Informal learning recognition through a cloud ecosystem

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Abstract

Learning and teaching processes, like all human activities, are mediated through the use of tools. Information and Communication Technologies are now widespread within education. Their use in the daily life of teachers and learners affords engagement with educational activities at any place and moment and not necessarily linked to an institution or a certificate. In the absence of formal certification, learning under these circumstances is known as “informal learning”. Although without certification, learning with technology in this way presents opportunities to gather information about an individual’s learning and to present new ways of exploiting their learning. Cloud technologies present ways in which this can be made possible, through new architectures, methodologies and workflows that facilitate the semantic tagging, recognition and acknowledge of informal learning activities. The transparency and accessibility cloud services means that institutions and learners can exploit existing knowledge to their mutual benefit. The TRAILER project facilitates this task by providing a technological framework using cloud services, a workflow and a methodology. The services facilitate the exchange of information and knowledge associated with informal learning activities ranging from the use of social software through ‘widgets’, computer gaming, and ‘remote laboratory’ experiments. Data from these activities is shared among institutions and learners/workers., etc. The project demonstrates the possibility of gathering information related to the informal learning activities independently of the contexts or tools used to carry them out.
Keywords
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1. Introduction

The emergence of Information and Communication Technologies (ICT) and its application in different contexts has entailed a revolution in the way communication tools are used by people in their daily life. Computers, the Internet, mobile devices and more recently “Web 2.0” tools, provide new ways to access, share and exchange information and knowledge. As part of this process, learners and teachers have embraced new technologies as a means of acquiring tools and resources for learning [1] and engaging with each other through the use of social networks. Teaching practices have consequently adapted to changes in the technological environment [2].

However, new organisational challenges arise from the new technology. These include:

1) The problem of ‘technology deviation’ [3], where the need to continuously upgrade technologies confines learners and teachers to technical processes, rules, and resource constraints meaning that technological concerns rather than pedagogical requirements take precedence.

2) The problem of interoperability [4], exemplified by fact that the most representative ICT tool applied in learning context, the Learning Management System (LMS), has limited synergistic capabilities. Lack of reusability and portability can lead to lock-in with system vendors, lack of flexibility for learners and presents barriers for the integration of new tools or the evolution of existing systems.

3) The problem of centralisation, where institutional requirements shape the technology, not the requirements of learners. Rather than bringing their own favoured tools to their learning, learners are forced to use institutional tools whose functionality often reproduces that in extra-institutional tools which invariably are more effective than the institutional variety [5, 6].

4) The problem of access beyond the institution, where the LMS (Learning Management Systems) is often unavailable to learners once they finish their studies, making integration of lifelong learning with institutional learning difficult [7, 8].

Cloud computing, defined as “a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g. network, servers, storage, applications, and services) that can be rapidly provisioned and released with
minimal management effort or service provider interaction” [9] is one of the major drivers of change in education. Broadly, this technology marks a transition from local computing offerings to external ones [10]. Offerings can be fairly simple, services such as virtualised desktop, data storage, and email or whole applications such as office application suite, security package, and collaboration tools [11].

Cloud computing applied to learning and teaching processes is known as cloud learning. The concept is built on three services models: Infrastructure as a Service – IaaS; Platform as a Service – PaaS; and Software as a Service - SaaS. It can be understood as a shared pool of learning courses, digital assets and resources, which instructors and learners can access via computers, laptops, IPTVs, mobiles and other portable devices [12]. The technical affordances of cloud learning invite new pedagogical designs that emphasize learner-centred, resource sharing, and collaboration among learners to jointly build personalized learning environments [3].

The flexibility of cloud technology can help learners bring technologies of their choice to their learning, rather than having institutional technology imposed on them. In this way, some of the issues identified within the problem of “technological deviation” might be addressed, with greater personalisation enabling more attention to be paid to higher level thinking skills and group intelligence rather than technical coordination. At the same time, problems of interoperability, integration and reuse can be overcome with increased use of web-services on cloud platforms.

In considering the third problem of institutional-centred platforms, integration with personal cloud-based technologies are becoming technical architecture requirements as institutions seek to integrate their own services with Web 2.0 tools that are under the student’s control [13]. The rationale for the shift of this ‘locus of control’ is that personalization can improve learning by empowering the students to manage their learning at their own pace [14] with their own technology within the context of the activities of their daily lives which are also managed by the same technologies. This can be achieved through the broad concept of the Personal Learning Environment (PLE), which directly addresses the technical coordination problems of learners by providing the means of coordinating services from the institution with other services from the web [15].

The approach of the PLE is to provide an accommodation between institutional learning episodes and the coordination of real life. Within the latter, informal learning is an important element in the support of lifelong learning. With the technical means of coordination of informal learning comes the potential for recognition and exploitation of informal learning activities. In the workplace informal learning is important because it can enhance employability and produce positive benefits for managers and companies.
Recognition of informal learning produces information that can develop knowledge of skills and knowhow within an organisation and be an indicator of social norms and preferred patterns of behaviour [16, 17]. For employees, recognising informal learning provides the opportunity keep their skills up-to-date, where such recognition can become part of workplace culture for self-development beyond corporate training regimes. These opportunities have led to interest in informal learning from the corporate world, driven by the desire to capitalise on the intellectual assets of the workforce, to manage organisational knowledge and in recognition that informal learning may prove a cost effective way of developing competence [14] driven by the increasingly transparency of technology [18].

The TRAILER (Tagging, Recognition, Acknowledgment of Informal Learning Experiences) project [19, 20] describes an architecture and methodology that aims to facilitate the exchange of experiences among the employees or students and the institutions. The aim is to expose those competences acquired informally that would otherwise be invisible to the institution. The methodology is supported by a cloud-based architecture that combines different tools allowing for the addition of semantic tagging of learning activities that are carried out in different contexts such as web-browsers applications, remote labs, games and social software widgets. TRAILER does not aim just to define a cloud-based system that integrates resources [21], facilitates a set of specific services (such as mobile services) [22], facilitate teaching [23], define a cloud learning management system [24], or a PLE [25]. It tries to facilitate the exchange of knowledge related to informal learning activities among learners and institutions. The present paper is focused specially in how the different kind of activities (the activities carried out through a browser, a game, a widget, or in a remote lab) are integrated in the architecture, tagged by the user and published to institutions, employers and other individuals.

The paper is structured as follows: first (in section 2) the TRAILER project and its architecture is described. After that, three informal activities gathered by the system are described: games (section 3); remote labs (section 4) and social software widgets (section 5). In section 6 some results of the evaluation of the system are discussed.

2. TRAILER project

The TRAILER project [19] is a research project funded by the European Union through the Lifelong Learning Programme. The project is based on the premise that although technology may afford practical solutions to problems of personal learning, technological approaches can present new issues of ownership and control. The desire is that learning processes are under the control of the learner, and this entails the
integration of informal learning with formal approaches balancing personal inquiry and coordination with the need for institutional accreditation of evidence of competency.

The project aims to achieve this balance by bridging the learner's activity with institutional processes. The learner identifies episodes and evidence of informal learning in any of the different spaces in which she learns (formally or informally). She then submits links to these or uploads them to the TRAILER tool located within her portfolio, and then tags them in relation to a predefined but evolving catalogue of competences. The tool is linked to the institutional interface in such a way that relevant experiences are accessible to the institution. Other experiences that may be personally relevant to the learner are accessible to her alone.

In this way informal learning experiences become transparent and useful both for the individual, who can thus monitor and justify to others the development of her competences, and for the institution, which can follow the progress of individual and group competences, and identify emerging new competences.

The technical architecture and methodology of TRAILER aims to facilitate a process that leads to the co-creation of a portfolio of informal learning activities and a discussion that helps both learners and institutions to integrate informal learning in preparation for sharing or for formal accreditation [26]. The architecture comprises a cloud-based framework with several components and interfaces to make possible the interaction required. The interfaces are based on the use of web services, which afford connections between components developed in different programming languages in a transparent way to the user. The framework is described in Figure 1.
Figure 1. – Technological framework to support the methodology that includes the Cloud Personal learning Network (on the left side) which integrates a portfolio system and some institutional tools (on the right side) such as an institutional environment, a repository and a competence catalogue.

It consists of:

- A Personal Learning Network (PLN) which includes different learning tools that the learner can use in an informal way. In order to implement the system and gather the informal learning activities, several types of tool-mediated activity have been considered: informal activities carried out through browser (for example the use of online tools, the use of forums, searches of resources in repositories, use of remote labs in informal contexts, etc.), with a widget container (that could combine different kinds of tools including social software), or playing games through a mobile device browser. With this architecture, other possible informal activities could additionally be included, particularly other web-based activities.

- A portfolio system in which informal, non-formal and formal learning experiences can be stored and published. The TRAILER portfolio has an interface to facilitate the gathering of informal learning activities. This is called the Informal Learning Collector (ILC). By using this interface it is possible to gather the informal learning activities carried out in the different tools.
• There are several institutional tools. These are: a Competence Catalogue that facilitates a way to categorise informal learning experiences taking into account learner or institutional perspectives; an Institutional Environment that facilitates the analysis of the published information in order support dialog with the learner and to facilitate decision-making concerning learning issues within the institution (for example, accreditation processes); and a Repository to store the information to be analysed and facilitate the generation of reports that could be useful to both institution and learners.

The competence catalogue facilitates the semantic description of informal learning experiences. It includes some competences at a ‘general’ level that are in any institutional catalogue, competences related specifically with the institution and other competences provided by the users. Each of the competence levels can feed the others. For example, if a competence at the institutional level appears in several institutions and several times, it can be incorporated at the ‘general’ level. A similar process applies to students’ individual competences. The competence catalogue in addition links the competences with a reference framework, and to do this the project collaborates with others as INLOC (http://wiki.teria.no/display/inloc/Home). The competence catalogue operates as a web service, which is consumed by the other components of the TRAILER architecture. This component facilitates the association information to an informal activity that later can be exploited in a semantic way.

With this framework it is possible to define a workflow that makes informal learning experiences transparent to learners and institutions in such a way that both of them will benefit. The workflow comprises: 1) The learner, after identifying an instance of informal learning that has taken place in her PLN, tags it using an interface known as the Informal Learning Collector with tags from a predefined competence catalogue. This information will then be stored in a portfolio belonging to the learner. 2) The learner then at a later moment reviews the range of tagged informal learning instances and decides which of them she will make visible to institution (her employer or her tutors). 3) The institution is able to view this information and analyse it. 4) The information permits a dialogue with the learner in order to agree on the competences that have been acquired through informal processes, and orient future activity. The information also allows the institution to plan formal and non-formal actions in the light of the informal learning that is taking place, and permits matching of learners to others with similar interests based on their informal learning activity, interests and development.

In this paper special emphasis is done as to why some non-common informal learning activities are considered in the project (games, remote labs and widgets), how they are
integrated in the framework and how they facilitate tagging informal learning experiences.

3. Special tools on the cloud to gather informal learning activities

The TRAILER project facilitates the use of contrasting tools to gather informal learning activities. The most common tool is the web-browser. Navigation to a web page, participation in a forum, reading a blog or seeing a video constitutes examples of activities which the learner might choose to submit. However these are not the only ways to gather information and in this section are presented some other significant ways to take into account informal learning activities by using tools on the cloud.

3.1. Games

Games represent a new interactive media, different from TV, radio and books. Research shows that the proportion of leisure time spent with games is increasing to overtake that spent watching TV. Whilst ‘fun’ is often cited as a reason to play games [27], often the source of fun in different kind of games comes from solving puzzles or demonstrating acquired skills, as a response to a challenge that the game provide. If there is no challenge, or if the challenge is insufficiently great, a game can be perceived as boring and usually abandoned. Consequently, the main problem in constructing educational tools based on games is the question of finding the balance between entertainment and educational value [28].

Games as an interactive medium provide possibilities for educators to create learning contexts as simulations closely related to real life situations. The assumption is that effective simulations within a game context can be programmed in a manner where the inherent motivating factors from real life also apply to engagement with the game.resulting in authentic activity in which meaning and relevance naturally emerge [29].

Recent research exploring the effect of games on concentration, decision-making processes, problem solving skills, logical thinking creativity, teamwork and computer skills indicates positive effects [30]. Estallo [31] goes further and claims that people who play games have more developed intellectual skills than those who don’t.

There is an evidence that the experience of ‘fun’ is related with levels of dopamine [32]. On solving some problem or situation, neural activity appears to lead to higher dopamine levels. This presents some intriguing explanations for the motivation for problem solving and biological survival mechanisms. It further suggests a positive correlation between learning and fun.

The mechanism described above only appears to work when the learner’s tasks are suited towards their immediate needs and context. Thus one-size-fits-all approach,
usually taken into schools, is not good enough, and cannot satisfy learning needs of each student in a class.

The emphasis within a personal learning environment (PLE) is similarly on the contextual needs of learners and their coordination challenges. If flexibility and personalisation can be leveraged to personalised learning then it may be possible to enable learners to learn in ways they determine to be fun.

Educational games consequently become important part of any PLE, as an informal learning tool and therefore they form part of the activities within the TRAILER project. The challenge is for a player to pursue enjoyable activities within a game without explicit acknowledgement of their learning, and yet for that learning to be retrospectively tagged and entered into their portfolio.

A software platform has been developed with the aim of supporting the production of educational games by educators without any programming skills. The software separates the roles of game designer and knowledge expert. By doing this, both participants in the game creation process perform only the activities within their own specialty. The system consists of three parts: a knowledge repository; a game editor (Figure 2) and a web-based game interpreter (Figure 3). Learning objects, which are stored in the data repository, represent knowledge. The Game editor is used for defining the game world, rules, scenarios, interactions between players and characters, as well as incorporating knowledge into the game. The Game interpreter presents the game to the user, creates the game interface and monitors communication between the game and the user. The Game editor creates a special XML file which contains the game definition and the knowledge definition. The XML file is then used by the game interpreter to create a game instance [33].

The software is written in Java: the game editor is developed as a standalone desktop application, the learning objects repository is developed as a web application with web service interfaces, and the game interpreter is developed as Java Applet and provided to the end users via Internet [33].

The tagging of informal learning occurs in a number of ways. With smaller games, informal activity is send to informal learning collector (ILC) data about the game played. Larger games can take hours and often days or months to be finished. When this is the case, tagging occurs after each finished game level or even few times in one level, while player progress through the game.

The educator can offer tagging of informal learning at any stage of the game, depending on his estimation about significance of each quest or quest step. The game editor is expanded to allow the educator to offer tagging in any moment of the game (see Figure 1). Tagging can happen with player acknowledgement or without. This will
enable educators to automate the process of sending informal learning activities to the ILC.

Figure 2. Educational game - Game editor

In the game developed for the TRAILER project, with the educational content in the field of computer networks, the player has the option of sending learning activities to ILC after each quest completion (see Figure 3).

Figure 3. Educational game - Computer networks
In the current version, the educator can submit textual descriptions only, which will be sent together with the URL of the game to ILC. In future developments, we plan to send a screenshot of the game state.

Communication with the ILC is realised utilizing web services, available through JSON-RPC calls. Since the game is executed as Java applet, this communication requires the integration of a Java library. Security restriction on the communication of Java applets, the applet has to be signed with appropriate security configurations which allow the connection across network domains.

In order to authorize player to the ILC, the first step of the game was modified, with the player being asked to provide their ILC username and password. Game applet is deployed on separate server, but such game can be easily added as a resource to any learning management system, such as Moodle.

3.2. Remote LABs

Remote laboratories are physical spaces with real apparatus and real instruments connected to the Internet. They allow both students and teachers to remotely conduct real experiments through a simple web browser. Aktan et al. [34] first described the concept of remote experimentation in 1996, and since then many other authors have converged into the idea that remote labs play a significant role in the acquisition of experimental skills if successfully combined with real, hands-on laboratories and virtual laboratories [35-39]. The sort of experimental skills students are able to acquire in any type of laboratory has also been clarified in a recent work of Feisel and Rosa [40]. In this paper, Feisel and Rosa describe thirteen (13) fundamental objectives of engineering instructional laboratories, which serve as a guide when considering the sort of skills one can acquire when running a particular experiment in a real, virtual, or remote laboratory. In the case of a remote experiment, if the provider is able to clearly identify the learning outcomes and the gained skill then it is possible for a student successfully completing such a remote experiment to acknowledge having acquired the associated skill.

Thus, by completing a given remote experiment available in the web, individuals are able to tag an informal learning activity and associate a gained skill to it. The question remains on how to tag that activity and provide evidence of actually having done it. Remote laboratories fit into the TRAILER project by being a source of learning activities and gained competences in the area of Science, Technology, Engineering and Maths (STEM), in particular in experimental activities.

Taking an example from informal learning activities promoted under an initiative named STEM Scouts [41], young individuals first (1) study online a given subject, following a
recommendation by a teacher or mentor. They then (2) buy an experimental kit to practice the associated practical component (build a scale model, perform a given chemical experiment, etc.) and finally (3) demonstrate the result to the teacher or mentor, who (4) recommend individuals for a STEM Scout badge. Individuals may then (5) add the gained badge to their STEM Scouts electronic portfolio.

Tagging informal activities executed in remote laboratories and adding them to a portfolio, follows a similar process in the TRAILER project, with the exception that no teachers or mentors are included in it. The main requirement resides on the need for all experiments performed in the remote laboratory to be permanently stored in an associated, Internet accessible and searchable database containing the following information:

- Who did the experiment (requires registration and login credentials): <user id>.
- Which experiment (A remote laboratory may host a number of different experiments) was done: <experiment id>.
- When was the experiment performed: <timestamp>.
- What were the experiment input parameters & output results: <experiment setup & results>.

Additionally, the remote laboratory should also contain information about the pedagogical framework associated to each supported experiment, i.e. what is the experiment about, the prerequisites, the learning outcomes, etc.

Tagging a remote experiment in TRAILER thus simply requires two (optionally, three) actions, namely:

1. Transferring the unique URL identifier of the remote experiment pedagogical contents to the ILC.
2. Transferring the unique URL identifier of the remote experiment execution data to the ILC.
3. (Optional) Inserting an image illustrating the remote experiment interface for facilitating the reader comprehension.

At the moment, there is no remote laboratory deployed in the TRAILER project supporting the two tagging actions described in the previous list. One remote laboratory under development is addressing these specifications, namely by supporting the database with the identified items (who, which, when, what). The remote laboratory in question allows an individual to perform projectile launch experiments with a number of user-configurable parameters, which enable different pedagogical scenarios, all having in common the physics laws that rule the trajectory of a falling object with a variable launch speed. Figure 4 provides an overview of the remote laboratory, and
Figure 5 illustrates the user interface, where the elements that will form one record entry of the database are depicted in detail.

Figure 4: Overview of the physical apparatus for remote projectile launch experiments

Figure 5: User interface depicting the elements forming a database entry
3.3. Social Widgets

Social software services like Facebook or Twitter are virtual environments where individuals can make communications to a large audience. The social affordances of what amounts to a large-scale publication mechanism have emerged in recent years, and chief amongst them is the capacity to raise social capital through strategic communications online [42]. Communications online have real effects in day-to-day life [43]. Amongst these effects, the increase in employment prospects has attracted much attention in the discourse [44]. In recent years, professional online services for specifically harnessing professional profiles have become a significant element in the employment market. The strategic use of technology is become increasingly important in the process of making one’s way through the world.

However, the data submitted to social networks tends to be generic, personal and available only to specific group of individuals selected on the basis on friendship or acquaintance. Whilst social networks like LinkedIn have targeted specific social networks around professional activities, the network of friends, acquaintance, followers, etc. tends to be something of a mishmash of individuals, with communications in those networks similarly generic. However, much is revealed about individual interests, competencies and habits in these communications (including the digital habits which are evidenced by all participants in these media). Given the capacity to access and reorganise this data, the opportunity presents itself to find new ways of harvesting social network data for new purposes including the ascription of competencies to social network activities for individual or corporate purposes. This may be achieved through aggregating specific social network activity with new pieces of metadata (for example, competency information) to contribute to different kinds of knowledge bases.

This work may be regarded in a similar vein to Customer Relationship Management Systems (CRM). CRM systems have sought to harvest corporate intelligence from individual employee communications and to pinpoint particular corporate needs [45]. In the CRM world, these communications tend to be directly related to work purposes. The harvesting process highlights specific operational issues concerning, for example, gaps in service provision, relevant networks of communication, patterns of engagement and corporate knowledge management. But reflexive processes in business rely on deep knowledge of individual employees, their skills and competences. CRM data will reveal patterns of practice within the existing paradigms of the business, but not reveal data about possible new developments that would build on hitherto untapped personal competency. Therefore, to meet the need for this kind of personnel knowledge management, a bridge is required which users, having acted strategically with
technology in the social software domain, may then make available some of the data from those acts to corporate services.

This process requires bridging between different domains of practice. Technically, there are two fundamental issues regarding the connection between services in this way: authentication and context. Regarding authentication, each social software service is organised on the basis of individual user accounts. Owing partly to pressure to simplify ‘identity management’ across these different services, much development effort has gone into creating architectures that make it easy to connect to different authenticated services from different contexts. The currently most dominant technique is oAuth, which uses a token-passing method to authorise access to different services.

Regarding the context, the concept of mashups has increasingly meant that different web services can be accessed in ways controlled by the user through small interoperable components. This means that those contexts users are familiar with can be enhanced to include new tools or widgets, removing the need to learn new interfaces for new systems. Therefore mashups in conjunction with authentication mechanisms like oAuth means that a variety of services may be brought together in user-defined ways to maximise effective workflows and the negotiation of different services.

In order to achieve this connection, a bridge between the social software world and the world of the company is required. To achieve this, two experimental W3C widgets have been produced. Using authentication technology (oAuth) these widgets make a connection between the APIs of social software providers (Facebook and Twitter have been integrated in the first instance) and the APIs of the TRAILER corporate intelligence system (in the form of the TRAILER Informal Learning Collector). The basic architecture of the system is shown in Figure 6.
The Figure 6 diagram shows how a user working in any context within which they can create a mashup can embed a TRAILER widget (A) from the Wookie Server. The widget first displays an invitation for the user to authenticate with the particular social software service that applies to the widget (either Twitter or Facebook in our case). The authentication takes place through the oAuth protocol and the widget then displays the social software feed from the selected service. In order to make the bridge to TRAILER, the user is invited to further authenticate to the TRAILER service (C). This gives the user options as to whether to send entries from the social software service to the TRAILER store. Using the TRAILER APIs the user is able to add competency metadata and keep track on which social software items have already been added to the store.

In conceiving of this software approach, a number of use-cases have been considered:

Use-case 1: The worker's informal competencies

There is a case where a worker is engaged in social network activity outside work. Social communications online may be valuable to corporate intelligence as to the worker's competencies. Therefore, such a user would be able to make a connection between their informal practice of engaging in social networks and the strategic tagging and engagement with the corporate tools.
Use-case 2: The University student’s portfolio

A learner in university is required to submit evidence for their e-portfolio. However, some of this evidence is more suited to the social networks. By establishing the e-portfolio tool as a means of harvesting competence information from social network activity, the widgets may act as a vehicle for bridging informal activities and relating them directly to formal learning. The process of collecting e-portfolio data becomes a process of identifying social network activity and tagging it with relevant competency information.

Use-case 3: The reluctant user of social software

The metaphor of ‘bridging’ different kinds of activity and making connections between one area of life and another may present ways in which the underlying message of TRAILER – the strategic use of technology – may be delivered in an unthreatening way to individuals who might otherwise have resistance to engaging with social software in the first place. Whilst the functionality and rationale behind the widgets might not result in a user engaging fully with the TRAILER tools, it may nevertheless prompt more engagement in social software. The widgets help in this because, unlike other eportfolio-type tools, they do not burden the user with new systems specialised to the purpose of recording data, but instead present novel ways of looking at existing large-scale systems. This principle of coordinating services rather than creating new systems is in keeping with the basic principles of the Personal Learning Environment [46].

By creating a simple interface, which authenticates between services and giving the user control over how data flows from one service to another, the widgets accomplish what might otherwise be achieved by creating a new system. However, consistent with the ideals of the PLE, we believe that creating new systems should not be preferred to finding new ways of connecting existing systems. The cognitive burden for the user is minimised because the fundamental skills of submitting data to the TRAILER store are the generic skills of using social software. This means that a variety of different approaches can be taken with regard to the different types of users who come into contact with the TRAILER tools. Either this is an opportunity for social software enthusiasts to make new kinds of connections, or it is an opportunity for encouraging the use of social software itself. Either way, the strategic engagement with technology for personal and corporate advantage presents itself as a realistic and achievable goal.

4. Making decisions as a service
The tools described above can work in an independent way to carry out informal learning activities. However, the TRAILER project proposes a way to make such activities visible for the users' institutions or employers. One of the TRAILER aims is to facilitate institutional decision-making by harvesting the informal learning activities carried out by their users. To do this, it is necessary to gather all the activities carried out in those tools and others on the cloud, and provide to learners a way of classifying and publishing that information to the institutions.

All the tools previously described use ILC web services API to send information to the ILC about what has been done. This information is selected and completed by the learner and sent, also with web services, to the portfolio. This tool allows the user to classify and manage their informal learning instances, which can be published to the institutional environment. An example of such workflow can be seen in Figure 7 as a BPMN diagram [47]. On it, a user could carry out an informal activity in the game applet on the cloud. He/she can decide to send the information of the activity to the ILC. Once there, it is possible to add extra information (such as tags, comments, contents) to the activity and send it to the portfolio. In the portfolio, the learner manages the informal learning instance by using the competences defined in the catalogue, add extra information and publish it to the institution.

Figure 7. Business process diagram of how an activity is carried out in a tool on the cloud and sent to the portfolio where, if the user decides so, it will be accessible to the institution.

With the public information, gathered from the cloud-based tools, the institutional environment should provide a set of services to facilitate decision-making with
institutional managers. These services present information to the institution about the users, their informal learning activities, the competences associated to those activities, etc. Thus web services in the system exchange information with the portfolio and the ILC in order to gather and present the required information. Later the institution can access dynamic reports which process such information. Specifically the institutional system provides the following services:

- Information about the distribution of competences in the catalogue.
- Information about the distribution of public competences associated to learners' informal activities.
- Information about the distribution of the public competences associated to a specific learner.
- Information about the tags associated to the informal learning activities of the persons of an institution.
- Search service to locate the people with a specific combination of competences in an institution.

The detail of this process of data-gathering is described in the BPMN of Figure 8. It shows how an HR Manager requires information to make decisions within the institutional environment. This system uses different web services APIs to get information about the competences included in the catalogue, the informal learning activities stored and published in the portfolio, and the words used to tag the informal learning activities in the ILC. The information is processed and several services are provided to the HR-Manager in order he/she can make decisions related to the learning strategy of the institution or the personal development of a specific user.
In this way, the informal learning carried out on the cloud by the user can be exploited by the institution.

5. Results
TRAILER project has recently finished its first year and most of the developments have been carried out as a proof of concept. The main components (the competence catalogue, the institutional environment, ILC and portfolio) have been developed and integrated. Regarding with the tools previously described, the game and widgets are fully implemented. All these components will be tested through two pilot actions: one oriented around the users (learners/workers) and the other around institutions. Before these tests are carried out it was necessary to undergo an expert testing exercise to assure the usability of the system. This was done through a usability test.
In the first instance, usability tests have been conducted with people from the TRAILER partnership. The idea of this ‘expert testing’ is to test the TRAILER concept and how the concepts and ideals relate to the experience of using real implemented systems. In order to do so several scenarios were posed and tested and several methodologies applied to do this. A Cognitive Walkthrough (CW) [48] has been used to explore the scenarios within the project and the potential experience of completing project tasks in an early prototype of the system. This is a useful way of highlighting potential problems in the concept or implementation of the system. The primary concern is to support the development of usable systems by identifying design deficiencies [49].

The CW results have been complemented with a Think Aloud - TA [50] technique. Think Aloud protocols involve participants talking about their experience as they are performing a set of specified tasks. Software to record the screen and voice were used to support this.

In addition, surveys were used to gather the users perception of the system and a System Usability Scale (SUS) form [51] to know the final user satisfaction; and also to gather the Perception of Ease Of Use (PEOU) by following a Venkatesh and Bala adaption of TAM3 [52].

Moreover some open questions were posed to the testers and a qualitative evaluation was done. The answers of the text have been analysed, units are defined depending on the component and/or the thematic area to which they are referred; after that the outcomes are synthesized and they are grouped according to the units. Later the results are shown in two matrixes and conclusions posed from that information [53].

In order to carry out the expert testing from each partner at least two people (if possible with different familiarity with the framework) have tested the system, which is in total 14 experts. They had to complete different activities that take into account the most common actions that can be carried out with the components of the system (ILC, the Portfolio and the Institutional Environment). Each user performed 2 activities with the ILC, 4 with the portfolio and 3 with the institutional system. These activities were the scenarios of the CW.

Amongst the challenges of analysing the data produced by this method, distinguishing particular types of errors and determining the severity of those errors was the priority. In terms of the former, patterns of recurrent ‘breakdowns’ [54] in practice were identified through an analysis of the videos. The degree of severity of breakdown was determined by the extent to which the breakdown caused a disruption to the flow through the CW. In effect, what is produced is a probability distribution of breakdown moments in the experience of the expert user testing group.
From the CW and the TA application 52 moments of breakdown were identified. The indication of severity level followed the Nielsen classification [55]. Each component of the software architecture was tested in this way, with the numbers of specific identifiable breakdown moments per user indicated in Table 1.

<table>
<thead>
<tr>
<th>Component/Severity</th>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILC</td>
<td>1</td>
<td>6</td>
<td>7</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Portfolio</td>
<td>5</td>
<td>7</td>
<td>14</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Inst. Environment</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 1. – Number of issues per Nielsen classification level and the component to which they are related

Whilst many breakdown moments did not severely disrupt from the flow of the task (i.e. they were at Levels 1 and 2), it is fair to say that the video evidence showed that the cumulative effect of these was more disruptive in terms of user disposition to the tasks overall (this was captured in the surveys described below). Some software issues were more serious and did cause significant interruption in the task flow (i.e. at levels 3 and 4). These results regarding the flow of experience were fed back to development teams leading to a redesign of parts of the process.

This data was triangulated with data from the surveys. The survey data captured a more general level of satisfaction. Possibly as a result of the low-level breakdowns in experience, satisfaction levels were 18.4% below the acceptable satisfaction level of 68% described by Sauro [56].

In order to validate reliability of the distinction-making in the survey analysis, a Cronbach’s Alpha was calculated on the variance between user responses to the questionnaire questions. The alpha coefficient showed a value of 0.934 indicating a high level of consistency in the user experience across the sample of expert users. The questions relating to the Perception of Ease of Use showed a neutral value.

Regarding the opinions of the experts, two matrices of results were defined (Table 2 and Table 3). The former gathers opinions related with each of the components while the latter classify their opinion on different themes.

<table>
<thead>
<tr>
<th></th>
<th>ILC</th>
<th>Portfolio</th>
<th>Inst. Comp</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expert 1</strong></td>
<td>-</td>
<td>Complex, more description, explanation needed</td>
<td>-</td>
</tr>
<tr>
<td><strong>Expert 2</strong></td>
<td>Confusing at the beginning</td>
<td>Complex, difficult interaction</td>
<td>Works good</td>
</tr>
</tbody>
</table>
From this table it is possible to see that although the ILC is for most of the experts quite simple and straightforward, it is necessary to simplify the steps and clarify the meaning of some fields of the form. With regard to the portfolio, some complexities of the interface make it occasionally not very intuitive, with specific areas of improvement necessary around navigation, and more clarity about the user instructions for each section. With a complex component-based system, there is some inefficiency in the number of clicks required to perform an action, and where possible steps can be taken to reduce this. Regarding to the institutional environment it is seen as a quite simple tool but further clarity is required in describing each concept managed with the tool.

General opinions about the system have also been gathered. These opinions are classified in the different themes they deal with: Integration, Training and Improvements. The results can be seen in Table 3.
<table>
<thead>
<tr>
<th>Expert 7</th>
<th>Some training could be helpful</th>
<th>Explain concepts, improve interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert 8</td>
<td>Too much changes between contexts</td>
<td>Adaptation of the tools to the user</td>
</tr>
<tr>
<td>Expert 9</td>
<td>-</td>
<td>Need to simplify</td>
</tr>
<tr>
<td>Expert 10</td>
<td>Integration is not correct</td>
<td>Training needed</td>
</tr>
<tr>
<td>Expert 11</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Expert 12</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Expert 13</td>
<td>-</td>
<td>Training needed</td>
</tr>
<tr>
<td>Expert 14</td>
<td>Integration is not crude</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 3. Qualitative analysis of the opinion of experts about the whole system classified by theme.

From Table 3 is possible, integration between components can be problematic. The final user should not perceive a change of context, so both integration and look and feel should be improved. This problem can be seen to directly reflect the technical requirement for flexibility and interoperability: flexibility and interoperability can comes at the cost of the coherence of user experience. Regarding the necessity of special training, although the system is quite simple, a workshop with users to facilitate the use of the system is recommended.

Taking into account these results and those of the other techniques applied, the challenge of finding a technical solution to the bridging of formal and informal learning activities still requires significant work in order to appear seamless and natural to users. However, it should be noted that developments to date have created the opportunity for exploring these experiences in more detail and addressing issues of breakdown in experience. Furthermore, the data reveals that the breakdowns resulted from practical problems rather than conceptual difficulties in understanding what the TRAILER tools were attempting to do. Further work will reveal whether improvements in the tools can produce a more smoothly aligned match between the ideals of TRAILER and the practice.

6. Conclusions
This paper has presented the cloud-based technologies and services used in TRAILER project in order to tag, recognize and acknowledge informal learning activities, with the main aims of allowing employees/persons to reflect and make visible the competences and knowledge gained by what they have acquired through informal means, building dialogue interfaces between the organizations and their employees to recognize the
overall hidden value of the informal learning processes, and establishing methods to analyse and discover knowledge in the organizations to make decisions in the short-middle-long terms.

Whilst the integration of a complex component-based architecture overcomes many of the problems of institutionally-centric technology, such integration can present problems of coherence in user experience. Here we argue that the benefits outweigh the disadvantages. Problems of coherence of user experience can be overcome, and TRAILER has demonstrated how systematic user testing can address each challenge. The potential reward is a truly learner-oriented system which also meets the needs of employers and educational institutions.

The TRAILER project takes into account informal activities carried out in different contexts that are not only web pages but also games, social widgets and remote labs. These contexts are deployed on the cloud, which facilitates the exchange and exploitation of information. The project has shown that the integration and recognition of these informal learning activities is possible even if they are carried out in very heterogeneous contexts. The cloud-based framework facilitates the integration of those tools with which the activities are carried out, gathering evidence and sending it to the institution. With such information it is possible to define new services that can be used to make decisions. Those services facilitate the dialogue between individuals and amongst managers within institutions to the benefit of everyone.
### Appendix A – Measurement instruments

Table 4 shows the measurement instruments with the questions of each type of questionnaire and the reference in which they are based.

<table>
<thead>
<tr>
<th>ID</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>I think that I would like to use this system frequently</td>
</tr>
<tr>
<td>S2</td>
<td>I found the system unnecessarily complex</td>
</tr>
<tr>
<td>S3</td>
<td>I thought the system was easy to use</td>
</tr>
<tr>
<td>S4</td>
<td>I think that I would need the support of a technical person to be able to use this system</td>
</tr>
<tr>
<td>S5</td>
<td>I found the various functions in this system were well integrated</td>
</tr>
<tr>
<td>S6</td>
<td>I thought there was too much inconsistency in this system</td>
</tr>
<tr>
<td>S7</td>
<td>I would imagine that most people would learn to use this system very quickly</td>
</tr>
<tr>
<td>S8</td>
<td>I found the system very cumbersome to use</td>
</tr>
<tr>
<td>S9</td>
<td>I felt very confident using the system</td>
</tr>
<tr>
<td>S10</td>
<td>I needed to learn a lot of things before I could get going with this system</td>
</tr>
</tbody>
</table>

**SUS Questionnaire [51]**

<table>
<thead>
<tr>
<th>ID</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOU1</td>
<td>My interaction with the system is clear and understandable</td>
</tr>
<tr>
<td>EOU2</td>
<td>Interacting with the system does not require a lot of my mental effort</td>
</tr>
<tr>
<td>EOU3</td>
<td>I find the system to be easy to use</td>
</tr>
<tr>
<td>EOU4</td>
<td>I find it easy to get the system to do what I want it to do</td>
</tr>
</tbody>
</table>

**PEOU Questionnaire [52]**

<table>
<thead>
<tr>
<th>ID</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Op1</td>
<td>What is your opinion about the system (you can describe also you opinion of a specific component</td>
</tr>
</tbody>
</table>

**Experts’ Opinion**

**Acknowledgment**

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