody because has not closed the debate on what he understands, in more general sense, for quality of a formative intervention, with all what which this involves yet: didactic effectiveness, social and professional impact, investment, etc. We would like to assume for quality not as much the excellence as rather the management of a continuous process to approach the most possible the wished effect (for instance, what one wishes is learned) to real effect (what which has been learned). We call such systems closed ring, key element of this kind of systematic realignment is a constant monitoring aiming to the evaluation both of the users and of the whole process. The system of new generation which we intend to develop is based on the interaction of all the parts of the process, to give way to the distributor of the formative action, to monitor the process and to regulate it, when necessary, wished to redirect it adequately toward the effect.

A key element for this is a constant monitoring, whose aim is to both evaluate users and the whole process. The new generation tool that we intend to develop is based on the interaction of all process components, so as to allow tutors to monitor and steer the process. In such way it will be possible to achieve a better coherence with the stated objectives, making therefore easier to reach the desired goals. More in detail, the evaluation of the proposed system is expressed in functionalities which refer to various kinds of Assessment. The first and simpler functionality is the self-evaluation which must be understood as complement of an educational process. The self-evaluation is not sufficient to guarantee the success of an educational process, in fact, not all the students are able to self-manage it in an effective way. So, we would like to consider some other assessment strategies. The evaluation process assumes as a good evaluation is not reduced to the administering of a final test and to the production of a judgment, or more simply of a vote. The assessment must to precede, to follow and to direct all the formative process. That means that the system obtains information about the students before beginning a course (using previous relationships with the same student or a diagnostic test), during the development (through the analysis of link and documents chosen by the same students, explicit preferences and formative tests) and in conclusion of unitary subject sections.

A big complexity resides in the difficulty for the electronic computers to semantically interpret sentences in natural language. A first approach to the problem has been performed trying to isolate the verifiable difficulties in traditional testing systems

(refer in particular to the North American model, which uses questions with answers to multiple choice). These have been summarized in the following six points, concerning multiple choice tests:

- they are concerning the results of the learning process, not to the processes
- they underline the knowledge level not the potential of learning
- they are far from the working contexts
- the memory can sometimes be more useful than the comprehension
- the so-called tests-taking skills can affect the result.

Possible answers to these problems are presented in [27]. In the context of the present project we would like to highlight two particulars. First of all, the personalization of the tests is possible only in presence of a student model that memorizes a description of his expertise and brings up to date. Besides, the enlargement of the field of action of the evaluation, from the results to all the educational process, makes it possible the use a graph structure.

As a third key element of the project, in order to support the experimentation of any tool or technique of m-learning, a rather complex information system is necessary. Its role includes distributing didactic material, users identification and authorization, gathering of data relative to the user-system interaction, provisioning of mobile services, supplying statistics on level of usage and satisfaction etc. From this point of view, the project attempts to interconnect m-learning technologies with e-learning, and e-learning is in turn always more integrated in the information systems of academic institutions.

E-learning systems, and Learning Management Systems (LMS) in particular, are nowadays a key element in the learning processes that take place at Universities, and they are widely investigated in literature [28], [29], [30], [31]. Several implementations are available on the market, like for instance LearningSpace™, WebCT™, Blackboard etc. [32]. They are in the middle of a transformation from simple support of on-line learning (like in the case of LMSs) into real information systems (Learning Information Systems -LIS). As such, they integrate many components of the wide spectrum of a formative action [33]. Our project needs to integrate such systems with our project's specific mobile-computing requirements. This means that we have to focus mainly on two points: on the one hand we have all the administrative and back-office processes of a Faculty (e.g. exam registration, didactic design, theses management, bookkeeping of teacher's activity, University marketing etc.).

On the other hand, research attempts to focus on the technological evolution that brought to people mobility and mobile terminals (PDAs, pocketPCs, cellular phones, smart-phones, tabletPCs etc.) that are now present in every day's life. These tools are an interesting for a LIS, since they allow the various actors (such as students, teachers, administrative personnel etc.) to have a mobile platform that keeps them in touch with the LIS wherever they are. The possible applications are therefore very many: we can for instance think at the possibility for a secretary to communicate with mobile-technology enabled students, or at possible mobile collaboration among teacher and students within a course framework (our research will explore this aspect).

Some work has been done on Learning Management Systems, but the idea of a University Information System having a mobile component that belongs to the skeleton of the Information System is still in its infancy. It is therefore clear that it is not possible to be concerned with single classes of actors without considering the whole picture, since LIS aggregates users with different roles. The focus therefore moves

from a system dealing with "courses" to a system that deals with "virtual communities", i.e. with a generalized communication space that allows using a variety of tools to support collaboration needs that may arise in various situations. A virtual community can be supported at various levels by mobile technologies. LIS, in our definition, become computerized tools that give various kinds of services to virtual communities. Such services can be adapted to the special needs of a given community. One research aspect of the present project is therefore linked to virtual communities and info-mobility related to learning: we intend study and experiment how activities of an e-learning portal can be integrated with the emerging mobile technologies. The research group will use an already existing community-oriented e-learning portal that has been in use for some time to integrate and test mobile technology and related methodologies.

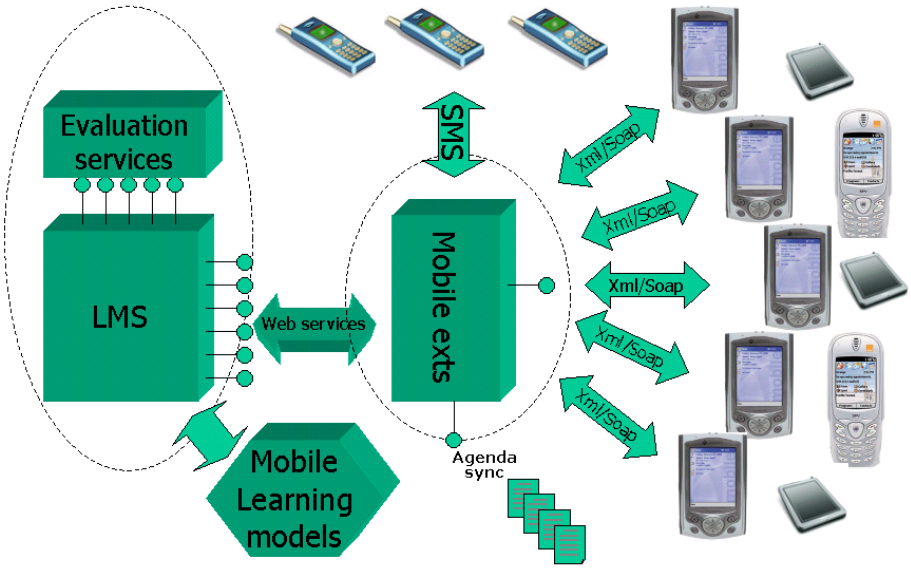

Fig. 1. A general schema of the prototype

4 Evaluating Mobile Learning Settings

The experience from years of development and use, the advance of technology, and the development of authoring tools for questions and tests has resulted in a sophisticated, computer based assessment system. However, there is still a lot of room for further development. Some of the current ideas for development are discussed in the remainder of this paragraph. In line with many writers in the field of assessment, we distinguish three types of assessment:

- diagnostic assessment; it provides an indicator of a learner's aptitude for a programme of study and identifies possible learning problems;
- formative assessment; it is designed to provide learners with feedback on progress and informs development but does not contribute to the overall assessment;
- summative assessment; it provides a measure of achievement or failure made in respect of a learner's performance in relation to the intended learning outcomes of the programme of study.

The most common distinction in the literature is that made between formative assessment and summative assessment. A formative computer-based test is described as one where the results of the test do not contribute to a student's final grades. Instead, the student's scores are used to assist in improving the student's learning, often by identifying weaknesses in the student's knowledge and understanding of a given area or by helping them to identify and correct misconceptions. In a similar way, lecturers can also make use of the results obtained to help them improve their teaching by identifying areas that students have found difficult to understand. Nonetheless, in many assessment activities the difference is not so evident.

A primary aim of assessment is provide the necessary information to improve future educational experiences because it provides feedback on whether the course and learning objectives have been achieved to satisfactory level. Yet, it is important that the assessment data be accurate and relevant to effectively make informed decisions about the curriculum [34]. As discussed above, formative assessment can also be used to help bridge the gap between assessment and learning. This may be achieved particularly where assessment strategies are combined with useful feedback, and integrated within the learning process [35].

This feedback need not be limited to correct/incorrect responses, but can include detailed textual feedback about answers and the topic area of the question. Formative assessment can assist in consolidation of learning, and in identifying weaknesses in assumed understanding. We think that it would be helpful to be able to deliver the same questions in a number of modes. For example, help mode, exercise and exam, with the test author being able to configure this to their own requirements. The help mode supports students when they start out on their learning; accordingly, the questions are delivered with maximum feedback including hints, visible marking on screen and the chance to reveal a correct answer. Exercise mode restricts the help to just visible ticks and crosses on screen for right and wrong responses. Finally, exam mode presents questions with no option for revealing answers and no ticks/crosses appearing.

Our summative strategy consists of two phases: the former to find the approximate student level, the latter to give the student the right mark using a set of questions customized on his capabilities. The preliminary examination contains for every subject two or more questions for each difficulty level. The score obtained by the student in the first test is used to choose questions to propose in the second test. Using this technique we can build a test which is not redundant (due to the adaptivity) and the same firs test set for every student, so we can get data on the quality of the items. Diagnostic assessment is quite similar. In particular, the two-session strategy is the same. The main difference is that it is taken before starting a course, to decide what kind of resources will be used. In this case, the system knows nothing about the student's knowledge; it also records the scores of every answer, so the system can use them when it needs to explain a topic already scored.

When an exam session is completed, we will have a score for every candidate and for every question. To obtain a human-understandable mark we used a function depending on two parameters α and p. We used this function in a large number of real cases and the experimental data showed that the choice of α is important to obtain well-distributed marks. This value can be adjusted after the test correction, in response to the candidate's answers. Moreover, useless items may be discovered. The value p is used to give full marks.

To compose tests easily from a set of items and correct them, the system uses normalized questions and manages the item weighting: when an author creates a course, he sets weights that will influence the automatic item selection and the scoring algorithms. Some of the available forms of assessment strategies included in the proposed system are:

- true/false,
- multiple-response question; it is defined as a question in which the candidate is required to select two or more correct answers from a list of options. Both the number of correct answers and the number of options may vary. We consider the following three principle modes: i) constrained selection: the student is forced to make a prescribed number of selections, usually the same as the number of correct answers; ii) partially constrained selection: the student may make any number of selections up to the number of correct answers; iii) unconstrained selection: the candidate may make any number of selections up to the maximum number of options,
- extended matching item and drag and drop question types share the same process of selection. In either case the student is required to select a number of items from a list then enter or move them to their correct positions. Thus the candidate must make two selections - which item and where to put it. The scoring simplest form considers a positive score allocated for each item correctly positioned,
- image hot spot,
- code writing.

The process of assessment involves gathering information from a variety of sources to develop a rich and meaningful understanding of student learning. Modern computer assisted assessment packages are capable of storing and analysing vast amounts of information on student learning. With appropriate analysis this data can be used to identify the strengths and weaknesses of individual students and match them to learning resources that meet their needs.

Finding appropriate, high quality resources has now become a significant challenge. Furthermore, based on user's requirements and interests, filtering and retrieval tools should be developed, improving their usage. Information filtering systems can help learners by eliminating the irrelevant information, operating like mediators between the sources of information and the learners. Personalized filtering should be also a process of filtering based on not only the long-term interests but also the short-term requirements. For these purposes, we consider relevant the integration of an hybrid recommender system that combine content analysis and the development of virtual clusters of students and of didactical sources. This information management system provides facilities to use the huge amount of digital information according to the student's personal requirements and interests, with special focus on the development of new algorithms and intelligent applications for personalized information

classification and filtering. In this way data can be obtained about which material is proving to be most effective in raising student achievement. Taken together with the profiles of student strengths and weaknesses, this may prove an effective tool for identifying which resources are most suitable for each student, giving them an individual program of study, tailored to their needs.

The assessment process could be organized in the following phases:

a) Creation of the architecture for the management of the evaluation moments for the whole formative process: that is, the teaching interface building (through mobile devices and through fixed Web positions), the student interface building (through mobile devices as cellular telephones, PDA, Smart-phone etc.) and the administrative interface building, for example for the creation of authorized teachers and students.

b) Creation of the test databases organized in atomic sets of different kind of requests (multiple choices, open, closed, fill in gap, building of sentences, problem-solver …). Please notice as the sentences building is applicable to also very different contexts among them, what, to example, the program writing (building of code) and the slang contexts of hypothetical deductive disciplines: in these cases, in fact, we should use words extracted from a predefined vocabulary and verify the respect of detailed set of rules.

c) effectiveness and consistency analysis of the databases produced to the previous point through the application of "item analysis specifications" (on real cases)

d) Management of the various assessment processes. The distinction of the evaluation moment affects the management, for example, the choice of questions to be submitted to each student.

e) system evaluation which allows to make experimentations on the principal platforms which at present the more diffuse PDA computers equip on the market. We intend to experiment the project using different student groups, for example in "Programming" course (Laurea Triennale in Scienze dell'Informazione, Cesena) and "Artificial Intelligence and E-learning" (Laurea Specialistica in Informatica, Bologna).

5 Adapting a Learning Management System to Infomobility

As already mentioned, a rather complex information system is needed in order to support the experimentation of any tool or technique of m-learning,. The role of such system includes distributing didactic material, user identification and authorization, gathering of data relative to the user-system interaction, provisioning of mobile services etc. The objective of the project is to obtain an unified platform where the various actors can use different communication services, both mobile and not. In this regard, e-learning systems in general, and more specifically Learning Management System, are by now a vital component in the distance educational field. We have to integrate LMS with two different classes of processes:

- on one hand, processes connected with the administrative (back-office) activity of a faculty (like registering exams, programming the teaching activity, theses management, bookkeeping of the lecture hours, faculty marketing etc.: all such processes have important overlaps with processes managed by an LMS.

– on the other hand, technology evolution has pushed toward a strong mobility of all the actors, and has furnished mobile devices (PDA, pocketPC, cell-phones, smartphones, tablet-pc) that accompany the user in every day's life. Such tools can become additional terminals for a LIS, because they allow all actors (students, teachers, secretaries, dean, tutors, administrative personnel etc.) to stay in touch with the LIS wherever they are.

The number of possible applications is huge: for instance, the possibility for the administration to communicate in real time with students equipped with such devices, new forms of collaboration among students and teachers within an University course, the chance for the students to interact among them regarding the courses etc. The focus moves therefore from a system that is based on "offering courses" into a system based on the idea of "virtual community". A virtual community is a highly generalized collaboration space. In such way, a course given by a teacher, a seminar, the group of students preparing their thesis with the same teacher, students working together on a project, etc. are all instances of virtual communities. A LIS becomes a computer-based tool that gives services to virtual communities, and must be adapted to the specific needs of each particular community. We already built, over several years, a community-oriented learning portal. Starting from this existing background, we intend to experiment various ways to support collaboration among users interconnected by mobile technologies through the already active portal based on our LIS.

The adaptation of the Learning Information System to info-mobility will need different steps:

a) Extension of the traditional functions of a Learning management system to the mobile-computing needs required by the project. This will imply the creation of teacher-system-student interaction tools mainly based on SMS messages concerning the activities of these actors in the system. Moreover, the portal will provide an access point to the system's actors, in order to download the educational material and the self-evaluation tests produced according to the objectives of the project. Besides, different structures will be created to support the research activities, like forums usable via mobile technologies, mailing lists for the various users, management of some virtual communities (students enrolled in a course, participants to laboratories etc.).
b) Distribution of the educational material specifically created for the fruition on mobile equipment. This will regard both the educational materials and the self-evaluation tests created in point c)
c) Integration of the self-evaluation system into the LIS. This system will allow conducting tests on the main platforms that currently equip the most widespread PDAs on the market. The choice of producing self-evaluation applications for both the PDAs environments is because we want to extend as much as possible the experiment, and most of all we want to create a self-assessment mechanism that must be generalized as much as possible with respect to technological platforms, due to the extreme volatility of the market.

As regard as the development of the systems, we decided on which devices to concentrate our development. This is a very important issue, as the market is continuously changing with new products emerging everyday. So, it is practically impossible to have a general mechanism for involving all possible devices currently available. We found the following devices useful for our experimentations:

- GSM/GPRS cellular phones
- PDA
- Smart-phones
- UMTS telephones
- Tablet PCs

The platforms have been already found in their main components. These platforms will be the ones based with Symbian OS on one side (this means to involve the whole cellular phones market with the biggest world producers), and on the other side the platforms equipped with Windows CE, i.e. the PDAs that present points of contact with the Windows desktop environment in terms of applications and working environment. We will also experiment with the Palm OS, so that our experiment will cover a very large share of the market. In the first step of the project, however, the choice made on some Microsoft™-dependent PDAs is related mainly on the consideration that most of the educational material is currently published in Microsoft™ software tools, especially PowerPoint and Word. In this sense, a device equipped with Microsoft™ operating systems will facilitate the interchange of educational material already available. However, the modular structure of the approach followed in the building of web services based on XML and SOAP will provide a sufficient grade of extensibility of our mobile platform to other PDAs, like those that are equipped with Symbian OS.

The test of the system will consist in some lessons conducted using Learning objects distributed using the LMS and used by students and teachers using PDAs, traditional viewers (like PowerPoint and Acrobat Reader) and other available mobile devices. Part of these educational materials will be available only through mobile devices: students will have to learn studying only on PDAs. In this way, different groups that have studied on different devices with different approaches will be available for our research: those who followed face-to-face lessons, those who studied on learning objects without following the lessons and those who studied on mobile devices. By creating a specific and calibrated set of tests, we want to verify the level of learning of the single groups, by analyzing the differences and the relative motivations. The results of these tests will be matched with the results of the self-evaluation tests distributed to the students, in order to verify thoroughly the level of learning reached by the students. The reactions of the students will be also analyzed, especially those related with problems in studying with a new but limited tool like a portable device. For this purpose, a forum on the web will be specifically activated, and some tutors will be available in order to help students with practical or technical problems.

As regarding the use of specific tools available with mobile technology, the most evident problem we faced in the design phase was the choice of the technology by which building the tools provided to the client in order to use our services. The current project provides ten different classes of services to mobile users, but in order to simplify the choice, we decided to concentrate initially on two different services for mobile devices:

- The management of SMSs sent by teachers to students or by administrative staff to teachers and students when particular events happen (meetings, reminder for expiration dates etc.)

- The consultation of a common agenda (we call it organizer) that will be available on the mobile device and will keep all the important dates for the actor (mainly students and teachers)

The first service is quite simple to build but not so easy to manage, if the LMS that operates behind the scenes does not have all the information needed. The main problem has been found in allowing the right person to send and receive SMSs, and in granting this permission inside correct boundaries, in terms of number of SMSs sendable by the user. The second service is under development and is more complicated, as it involves one of the most difficult task to manage inside a LMS, i.e., time management. We are currently building a system that allows students and teachers to connect with their mobile device and consult their agenda, dynamically built with all the events that could happen during a normal university activity. This implies a great effort of abstraction and integration between the LMS platform and the mobile devices. We have evaluated five different alternatives to build the interaction between the PDA (the platform chosen for the experimentation) and the central database. The problem is related to the way the client (the PDA) interrogates the remote server module requesting the update of the events since last connection. These are the alternatives we evaluated and tested, from the simplest to the most complicated:

- Using the embedded browser of the PDA to navigate through the web pages that web users will see using the traditional browser available for desktop PCs. This is the simplest solution, both for the users and for the development team. Only a particular attention to screen adaptation is necessary, in order to concentrate the most important information on the left-uppermost part of the screen and to avoid the necessity of frequent scrolling. The web page will be created using device-specific tags and languages, like the .NET™ mobile toolkit, in order to navigate through the data available on the server. However, we decided not to follow this solution as the primary one, because of the necessity for the user to be constantly connected to the Internet to navigate through the organizer, thus requiring permanent connections (like WI-FI settings) or a significant expense for the students and the teachers when connected to the net using GPRS technology. In Italy this solution is very costly at the moment, and WI-FI technology with wireless LAN is still in its infancy. Other short-range connection solutions have been abandoned, as we want this service to be used outside the campus.
- Using a client database application, built specifically for mobile devices, that interrogates the server DB through the internet, synchronizing the data on the mobile device. This is a proprietary solution bounded to the back-end DB used and the availability of a Internet connection on the PDA, that requires also quite complicated settings from a end-user perspective. However, from our tests, this solution has the advantage of dramatically boosting performance, thus reducing connection times.
- Synchronizing the PDA with the central database and the agenda of the user by using cradles and database synchronization: this solution will solve a lot of issues, but creates a problem in terms of cradle availability around the campus, and especially the problem of supporting different cradles for different models of PDA.
- Building a client/server application in which the client (on the PDA) uses traditional RPC/RMI mechanisms to invoke server methods in order to receive data. This has the advantage of requiring short-time connection to the central system,

and could be personalized to the PDA device. The disadvantage of this solution is the proprietary mechanism of communication between server and client, and also the necessity of using particular TCP/IP – UDP ports that could complicate the management of security on the server side due to firewalls.

- Building a web application that request a web service through the use of XML/SOAP messages to the server. This is the best solution we found, as it provides the access in short time to the central database through the use of open technology like XML/SOAP, will use a port that is already opened for web access, and finally will guarantee the extension of the client part to other PDAs simply by creating the new client interface to the web service. We will therefore provide the agenda synchronization through a web service that will recognize the user, verify the state of his/her agenda, and will send an XML-formatted packet of data regarding last events in the system. The client side of the application, specific for the device, will format this data for the display: after that, the connection with the server will be closed and the navigation on the agenda will be completely off-line.

References

1. Waycott J., *An Investigation into the Use of Mobile Computing Devices as Tools for Supporting Learning and Workplace Activities* , 5th Human Centred Technology Postgraduate Workshop (HCT-2001), Brighton, UK, September 2001, available online at http://www.cogs.susx.ac.uk/lab/hct/hctw2001/papers/waycott.pdf
2. Roibás A.C., Sánchez I.A., *Design scenarios for m-learning*, Proceedings of the European Workshop on Mobile and Contextual Learning, pp. 53-56, Birmingham, UK, June 2002
3. Rogers T., *Mobile Technologies for Informal Learning – a Theoretical Review of the Literature*, Proceedings of the European Workshop on Mobile and Contextual Learning, pp. 19-20, Birmingham, UK, June 2002
4. Dvorak J. D., Burchanan K., *Using Technology to Create and Enhance Collaborative Learning*, Proc. of 14th World Conference on Educational Multimedia, Hypermedia and Telecommunications (ED-MEDIA 2002) , Denver, CO, USA, June 2002
5. Kukulska-Hulme A., *Cognitive, Ergonomic and Affective Aspects of PDA Use for Learning*, Proceedings of the European Workshop on Mobile and Contextual Learning, pp. 32-33, Birmingham, UK, June 2002
6. Waycott J., Scanlon E., Jones A., *Evaluating the Use of PDAs as Learning and Workplace Tools: An Activity Theory Perspective*, Proceedings of the European Workshop on Mobile and Contextual Learning, pp. 34-35, Birmingham, UK, June 2002
7. Keegan D., *The future of learning: From eLearning to mLearning*, available online at http://learning.ericsson.net/leonardo/thebook/book.html
8. Trifonova, A and Ronchetti M,. *Where is m-learning going*?, in Proceedings of E-Learn 2003, Phoenix, Arizona, USA November 7-11, 2003.
9. Trifonova, A., *Mobile Learning - Review of the Literature*, DIT Technical Report DIT-03-009, available online at http://eprints.biblio.unitn.it/archive/00000359/01/009.pdf
10. *Mobile Learning Explorations at the Stanford Learning Lab: A newsletter for Stanford academic community*, Speaking of Computers, Issue 55, January 8, 2001, available on line at http://acomp.stanford.edu/acpubs/SOC/Back_Issues/SOC55/#3
11. Trifonova, A, Knapp, J., Gamper, J. Ronchetti M., *Mobile ELDIT: challenges in the transition from an a-learning to a m-learning system,* in printing, University of Trento
12. HandLeR project web site: http://www.eee.bham.ac.uk/handler/default.asp

13. Ketamo H., *mLearning for kindergarten's mathematics teaching*, Proc. of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2002) , pp. 167-170, Växjö, Sweden, August 2002
14. Stone A., Briggs J., Smith C., *SMS and Interactivity – Some Results from the Field, and its Implications on Effective Uses of Mobile Technologies in Education*, Proc. of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2002) , pp. 147-151, Växjö, Sweden, August 2002
15. Stone A., Briggs J., *ITZ GD 2 TXT – How to Use SMS Effectively in M-Learning*, Proceedings of the European Workshop on Mobile and Contextual Learning, pp. 11-14, Birmingham, UK, June 2002
16. Seppälä P., *Mobile learning and Mobility in Teacher Training,* Proc. of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2002) , pp. 130-135, Växjö, Sweden, August 2002
17. Garner I., Francis J., Wales K., *An Evaluation of the Implementation of a Short Messaging System (SMS) to Support Undergraduate Students*, Proceedings of the European Workshop on Mobile and Contextual Learning, p. 15-18, Birmingham, UK, June 2002
18. Divitini M., Haugalokken O. K., Norevik P., *Improving communication through mobile technologies: Which possibilities?*, Proc. of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2002) , pp. 86-90, Växjö, Sweden, August 2002
19. Sariola J., Sampson J. P., Vuorinen R., Kynäslahti H., *Promoting mLearning by the Uni-Wap Project Within Higher Education*, Proc. of International Conference on Technology and Education (ICTE 2001), available online at http://www.icte.org/T01_Library/T01_254.pdf
20. Sariola J., *What are the limits of academic teaching? - In search of the opportunities of mobile learning*, TeleLearning 2001 Conference, Vancouver, Canada, available online at http://ok.helsinki.fi/tekstit/Article.rtf
21. Sariola J., *What Are the Limits of Academic Teaching? – In Search of the Opportunities of Mobile Learning*, available online at http://ok.helsinki.fi/pdf_tiedostot/mobileEN.pdf
22. Seppälä P., Sariola J., Kynäslahti H., *Mobile Learning in Personnel Training of University Teachers*, Proc. of IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE 2002) , pp. 23-30, Växjö, Sweden, August 2002
23. Traxler J., *Evaluating m-learning*, Proceedings of the European Workshop on Mobile and Contextual Learning, pp. 63-64, Birmingham, UK, June 2002
24. Collett M., Stead G., *Meeting the Challenge: Producing M-Learning Materials for Young Adults with Numeracy and Literacy Needs*, Proceedings of the European Workshop on Mobile and Contextual Learning, pp. 61-62, Birmingham, UK, June 2002
25. Steinberger C., *Wireless meets Wireline e-Learning*, Proc. of 14th World Conference on Educational Multimedia, Hypermedia and Telecommunications (ED-MEDIA 2002) , Denver, CO, USA, June 2002
26. Figg C., Burston J., *PDA Strategies for Preservice Teacher Technology Training*, Proc. of 14th World Conference on Educational Multimedia, Hypermedia and Telecommunications (ED-MEDIA 2002) , Denver, CO, USA, June 2002
27. Casadei G., Magnani M., *Assessment strategies of an intelligent learning management system*, accepted for publication in "International Conference on Simulation and Multimedia in Engineering Education, 2003" conference proceedings
28. A'herran A., *Integrating a course delivery platform with information, student management and administrative systems*, in Proc. EDMedia 2001, Tampere, Finland, June 25-30 2001
29. Hall B, *Learning Management Systems. How to Choose the Right System for your Organisation*, Brandon Hall, 2001

30. McMahon M., Luca J, *Courseware Management Tools and Customised Web Pages: Rationale, Comparisons and Evaluation*, Proc. EDMedia 2001, Tampere, Finland, June 25-30 2001
31. Hanna, D. E., Glowacki-Dudka, M. & Conceicao-Runlee, C., *147 Practical tips for teaching online groups: Essentials of Web-based education*, Madison, WI: Atwood Publishing.
32. Aggarwal, A. *Web-based learning and teaching technologies: Opportunities and challenges*, Hershey, PA: Idea Group Publishing 2000.
33. Colazzo L., Molinari A. *From Learning Management Systems To Learning Information Systems: One Possible Evolution Of E-Learning*, in Proc. Communications, Internet and Information Technology (CIIT) Conference, St. Thomas, USA – November 18-20, 2002
34. Huba, M.E. & Freed, J. E., *Learner-centered assessment on college campuses. Shifting the focus from teaching to learning*, Needham Heights, MA: Allyn & Bacon.
35. Dalziel, J. R., & Gazzard, S., *Beyond Traditional Use of Multiple Choice Questions: Teaching and Learning with WebMCQ Interactive Questions and Workgroups. Open, Flexible and Distance Learning: Challenges of the New Millennium,* Collected papers from the 14th Biennial Forum of the Open and Distance Learning Association of Australia, pp.93-96. Geelong: Deakin University.