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Mobile devices applied to Computer Science subjects to consume institutional functionalities trough a Personal Learning Environment

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Abstract

The application of Information and Communication Technologies to learning and teaching processes has caused several effects, such as the emergence of new educational software systems or the use of different technologies to carry out educational activities. One of the most popular trends on this sense is the use of mobile devices to learn, in which is known as mLearning. It facilitates the participation and the interaction of students anywhere and anytime through such kind of devices. However mLearning should not be considered as a replacement of eLearning (understood as the Internet application to learning). It supports eLearning, therefore it should take into account the existing eLearning landscape. This implies that it is necessary to take into account the application of 2.0 Web tools, which enables an online implementation of the student-centred learning paradigm, where the learner happens to have a more central role in her training. This, joined to the necessity to take into account the learning obtained not only in the institutions, leads to definition of the Personal Learning Environments that need to coexist with the traditional learning platforms, the Learning Management Systems. So, in this case mobile learning should facilitate the use of mobile devices to support these two learning ecosystems.

To do so, this paper describes a service-based framework approach to implement a mobile Personal Learning Environment, which allows the integration of functionalities from the institutional learning platforms. With such system the learner can combine institutional tools with others she use to learn in a mobile system and reflect the activity carried out on them into the institutional side. This system is implemented and validated through its application into a Computer Science subject. The paper will show the difficulty of such application and some of its benefits such as the increase of student motivation and participation because of the use of the PLE and the mobile tools.

Keywords: mLearning, Mobile Devices, Personal Learning Environments, Interoperability, Computer Science, Validation

1.Introduction

Learning and teaching processes are affected, as many other areas by the application of the Information and Communication Technologies (ICT). Specifically, two main changes should be considered, the way in which people learn and the digital skills set that the learner and teachers should now achieve. This paper explores the former through the application of new technologies.

Regarding with such technologies the relevance of the Internet in educational processes has stood out; but the application of ICT to learning is not just limited to that particular technology, and other technologies are also used for educational purposes, which lead to the definition of different learning modalities such as mLearning, uLearning, cLearning, tLearning, etc.

From all these possibilities the application of mobile technology is especially popular, mainly because: 1) Its high uptake, there is an 86,7% of this technology penetration and more than 5981 millions of mobile devices connections, which means that most of first world population use one or more mobile devices [1]. 2) Each day it is cheaper and easier to access to best Internet connections through these devices, which implies that the user has more tools and functionalities when and where they want [2]. 3) Also each day mobile devices are evolving technologically, which implies to overcome some of the limitations that mobile devices have, mostly related with the interaction with the applications and contents (the size of the screen, the absence of a complete keyboard, etc.) [3].

Given these reasons it is possible to apply mobile devices to learning and teaching processes in which is known as *mLearning*. This learning modality provides several advantages such as: more time to learn, geographically availability, independence from a fixed context and personalization, context awareness activities, a small learning curve to use the technology, new motivations, etc. [3-7]. Despite all these

advantages mLearning should be seen as a way to support other learning modalities and not as a replacement of eLearning [4], so it is necessary to consider how to apply it and the current eLearning landscape.

Regarding to this, in eLearning contexts one tool has achieved special relevance, the Learning Management System (LMS). These learning platforms are employed by most of the institutions to carry out different learning activities [8, 9]. However, despite this high level of adoption they have not resulted in the educational improvements, which might have been expected. Three principal reasons have been offered for this: 1) The tools provided are not used properly and often are used as mere spaces to publish courses [10]; 2) LMSs restrict opportunities for collaboration in student learning and for the promotion of social constructivism which is not limited to a period of time (i.e. academic year)[11]; and 3) They are focused on the course and the institution rather than the student and their needs [12].

In order to address these problems, learning institutions need to change their strategies. They must provide environments more adapted to the student and open to include the new set of Web 2.0 tools that are under the student's control. This can be done through the Personal Learning Environment (PLE). It seeks to unburden the learner of the need to learn new systems when they engage in formal learning. PLEs facilitate the user learning process by allowing them to use the tools they want to use and not joining them to an specific institutional context or learning period [13].

PLEs are not a replacement for LMSs because: 1) both environments support different kind of learning (LMS support formal learning while the PLE are more oriented to informal contexts) [13]; and 2) LMS have a high acceptance (especially in institutional environments), have been used during several years and are strongly tested, both teachers and students are used to using them, and institutions have made a great investment for their implementation, improvement and adaptation [14]. All this means leads that both environments should coexist. Given this context, it is necessary that the environments which support formal learning (LMS) and those related with informal learning (PLE), have a certain degree, the higher the better, of integration and interoperability. In this way formal environments can export functionalities to the informal ones and the activity that is carried out in informal environments can be taken into account into the institutional learning platforms.

In this situation, mLearning could support eLearning activities facilitating the representation of a PLEs in mobile devices (mPLE) that can interact with the institutional LMS. Specifically during the paper an approach is posed on this sense and it is applied through several pilot experiences carried out with students of the University of Salamanca.

In order to do it, the context of the research is explained in section 2, which describes mPLE implementations experiences and integration possibilities. Later, the architecture proposal is described focused specifically in the exportation of institutional functionalities from the LMS to the mPLE and how it is implemented. The following section describes how the pilot is carried out. Finally, some conclusions are exposed.

2. Mobile PLE initiatives and the integration with the LMS

As commented above, the present paper aims to define a way to implement and deploy a mobile Personal Learning Environment that can interact with the LMS, this implies two main issues that define the research context: the representation of personal learning environments in other contexts (such as mobile devices) and the interoperability between the LMS and the PLE.

Regarding with the first issue. The present technological landscape makes it necessary not only to consider web environments, but also new realities such as mobile devices or interactive TVs. That is, the LMS and/or PLE should not only be considered from a traditional perspective, but they must be open to other contexts. There are several possibilities to achieve this desired portability.

Some trends consider that it is not necessary any kind of adaptation of neither information nor functionality because the new devices provide by themselves the tools and frameworks which allow the learners to personalize their learning [15-17]. For example, mobile devices or tablets could be understood as a PLE. This idea is correct but the integration of the tools the students use to learn is not so clear because they are not in the same space and the tools that are valid in a context do not always work in others, which can mislead the learner of her ultimate goal, to learn.

Other initiatives define tools for learning using the specific capabilities provided by the devices (GPS, camera, accelerometer, etc.). Some good example can be: the CONTSENS Project [18] used in several learning experiences in London; a Mobile Personal Environment (MPE) helping students to communicate between them and with experts by using the mobiles [19]; and experiences to learn languages by using the mobile and taking into account the context of the user [20]. The problem of these solutions is that they have a great dependence with the hardware and software of the devices (although software dependences

are being solved because of the popularity of some operative systems such as Android and iOS, and other technologies such as HTML5 or widgets-based solutions).

On the other hand, there are many projects that use mobile devices as PLE by including learning functionalities and institutional tools to them. Two representative examples could be MOLLY project [21], a free open initiative integrated with the LMS Sakai, which allows students to contact with experts, to access to academic podcasts and libraries and to obtain information related with a institution; and CampusM, a mobile application that provides different tools to each student adapted to her necessities (internal messages, blogs, portfolio, maps, calendars, alerts, etc.) and which allows integration with LMSs like Moodle or Blackboard [22]. The main drawback of this kind of solutions is that they are too specifically defined for an institution in a technology although this can be solved through the use specifications and standards.

Other possibility is to use mobile communication features, such as the use of RSS clients or SMS. Two examples of this use of mobile devices' features are OnlineConnect Project, which sends custom information to each student's mobile phone [23] or REACh (Researching Emerging Administration Channels), which sends alerts from the LMS to mobile devices by using that technologies [24]. The problem of these solutions is that they are quite limited by the use of those communication technologies.

There are also some interesting initiatives to define PLEs such as Elgg, that has released mobile versions in order to make possible an easy way to build PLE and access to them through mobile devices [25]. With this system it is possible to access from a mobile device to virtual communities defined with Elgg, but this tool is not always enough to define a PLE because it should be enriched with other learning tools and has no communication ways with the LMSs.

Moreover, it is also possible to use widget-based solutions employed to define a PLE in other contexts. In this sense, there are several initiatives such as Aplix Web Runtime[26], the Widget runtime: WAC-1.0 Compliant Golden for Android [27] and the consortiums between different companies to define common interfaces for mobile applications [28]. Also related with widgets, other projects such as Webinos (http://webinos.org/) should be considered. Webinos defines an open platform to share applications between different contexts. This means that an application can be used in a TV, a mobile device, in a car navigation system etc. Particularly, they define interfaces to allow information exchange and component integration (components that are an extended version of the W3C widgets) [29]. The problem of these solutions is that not all of them use standards to define widgets, so they are not valid solution in platforms different from which they are defined.

Last, but not least, it is possible to use tools LMS native tools from the mobile device, in a way that these tools can be combined with the device own tools. These are very common solutions implemented by most LMS [30-33]. These initiatives are closely linked to the institution and it is not easy to integrate additional functionalities into the mobile PLE and to combine them with other tools.

All these solutions show that it is possible to open the PLE to other contexts. However, the heterogeneity of communication interfaces, software and hardware, and the lack of control over the activity, is hampering the definition of real independent PLEs.

The other issue to explore in the research context is the interoperability between the LMS and the PLE, Wilson and others proposed three possible ways to integrate PLEs and LMSs [34]:

- PLEs and LMSs could exist in parallel, as formal and informal environments respectively, without any interaction or integration of the activity that happens in those contexts.
- One could open the LMSs through the inclusion of web services and interoperability initiatives. This integration trend includes: *iGoogle* based initiatives [35], social networks connected with LMS [36], the LMS that offers support for implementations of interoperability specifications [37], PLEs with specific communication protocols [38] or integration based on service-oriented architectures - SOA [39]. There exist two main difficulties for these initiatives are: institutional barriers to the opening of formal environments and the fact that those initiatives are focused on information exportation and not on interaction exchange. That is to say, communication is oriented in one direction, from the LMS towards the external tools; basically exchanging information about what happens on the platform and providing no information or interaction back to the LMS.
- Integration of external tools into the LMS. In these initiatives, the user might not decide which tools she is going to use and they will be limited to institutional decisions. Some initiatives that can be included this group are: LMSs defined for the integration of external tools [40], *Google Wave* Gadgets integrated into *Moodle* [41], PLE introducing tools based on log analysis [42], initiatives based on tool integration driven by learning design activities [43], integration architectures [44], etc. These initiatives pose several problems, such as: integration problems between tools, context integration difficulties, inflexibility for customization by the student and so on. Those that best overcome these problems are the ones that define a learning platform

starting from scratch or from a previous institutional development. This will greatly limit the scope of use of the solution, which will be applied to a very specific context and implies that the student should learn to use the new systems.

Taking all these solutions into account, with their problems and how they are faced, a possible solution could be based on the combination of second and third scenarios. In the present article this is done through the use of a service-based framework and a set of interoperability scenarios. It allows the integration in the PLE of tools from the LMS and any user interaction carried out in the personal environment is recorded in the institutional one. In addition it is possible to represent the functionalities in mobile devices.

3. Service-oriented approach

In the previous sections the necessity to represent a Mobile PLE able to interact with the LMS, has been presented. To achieve so, it is necessary the use of service oriented approaches. The authors of the present paper have defined in a previous work a service-based approach to support such kind of representation and interoperability [45]. It is based on an institutional environment represented by one or several LMSs and a PLE that includes different tools represented as widgets (that can be included in different contexts including mobile devices). Those components interact among them by using the web service layers provided by the LMSs and interfaces based on interoperability specifications. In addition, some elements are introduced to facilitate such interoperability as mediators. In order to describe the most common interaction ways between the LMS and the PLE, some interoperability scenarios have been defined [46]. Such architecture is shown in Figure 1.

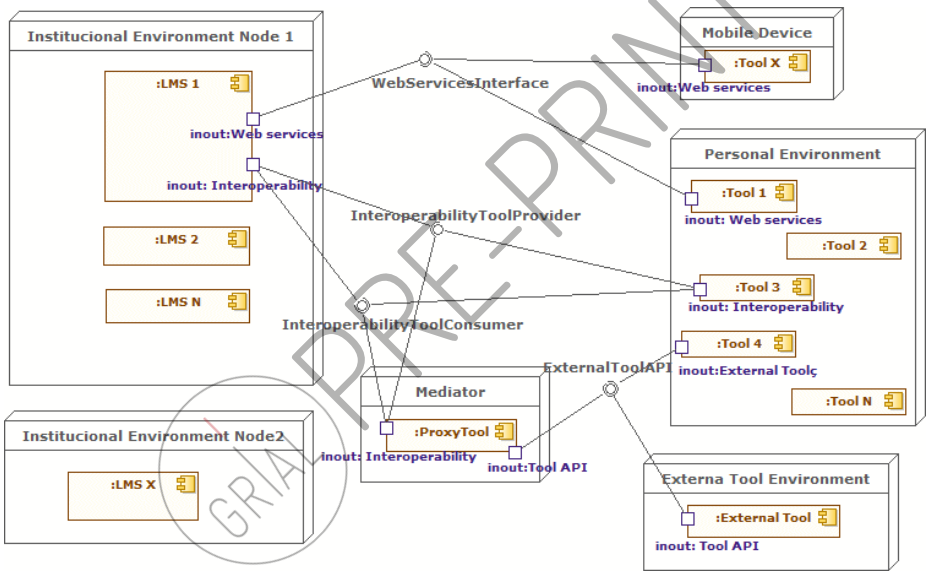

Figure 1. *Architecture deployment diagram. It includes two institutional nodes with different LMS, a proxy tool in a mediator node, the personal environment, an external learning tool and a Mobile device.*

In this case just one of the interoperability scenarios and the some of the components should be taken into account, because although the mobile devices can be employed with all of them it was just taken into accont with the exportation of institutional funcionalities. This means that from the previous diagram just the institutional node with the LMS 1 and a web service interface that is used by the Mobile device should be considered. The functionality in the mobile device is represented in two possible ways, as a widget (a kind of mini-application), which can be displayed in a widget container (such as Aplix Web Runtime or the Widget runtime: WAC-1.0-compliant Golden for Android described above); or as a LMS mobile version that can include other tools such as could be Moodbile [47]. The widget option allows the user to combine functionalities exported from the LMS with other tools she used to learn. The LMS mobile version includes several tools and can include new ones (although this is conditioned by the solution selected from the existing ones).

This architecture has been implemented in order to validate it with real users. To do so a proof of concept is carried out using: 1) Moodle as the LMS in the institutional environment, this LMS is selected because of its high uptake [48] and the web service layer that includes [49]; 2) a W3C Widget [50] to represent the tool into the mobile device [34] because it is the specification to define widgets proposed by the W3C and in this way it is easier to represent this widgets in other contexts (Left side in Figure 2); 3) Moodbile as a

Mobile LMS software to check the other possible tool representation in the device (Right side in Figure 2); and 4) the web services interfaces to facilitate the interaction with the LMS.
With this implementation the learner can include an institutional functionality into her mobile PLE and combine it with other tools she use to learn through this mobile device. The selected functionality has been the forum because it is one of most used Moodle tools in the University of Salamanca. All that happens in that mobile version of the forum will be automatically reflected into Moodle, so the teacher can controlled the activity of the user outside of the institutional environment.
In the following section the pilot carried out by using this implementation is described.

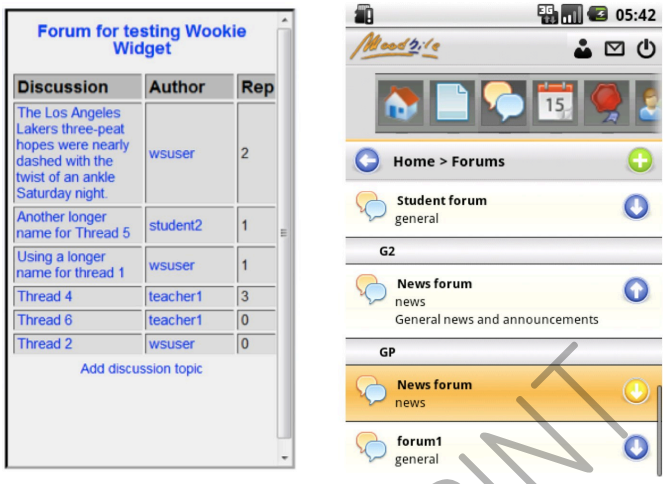

Figure 5. Forum representation in a W3C widget (on the left side) and in Moodbile (on the right side).

4. Pilot

In order to validate quantitatively a pilot is carried out with students of Project Management Subject of the University of Salamanca.

4.1. The subject and the mPLE application

During the academic year 2011-2012 the Adaptation Course to the Degree in Computer Science studies of the University of Salamanca was launched. It appeared this year to facilitate adaptation to new learning programs derived from the Bologna process of students in previous Computer Science learning programs. In the context of this course there are different subjects and the experiment was applied to the "Project Management Subject". This subject studies Management Activities related with Software Engineering: Software Measurement, Effort and Cost Estimation, Planning, Risk Management, Quality Management and Software Configuration. The subject comprises 6 credits (4.5 theoretical and 1.5 practical). These credits are distributed in 20 face-to-face hours, 6 practical seminars and 2 tutorial sessions, complemented with several hours of student personal work. The evaluation of the subject consists of a final exam that supposes 40% of the final grade, several surveys and tests that the user should complete during the subject (20%) and a final project (the remaining 40%).
Sessions are supplemented by using Moodle as a space to discuss issues related with the subject, download documentation, submit surveys and works, and so on. During the pilot the idea is to export Moodle forum to the mobile device and set up an activity based in such tool. The learners use the mobile to answer about the different project management estimation costs.

4.2. Methodology

The idea behind this experiment is to validate the scenario by taking into account both students and teachers' perceptions about it, understanding this issue as something that can be addressed in a qualitative way. However, to generalize the conclusions it is also interesting to use quantitative techniques so during the experiment both perspectives are used. This is known as mixed research methods and provide a more complete approach to validation [51].
Specifically, all 40 participants in the course have been involved. The quantitative methodology used to validate the system is a quasi-experimental design [52]. This methodology is used because in this experiment pre-established groups of students (class-groups) are involved, so it is not possible to have a complete randomized group of people [53]. Thus experimental design is not applicable. Quasi-experimental design implies the definition of a hypothesis that is checked by using an experimental group and a control one (independent variable). In both groups the same tests are applied, a pre-test at the

beginning of the experiment and a post-test after it. The students of the experimental group test the system (that is to say they use the forum application in the mobile Personal Learning Environment) while the people in the other group do not. After running the experiment data is analysed by using probabilistic techniques to validate the initial hypothesis.
The qualitative analysis is based on open questions related to students' opinion about how utility of the mobile PLE and the possibility to combine institutional functionality with other tools to learn in their mobile devices. The answers of the text have been analysed, units are defined with a thematic criteria; after that the outcomes are synthesized and they are grouped according to the units. In this case the units are interaction, combination, and participation. Later the results are shown in a matrix and conclusions posed from that information [54].

4.3. Ressults and disscussion

Regarding with the quantitative techniques the scientific hypothesis defined for the experiment was "The students value as a positive asset to the use of institutional functionalities in a mobile device, which helps them to learn". From such hypothesis a dependent variable is defined: "The impact of the use of institutional functionalities through mobile devices". To operationalize this dependent variable, some asserts (also called items) have been proposed to the students and they have graded their agreement by using five value levels (1=Strongly disagree, 2=disagree, 3=indifferent, 4=agree, 5=Strongly agree).
In the pre-test:

- I.1. Sometimes I use my Smartphone to access to Moodle and its resources.
- I.2. I use my mobile device to learn through online tools and some mobile applications.

In the post-test:

- I.3. The application of online tools, mobile native applications and Moodle functionalities into the mobile help me to learn.

The scientific hypothesis is accepted if the results of the pre-test are similar in both groups (which prove that both groups are similar and have a common knowledge and background) and the results of the post-test between the persons involved in the experimental group and the control group are different (those who have tried the tool should answer in a different way). So we propose the following null hypothesis for both groups H0: μE = μC (where μE is the average grade for the experimental group and μC for the control group). To check it, two statistical tests are applied, Student's T test and the non-parametric Mann-Whitney U test. The second one is applied to further validate the results of the first, because the sample consists of only 40 students, and this number is near to the limit for the application of Student's T-test and also because the scale used to measure students' perception is not exact (it is an ordinal scale). The results of the first test can be seen in the Table 1, with a signification of a 0.05. If the signification of the item is under 0.05 the null hypothesis is accepted, if not, it is rejected.

Pre-test results for Student's T test						
VD	$\overline{X_E}$	S_{X_E}	$\overline{X_C}$	S_{X_C}	t	ρ
I.1	2,70	1,081	2,85	1,348	-0,388	0,700
I.2	3,15	0,933	2,75	1,209	1,172	0,249
Post-test results for Student's T test						
I.3	4,05	0,759	3,35	0,988	2,512	0,016

*Table 1. The results of the Student's T-test. The table shows the medium ($\overline{X_E}$, $\overline{X_C}$) and standard deviation (S_{X_E}, S_{X_C}) for each item of the pre-test and post-test, the result of the contrast test (**t**) and the bilateral signification (**ρ**).*

In Table 1 one can see that in both pre-test items the null hypothesis is retained (that is, the experimental and control group answer more or less the same) with a bilateral signification of 0,700 and 0,249 that is greater than 0,05. In the post-test the null hypothesis is rejected (the results between the experimental and control group are different). It should be noted that in item I1 and item I2 the average for the experimental and control groups are around 2 or 3, which means that most of them do not use mobile devices to access Moodle or other learning tools. It is also interesting to consider the average of the experimental group in the post-test (4,05) which shows that the students who tested the system consider it useful for learning. These results are also endorsed by the Mann-Whyney U test (Table 2), so it can be affirmed that the scientific hypothesis is correct, so from the perspective of the students that use the mPLE the initial hypothesis is correct, that is to say the use of institutional learning functionalities in mobile devices helps them to learn.

Pre-test results for Mann-Whitney U test

$VD_{pretest}$	Signification	Result
I.1	0,585	Retain null hypothesis
I.2	0,186	Retain null hypothesis
Post-test results for Mann-Whitney U test		
I.3	0,017	Reject null hypothesis

Table 2. The results of the Mann-Whitney U test. The table show the signification per each item of the pre-test and post-test.

To support this conclusion an opinion assertion about the experience was posed to the students of the experimental group. This assertion is: "After using the Moodle forum through a mobile device I consider export tools like that to mobiles make me easy to follow discussions and participate in the forum, so my learning is improved and the forums use is in my opinion more attractive". The 85% of the students agree or strongly agree with the assertion, they consider useful to export this kind of functionalities.
In addition, in order to evaluate the students' opinion they were asked about their opinion through an open question. As previously commented, in this case qualitative techniques are used. The results of the qualitative techniques can be seen in Table 3. It shows some of the words that students provide in issues related to the interaction with the device, the combination in the mPLE of institutional and other tools they use to learn and the influence of the system in their participation.

	Interaction	**Combination**	**Participation**		**Interaction**	**Combination**	**Participation**
S1	Good	Positive	Increment	S11	-	Innovative	The same
S2	Very good	Positive	Improvement	S12	Interesting	Interesting	Better
S3	Excellent	Positive	Increment	S13	Good	Useful	Increment
S4	Normal	Useful	-	S14	Easy	-	-
S5	Excellent	Open	All tools toguether	S15	Easy	Flexible	All in one
S6	Interesting	Evolution	More engagement	S16	-	-	-
S7	-	Improve	All in a device	S17	Cool	Improve	Anywhere/Anytime
S8	Good	Innovation	Improvement	S18	Excellent	Useful	Better
S9	Cool	Positive	-	S19	-	Useful	-
S10	Better	-	Indifferent	S20	Amazing	-	Indifferent

Table 3. Results of the text analysis grouping the text by the units defined. The values of the first and fifth columns represent the student id and the rest of the columns the answers extracted from the open questions.

From Table 3 it is possible to conclude that most of the students see useful the exportation of institutional functionalities such as the forum to mobile devices. They see an improvement in the interaction with the information through the mobile devices in comparison with the traditional browser access to the forum. They also think that the combination of such tools with others that they use to learn are positive and enriches their learning. In addition, the participation can be increased because they can use the tools in other contexts more adapted to their needs and because they have all the tools they use to learn in the same framework.
Moreover during the pilot also teachers' opinion is taken into account through several semi-structured interviews. On them, the system is presented to the teachers, and afterwards their opinion is requested. The results are: 1) the 70% of the teachers agree or strongly agree with the exportation of institutional functionalities to mobile devices in order to improve students participation and enrich institutional learning. The other 30% consider that is not easy to have mobile devices involved in all kind of learning contexts.
The conclusions obtained from these experiences allow the validation of scenarios, which means that the exportation of institutional functionalities to a PLE is possible and useful, but always from the students' and teachers' perception; as a future work they should be checked in other contexts, with other kind of students, etc.

5. Conclusions

Along this paper a main challenge has been introduced, the possibility to employ mLearning theories and technologies in order to develop a mobile Personal Learning Environment. Such system allows learners to include into a mobile PLE, institutional activities and tools imported from the LMS. These learners can combine the imported tools with other they use to learn in non-formal environments. In addition it is

necessary to take into account what happens in the external activities from the institutional side in order it can be taken into account to assess learner activity.

In order to do so an architectural approach has been posed and a proof of concept that implements part of it is described. In such implementation two possible ways to represent the system have been developed. This proof of concept has been validated in a quantitative and qualitative way with students and teachers of the University of Salamanca. From this pilot it is possible to conclude that from the students perspective and in a controlled context, the opportunity to represent students' PLE in a mobile device that includes functionalities and/or information from the LMS which could be combined with other tools they use to learn, encourages them to participate in the subjects and helps them to learn. This conclusion is reinforced by teachers from different context that consider the system useful and engaging, however they see some problems such as the cost of mobile devices in several educational contexts. Moreover the students consider that, the kind of interaction and the portability that this system provides them, makes easier their participation in the institutional learning activities.

As a future work, it would be interesting to consider other of the possible interoperability scenarios that the architectonical approach provides in order to facilitate the interaction between the mPLE and the LMS, such as the use of BLTI and not only the web services to communicate with the LMS. In addition, to guarantee the achieved results the experience should be repeated in other different contexts such as Secondary and Primary contexts. Moreover some improvements should be done in the system i.e.: new tools needs to be adapted to be included in the PLE; problems related with widget representation in mobile devices have also to be solved; new ways to represent contents in such devices must be developed, etc.

As a final conclusion it can be said that the definition and application of Mobile PLE is possible, there exists several ways to do it, but any of them should consider the interaction with the LMS.

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