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FRAMING THE THEORETICAL AND TECHNOLOGICAL CONTEXT OF MLEARING ENVIRONMENTS – ISSUES AND CONCERNS

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FRAMING THE THEORETICAL AND TECHNOLOGICAL CONTEXT OF MLEARING ENVIRONMENTS – ISSUES AND CONCERNS

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Abstract

The development and adoption of wireless technologies is rapidly increasing around the globe. The use of mobile, portable, and handheld devices is gradually embraced across every sector of education. Based on these phenomena, mobile learning (mLearning) has a growing visibility and significance in an attempt to offer functionalities and alternative support to the pedagogical approaches and teaching strategies, for enhancing the learnability process and satisfaction of individuals. Even though there are various potentials and opportunities like anytime, anyhow and at any place access on content, collaborative learning settings, personalized and interactive environments, guided and efficient learning engagement through multimedia intelligent environments, etc., the concerns and hindrances for ubiquitus, transparent and secure development of mLearning applications and systems are still numerous. These problems could be generally percieved as conceptual, that is the challenge of developing consistent interdisciplinary user-centric models based on the unique individual/learner needs, psychological (social, cognitive, and affective) intrinsic characteristics, and the conventional pedagogical models and teaching approaches; and technological, where the constraints (like memory limitations, small screen sizes, restricted computational power, limited battery life, small storage capacity, wireless networks instability, insufficient protocols standardization, etc), are still in place. In this regards, main scope of this paper is to review key theoretical and technological considerations of mLearning, that could lie under the overarching terms of human factors, context, activity, and educational technologies classification.

Keywords: mLearning, Human Factors, ICT, Context-aware, Activity-based, Personalization.

1 INTRODUCTION

MLearning figures as one of the emerging concepts in the current dynamic digital era since academics, and educationists in general, are employing this information and communication technological challenge to their practices. The term mobile learning (mLearning) refers to the use of mobile handheld IT devices, such as Personal Digital Assistants (PDAs), mobile telephones, laptops and tablet PCs, in teaching and learning. In this regard, learners nowadays are able to learn anywhere and at any time, enabled by mobile technologies and wireless internet connections, accessing materials online via mLearning management systems and intelligent tutors, or using offline learning materials downloaded to their PDA/phones. In many cases the development of mLearning context-aware applications and systems constitutes an interdisciplinary academic subject, and most approaches derive from the fields of Computer Science and/or Psychology, as a result of combined efforts to improve the effectiveness of Web-based education. The context of learners may be constituted from time, location, and activity-based patterns during interaction and learning processes, as well as from intrinsic and psychological characteristics, such as learner's information processing abilities and state-like cognitive and affective parameters.

Today's consensus that computers, portable devices and internet are broadening the scope and potentials of administration, organization and support of educational methodologies (i.e. affordable, effective, ease of use), has created new opportunities of content delivery, teaching tools, and teaching approaches/strategies. Some of the main benefits are summarized as: Learners can interact with each other and with their practitioners more efficiently in a common collaborative learning environment, exchanging notes and assignments in a real time mode (benefited by the technological advancements, such as wireless networks and/or infrared functionalities) increasing decision making in a given learning task; Mobile devices are much easier to be installed in a classroom setting than desktop computers (i.e. the approved governmental funding schemes and attempts recently to install iPad devices in various schools in United States, substituting the old PCs); PDAs and/or tablets are more convenient to hold notes and e-books are lighter than textbooks, files or even laptops; Handwriting with stylus pen is more intuitive than using keyboard and mouse; Mobile devices can be used anywhere and anytime, as well as be personalized given the needs, requirements and perceptions of a user, increasing the familiarization and engagement during the learning process; while last but not least, this technology may contribute to the digital equality, as it is generally cheaper than desktop computers.

However, building intelligent applications and smart solutions (i.e. promote reflection on individuals' evolving knowledge and misconceptions, and to increase their understanding of the learning process more generally – Cheverst et al., 2003) on mobile/handheld devices could be considered as not an easy task, but rather as a time consuming and conflicting procedure. This realization could be supported by various technological and conceptual constraints, such as: The non-reliable connections, due to uneven coverage of the wide areas (or fluctuations on the bandwidth capacity based on usage); The limited screen size of such devices, making it difficult to design user interfaces that provide the range of functionality needed to support users in their tasks (as in conventional desktop screens); The limited storage capabilities (i.e. to keep the demanding multimedia objects used in eLearning environments nowadays); The limited life-time and variability of the batteries (may lead to disruptions in the learning process and/or loss of content, if there is a malfunction or there is not the possibility of immediate re-charging); The lower computational power may restrict the use of complex models and representation content schemes, such as moving graphics (although 3G and 4G technologies eventually allow to overcome this problem); The reduced robustness of such devices, compared to desktop computers, may restrict the implementation of complex algorithms and secure routines (especially when building adaptive mLearning environments where the resources and processes are more demanding.); and so on.

Henceforth, according to the scope of the research that is included in this paper, the main goal is to review some overarching theoretical and technological insights and considerations for building

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transparent and interoperable mLearning environments and applications. Main components of such systems are the device, data and users' models that have to be integrated under a common architecture and ensure provident and continuous information flow, despite the frequent interruptions in connections caused by the mobility of the individuals/learners, as well as effective presentation and support of the learning content adapted to the unique perceptual characteristics and demands of the users.

2 DEFINING MLEARNING

The availability of advanced mobile technologies, such as high bandwidth infrastructure, wireless technologies, and handheld devices, has started to extend eLearning towards mLearning (Sharples, 2000). This phenomenon fits well with the new paradigm "anytime, anywhere computing" (Lehner & Nösekabel, 2002). Research in the mLearning area is really flourishing in the last decade, revealing many opportunities and limitations of employing such platforms and techniques in the delivery and monitoring of knowledge. Comparing the definitions and characteristics of mLearning we could understand that most of them are lying under some mutually accepted consideration with regards to the design and implementation of mLearning applications (Naismith et al., 2004). Generally, we could acknowledge that mLearning belongs to wireless learning and has two main interpretations; the first one emphasizes to the fact that learning is achieved through mobile devices and the other one focuses on the different location factor. One of the many definitions states that mLearning is the learning which occurs in different locations and uses the educational opportunities offered by mobile technologies. Therefore, mLearning uses the portability of mobile devices to lessen the restrictions regarding location that existed so far during the learning procedure. Having in mind a variety of definitions and perspectives concerning mLearning, we conclude that it involves learning through mobile technologies in a constant location. Moreover, the term implies learning which takes place in different locations interacting with mobile or immobile technology, stressing the mobility of the learner. Finally, mLearning includes learning in a "mobile" society, emphasizing the contribution of peers to the learning procedure (Ally, 2009).

2.1 Different views of mLearning

Although the main goal of researchers dealing with mLearning is the enrichment of education through mobile technology, there are many perceptions regarding the exact meaning and purpose of mLearning. Many researchers claim that mLearning is the answer to the question: "Is life-long learning possible in our busy lives?" These views highlight mLearning as the natural way of learning, since it enables learners to identify and evaluate their environment and then recur to standard definitions on the spot. They consider mLearning as a general term which redefines education/learning, locating it outside educational institutions and inside the natural environment (Kukulska-Hulme & Traxler, 2005). From another point of view, mLearning is available as a tool which can aid education/learning as we realize it today; within educational institutions. MLearning is referred as a new way of learning which aims to enhance learning inside educational institutions and is inextricably linked with this kind of learning. This group considers mLearning as a non-autonomous way of learning, part of other supporting ways of learning, such as eLearning. The following definition of Quin (Quin, 2002) is illustrative: "MLearning is eLearning through mobile computational devices". Despite the disagreements regarding the meaning and purpose of the term mLearning, there are mutually accepted definitions which determine the type of systems that fall in the mLearning applications' category.

2.2 A Generic mLearning Environment

Given the theoretical complexity, technological dynamicity and constraints, researchers involved with mLearning need a common way of checking progression and evaluating mLearning systems. As noted in (Keegan, 2005), there is a general model of wireless learning environment depicted in Figure 1.

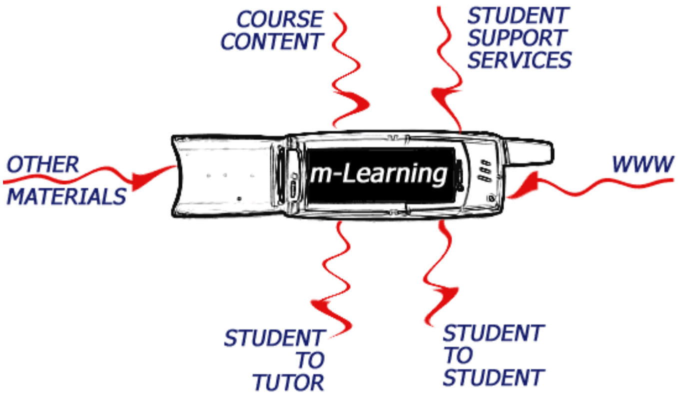

Figure 1. Wireless Learning Environment Model

The wireless learning environment according to this general model includes the course content, the World Wide Web (WWW), student support services, student to student communication, student and tutor interaction, and other material relating to the course content. Although this environment uses educational terms and implies the existence of a tutor, it can be easily generalized for learning outside educational institutions. The evaluation of the above mentioned model is based on the six major dimensions of distance education (Keegan, 2005, 2002). These dimensions are: a) The provision of course content to off-campus students, b) The provision of feedback to off-campus students, c) The provision of student support services to off-campus students, d) Links to the WWW and other resources, e) Student-to-student interactivity and f) Student to tutor and institution interactivity. The model in Figure 1 considers all of the six major dimensions, but the fulfillment of the necessary criteria is not ensured for every system following this model. In order to evaluate the operation and functionality of mLearning systems following this model, we consider four established parameters. These parameters consist of: a) Student user friendliness of the system, b) Didactic effectiveness, c) Technical feasibility, whether the system is easily transferred to other mobile devices and d) Cost effectiveness (Anani et al., 2008).

3 THE IMPORTANCE OF CONTEXT, ACTIVITY AND HUMAN FACTORS IN MLEARNING

In mLearning, users are able to learn at any time and at any location by using mobile devices. As a result, the different learning contexts that an individual is found in each time create a dynamic learning setting in the mLearning environment. For this reason, context-aware mLearning has become critical in an effort to identify the contextual parameters of mobile environments and to adapt on the changing context during a student's learning process. According to Dey (2001), "context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves"; Schmidt (Schmidt et al., 1999) depict context as a three dimensional construct, including the dimension of self (device state, physiological, cognitive). Contexts in mLearning have been categorized by Wang (Wang, 2004) into six dimensions: Identity, spatio-temporal, facility, activity, learner, and community.

However, there is a number of context-aware challenges identified for mLearning. Schmidt (Schmidt, 2005; Yau & Joy, 2006) refers to three challenges associated with context-awareness: (a) Context is difficult to identify – there is not a defined set of elicitation methods for obtaining context factors; (b) context is difficult to acquire – the challenge lies within the question of how to obtain the actual information about the user, once the relevant context features have been identified; and (c) context is difficult to make use of – If and how learning efficiency can be improved with context-awareness is not known. Context-aware learning support requires pedagogical theories and methodologies as its foundation.

3.1 Activity-based mobile learning practices

Even though there is an indicated lack of mLearning theories it is sufficient that many efforts try to formulate grounds for their development. Most existing reviews of mLearning have been concerned with the use of technologies to address specific curriculum areas. The following review (Naismith et al., 2004), takes an activity-centered perspective, considering new practices against existing theories. Given the dynamic change of learners' context, the identfication of the appropriate learning activity at each stage of the learning process and task engagement is considered of increasing importance in order for the mLearning systems to react and support individuals' accordingly; maximizing their information assimilation and satisfaction. This literature review reveals six broad theory-based categories of activity: (a) *Behaviourist* – Activities that promote learning as a change in learners' observable actions. The learning should invoke a stimulus and a response. In the case of m-learning, an SMS message, for example, invokes a stimulus which may lead to an action as a response; (b) *Constructivist* – Activities in which learners actively construct new ideas or concepts based on both their previous and current knowledge. With a mobile phone learners can construct their own knowledge and share it freely with peers at anytime in any place; (c) *Situated* – Activities that promote learning within an authentic context and culture. Situated learning posits that learning can be enhanced by ensuring that it takes place in an authentic context. Mobile devices are especially well suited to context-aware applications simply because they are available in different contexts, and so can draw on those contexts to enhance the learning activity. The museum and gallery sector has been on the forefront of context-aware mobile computing such as the systems Ambient Wood (Rogers et al., 2002) and MOBIlearn (Lonsdale et al., 2004); (d) *Collaborative* – Activities that promote learning through social interaction. Collaborative learning is based on the role of social interactions in the process of learning. Mobile devices can support mobile computer-supported collaborative learning by providing another means of coordination without attempting to replace any human-human interactions. Alternative interaction ways are the online discussion boards which are provided from a number of mLearning systems (Zurita et al., 2003); (e) *Informal and lifelong* – Activities that support learning outside a dedicated learning environment and formal curriculum. Research on informal and lifelong learning recognises that learning happens all of the time and is influenced both by our environment and the particular situations we are faced with. Informal learning may be intentional, for example, through intensive, significant and deliberate learning "projects", or it may be accidental, by acquiring information through conversations, TV and newspapers. Such a broad view of learning takes it outside the classroom and, by default, embeds learning in everyday life, thus emphasizing the value of mobile technologies in supporting it; and (f) *Learning and teaching support* – Activities that assist in the coordination of learners and resources for learning activities. Education as a process relies on a great deal of coordination of learners and resources. Mobile devices can be used by teachers for attendance reporting, reviewing student marks, general access of central school data, and managing their schedules more effectively. Examples of using mobile technologies in this context include a mLearning organizer which has been developed by Holme and Sharples (Holme & Sharples 2002).

3.2 Personalization and Adaptation of mLearning systems classification

In the same theoretical direction, many researchers have focused on content adaptation techniques and methods to provide users with personalized information in mLearning environments (Brusilovsky & Neijdl, 2004; Germanakos et al., 2010). The main goal of these systems is to take into account the heterogeneous characteristics of users and to improve the comprehension of content. There are three main types of these systems, classified according to their adaptation techniques:

(a) *Adaptation based on mobile device characteristics*. This adaptation approach is device-centric; it uses the mobile device's specific characteristics, like resolution analysis, data entry methods and the type of search engine it uses. Before content presentation and based on the device's characteristics, part of the content is altered in order to match with the device. The most common technique of this approach is the alteration of image types (.jpeg, .gif) and their size;

(b) *Context-awareness*. Throughout the learning procedure, context-aware systems monitor and sense the environment (location, time) (Panayiotou & Samaras, 2004) altering the content accordingly.

A paradigm is to recommend users with nearby restaurants based on their location and time of day (lunch, dinner etc.); and

(c) *User-centric adaptation*. User-centric adaptation systems take into consideration users' personal characteristics (Tretiakov & Kinshuk, 2008; Kinshuk, 2004; Brusilovsky, 2001; Germanakos et al., 2008), like learning and cognitive styles. These values are stored in users' profiles which are created either dynamically – the system analyzes users' navigation patterns while they navigate over the information space and based on various techniques and methods, their profiles are dynamically constructed; or statically – users' explicitly define their characteristics, through i.e. on-line questionnaires.

Henceforth, one of the key issues is the notion of adaptivity that allows the meaningful use of context related information in the area of individual differences. The function of adaptivity may as well be considered as a level of intelligence embedded in a mobile environment, regardless of whether users' or interface/technical characteristics are involved. A certain form of mapping rules and corresponding implications on the information space are required, in order for a system to alter visible to the user aspects of the environment, utilizing in our case the intrinsic context information. Therefore, a serious analysis of user requirements and characteristics has to be undertaken, documented and examined, taking into consideration their multi-application to the various delivery channels and devices.

3.3 Human Factors Considerations for the Design of Effective mLearning Applications

In more conceptual grounds, the utilization of human factors for constructing learning models, based on which Web-based and mLearning systems can be developed and offer more effective learning content, is a direction that grasps the attention of many researchers in the last two decades. It is an interdisciplinary approach that employs various cognitive and emotional features that can maximize information assimilation, comprehension capabilities, accuracy while searching for particular learning goals, satisfaction and usability, during users' interaction with a computer/mobile-mediated platform. The challenges and constraints are many, and out of the scope of this paper to be analysed, but essentially are converging in two overarching issues; of how can we select a set of human factors that can reach up to an adequate level of optimization and is not conflicting in a given learning setting (given the dynamic nature and behaviours of users), and furthermore how can we best apply these factors on the information space given the available technologies in order to have the desired results and learning impact. Most researchers are emphasizing in the selection of human factors that concern the learning/cognitive styles, visual and cognitive processing, working memory span and emotional processing of users' for building up more personalized and adapted (m-) learning environments.

Cognitive styles represent the particular set of strengths and preferences that an individual or group of people have in how they take in and process information. By taking into account these preferences and defining specific learning strategies, empirical research has shown that more effective learning process can be achieved (Boyle et al., 2003), and that cognitive styles nevertheless correlate with performance in a Web-based (Wang et al., 2006) and mobile environment (Germanakos et al., 2010). Within the context of educational psychology, theories of learning and cognitive styles have been developed, addressing the issue of individual differences in learning, or more specifically, the perception, processing and retaining of information. Cognitive styles have been defined by Messick as "consistent individual differences in preferred ways of organizing and processing information and experience, a construct that is different than learning style" (Sadler-Smith, 2001), while by Sternberg and Grigorenko as "a bridge between what might seem to be two fairly distinct areas of psychological investigation: cognition and personality" (Sternberg & Grigorenko, 1997). Cognitive styles represent an individual's typical or habitual mode of problem solving, thinking, perceiving or remembering, and "are considered to be trait-like, relatively stable characteristics of individuals, whereas learning strategies are more state-driven…" (McKay et al., 2003). *Learning styles*, as a term, are frequently used interchangeably with cognitive styles, but in general are broader concepts that incorporate a greater number of not mutually exclusive characteristics, and focus on learning rather than cognitive tasks (Cassady, 2004). Taking into account individual cognitive and learning styles is of high importance, since such an approach "can lead to new insights into the learning process, a greater knowledge of individual differences, and an expanding repertoire of methods for the teacher" (Banner & Rayner, 2000). Regarding the (hypermedia) information space, amongst the numerous proposed theories of individual style, a selection of the most appropriate and technologically feasible cognitive (and learning) styles (those that can be projected on the processes of selection and presentation of Web and mobile content and the tailoring of navigational tools) has been studied, such as Riding's Cognitive Style Analysis (CSA – Verbal-Imager and Wholistic-Analytical – Riding, 2001), Felder/Silverman Index of Learning Styles (ILS – 4 scales: Active vs Reflective, Sensing vs Intuitive, Visual vs Verbal and Global vs Sequential – Felder & Silverman, 1988), Witkin's Field-Dependent and Field-Independent (Witkin et al., 1977), Kolb's Learning Styles (Converger, Diverger, Accommodator, and Assimilator – Kolb & Kolb, 2005), and Dun and Dun learning styles model (environmental, emotional, physical, social, personality – Dunn and Dunn, 1978), in order to identify how users transforms information into knowledge (constructing new cognitive frames).

Regarding the cognitive processing parameters (Demetriou & Kazi, 2001), main factors that have been investigated are: (a) *control of processing* (refers to the processes that identify and register goal-relevant information and block out dominant or appealing but actually irrelevant information), (b) *speed of processing* (refers to the maximum speed at which a given mental act may be efficiently executed), and (c) *visual attention* (based on the empirically validated assumption that when a person is performing a cognitive task, while watching a display, the location of his / her gaze corresponds to the symbol currently being processed in working memory and, moreover, that the eye naturally focuses on areas that are most likely to be informative). In addition, an important mechanism that determines at a large extent the learnability process is *working memory span*, which refers to the processes that enable a person to hold information in an active state while integrating it with other information until the current problem is solved (Baddeley, 1992).

Emotional processing (a core human factor that determines the competence of learning process) is a pluralistic construct, which is comprised of two mechanisms: Emotional Arousal, which is the capacity of a human being to sense and experience specific emotional situations; and emotion regulation, which is the way that an individual perceives and controls his emotions. Main focus has been placed on anxiety, as the main indicator of emotional arousal, because it is correlated with academic performance (Cassady & Johnson, 2002), as well as with performance in computer mediated learning procedures (Smith & Caputi, 2007). By combining the levels of anxiety with the moderating role of emotion regulation, it is possible to examine how affectional responses hamper or promote learning procedures (Lekkas et al., 2007).

Research works and systems that have been developed incorporating the abovementioned human factors under a common model or in isolation are i.e. ACE (Adaptive Courseware Environment – Specht & Oppermann, 1998) that provides certain mechanism to adapt to student's learning styles; and mAIWeb (mobileAdaptiveInteliWeb – Germanakos et al., 2010), that adapts course content presentation to students' cognitive styles and visual working memory span.

4 CLASSIFICATION OF MLEARNING SYSTEMS

Education via wireless technologies and mobile devices is getting popular worldwide, resulting to the development of many mLearning systems. The wide range of technologies and devices used allow the classification of systems based on various characteristics. The most common classifications are related to Information Communication Technology (ICT) and educational technologies.

4.1 Classification based on ICT

According to the information and communication technologies (ICT) the systems are classified by the type of mobile devices and the type of wireless communication technologies that are supported. One of the technical classifications described in the literature (Naismith et al., 2004) employs two indicators – the portability of the devices and the personal use ability (see Figure 2). We can observe that systems accessed through devices such as mobile phones and laptops can be classified as personal, since they support a single user, and as portable since they can be available in different locations.

Some other technologies, less portable than mobile phones and PDAs, can still offer personal interactions with learning experiences. Classroom response systems, shown in quadrant 2, consist of individual student devices that are used to respond anonymously to multiple choice questions administered by a teacher on a central server. This technology is static in the sense that it can only be used in one location, but remains personal because of its small size and allocation to one single user.

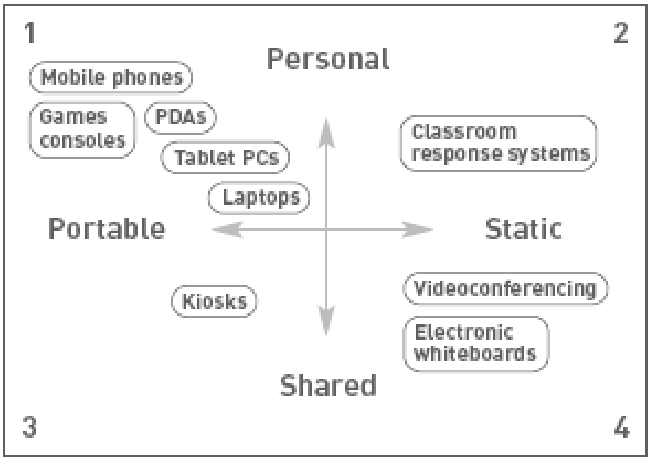

Figure 2: Classification of mobile technologies

Following, there are examples of technologies that can provide learning experiences to users on the move, but the devices themselves are not physically movable. Interactive museum displays offer pervasive access to information and learning experiences, but it is the learner who is portable, not the delivery technology. Such systems are typically seen as being less personal, and are likely to be shared between multiple users. These are shared portable technologies. As noted in (Naismith et al., 2004), only few of the technologies from quadrant 4 are considered as mobile technologies, namely the ones that are not at the extreme end of the "static" dimension.

4.2 Classification based on Educational Technologies

With regards to educational technologies the proposed classification is based on the support of synchronous and/or asynchronous education, eLearning standards, location of the users and the access to learning materials and/or administrative services. By examining each indicator separately we can create groups of classifications based on the corresponding attribute. Given the amount of time teachers and students share information with each other, the mLearning systems can be classified as follows: (a) Systems, which support synchronous education. These systems enable communication between students as well as among students and teachers in a real time environment. Often, voice communication and chat are employed for this purpose; (b) Systems, which support asynchronous education. Using these systems, students cannot communicate in real time with teachers and other students. Usually asynchronous communication is supported, exchanging information via emails and/or SMS; and (c) Systems which support synchronous and asynchronous education.

The second group that uses as a classification indicator the support of eLearning standards (even though at present there are no sufficient, to our knowledge, mLearning specifications and standards) divides systems in: (1) MLearning systems which don't support eLearning specifications and standards. At present, the main modules of most mLearning systems, to our knowledge, belongs to this group (i.e. WELCOME (Lehner et al., 2003), Mobile Education Platform (Guangzuo et al., 2006)); and (2) MLearning systems which support eLearning specifications and standards. To this group can be added some eLearning platforms which have a module for mLearning (like Blackboard).

In (Horstmanshof, 2004) and (Stratmann, 2004) the systems are classified with respect to the ability to support on-line and/or off-line access to the learning materials. Based on this attribute we have three kinds of systems: (a) On-campus systems, which can be accessed inside universities, schools and companies. The typical access to such systems is by using laptop computers or Tablet PCs and via the wireless networks of the educational institutions. The systems Mobilizer and Nanowave (Nanowave, 2009) belong to this group; (b) Off-campus systems, which can be accessed outside of universities, schools and companies. The access to these systems is realized by pocket size computers (PDA), cell phones or smart phones as these devices support long distance wireless communications and offer mobility at a larger extent than laptop computers and Tablet PCs. The University Mobile Portal (University Goes Mobile, 2009) is an example of such systems; and (c) Systems which can be accessed both inside and outside of educational institutions. The main modules of the existing mLearning systems belong to this group - Mobile Education Platform (Guangzuo et al., 2006), WELCOME (Lehner et al., 2003), Mobile ELDIT (Trifonova et al., 2004).

Depending on the access to learning materials and/or administrative services (Brown, 2005) existing systems can be divided into the next three groups: (1) MLearning systems which support access to the educational content – materials, tests, dictionaries. This group includes systems like MobiLP (Chan et al., 2003) and Nanowave (Nanowave, 2009); (2) MLearning systems which support access to the educational administrative services. An example of such systems is Mobile Quest (Leverage, 2009); and (3) MLearning systems which support access to the learning materials as well as to an educational organization's administrative services. A system of this type is WELCOME (Lehner et al., 2003).

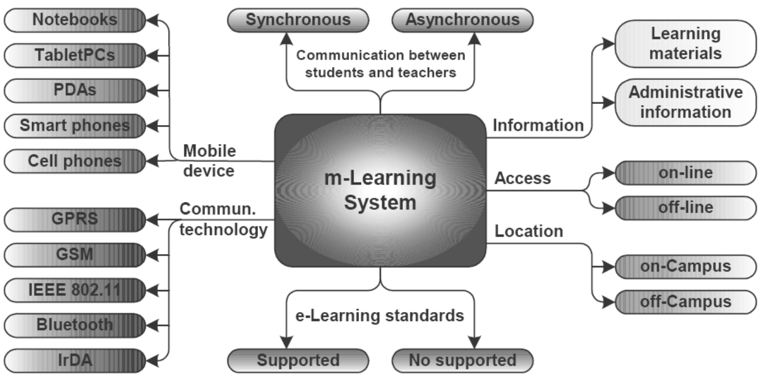

Figure 3: General Model of mLearning Systems

Finally, in sources from literature (Attewell, 2005) and (Rekkedal, 2002), systems are classified with respect to modules that support on-line and/or off-line access to learning materials. Existing mLearning systems can be divided as follows: (1) On-line mLearning systems. These systems require permanent communication between the system and users' mobile devices, i.e. Mobile Quest (Leverage, 2009) and Learner Support System (Learner, 2009); and (2) Off-line mLearning systems. The learning material is uploaded in the users' mobile device thus there is no need of wireless communication between the mLearning system and mobile devices, i.e. University 360 Mobile (University360, 2009) and AgilixMobilizer (Mobilizer, 2009). In systems which support both on-line and off-line mLearning, the access to learning materials is on-line while the access to the remaining materials is off-line (administrative materials initially must be uploaded to the memory of the mobile devices), i.e. Next Move (nextMove, 2009) and Mobile ELDIT (Trifonova et al., 2004).

In an attempt to clarify and generalize the main categories of mLearning systems through mobile devices, a general model (see Figure 3) has been designed that contains also some updates in the aforementioned categories (ICT and educational technologies – Georgieva et al., 2005). With respect to ICT categories, the general model contains PCs and mobile devices (Figure 3, 1st quarter), as well as wireless technologies such as Bluetooth and GPRS. Regarding the educational technologies, the general model contains all the concepts discussed above.

Nevertheless, according to Bull, McEvoy and Reid (Bull et al., 2003), a mLearning environment is not necessarily limited on mobile devices. In many cases mobile devices are useful for mLearning; when the user is moving or has limited time. However, when users do not face these constraints, and a desktop PC can be used, users' might prefer a desktop PC for searching learning material. Therefore, various systems split the learning environments for two different types of devices (C-POLMILE, MoreMaths – Bull & McEvoy, 2003). Combining desktop PC/mobile environments raises a lot of issues because of the heterogeneous devices and mainly the difference in their monitors' size. Is it better to use a unified method of presentation that can be applied in both types of devices, or a method that applies specifically in each type of device? Another issue is the ability to constantly update a learning profile. Is it preferable for users to negotiate, manage or just view their profiles? These issues have been taken into consideration by many researchers and incorporated in many mLearning systems.

5 CONCLUSION AND DISCUSSION

Even though mLearning is perceived as a generic notion, getting different meanings for different users, could be broadly acknowledged as a subset of eLearning, which itself is a subset of education, and has a distinct focus on learning through the use of devices that can be easily carried. As computers and the internet become essential educational tools, the technologies become more portable, affordable, effective and easy to use, providing many opportunities for widening participation and access to ICT. Wireless devices such as mobile phones and PDAs are reasonably priced (compared to desktop computers), and therefore represent a more optimum method (in terms of price and portability) of accessing the internet through wireless networks. The introduction of tablet PCs now allows mobile internet access with equal, if not more, functionality than desktop computers. These facts have motivated many researchers to investigate models and methods that can deliver more efficiently and effectively learning material to individuals supporting the teaching strategies and educational methodologies.

In this regards, this paper investigated the main theoretical and technological considerations, that in combination constitute the two (conflicting many times) ends of a mLearning environment. More specifically, it has overviewed a generic wireless learning environment and elaborated into its six dimensions, that is course content, the World Wide Web (WWW), student support services, student to student communication, student and tutor interaction, and other material relating to the course content. It has also placed special emphasis on the necessity of defining context-aware approaches and the activity-centred perspective, considering six broad theory-based categories of activity that can add value on the design of a mLearning environment. Furthermore, it has outlined the importance of adaptation and personalization issues that could support more efficiently the content presentation and navigation during individuals' interaction with the mLearning environment as well as it has underlined the significance of incorporating the analysis of learners' cognitive and emotional intrinsic values during the design phase of a mLearning system. Eventually, it has classified mLearning systems based on their most common characteristics which are related to ICT and educational technologies.

Nevertheless, the challenges in mLearning that researchers still have to confront with are many and in different levels and dimensions. In this regards, a major challenge in mLearning is to design dynamic personalized interfaces and software enabling easy access to information while being sufficiently flexible to handle changes in a user's context and available resources. Adapting to context, especially location and time, could help improve usability of small-screen interfaces (Brusilovsky, 2001). Various issues are relevant in supporting adaptive mobile access to information: location, connectivity, task, schedule, user type and others. These issues relevance is dependent upon the domain and context of use of the mLearning application and device. While sharing the function of adapting interfaces for information access, different user modeling and adaptation techniques may be suitable in different contexts. Other challenges, open issues and research questions regarding mLearning deployment include: How do we best track/measure information that is sent and received? How do we measure the perceived impact of the tools on learning? How do we integrate mobile learning into a learning management system? How do we determine whether a mobile device is the right tool for a particular objective/activity? Will the mobile tool be truly usable and practical? How may location of the user affect an interaction? How might desktop and mobile PCs be integrated to allow the user to interact with whichever device is most convenient at the time? How do we accurately measure usability and learners' attitudes towards the handheld devices and their provided tools? How efficient are the built-in affordances and knowledge reflective feedback during learners' interaction? etc.

Considering, researchers, these issues and concerns in their optimized approaches could be benefited for the design of mLearning environments that are driven from robust data structures and complex processing schemas encapsulating the diversified and multi-level requirements, for the provision of personalized, consistent and effective mLearning content.

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