SURVEY OF ADVANCED LEARNING SOLUTIONS FROM METHODOLOGICAL AND TECHNOLOGICAL PERSPECTIVES

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ABSTRACT

This paper presents the results of a recent literature survey of the methodological and technological evolution of advanced learning solutions for design and engineering education. In the field of educational methodologies, there is a shift from the conventional, teacher-centered instructional approaches to inquiry-based explorative approaches and constructive approaches, which apply the learning-by-doing principle in various forms and contexts. Our main findings can be summarized as follows: The concepts of distance-learning, electronic-learning, mobile-learning and ubiquitous learning, likewise their goals, methodological approaches, and technological platforms are not clearly distinguished. This leads to a confusion, which we tried to avoid in this paper by applying two distinguishing criteria, namely the level of provided methodological flexibility and the extent of amalgamation of technological heterogeneity. With regards to the enabling technologies, the fast evolving mobile communication and mobile learning infrastructure enjoy significant attention in these days. Researchers are also intensively studying the new educational opportunities offered by everywhere present computational and communication means, such as wearable computers and ad-hoc networks. Our conclusion has been that, though the evolution of advanced learning is triggered by the rapid advancement of the technologies, successful exploitation of the technological affordances requires a conjoint development of the associated educational methodologies.

1. INTRODUCTION: TOWARDS ADVANCED LEARNING SOLUTIONS

The rapid development of media-based information processing and mobile communication technologies is making a large influence on engineering education and training. The educational institutions and programs are supposed to follow the technology trends and adapt to them dynamically. They have to be open and market oriented, and to develop the mentality and capability of learning in a global world. From the aspect of individuals, there has been a need for continuous learning as well as for self-controlled personal efforts towards acquisition of new knowledge or competences. It has become clear that in order to cope with the above main challenges, both dedicated technological innovations and methodological reconsiderations are needed. Successful exploitation of the relevant technologies and development of efficient

educational methodologies also requires fundamental changes in our thinking about the daily practice of teaching and learning in the near future.

As for now, the interplay of the enabling technologies and utilization methodologies has resulted in various arrangements and systems that are often referred to as *advanced learning solutions* (ALS). A learning solution is a purposeful combination of coherent technology and methodology towards effective learning under different circumstances. They are also supported by various underpinning theories such as (i) behaviorism, (ii) cognition and (iii) constructivism. Over the years, instructional education has shifted from the objective theoretical basis of behaviorism to cognitivism and constructivism. Both behaviorism and cognitivism support a kind of analytic view by breaking down learning contents and tasks into manageable chunks, establishing objectives, and measuring performance based on them. Constructivism supports a synthetic view, based on the assumption that learners construct their own perspective of the world through individual experiences. Therefore, constructivism promotes a more open-ended learning experience where the methods and results of learning are not easily measured and may not be the same for each learner. The formation of ALSs is also accompanied by the emergence of many new concepts such as learning objects, knowledge networks, and ambient intelligence. The technological advancements and the new educational concepts give floor for new reasoning models, provides additional stimulus for the developments, broaden the spectrum of implementation and application opportunities, and increase the accessibility, efficiency and convenience of learning.

1.1. Proposed categorization of learning approaches

In the framework of an international collaborative research project, called EADIS, we have completed a widely-based literature study with the goal of exploring the new developments in the field of product design and engineering education. Our first observation has been that (i) a huge variety of methodological approaches have been reported upon, (ii) various forms of computer-supported and electronic learning are discussed as overlapping or escalating concepts, (iii) the terms are often used as interchangeable synonyms, and (iv) the proposed and/or studied learning frameworks and practices show a rather complex, if not confusing picture. The overwhelming majority of the published papers are research communications that contribute new concepts and implementations. There were some initiatives for taxonomy and ordering. For instance, Xxx used the term flexible learning to create an ‘umbrella’ category that includes both contact learning and distance learning (, 200x). In the category of distance learning, he identified paper-based distance learning and electronic learning as sub-categories (Figure 1). He considered on-line learning and mobile learning as parts of e-learning.

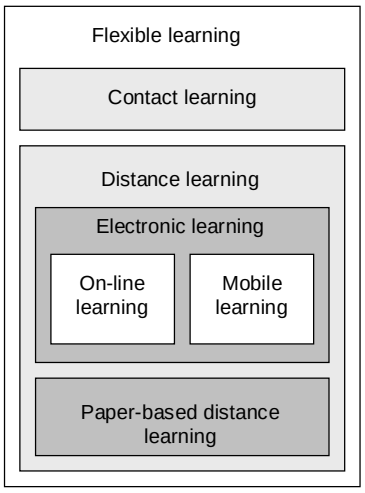

Figure 1 Classification of learning approaches according to xxx ().

Though a couple of survey and review papers have recently been published, there is a strong need for more clarification, structuring, validation and consolidation of the research results. This explains why the objective of this paper has been to consider the technological advancement and the methodological approaches in a systematic manner. In order to reduce the

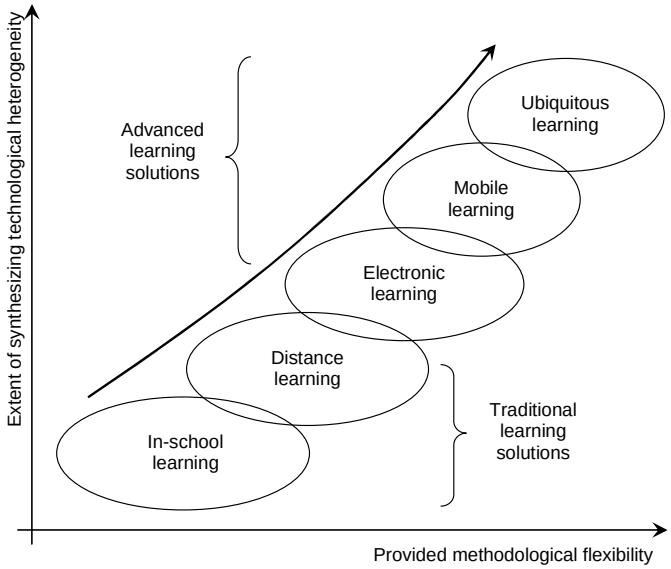

Figure 2 Proposed categorization of learning approaches

terminological and conceptual ambiguity that has apparently been caused by the non-distinguishing treatment of the various advanced learning approaches, we have applied two distinguishing criteria in this paper, namely, (i) *the level of methodological flexibility provided*, and (ii) *the extent of synthesizing technological heterogeneity*. Based on these two factors, we managed to demarcate *classroom learning*, *distance learning*, *electronic learning*, *mobile learning and ubiquitous learning*, as well as their dialects, from each other. We consider the last three as manifestations of ALSs. This is shown in Figure 2. Like the traditional learning solutions, ALSs also share certain features, for instance, the flexible availing of learning contexts, and exploiting the affordances of the pertaining technologies.

1.2. Structure of the paper

The first part of this paper will outline the major methodologies, frameworks and designs of traditional learning solutions. They form the methodological basis of ALSs, but many papers reported on conceptual and implementation issues, in particular, related to application of constructive learning methodology in mobile and ubiquitous learning environments. The second part of the paper will survey the advanced learning approaches, that is, electronic, mobile and ubiquitous learning. They will be discussed from three aspects: (i) main concepts and theories, (ii) technologies and infrastructure, and (iii) application methodologies and experiences. Finally, the goals and conditions of future developments will be considered. Due to the space limitation, we do not deal with commercialized systems, experimental system developments, or application cases.

2. METHODOLOGICAL APPROACHES OF CONVENTIONAL IN-SCHOOL LEARNING

2.1 Instructional learning

Instructionism is a kind of educational application of objectivism and a typical methodological approach of in-school learning, involving lecture halls, class rooms, laboratories, practice rooms and study/library rooms. Instructionism is an education strategy which presumes that learning entails knowledge transfer and submission of learners (Coleman, E. B. et al., 1997). As a methodological approach, instructional education focuses on the knowledge flow from educator to learner, and describes not only what is to be learned, but also how it is to be done. Instructive learning typically involves lectures and demonstrations in which the students play a passive and dependent role. Instructionist approaches have been found more useful for teaching theories and other knowledge constructs than for developing competence and experiences (Reigeluth, C. M.,

1999). The goal of instructional methodology is to improve instruction and comprehension. To this end, it employs teaching methods, processes and study materials that support the intensification of transfer of knowledge by the instructors and of absorbing knowledge by learners.

One way of this intensification is to use computers in education. Instructional technology means integration of computer and network technologies into the curriculum and instruction. Actually, in some approaches, computers do the instruction, which leads into the whole idea of computer-aided instruction and computer-based instructional systems (Reeves, T., 1993). Having many advantages, learning through hypermedia has become a popular form of instructional education. For the time being, successful navigation in hypermedia systems needs the orientation and explanation of the instructor, or else it might lead to disorientation and confusion (Chu, K. et al., 1999).

Although instructional education is proliferating due to the push of computer-based technologies, cognitive and developmental psychologists criticize it for imposing constraints on the dynamic interaction of the learners with the real world while they are constructing their own knowledge. It is also criticized for the inherent constraints and for the dependence on the school facilities. In addition, it has been found that instructional education does not support learning in complex domains and socialized knowledge creation sufficiently. One part of the trouble with instructionist learning is that its goal remains to communicate knowledge by teachers in the most objective and efficient manner (Jonassen, D. H., 1991). Other part of the trouble is that it is not easy to include interactive learning strategies that facilitate the active and interdependent involvement of students on the basis of the underpinning educational theories and infrastructure (Villabla, C. and Romiszowski, A., 2001). This explains why many researchers propose to combine acquisition strategies and participation strategies instead (Sfard, A., 1998).

2.2. Explorative learning

Explorative approaches of learning go beyond posing questions and seeking answers. They stimulate intentional searching for information and knowledge, and support aggregation of domain knowledge based on the development of hypotheses and theories (Paul, H., 1995). It has been observed that exploration embedded in real work context increases the authenticity of the learning tasks and increases the motivation of the learner (Oppermann, R., 2001). In general, what learners do is experimenting, research, discovery, or a combination of these. Methods of empirical and qualitative research have been considered the most effective facilitators for explorative learning, in particular, in university level engineering education. The cognitive interaction between the learners and collaborative groups work has been also activating.

Explorative learning can be further articulated according to the way of implementation, or, in other words, the methods of exploration (Billett, S., 1992). Three typical representatives of this methodology are (i) learning by experiments, (ii) learning through research, and (iii) learning by discovery. In the case of *learning by experiments*, the learners create simplified models of parts of the world, design their own experimental environments, observe and analyze experimental results, and regenerate alternative hypotheses. *Learning through research* is a structured inquiry-based learning, helping the learners formulate research questions and generate knowledge with sufficient rigor. Typically, a structured process is involved proceeding with identification of the problem, forming hypotheses/theories, collecting/analysis of data, and verification and

conclusion. *Learning by discovery* combines experimenting and doing research, requires development of search strategies, investigation of cases, analogies and patterns.

2.3. Constructive learning

The theory of constructivist education explains that learning is a process of construction and confrontation of meaning rather than exploration and memorization of facts. In addition to the making of meaning, it emphasizes the social aspects of learning, interactions with the environment, distributed cognition, and the endeavor of completion (Prawat, R. S. and Floden, R. E., 1994). Constructivism holds that it brings an advantage for the learners if they acquire knowledge by building it from innate capabilities by solving problems in an organized process and in interaction with the environment (Piaget, J., 1973). It assumes the learners constructing knowledge for themselves by creative activities such as planning and design. The *cognitive constructivists* give priority to sensory-motor and conceptual activities of individual learners (Cobb, P., 1994). The *social constructivists* prefer building knowledge by a group of learners in social context (Phillips, D. C., 1995).

Constructive learning represents a learner-centered form of education and manifests in a broad diffusion of approaches of *stimulated active learning*. In the fields of design and engineering, constructive learning involves creative action, and targets both individuals and groups. Form a didactic point of view, the learners involved in stimulated active learning can follow individual learning paths, can act in different functions, but they may also collaborate (or compete) with each other in teams and with other teams. This latter gives the floor to more social interaction and prepares the learners for the challenges posed by working together with unfamiliar individuals, solving complex tasks based on remote cooperation, and other real life situations. They can integrate new knowledge in various ways according to their own mental schema and get immediate confirmation on the appropriateness of the use of this knowledge. This way, they can constantly check the validity of their mental models in the course of inquiry and problem solving. It has been recognized that the constructive methods are working well with learners who have reached the formal operation level of development.

Constructive learning also applies *co-operative learning strategies*, and places emphasis on the development of cohesion, communication, and endeavor. When oriented to a group of learners, it forwards group learning to group functioning (Delson, N. J., 2001). Supported by web technology, collaborative learning enables interaction with distance partners and repositories of data (Sclater, N. et al., 2001). In an ultimate case it creates active learning communities based on virtual communication and course programs developed for multi-cultural study groups (Bodendorf, F. and Swain, P. H., 2001). There are three major forms of constructive learning (i) case-based learning, (ii) problem-based learning, and (iii) project-based learning.

The objective of *case-based learning* is to place the learners in direct contact with the subject matter through practical (real-life) and to facilitate finding information through critical analysis and social communication. Problem-based learning concentrates on (i) better understanding and solving recognized problems, and (ii) motivating learners to achieve better performance (Cheaney, J. and Ingebritsen, T. S., 2005). Project-based learning gives priorities to learning activities that are for long-term, multidisciplinary, and connected to real world issues and practices (Cronjé, J., 2006).

Problem-based learning emphasizes learner-centered learning activities that are long-term, interdisciplinary, and integrated with real world concerns and approaches (Hadgraft, R. G., 1998).

As Schmidt, x. (1993) analyzed, problem-based learning stimulates learning through a number of cognitive areas, e.g., (i) activation of learners' prior knowledge, (ii) elaboration of prior knowledge through cooperative discussions, (iii) restructuring of knowledge to fit the problem presented, (iv) construction of an appropriate semantic network through internal discourse, (v) learning in the scaffolding context of a real-world problem, and (vi) emergence of epistemic curiosity due to relevance of problem.

Various approaches to *project-based learning* have been developed and investigated (Barrows, H., 1986). In the field of product design and engineering, project-based learning is either an artifact synthesis process, or an artifact analysis process. Project-based learning is an adequate pedagogical methodology for design and engineering education since it allows a group of learners to collect, analyze, and synthesize information, develop alternative problem solving strategies, and improve their skills and capabilities. Obvious advantages of project-based learning are (i) the opportunity of collaborating productively in teams, (ii) identifying someone's own strengths and weaknesses, (iii) preparation for problem solving in unfamiliar situations, (iv) enforcing a holistic approach and thinking, (v) reasoning critically and creatively, and (vi) committing oneself to lifelong learning.

2.4. Learners in traditional learning approaches

From the aspect of methodological approaches of traditional learning, an important feature is the learner targeted, which can be an individual (one person), group (team, class, year) and public (communities, segment of population). The philosophy of individual oriented approaches is that learners with different background, interests and capabilities may follow different learning paths adapted to their personal needs (Twigg, C. A., 2002). The philosophy of group oriented approaches puts the dynamic interactions and collaboration of multiple learners into the center and pursues methodologies for a full scale exploitation of the social elements (Barron, B., 2000). Finally, community oriented learning methodologies try to satisfy the learning needs of large segments of the population relying on various public media (,). By combining the methodological approaches with the targeted learners, we can define a kind of topography of the conventional learning approaches. This is presented graphically in Figure 3. We can observe the scarceness of explorative and constructive methodological approaches for direct public education and learning, whereas several methodologies are available for individual and group learning.

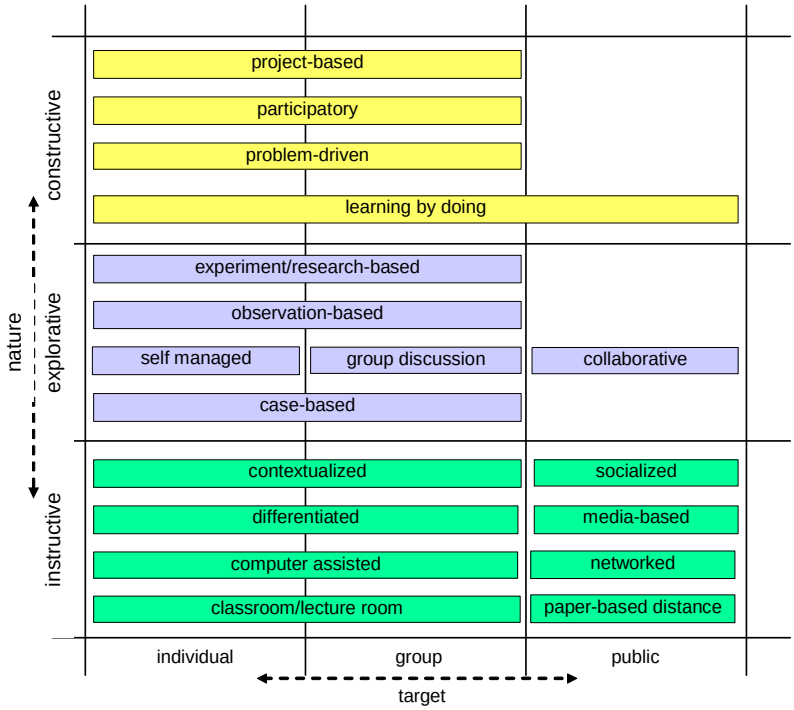

Figure 3 Topography of traditional learning approaches

A further aspect of discussing educational methodologies is form of participation of learners in the learning process. From this aspect we can sort the methodological approaches into the categories of passive and active learning. *Passive learning* methodologies are directed to absorption and imprinting, and establish a short term, educator-centered, and isolated educational practice. Conventional lecture hall and class room presentations are representatives of passive learning set-ups.

Active learning reflects the principles and assumptions of the cognitive and constructivist philosophies. Its typical goals are: (a) substitution of absorption of information with more intensive forms of thinking, (b) engaging the learners in a fast-paced and intuitive learning process and environment, (c) improvement of creative skills, capabilities and competencies, (d) enhancement of experiences and sharing know-how. To achieve the above goals, active learning methodologies applied in design and engineering embed various facilitators such as (i) problem-solving, (ii) systematic inquiry, (iii) task, context and semantics analysis, (iv) creative synthesis, (v) application of equipment, tools and computer programs, (vi) artifact evaluations and experimentation (vii) literature studies and operative research, and (viii) discussion forum and workshop.

In case of active learning, learners are supposed to take a greater responsibility over their own inquiry and learning, and over the organization of what has to be learned or what they prefer to learn. That is, the tasks of self-management, self-motivation and self-critique are delegated to the learners. Learners are, to a large extent, their own educator, and this improves the skills and capabilities needed to extend the existing knowledge, and to apply what they have learnt. As indicated in Figure 3, the fundamental didactic approach of active learning is *learning by doing*. It has several manifestations, which have been described by various, often synonymous, terms such as, self-managed learning, problem-driven learning, project-based learning, networked collaborative learning, and so forth. The supporting technologies can be categorized as conventional and advanced ones (Lowman, J., 1984).

Active learning can involve a single learner or a community of learners with homogeneous or heterogeneous interests in the mind (McConnell, J., 1996). Active learning of a single learner may manifest in a variety of forms, such as collaboration with the educator, multi-media study, and carrying out a personal project. The typical forms of active learning of teams are cooperative problem analysis, team and multi-team projects, or taking part in real life undertakings. Active learning seems to offer better opportunities for learning in the emerging knowledge society, where the dynamics of knowledge is high, and the amount of knowledge is rapidly growing Due to the increasing need for new knowledge, there is a need for flexible life-long learning (LLL) (Oliver, R., 1999). Preparation for LLL involves the development of the attitude and mentality of being interested in new knowledge, of generating innovative ideas, making founded decisions, and the skills needed to co-operate with other people and for solving complex multidisciplinary problems.

3. DISTANCE LEARNING

3.1. Forms of distance learning

Distance learning is a well-established and world wide tested concept (Keegan 1996). In the 1970s, the open universities in Europe were pioneering and gave a leadership in distance learning. Distance education has been defined as “the offering of educational programs designed to

facilitate a learning strategy which does not depend on day-to-day contact teaching but makes the best use of the potential of learners to study on their own" (John, D., 1997). The availability of remote information communication, let alone consider the conventional document mailing, naturally opened the way to participatory education of people, who were constrained in taking part in classroom-based education on a daily basis. The above mentioned form has been called paper-based distance education. Since the early 1980s, personal computers are intensively used to support distance learners to process study materials. These two forms are often referred to as asynchronous (off-line) distance education.

A characteristic of distance learning that it is established based on fixed (non-portable/mobile) technologies. The first generation of infrastructure for *asynchronous distance learning* was physical mailing of pre-recorded lectures or prepared learning materials to individual or group learners, or using public radio and television broadcast programs as instructional media related to public distance education. The second generation infrastructure included digital computers and CD-ROMs or other digital media. The advantage is that learners can study the content and execute learning tasks on their computers irrespective of Internet connectivity.

Nowadays, we are using third generation infrastructure, which involves computer networks and interactive technologies. This infrastructure lends itself to computer network-mediated distance learning, which enables synchronous (on-line) learning for those who are away from the physical school campus. Internet-based distance learning requires learners to have reasonably sophisticated computing facilities and access to fast, reliable networks. On the other hand, Internet and World Wide Web are accessible from virtually all computer platforms. Interactive remote learning makes it possible for learners to schedule their time and progress according to their own learning style. Electronic guides are provided in the form of on-screen helps, workflows and digital workbooks.

On-line distance learning pursues creating a face-to-face interaction, that is, learners can view and interact with the educator(s) over a live feed. The face-to-face interaction between educators and learners is typically based on video- or media-conferencing. Often virtual classrooms or other advanced virtual environments (e.g. academic virtual enterprise) are established. Most distance learning programs include a computer-based training (CBT) system and communications tools to produce a virtual classroom. On computer network, distance learning can happens across school locations, or independent of learners' location. When supported by high-end imaging and virtual presence, the learners may have the same experience with the presentation of the course material as in the case of classroom lecture and may interact with the educator(s) in real time via video conferencing technology. Synchronous distance learning allows recording the learning sessions and lectures which can again be studied at a later time. A lot of research has been done to find out which form of virtual presence is needed, what the most effective solutions are, and how virtual presence influences the educational objectives.

More often than not, off-line distance learning relies on particular implementations of the instructional methodology, whereas on-line distance learning is based on explorative or constructive methodologies (Jonassen, D. H. et al., 1995). Modern approaches to on-line distance learning strongly counts on the active engagement of learners in the construction of their own knowledge, and in the understanding of facts, processes and concepts. Collaboration in virtual learning environments is facilitated by multiple means, such as live communication and file exchange tools, shared electronic whiteboards, etc. The recent development of distance learning

environments is exemplified by various groupware programs or integrated distributed learning environments (IDLEs), such as BSCW, WebCT and Blackboard, that support communal learning.

Virtual classrooms have several drawbacks. They share many of the limitations of the conventional classroom in that they require learners to be online at a particular time. The learning tends to be instructor-led rather than participatory, i.e. involving learners and educators in a two-way communication. This negates one of the major advantages of electronic communication, which is its ability to offer flexible access. Tele-learning activities, teleconferencing and videoconferencing supported interactive remote learning is still costly and the services are not yet available openly in every country. Nevertheless, on a global scale, advanced versions of distance education is the only viable option to meet the escalating worldwide need for LLL by providing wider access, lower costs and greater flexibility.

3.2. Social aspects of distance learning

The distance learning methodologies aims at assisting the students to study wherever they want, and to earn credits and degrees. Three types of models of the learner have been conceived: (i) independent learner, (ii) interactive learner, and (iii) collaborative learner. When distance learning is arranged according to the principles of constructivist learning, communication, social negotiation and collaboration with others learners become important elements of the learning process. Social negotiation means that learners show interest to and inquire about the understanding and views of the others, jointly explore alternative interpretations or possible solutions for problems, and share the commitment to and responsibility of being successful in the learning process. As indicated by xxx ( ), this form of communication requires reflection and introspection for learners to make sense of their experiences. Engagement in real world or authentic tasks anchored or situated in a context enables the learner to construct personal meaning from their experiences.

The various activities of distance learning systems can roughly be sorted in the following categories: (i) course development and design, (ii) production of course contents, (iii) course delivery, (iv) learner administration, support and assessment, (v) evaluation of the course and methods, including cybernetic control, instructional effectiveness and learner performance and; and f) research and evaluation of distance learning systems. Towards optimum outcomes, two forms of guidance have been applied in association with synchronous distance learning, tele-mentoring and tele-tutoring. Tele-mentoring is on-line (virtual) mentoring that focuses on the process of learning and creates helpful, personal and reciprocal relationships between learners and educators who are separated in space and time. Tele-tutoring is concerned with the correct processing of learning contents and is orientated to academic and remedial assistance in a particular area.

Interestingly, Simmons, J., (2001), argued that asynchronous distance learning is being used fundamentally as an economic tool, rather than as a teaching tool. He claimed that the financial benefit of distance learning is gained by replacing the educators with technology. Having developed the course, the contents and methods developers need no longer to be present. Second, on-line courses are not physically limited to the size of a lecture hall. Hence, thousands of learners may simultaneously enroll in a single course. But he also observed that asynchronous on-line distance learning weakens the role of university professors as well as academic freedom by eliminating a large portion of educators, or transforming them into facilitators. Video- or media-conferencing-based synchronous on-line distance learning seems to be a better alternative, though

not without problems. Asynchronous distance learning allows for maximal standardization, and increasing the flexibility of completing the courses and taking the exams.

4. ELECTRONIC LEARNING

4.1. Concepts and theories

Advanced learning approaches have a complex goal of using electronic technologies to create various platforms for flexible learning to intensify the empirical/rational knowledge inquiry and competence development of learners. Electronic (e-learning) is a first stage of the implementation of this concept. However, the concept of e-learning has been variously interpreted and defined by various authors. The different interpretations also reflect different objectives, contexts and levels. From a technological point of view, e-learning refers to enabling and delivering instructional content or learning experiences by electronic (analogue and digital) technology. From a methodological point of view, e-learning means a combination of computer-enhanced learning (training and education) methodologies and knowledge management (information and technology). From an implementation point of view, e-learning can manifest either as local computer learning (using CD-ROMs and other media), or as web-based on-line learning. The latter may have a 'looking outside' view, where the Internet contents is used as an extension of the locally availed learning materials, and a 'virtual contact' view, where the Internet is used to establish channels and share information between various stakeholders of education.

Though the idea of e-learning has been around almost for two decades, many experts believe that it is still in its infancy and the development has not been tested by time (Kahiigi, E. K. et al., 200x). Our literature study explored that part of the current interpretations are strengthening or complementing each others, whereas other part is contrasting or even conflicting. One reason of confusions is that e-learning has many similarities to computer-mediated distance learning. Therefore, at the beginning of the 1990s, e-learning was considered as a means of reducing the educational costs by providing pre-packaged learning contents to large populations of learners by means of electronic networks. In the conceptualization of Watanabe, K. (2005), e-learning is a kind of distance education using the internet and/or other information technologies. In the interpretation of Tyler, K. (2001), it is the ability to deliver training and education via web-technology in order to achieve improvement by providing current contents anytime and anywhere, and to offer to the learners a customized, interactive, just-in-time experience. Abram, S., (2003), defined e-learning as the use of an intranet, an extranet, or the Internet to provide training to individuals in a synchronous or asynchronous mode. According to the definition of Welsh, E. et al., (2003), e-learning is the use of computer network technology, primarily over or through the Internet, to deliver information and instruction to individuals.

E-learning has not only similarities, but also differences, which distinguish it from distance learning. For instance, while the location of learning in case of distance learning is a remote access place, it can be both local access place and remote access place in case of e-learning. That is, the widely used description of e-learning as "internet enabled learning" is therefore not completely correct. The implementation of e-learning, in which the site of production, circulation and consumption of learning contents is a computer network, is often referred to as *network learning*. Though, according to some publications, e-learning can also be implemented on portable technologies, we consider e-learning as fix connected learning that happens in places such as classrooms, home and offices, based on fixed communication technology. That is, in our

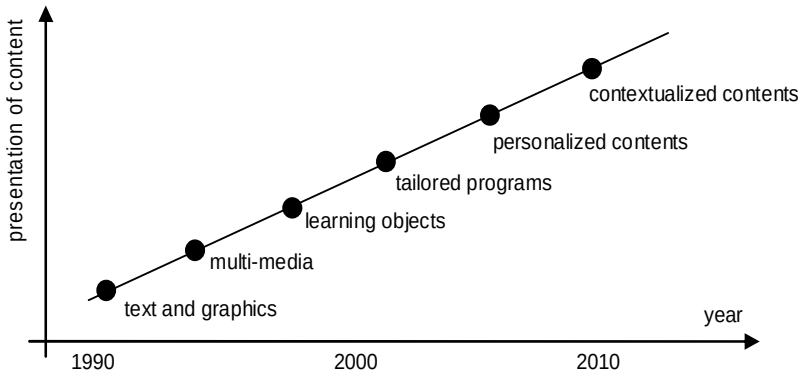

Figure 4 Development of presentation of learning contents

interpretation, arbitrary access place is not considered as characteristics of e-learning, but of mobile- and ubiquitous learning. This clarifies why we talk about wired e-learning solutions. As it will be discussed in the rest part of the paper, there is also a difference in terms of the technological platforms, set of functions, and way of content delivery. The set of functions offered by different e-learning technologies can vary, but in general, four categories of functions can be identified: (i) management of resources of the learning system, (ii) support of contents development, (iii) contents composition and availing, (iv) specific learner assistance, and (v) collaboration support and management.

4.2. Technologies and infrastructure

E-learning relies on fixed information and communication technologies (landline network) to deliver learning contents. In its simplest off-line form, the infrastructure of e-learning is personal computer (desk-top PC and laptop PC) with standard visualization hardware and electronic (digital) media. On-line e-learning is based on networked desk-top PCs, laptop PCs, tablet PCs, which are connected to the Internet through landline network cards, asymmetric digital subscriber line (ADSL), or to company's wide area network (WAN) with wireless transfer channels (Figure 5). The learning process and environment are organized either on a one-way (asynchronous) or on a two-way (synchronous) basis. With regard to (Figure 2), e-learning as an advanced learning solution represents an entry level in terms of the provided methodological flexibility and of the extent of synthesizing technologies. On the other hand, e-learning has introduced new carriers for structuring and presentation of learning contents such as learning objects and knowledge nets.

Learning objects are knowledge constructs, which capture the content of the learning (Figure 4). They can be represented in various forms including text, graphics, audio/video and other media, and can be organized into learner and topic oriented education modules (Churchill, D., 2007). Learning objects have been considered by many researchers as neutral and independent content building elements, such as bricks in a wall . Wiley, x. ( ) pointed at the shortcomings of this interpretation and proposed to regard learning objects as analogous to atoms, for the reason that (i) not every atom is combinable with every other atom, (ii) atoms can be assembled only in certain structures prescribed by their own internal structure, and (iii) some training is required in order to assemble them.

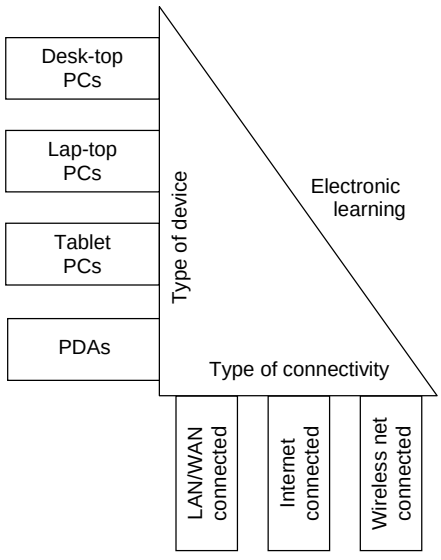

Figure 5 Types of devices and connectivity for electronic learning

E-learning may be orientated to individual, group and community. The concept of knowledge nets have been introduced to make courseware universally available for e-learning systems' users. The goal is to make free compilation of learning contents possible according to the personal interests, background knowledge, learning attitude and goals of the learners, and making this content truly available anywhere and anytime in multiple formats, while not compromising the learner experience. Richness, interactiveness and other cognitive aspects of the *dynamic courseware* are still issues for further research. But it will play an important role in the case of mobile and ubiquitous learning for its potential of increasing productivity of learning.

4.3. Application methodologies and experiences

E-learning offers practical solutions to involve learners who have in the past been excluded. Evidently, an e-learning program or environment should be designed to be a motivating experience for all learners with different objectives and backgrounds, and should increase the learners' self-efficacy. Typically, (i) flexibility of accessibility/availability, (ii) modularity of course matters, (iii) individual speed of learning, (iv) privacy and comfort of completing courses, (v) interaction and feedback in alternative forms, (vi) reduction in training costs, (vii) fast distribution of the training material, (viii) meeting various learning styles, (ix) possibility of presenting the course material in various formats, (x) customizing the training according to each participant's needs, (xi) evaluation of progress on a continuous basis, and (xii) consistent delivery of the course content are mentioned as major issues in terms of the success of e-learning. Piccoli, G. et al., (2001) also emphasized the importance of interaction, personalization and control.

An often heard criticism is that many courses offered on-line focuses on course completion as a primary goal, rather than on the extent of pick up and quality of understanding of the learners. This kind of courses tends not to produce the same achievement as the conventional educational approaches, unless the participating learners have got sufficient internal motivation and determination to acquire knowledge and not just to get the course done. Most general motivating factor is the e-learning experience itself, including meaningful immediate feedback and adaptive navigation mechanisms. It has been reported that laptop learners showed significantly higher achievement in nearly all measures after one year in an e-learning program.

On-line e-learning offers many potential benefits over the traditional learning solutions, but it also suffers from a couple of limitations. Miller, x. et al. (2003) pointed at the major concerns related to the educators' attitude to and experience of e-learning: (i) not having sufficient face-to-face contacts, (ii) anxiety caused by the nature and quantity of information transmitted through technology, (iii) reluctance of teachers in adopting pedagogic changes, (iv) perceived increase of educators work load in preparing interactive media, (v) preference of traditional teaching styles, and (vi) lack of full commitment and support from management support.

Despite the advancement of e-learning tools, there are many open issues of a successful implementation. These include: (i) pedagogical underlying of how individuals acquire knowledge and retain skills and information in on-line courses (Garrison, y. and Anderson, x., 2003), (ii) improving the level of ICT skills of educators and learners (Graschew, G. et al., 200x), (iii) reducing the barriers to confidence, comfort, learner motivation and social interaction in using on-line learning technologies (Muilenburg, x., Berge, y., (2005). This emphasizes the need for learning strategies but also enables learners to transfer the knowledge across disciplines. Increase of adaptability and efficiency raises the issue of combining multiple learning media and ways of contents delivery, which has been coined as blending.

5. MOBILE LEARNING

5.1. Concepts and theories

In our modern time, a lot of changes can be observed in life-styles. Mobility, as well as mobile communication, is playing a very influential role in this. Daily activity programs of humans are decomposed to a large number of action slots and organized dynamically for various locations. Supplying and gathering information, while moving between locations, has become a commodity. Learning should also adapt to the changed life-style - it is supposed to be possible at any time and place. This explains why *mobile learning* (m-learning) has in such a short time grown out from e-learning and has become an self-determining approach of flexible learning. The main concern is how the conventional educational institutions can provide the platform, contents and stimulation for learning of an increasingly mobile population. The primary objective of mobile learning has been to move from the wired learning environment of today to the wireless virtual learning environment of tomorrow. Wagner, x. (2007) defined m-learning as learning or delivery of content by mobile communication technologies (MCTs) for public learners. Current MCTs provide not only location and time independent access to learning systems and contents, but also different learning experiences.

As indicated by the huge variety of interpretations and definitions we found, m-leaning apparently means different things for different communities. In addition, the distinction between e-learning and m-learning is blurred in many publications. M-learning inherited several of its features from distance education and remote (on-line) e-learning, but it has its distinctive feature, which are increasing the learners' geographical freedom. In addition, m-learning utilizes the opportunities offered by portable technologies and mobile devices, enables personalized learning across locations, and puts learning into and above contexts. According to Laouris, Y. and Eteokleous, N. (2005), e-learning can be described by terms, such as hyperlinked, interactive, adaptive, multimedia-based and media-rich, whereas m-learning can be described as connected, situated, informal, personal, intimate, spontaneous and lightweight. Kukulska-Hulme, A. and Traxler, J. (2007) identified some emerging categories of mobile learning: (i) technology-driven mobile learning, (ii) miniature but portable e-learning, (iii) connected classroom learning, (iv) informal, personalized and situated mobile learning, (v) mobile training/performance support, and (vi) remote/rural/development mobile learning.

The rapid proliferation of mobile communication technologies have lent itself to the emergence of the concept of truly mobile learning. The focus of current m-learning system developments is on the mobility of the learner and on the accessibility of the learning material from any place and any time, based on a wide assortment of mobile communication technologies. In terms of the pedagogical issues, there are four centers of gravity: (i) generally useable mobile environments, (ii) learning objectives and methodologies, (iii) learning contexts for mobile learning sessions/courses, (iii) learning experiences of mobile learners. These all are wide ranging issues. For instance, the issue of generally useable mobile environments decomposes to topics such as (i) practical manifestation of mobility itself, (ii) different user profiles and their roles, (iii) user interfaces and learning aids, (iv) use of learning digital and traditional resources, (v) appropriateness of media objects, (iv) support of communication of learners and educators.

5.2. Technologies and infrastructure

Mobile learning takes advantage of learning opportunities offered by portable and wireless technologies, but it does not fully abandon fixed communication technologies. It creates a heterogeneity in terms of the mobile devices. Actually, this needs further articulation because availing electronic media and facilitation of digital distance communication may happen in multiply forms. Currently, four categories of devices can be identified as elements of mobile-learning platforms: (i) conventional portable computers (such as lap-top PCs, pocket PCs, tablet PCs, palm PCs, etc.), (ii) mobile communication devices (such as mobile phones, smart phones, etc), (iii) digital assistance devices (PDAs, iPods, etc), and (iv) embedded communication devices (GPS, etc). Connectivity among the portable devices is established through (i) wireless Internet, wireless local area networks (WLANs), and Wireless Application Protocol (WAP) (ii) mobile phone networks, such as Global System for Mobile Communications (GSM) and General Packet Radio Service (GPRS) (iii) local ad-hoc networks, based on IEEE 802.11, Wi-Fi, Bluetooth and Infrared Data Association (IrDA), and (iv) satellite networks (Figure 6).

The current generation of mobile communication of devices suffer from many limitations such as (i) limited memory and background storage, (ii) low-sized and low resolution displays (screens), (iii) too small and to many press- or touch buttons, (iv) limited cross-platform operation and transmission, (v) limited device interoperation, (v) poor connection to network hosted learning and content management systems, (vi) unsolved privacy and security issues, (vii) invariably high start-up and operational costs, (viii) connectivity with and using graphical engineering application packages, (x) tracking intermittent sessions and results is difficult, and (xi) multiple permissions for access. Compared to desktop PCs, most of mobile technologies and devices are of lower prices, but also are smaller size and technical capabilities. They can be easily carried, but their information processing capabilities and performances are still limited, in comparison with portable computers. The most obvious obstacle is the limited memory of current mobile devices. Latest mobile phones have typically 2-4 MB memory. Recent palm devices come with up to 64 MB of memory, which can be extended SD (Secure Digital) slot. This does not allow to run application programs, or to store digital material from the wireless Internet or other sources. Even more robust PDAs can handle only 2-8 GB information. On the other hand, researchers have signalized that handheld mobile phones will have much more capabilities and may become the dominant device for mobile learning in the next 5 years.

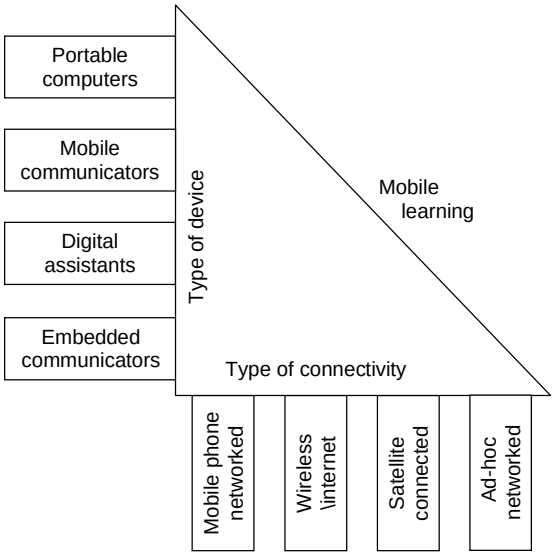

Figure 6 Types of devices and connectivity for mobile learning

As the focus is shifting to the use of handheld devices for mobile learning, the other technical capabilities are also becoming important. Current mobile technologies suffer not only from limited local data storage capacity, but also from limited transfer speed, constraints of visual presentation and sensitivity to digital biases. Limitation in terms of visualization comes from the small screen size, low resolution, and the orientation of screen, which make the imaging of large pictures, interaction

with complex images, reading of long texts and inputting of large amount of data difficult. The size proportions of displays are also different of those for laptop devices. As a consequence, screen images should be re-sized for proper display on the screen of a mobile device, which often leads to loss of information, and the navigational structures (menus, interaction elements) should be adapted. This emphasizes the need not only for enhancements, but also for standardization that is lagging behind even in the area of networking. Mobile learning faces the problem of network heterogeneity, just consider the protocols of wired Internet, mobile phone networks, local area networks, short range wireless communication.

Low, L., (2007) reviewed the various mobile hardware, software, transfer and interface developments and provided a rather comprehensive list. Main issues related to research in mobile educational technologies have been addressed by (Litchfield, A. et al, 2007). It seems to be necessary for educators to learn about wireless and mobile technologies, the related national pedagogical policies and international approaches, and the principles and strategies of development and application. On the one hand, there is a need for low-cost sustainable solutions that fulfils the needs of a large population. They can be based on off-line devices (e.g. Palm, Game Boys, etc) that download learning contents from a computer/network and store them on local memories (USB, cartridge). On the other hand, there is a need for large scale implementations reaching over institutions, disciplines and subjects. In the near future this can be based on portable computers, or on ultra-mobile personal computers (UMPCs), which can provide interactions with a server or online managed learning systems in real time and can include interactive multimedia resources too. M-learning depends upon media-convergence when data, voice and video are handled over a single channel or a limited bunch of channel.

Assuming steadily improving technological capabilities and decreasing cost, mobile phones are emerging as a viable option for mobile learning. As for now, apparently personal digital assistants (PDAs) are the most popular in education, for instance, in ‘just-in-time’ employee training, guide-based study tours, and field studies. They were also used in assessment exams to test learners’ knowledge based on downloadable banks of questions, and then report their results. Tablet PCs are also popular due to the versatility that originates fro the combination of the functionality of a laptop and a PDA. Services, such as GPRS, are currently relatively expensive, but the connection fees may progressively decrease in the coming years. In case of wireless networks, the bandwidth is usually relatively low and there are limits on the sizes of the transferable multimedia files. Mobile learning needs new content presentation technologies too. One proposal is Cybertext that can incorporate graphics and sounds, in addition to text and hypertext, such as a home page, a computer program, a web document, a network service, a database query (Aarseth, E., (1997). Another resource is Sharable Content Object Reference Model (SCORM), which is a set of specifications that guides learning system developers to chunk course content into small, reusable learning objects. SCORM-compliant objects can be easily merged with other compatible learning objects developed by various authoring tools in highly modular courseware.

5.3. Application methodologies and experiences

In comparison with desk-top computer-based or computer network hosted e-learning, mobile learning offers a higher level of mobility for learners. Continuous technology development stimulates changing to a life-style which adapts to unconstrained media accessibility and communication. People can get rid and out of their offices and homes, and still continue to be

logged onto the office's telecommunications network and to be a member of an information and communication society. This phenomenon was depicted by Attali (1980) with the notion of nomad. This is a new study field for social scientist.

The rapid development of mobile technologies create an attractive platform for m-learning, but the pace of developing application methodologies is lower (Attewell, J., 2004). Important is that m-learning creates not only enhancements for public and higher education, but it also allows genuine new forms and approaches of flexible learning (Armatas et al. 2005). Experts tend to agree that mobile learning does not mean to simply adapt pedagogical contents to portable communication devices, but rather to use the possibilities offered by these devices in an innovative and efficient way. Being emergent ALS, several test facilities have been built to evaluate m-learning as a knowledge transfer medium in campus, or towards specialized groups of learners ( ).

As a matter of fact, mobile learning has not yet been fully adopted as a learning methodology (Kinshuk, x. et al. 2003). M-learning is supposed to offer both proximal and personalized learning opportunities. Wang, x., ( ) proposed a thinking model can be a basis of personalized m-learning. He identified six aspects of defining m-learning context: (i) identity of users, (ii) learner's characteristics, (iii) learning activity, (iv) remote collaboration, (v) spatio-temporal dimension, and (vi) technological facilities [12]. The first four of these establish the situational contexts of m-learning, and the last two are associated with the environmental context. In proximal learning the contents or delivery are modified according to the learner's geographical location and learning needs in a particular real-life context. The dynamics of learning process assumes that learning sessions are relatively short (20-30 minutes), even broken down to learning episodes of just few minutes or less, and the learner should be able to seamlessly connect and integrate them.

M-learning has been found useful to (i) recognize existing abilities and knowledge of learners, (ii) identify areas where they need assistance and support, (iii) improve learners' literacy and numeracy skill, (iv) encourage independent and collaborative learning experiences, (iv) reduce the fear of using digital technologies, (v) eliminate the reluctance towards formal educational set-ups, (vi) conduct self-managed learning in multiple iteration loops, and (vii) raise self-esteem and self-confidence. Learners can read digital reading materials, listen to audio explanations, watch streamed video material recurrently, follow presentations, exchange information with fellow learners, process drills, complete questioners, and do tests.

6. UBIQUITOUS LEARNING

6.1. Concepts and theories

The term 'ubiquitous computing' has been coined to describe an everywhere presence of applied information technology and its widespread use in the professional and public applications (Lyytien, K., Yoo Y., 2002). Ubiquitous technologies are a set of ICT technologies which enable us to seamlessly utilize huge amounts and various kinds of "functional objects" anywhere and anytime. This paradigm of computing and the associated technologies are still in a premature phase of their development, but they have already opened up new perspectives in terms of utilization of computing capacities, detecting and processing surrounding information, and providing personalized services. Ubiquitous computing does not consider computers as well-defined processing nodes of digital networks, but as facilities making computing and

communication available in all facets of everyday life. It involves several technical approaches which specialized themselves in embedded, portable, wearable and communicatable implementations, serving as alternative technological platforms for ubiquitous learning.

The concept of ubiquitous learning (u-learning) is young and immature. It is facilitated by the paradigm and the rapidly advancing technologies of everywhere present computing and communication. On the other hand, its evolution is also stimulated by the growing need for alternative forms of learning and the endeavor to find the ultimate solution for flexible learning. Note that in the context of education, the adequacy of the term 'ubiquitous' is often questioned for the reason that this word does not express the active involvement of human parties, the tendencies to forming communities, and the related media-based services. Ubiquitous learning environments raise the issue of context-awareness; that is, the capability to sense the status and situation of the learners and provide them with adaptive contents and supports (Hwang, G.-J. et al., 2008).

Ubiquitous learning extends mobile learning with the concept of learning across contexts in a mobile society, which is facilitated by the use of ubiquitous communication means. The objective of u-learning is bringing the right learning interaction at the right time in the right situation to the learner. In terms of the level of mobility, ubiquitous learning and mobile learning offer practically the same freedom, but ubiquitous learning involves higher level of embeddedness than mobile learning. This comes from sensing the context by wireless communication sensors which detect and collect users and environment information.

6.2. Technologies and infrastructure

Ubiquitous learning relies on a very wide spectrum of portable, mobile, wireless, wearable and embedded computers and transmitters. The information processing devices and the communication network remains to be the two main ingredients of technological infrastructure of u-learning, but they will turn up in somewhat different forms. Ubiquitous information processing will be integrated not only into portable and hand held electronic devices, but also into home and office appliances, garments, and personal accessories. In addition to processing information in various media forms, they can also directly communicate with each other, concurrently forming the units of a local network and of a global network. We can anticipate a large heterogeneity of the ubiquities devices and communicators at least in the coming decade. The variety of them will be even higher that that of mobile devices. This arsenal of devices will involve all sort of portable computers, networked mobile phones, PDAs, PalmPilots, smart digital cameras, media

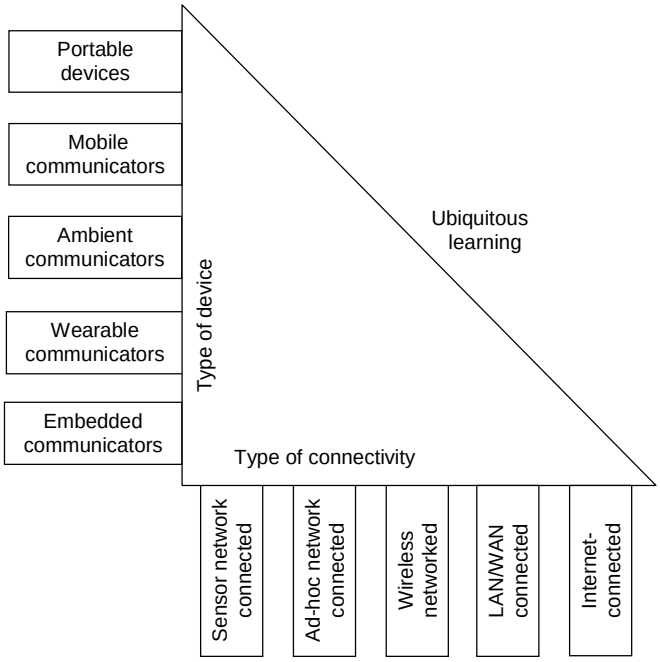

Figure 7 Types of devices and connectivity for ubiquitous learning

players, and even handheld gaming tools, such as NGage.

With respect to communication networks, the major difference will be heterogeneity and ad hoc formation. The first means that the network will not be based on a single technology, but on a combination of complementary technologies. Obviously, this heterogeneity will be invisible for the users of learning services. From the aspect of the technology, it requires seamless integration and synergic operation. As an infrastructure, the network is supposed to have some sort of intelligence to select the most suitable technology and the best way of operation. The second means that the network is not predefined, but formed according to the demands and opportunities. Various concepts of ad-hoc networks will be implemented in a dynamically changing network topology. In these ad-hoc networks fixed and mobile nodes and network segments will be interconnected. The nodes act as a router and repeater for other nodes, forming a wireless mesh network. Likewise, emerging wireless sensor networks, whose nodes will be devices with sensing and processing capabilities. It is expected that these networks will merge in so called hybrid ad-hoc networks in the near future. They may also incorporate other types of mobile networks such as vehicular, personal and ambient networks.

6.3. Application methodologies and experiences

Ubiquitous learning must be seen from the viewpoint of both developed societies and the underdeveloped societies, and these two viewpoints are completely different. In the developed countries, u-learning is just another enabler of well-being and adaptation of learning to life-styles, whereas in the underdeveloped countries it is seen as an elementary necessity and a potential means to fight against illiteracy and exclusion. According to certain estimation there were over three billion people whose education was in one form or another restricted (Dhanarajan, 2001). estimated that, illiterate, or in need of retraining. Moe, x. (2002) reported that there are only 10 countries that presently provide higher education to one-third or more of their college-age populations. Demographics indicate that absolute numbers of learners, the number of learners as a percentage of total population, and average age of learners, will increase over the next 25 years. Population growth, increased economic activity, and growing demand for white-collar workers will create an unequalled demand for higher education.

Currently, the most consolidated field of application of u-learning is language learning (Yannick, J., 2007). It has been confirmed by several researchers that this is a particularly well suited application field to this medium (Jacquinot, Y., Takahashi, S., Tanaka, J., 200x). Unfortunately, the concept of u-learning has yet not been tested in other application fields since they are currently emerging or are under exploration. Implementation and application of u-learning have brought up numerous new research issues, such as discussed above, related to mobile-learning. One of the specific research topics associated with u-learning is the understanding the learner's context in any situation. In the literature, hardly any methodological proposals are available, which would address the specificities of u-learning. On the other hand there are many discussions on the probable influences of technological developments such as digital paper, foldable screens, wearable sensors, processors and communicators, ambient intelligence and knowledge transfer networks (KTNS).

Ubiquitous learning raises many education philosophical issues, not only technological ones. Perhaps the main issue is if we should rework completely of our ideas about education and frameworks of education when moving from traditional learning environments into fully digital education platforms of the future. Just as computers have transformed the office in the last 20 years, ubiquitous learning solution will most likely transform the paradigm of car in the next

decade. In other words, as workplaces have been transformed by computers to learning places, the same can be expected to happen with cars and other vehicles. The issue of learning in vehicles guides the attention to many new research topics, such as attention grounding and theoretical frameworks for in-vehicle information system development.

Towards a full scale implementation of ubiquitous computing, the following advancements are expected:

- widespread acceptance and daily use of cost-effective carry-on (hand-held, packet, and clothing mounted) digital sensing, processing and communication technologies
- integrated heterogeneous networks with seamless transition between the satellite, terrestrial, wireless, mobile, and ad hoc segments
- invisible platform management, standardized knowledge repositories, and intuitive interfaces in order to avoid the user should bother with link technology
- tailored learning packages, progress stimulating services and scenarios for various communities of users
- support of comprehension and understanding with cognitive digital means such as personalized avatars, supervisor agents and intelligent knowledge/information mining tools.

7. CONCLUSIONS AND FUTURE PERSPECTIVES

We are living in the age of emergence of knowledge economies, technology-induced globalization, and strive for all-inclusive well being. In the cyber-culture of the knowledge society, education is becoming an extremely important issue. In the last four decades, shift from the instructive educational methodologies to the explorative and constructive educational methodologies could be observed. This shift is also confirmed by a large number of literature sources. The rapid development of wired and wireless networked computing/communication devices has created a solid basis for advance learning solutions, such as electronic, mobile and ubiquitous learning. The latter two have actually branched off from electronic learning, and established themselves as self-defining approaches. The current trend is that e-learning research and practice are blending various electronic forms of media and communication with face-to-face instruction and elements of traditional distance education.

E-learning is strongly associated with advanced learning solutions (ALSs), which deal with both the technologies and associated methodologies in learning using multimedia and/or networked technologies. M-learning has the potential to improve efficiency in the education sector and expand educational opportunities to underserved communities in remote areas. However, it is a prerequisite that sufficient infrastructure must be established, innovative policies administered, curriculum and content developed, school administrations reorganized and teacher training conducted, ICT services expanded before m-learning programs can be implemented. Dedicated devices and networks for mobile learning platforms face a number of challenges and obstacles that must be overcome before the full potential of mobile and ubiquitous learning can be realized. Learning in a mobile society puts the focus of research on how society and its institutions can accommodate and support the learning of an increasingly mobile population.

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