

CUSTOMIZED x-LEARNING ENVIRONMENT¹

Anabela Mesquita^{1,3}, Fernando Moreira², Paula Peres¹

¹*Polytechnic of Porto / ISCAP (CICE) (PORTUGAL)*

²*Univ Portucalense, Portucalense Institute for Legal Research – IJP & Univ Aveiro, IEETA, (PORTUGAL)*

³*Algoritmi RC – Minho University (Portugal)*

Abstract

The education sector is facing several challenges due to changes concerning the needs of students who arrive at HEIs, as well as due to labour market requirements. There are already solutions that try to meet the new requirements. However, the evolution of ICT requires a rapid and demanding adaptation. In this context it is assumed that education systems must address the diversity of students' backgrounds, taking into account their needs in order to provide access to learning objects, as well as the validation of knowledge of each student. In this paper, we propose a model where all the learning elements are present and where the student is the focus and the one who decides what should be included in this learning environment in order to create a Customised x-Learning Environment.

Keywords: Education; PLE; Vertical Social Networks; Horizontal Social Networks; Cx-LE.

1 INTRODUCTION

The 21st century could be declared as the age of information and communication technology, in a holistic perspective. When we observe the education sector, we can see that it has undergone some changes, both from a technological and a social point of view [1]. As a matter of fact it is assumed that: (i) The educational model based on fixed time, place, curriculum, and pace is not enough in today's society and knowledge-based economy [2]. The education system must change in order to address the diversity of students' backgrounds and needs; (ii) Educational equity is not about equal access and inputs, but ensuring that a student's educational path, curriculum, instruction, and schedule is developed in order to meet students' needs; (iii) Personalized learning requires a leveraging of modern technologies enabled by smart e-learning systems, developed to track and manage the learning needs of all students, and to provide access to learning content, resources, and learning opportunities which are not all available within the traditional classroom. This is the time when more people everywhere are involved in acquiring new knowledge and skills. The "new" world citizens' people feel "naked" without the use of technology.

Additionally, the lack of interaction in traditional classes is a well-known problem with a long history of research [3]. The interaction between teachers and students is essential for learning in accordance with teaching theories [4], resulting in increased adoption of e-learning platforms and less frequently, of web 2.0 services. Electronic Learning (e-learning) is a subset of Distance Learning and Mobile Learning (m-learning) is a subset of e-learning and ubiquitous learning (u-learning) is a subset of (m-learning).

The comparison between e-learning, m-learning, and u-learning, in the context of distance education, taking into account the physical devices, computation and communication and finally learning features reveal that the physical devices start with wired (e-learning), evolve to wireless (m-learning) and finally disappear (u-learning). When computation and communication features are analysed there is an effective distinction between distinctive (e-learning) and blurry (u-learning) learning. As for the last feature, it is possible to confine it to a single desk (e-learning) or go until it becomes dynamic/flexible (u-learning).

The platforms designed for e-learning, whether open source or commercial, are more focused on the design of the needs of institutional progress or activities concerning teaching and learning. One

¹ Mesquita, A.; Moreira, F. and Peres, P. (2016). Customized xLearning Environment. Proceedings of the ICERI 2016 – Transforming Education, Transforming Lives. 14 – 16 November, Seville, Spain

possible solution could be Personal Learning Environment (PLE). This is an approach to integrate different practices and resources (web 2.0 services) to address individual learning needs. This approach is more flexible and aims to focus on the needs of students [5]. However, although PLE includes the integration of a number of web 2.0 technologies and envisages the creation of a personal learning centre, where content is used and reused according to students' needs and interests, it still relies on what teacher makes at students' disposal and not empowers the student to create his / her own environment.

In this paper, we propose a model where all the learning and x-learning elements – where x could be applied to e-learning, m-learning, and u-learning – are present and where the student is the focus and the one who decides what should be included in this learning environment in order to create a Customized x-Learning Environment (Cx-LE). The idea behind this model is to help students to develop their own learning environment using a set of tools and services that cover the functions in their learning process and customise their learning environment.

The paper is organized as follows. In section II Background we present the most important concepts related to the discussion of the development of learning environments. In section III we present some related work and in section IV we describe the proposed model and presents an example. Finally in section V we draw some conclusions and point out future work related with the testing and extending the proposed model.

2 BACKGROUND

In this section we present the most important theories or concepts that are in the base of the proposed model. We explain also what are the limitations of the existing concepts in order the reader understand what is proposed in the next section.

2.1 PLE

It is possible to find in the literature several definitions of Personal Learning Environment (PLE).

Personal Learning Environments (PLE) can be defined as “*conceptual and technological frameworks that help learners take control of and manage their own learning*”. This includes providing support for learners to: set their own learning goals and manage their learning in terms of both learning outcomes (content) and process [6]. Rahimi, van den Berg et al. [7] also define web 2.0 Personal Learning Environment as an environment becoming a “*promising area of development in e-Learning. While enhancing students' control over the entire learning process including constructing learning environment, it appears that introducing Web 2.0 PLEs to education is an essential objective, there is little consensus on how to attain this objective*”.

Sometimes the words “*personal*” and “*personalized*” are used interchangeably to designate the same learning environment. The words are not synonymous and bear some differences. We are not going here to detail the discussion about these differences (see the link <http://profiles.arts.monash.edu.au/sarah-pasfield-neofitou/personal-vs-personalized-learning/> where Pasfield-Neofitou, from the Monash University discusses and explains the differences). Nevertheless, it is important to summarize here the main differences. “*Personal*” is related with engagement with other learners and experts, something which consists of an assembly of resources from various sources, while “*Personalized*” is about a top-down, designed or tailored approach which modifies an existing tool (e.g. a search engine, or a quiz).

In 2010, attendees at an ASCD symposium on personalized learning agreed on five “*essential elements*” of personalized learning, namely: Flexible, Learning anytime/anywhere; Redefine teacher role and expand “teacher;” Project-based, authentic learning; Student-driven learning path; and Mastery/competency-based progression/pace [8].

The Association of Personalized Schools and Services (APLUS+) also attempted to develop a definition of personalized learning. They say that the fundamental aspects of personalized learning are: Putting the needs of students first; Tailoring learning plans to individual students; Supporting students in reaching their potential; Providing flexibility in how, what, when, and where students learn; Supporting parent involvement in student learning; Encouraging relationships between student, parent, teacher, school, and community; Preparing students to be life-long learners; and Engaging and motivating students by supporting their learning in a way that is relevant to each student's life, interests, and goals [9].

To sum up the most important elements concerning the “*personal*” or “*personalized*” learning environment emerging from the literature are thus: (i) Support – this environment should be planned in such a way that it helps students to design and manage their learning environment; (ii) Educational component – it refers to all the resources (and their different formats) that are available in the learning environment; (iii) Social – the environment should be developed taking into consideration the need to engage with other since knowledge is something that is socially constructed; (iv) Technological component – concerns the design of the tools used. All these components should be tailored, student-centred and driven.

2.2 Social networks

According to Boyd & Ellison [10], social network is “... a web-based service that allows individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system. The nature and nomenclature of these connections may vary from site to site.”

The Merriam Webster² dictionary defines social network as “a network of individuals (such as friends, acquaintances, and co-workers) connected by interpersonal relationships (This seems to make sense: partners of the same age, race, religion or educational level ... will reinforce each other's self-esteem, find mutually enjoyable pursuits and receive support from their extended families and social networks”.

The definitions presented above are very general and we need to look for definitions that are more precise depending on their orientation, i.e., horizontal or vertical use. Thus, the social network can be classified as horizontal and vertical, with the first being used for more general purposes, i.e., without a clear defined purpose, and the vertical dedicated to an activity or specific interest. Vertical networks can be characterized by a highly segmented user base, addressing specific topics in depth and has a high degree of specialization and are generally more private and closed. Horizontal social networks have a base of very diverse users, address a wide range of topics, have a reduced specialization and have less privacy and are public. For example, Facebook has more than 1 billion³ monthly active users that discuss and share everything. And this is precisely what a lot of users see as a problem – the fact that there is a lot of information available, with few or no filters, used by a diverse population of users. Users looking for more targeted experiences are looking for increasingly specialized social networks (vertical social networks).

2.3 Pedagogical Learning Theories

It is not our purpose to present here all the existing learning theories. We will just refer two of them that may contribute to the design of the learning environment: Constructivism and Connectivism.

Constructivism considers that all new knowledge and learning is based on previous knowledge and past learning and that we construct our concepts gradually from experience with the world. Main principles: 1) learning and understanding comes from interaction with the environment; 2) learners encounter cognitive conflict which in turn stimulates learning; 3) new knowledge develops through social interaction [11].

For Connectivist, learning occurs through the process of a learner connecting to and transferring information into a learning community [12] and [13]. The learning community can be aggregated into a cluster of similar areas of interest, which allows for interaction, sharing, dialoguing and thinking together [14]. These can be designated as nodes and connect to other existing nodes.

According to [14] there are several similarities between the connectivist theory and the “*personal*” (PLE). The shared facilities and the social networking components would conform to the connectivist nodes. In setting up their learning space, users of PLE would have access to several different networks. Information can be stored on PLE under different formats. Daily use of PLE would lead to aggregation of texts, pictures, videos, sound files, etc. Team-based learning is facilitated by the shared filespace and the student is motivated through engagement and the social networking possibilities.

² <http://www.merriam-webster.com/dictionary/social%20network>

³ <http://expandedramblings.com/index.php/by-the-numbers-17-amazing-facebook-stats/>

3 E-LEARNING, M-LEARNING AND U-LEARNING

The machine Pressey Testing⁴ developed in 1924 by Professor Sidney Pressey was considered the first mechanical systems to be associated with learning. This machine had as objective, the creation of a system of learning practice. The system was similar to the conception of a typewriter machine, with a monitor showing a question and a certain number of answers. The user pressed the key corresponding to the answer and the machine registered the answer. The machine was able to check the answers and give feedback. In this context Sideny observed that *"teaching machines are unique among instructional aids, in that the student not merely passively listen, watches, or reads but actively responds."*

The introduction of Computer Assisted Instruction, at the University of Stanford, during the decade of 1960, may be considered as the next step. The term e-learning emerged which may be considered as a network *"which makes it capable of instant updating, storage/retrieval, distribution and sharing of instruction or information, ... and it is delivered to the end-user via computer using standard Internet technology, ... it focuses on the broadest view of learning-learning solutions that go beyond the traditional paradigms of training"* [15].

Thus, e-Learning may be considered as a learning mode that takes advantage of the use of information and communication technologies in all levels of training, being seen as the dissemination of training using a network. In this context it means the capacity to follow a teaching program at distance, being it personalized or accompanied, individually or in group. The use of the internet for education was then introduced in all educational sectors, allowing to offer training modules of short duration, progressive, adapted to the levels and needs of the learners / students.

The next paradigm appears with the introduction of mobile learning (m-learning) in 1968, with the concept advanced by Alan Kay through the Dynabook. This device was a computer of a booksize that, through the use of tailored applications helped the learning process. According to this author this device could be used *"anytime, anywhere as they may wish"*[16].

The m-Learning or mobile learning is the learning process with mobile devices. The concept of m-learning incorporates the characteristic of student not needing to be fixed in one place or position and being able to use mobile technologies such as laptops, smartphones and netbooks

With this reach, the m-learning can bring a learning experience very valuable and beneficial because can be used to support and consolidate students' learning, allowing a different style of teaching and learning as for activities carried out in a more traditional way. Additionally, this type of learning can be a very valuable tool for the students with special needs, since it is possible to offer an adapted learning experience.

Although m-learning is a very interesting and recent concept, it is seen as an intermediate step between electronic learning and ubiquitous learning.

Mark Weiser, at the beginning of 1988, started to study ubiquitous computation, exploring the concept of non-intrusive interfaces able to deliver big amounts of information, leading to a very interesting statement – *"in the future personal computers and workstations will become practically obsolete because computing access will be everywhere"* [17] and *"the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."* [17]. This author identified 3 main technologies necessary for ubiquitous computation: low power computers with integrated monitors, software for omnipresent applications and a network to connect them.

When the ubiquitous computation reached the present state with the development of ICT, the concept of ubiquitous learning appeared [18]. The ubiquitous learning applies to contextual computation and adaptative learning in order to provide a new learning experience.

A more wide definition of u-learning is *"anywhere and anytime learning"*. The definition refers to any environment allowing that all mobile learning devices have access to the learning content through wireless networks, in any place, at any time. Through this environment it is possible to teach students adequate contents at the right moment and right place [19], [20] and [21]. The definition usually used for u-learning is *"learning with u-computing technology"* [22], with Hwang et al. [19] defending that *"learning with u-computing technology"* is more adequate for m-learning. As a result, the term *"context-aware u-learning"* is used to distinguish the definition of u-learning and the concept of m-learning. In a

⁴ <http://www.nwlink.com/~donclark/hrd/history/machine.html>

more specific way, RFID, smart cards, sensor network nodes and mobile devices are components of ubiquitous computational technology. Other definitions can be found, for instance, “a new learning paradigm in which we learn about anything at anytime, anywhere utilizing ubiquitous computing technology and infrastructure”[23], or “U-learning is a learning paradigm which takes place in a ubiquitous computing environment that enables learning the right thing at the right place and time in the right way.” [24]. This learning environment can detect contextual information in the real world and adapt to supply tailored learning content through mobile devices as a response to different learning contexts.

The U-Learning or the ubiquitous learning is an innovative concept that incorporates the best characteristics of both e-learning and m-learning, as well as other advances in technology. The U-learning can be seen as a big boost in education since allows an adaptative learning and provides a generalized omnipresent learning environment. To sum up the conceptual transformations from E-Learning to M-Learning and then to U-Learning are the following (see figure 1:

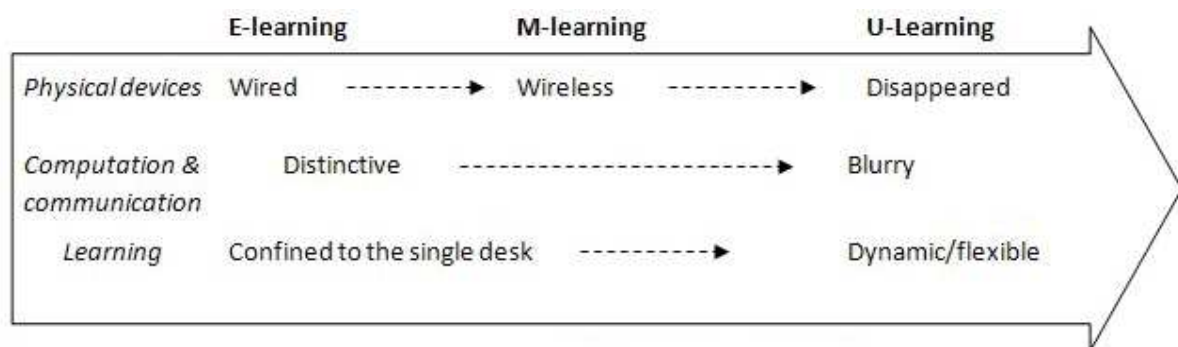


Fig. 1. Comparison and flow of E-learning, M-learning, and U-learning [25].

4 RELATED WORK

In an attempt to give the student the total control of his / her learning space, while allowing the registration of all learning activities, [29] suggest a possible solution to integrate the static nature of Learning Management Systems in the dynamic notion of a Personal Learning Environment. The author designates it a service-based framework. One of the main goals of this service is to facilitate the communication between the learning environment and the institutional LMS. For that, the service should comprise as components: 1) the institutional context (include one or more LMS in which the students carry out their academic activities, e.g. Moodle), 2) the personalized context (facilitates de integration of the different tools that students use in their learning and 3) the communication channels (provide methods for bi-directional information exchange). In addition some other elements may be included, such as mediator elements (to facilitate communication between specific instances of the LMS and the online tools included into the personal learning environment) and / or the representation of these elements in other contexts (such as mobile devices).

5 PROPOSED MODEL

Taking into consideration the previous work and existing learning theories, as well as the necessity to integrate the learning environment with specific social networks (one or more, according to the needs of the student), we present here our contribution to the discussion of the development of learning environments. This solution represents an evolution of the model presented at [26].

Knowledge is a social product meaning that is the result of interactions between people. Thus an e-Learning environment should provide learners with opportunities and tools to integrate learning communities and networks and to benefit from knowledge and practical advice from peers and experts. In this context, the integration of social media tools and networks in an e-learning course is important. As for these social media, there are two possibilities – horizontal networks and vertical networks as presented above.

5.1 Model proposed – the Customized x-Learning Environment

The construction of the Customized x-Learning Environment (Cx-LE) requires the definition of a set of very important activities concerning the integration of the various components, due to their heterogeneous characteristics. First, it is necessary to define which model to use, i.e., to establish if the learning environment will be customized for e-learning, m-learning, or u-learning, being the “x” the *e*, *m* or *u*. This initial decision is related with the technologies that will be used as well as with the adequate learning theories. Then it is necessary to define a learning environment in wider context, the interaction with social networks (horizontal and vertical) and ways to communicate with the institutional environment (LMS). For this purpose a communication structure is required between the institutional, personal environment and social networks. The model should work as follows: (i) what happens in the wider context can be used from the institutional environment: (ii) Learning contents can / should be enhanced with the functionality of the LMS; and (iii) enhanced with social networking contents.

With this model it would be possible to implement the Learning Environment as a set of services, tools and communication channels that allow students to complete the learning activities in different institutional contexts. Furthermore, this Learning Environment provides ways of displaying to the institution, the results of the learning activities carried out outside the LMS.

The model presented in this paper is service-oriented and enables the communication described above using web services and interoperability specifications. This structure facilitates the representation of institutional features in devices (fixed and mobile devices) using web services. Although the export functionality allows the representation of PLE in several contexts, this model needs a way to combine tools, social networks, a common environment and communication channels to return the results of learning activities to the LMS.

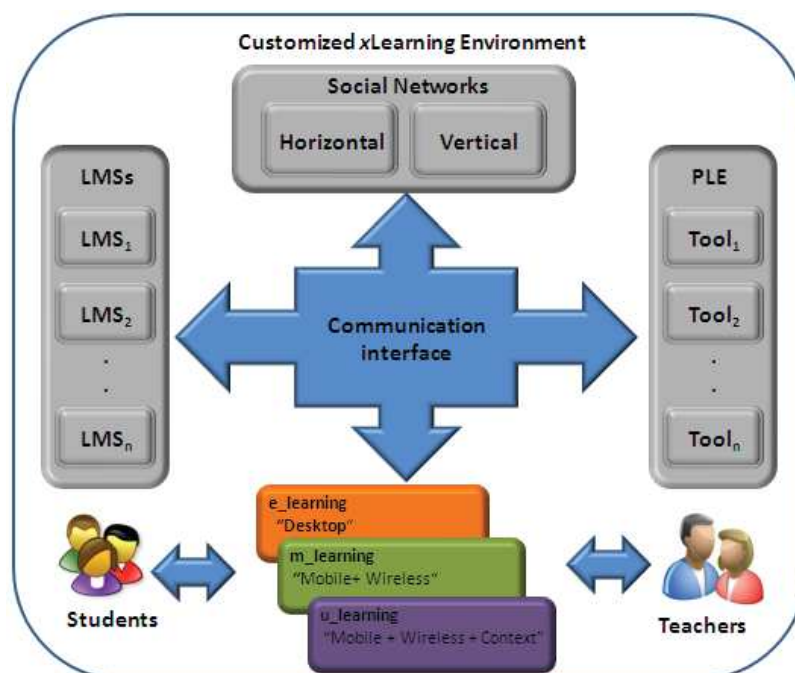


Figure 2. Proposed model adapted from [26].

From an architectural point of view (Fig 2) the five core structural elements are: the institutional environment (one or more LMS), PLE (one or more tools), social networks (horizontal and vertical), the channels and interfaces of communication and the model to use, i.e., which learning environment will be customized. In this architecture the institutional environment includes one or several LMS. The PLE includes tools and devices, institutional and own tools. Social networks include some other horizontal and vertical, depending on the area Customized x-Learning Environment (Cx-LE) apply. In addition, the model must include proxy tools to interact with, for example, Google tools, social networking, i.e., use the APIs provided by the various suppliers. An important issue for the use of these APIs is the need for evaluation of the activity performed in the external tools (not controlled by

institutions) so it is necessary to integrate information (performed activity) for the assessment to be carried out “internally” so that evidences of assessment remain preserved, since it is a formal teaching-learning process. In this context, the components must be connected by interfaces based on web services and interoperability specifications.

The way to test this model is by implementing it as proof of concept. This implementation involves some restrictions of design that affect the technologies used in the components of the model. The first issue is the institutional point of view, that is, in this context there are many LMS available (commercial and open source) but the option is the use of multiple instances of Moodle LMS. This platform was selected because it is open source and has a very wide community of users, includes a web services layers that allows the inclusion of new technologies and facilitates the integration with other tools as well as the existing experience in national educational institutions (<http://moodle.org/stats>).

The second issue is directly related to the choice of the most appropriate social networks for training activities (hard skills or soft skills), with a natural tendency, in horizontal social networks to Facebook (<https://developers.facebook.com/>), Twitter (<https://dev.twitter.com/>), etc., and in the vertical social networks, Stackoverflow (<https://api.stackexchange.com/>); Github (<https://developer.github.com/v3/>), Doximity (<https://www.doximity.com/developers/home>), etc. Finally, the communication channels can be implemented through the mechanisms of communication between the components of the model, for example Moodle web services (https://docs.moodle.org/dev/Core_APIs) and BLTI (<http://www.imsglobal.org/developers>) (an interoperability specification), and to interact with the LMS to integrate the results of students in relation to activities carried out in other environments / tools.

5.2 Example of an application for u_learning

With the objective to understand, from a practical point of view, the use of the Cx-LE model, we present briefly one possible application for the Cu-LE, i.e., using the u-learning in the model proposed in figure 2.

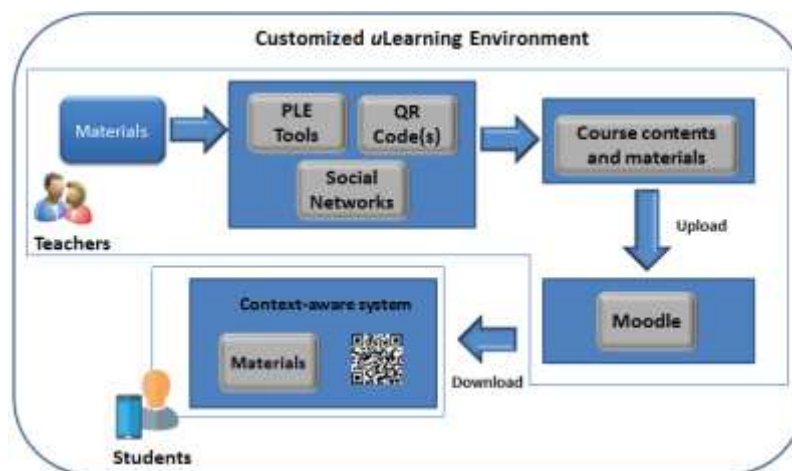


Figure 3. Architecture of the system

The example presented in figure 3 describes a system that assists in the creation of u-learning materials, improves learning during the activities in open air and develops u-learning environments oriented to the context. The objective of this solution is to provide an alternative method to teach concepts related with a specific area of knowledge that can take advantage of an open air environment. As portability and mobility are necessary factors for an authentic learning experience in open air, this system needs to incorporate mobile devices touchscreen, with wireless communication capabilities in order to accomplish the necessary portability and mobility.

In order to understand the use of the proposed model, the example described in figure 3 estimates the use of Quick Response (QR) codes together with a u-learning context-aware, system that allows teachers to create u-learning customized materials adequate to the context. The integration of QR codes allows to connect users to information in an easy and quick way [27]. The creation of u-learning educational material is easy as well as the accessibility to QR codes readers and thus it allows teachers to build learning environments without difficulty. As QR codes readers are available in the majority of mobile devices, these codes are more and more popular and widely used in mobile

learning applications [28]. For this example we will use the QR codes technology as the one adequate to the u-learning context-oriented.

As shown in figure 3, this example comprises 3 subsystems: (i) the system to edit materials based on the QR, including materials obtained in social networks (horizontal and / or verticals), (ii) the material available in the LMS Moodle together with assessment activities and (iii) the system oriented to the context.

6 CONCLUSIONS

With all the challenges in the educational environment, educational institutions need to be more and more dynamic and entrepreneurs. The availability of different information technologies are entailing changes concerning teaching methods and pedagogy. Discussions are also covering aspects such the need of learning to become “personalized” meaning that every student is different and so materials and strategies of teaching and learning should be adapted to the different types of learners and targets.

In fact, we are far from times where teaching was teacher-driven and centred and where education was the “same” for all students, ignoring their idiosyncrasies. Thanks to e-learning platforms, social networks and web 2.0 as well as the recognition of the need to move student to the center of all the process new models of learning environment are emerging. Learning does not only occur in the classroom. And so, the LMS should also take into consideration informal learning, valuing and assessing it. The assumption of the need to bring to take learning out of the classroom was the main discussion and contribution of this paper. We presented a model – Customized x-Learning Environment – that takes into consideration all the elements present in the learning process as well as the available technologies, allowing learning to take place anytime / anywhere, depending on the student’s needs and characteristics. Of course this represents a huge step towards ubiquitous learning and to the increased responsibility of the learner since he / she will need to become more active and participative. There is still a long way before this kind of model becomes a reality. Our aim is to contribute to the reflection and discussion about this topic. Nevertheless, it constitutes a step towards the desired real customized learning environment where the student is the real actor of the whole process.

REFERENCES

- [1] Lee, Y. C. (2006). An Empirical investigation into factors influencing the adoption of an e-learning system, *Online Information Review*, 30(5), 517-541.
- [2] Council of Europe (2015). Education for change. Change for Education. Teacher manifesto for the 21st century of the conference The Professional Image and Ethos of Teachers, April 2014, Council of Europe, Strasbourg.
http://www.coe.int/t/dg4/education/pestalozzi/Source/Documentation/T21/FinalManifesto_En.pdf
- [3] M. Gleason (1986). Better communication in large courses, *College Teaching*, 34 (1), pp. 20-24.
<http://dx.doi.org/10.1080/87567555.1986.10532325>
- [4] Motschnig-Pitrik, R. and Holzinger, A., (2002). Student-Centered Teaching Meets New Media: Concept and Case Study, *IEEE Journal of Education Technology & Society*. 5(4), pp. 160-172.
- [5] Attwell, G. (2007). The Personal learning environments – the future of elearning? eLearning Papers, 2(1)
- [6] Seufert, S., et al. (2015). The Design of Personal Learning Environments (PLE) with Scope on Information Literacy in High School. Learning Technology for Education in Cloud: 4th International Workshop, LTEC 2015, Maribor, Slovenia, August 24-28, 2015, Proceedings. L. Uden, D. Liberona and T. Welzer. Cham, Springer International Publishing: 148-163.
- [7] Rahimi, E., et al. (2015). Facilitating student-driven constructing of learning environments using Web 2.0 personal learning environments. *Computers & Education* 81: 235-246.
- [8] Wolf, M.A. (2010). Innovate to Educate: System [Re]Design for Personalized Learning. A Report from the 2010 Symposium. Edited by Partoyan, E., Schneiderman, & Seltz, J. ACSD. P. 21. <http://siaa.net/pli/presentations/PerLearnPaper.pdf>

- [9] "What is Personalized Learning?" Personalized Learning Foundation.
<http://personalizedlearningfoundation.org/id3.htm>
- [10] Boyd, D. M., & Ellison, N. B. (2008). Social Network Sites: Definition, History, and Scholarship. *Journal Of Computer-Mediated Communication*, (1), 210 –230. doi:10.1111/j.1083-6101.2007.00393.x
- [11] Savery, J.R. & Duffy, T.M. (1995). Problem-based learning: an instructional model and its constructivist framework. In B. Wilson (ed.), *Constructivist learning environments: case studies in instructional design*. Englewood Cliffs, NJ: Educational Technology Publications, pp 135-148.
- [12] Downes, S. (2005). An introduction to connective knowledge. Stephen's Web.
<http://www.downes.ca/post/33034>
- [13] Siemens, G. (2005). Connectivism: Learning as network creation. Elearnspace.org website.
<http://www.elearnspace.org/Articles/networks.htm>
- [14] Archee, R. (2012). Reflections on personal learning environments: theory and practice, *Procedia – Social and Behavioral Sciences*, International Conference on New Horizons in Education (INTE 2012), 55, pages 419 – 428).
- [15] Rosenberg, M. 1. (2001). *E-learning: Strategies for delivering knowledge in the digital age*. New York: McGraw-Hill.
- [16] Kay, A. (1972) *A Personal Computer for Children of All Ages*,
<http://mprove.de/diplom/gui/Kay72a.pdf>
- [17] Weiser, M. (1991). *The Computer for the 21st Century*, Sept 1991.
<http://sandbox.xerox.com/want/papers/ubi-sciam-sep91.pdf>
- [18] Song, X and Zong, H. (2008). Research of Ubiquitous Learning Application Environment, *Seventh International Conference on Web-based Learning, 2008, ICWL 2008*, pp.37-40
- [19] Hwang, G., Tsai, C. and Yang, S. (2008). Criteria, strategies and research issues of context-aware ubiquitous learning, *J. Educational Technol. Soc.*, vol. 11, no. 2, pp. 81–91.
- [20] Peng, H., Chuang, P., Hwang, G., Chu, H., Wu, T. and Huang, S. (2009). Ubiquitous performance-support system as mind tool: A case study of instructional decision making and learning assistant, *J. Educational Technol. Soc.*, vol. 12, no. 1, pp. 107–120
- [21] Huang, Y, Chiu, P., Liu, T. and Chen, T. (2011). The design and implementation of a meaningful learning-based evaluation method for ubiquitous learning, *J. Comput. Edu.*, vol. 57, no. 4, pp. 2291–2302.
- [22] Yang, T-Z., Kuo, F-R., Hwang, J-G. & Chu, H-C. (2008) *A Computer Assisted Approach for Designing Context-Aware Ubiquitous Learning Activities*. *IEEE International Conference on Sensor Networks, Ubiquitous and Trustworthy*
- [23] Boyinbode, O.K. & Akintola, K.G. (2008). A Sensor-Based Framework for Ubiquitous Learning in Nigeria. *IJCSNS International Journal of Computer Science and Network Security*, vol.8, no.11, pp.401-405.
- [24] Yahya, S., Ahmad, E. and Jalil, K. (2010). The definition and characteristics of ubiquitous learning: A discussion, *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, 2010, Vol. 6, no 1, pp. 117-127.
- [25] Park, Y. (2011). A Pedagogical Framework for Mobile Learning: Categorizing Educational Applications of Mobile Technologies into Four Types, *The International Review of Research in Open and Distance Learning*, Vol.12, No.2, February.
<http://www.irrodl.org/index.php/irrodl/article/view/791/1699>
- [26] Mesquita, A., Moreira, F. & Peres, P. (2016). Customized Learning Environment: A new approach. In *Proceedings of the 11th Iberian Conference on Information Systems and Technologies (CISTI)*, Vol 1, pp 228-231, DOI: 10.1109/CISTI.2016.7521621
- [27] Law, C. and So, W. (2010), QR codes in education," *J. Educational Technol. Develop. Exchange*, vol. 3, no. 1, pp. 85–100

- [28] Ozcelik E. and Acarturk C. (2011). Reducing the spatial distance between printed and online information sources by means of mobile technology enhances learning: Using 2D barcodes, *J. Comput. Educ.*, vol. 57, no. 3, pp. 2077–2085.
- [29] Conde, M. A., García-Peñalvo, F., Alierb, M., Mayolb, E. and Fernández-Llamas, C. (2014). Implementation and design of a service-based framework to integrate personal and institutional learning environments, *Science of Computer Programming*, Vol 88, pp 41–53.