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Experiencing Personal Learning Environments and Networks using a 3D Space Metaphor

Francesco di Cerbo[1], Gabriella Dodero[1], Laura Papaleo[2,3]

[1] Center for Applied Software Engineering, Free University of Bolzano-Bozen, Bolzano-Bozen, Italy
[2] Department of Computer Science, University of Genova, Italy
[3] IT Department, Provincia di Genova, Italy

{fdicerbo, gabriella.dodero}@unibz.it
papaleo@disi.unige.it

Abstract. The paper describes our proposal for adopting 3D spatial representation, based on suitable indications and metrics, for the evaluation of experiences conducted in a Personal Learning Environment (PLE) and its social extension, the Personal Learning Network (PLN).
The use of 3D space is a mean for integrating different perspectives (e.g., structured and non-structured learning) but also to foster the cooperation between users. Moreover, information coming from the use of 3D space can represent a precious feedback for better understanding ongoing learning activities, but it will be extremely useful for enhancing and improving the development of existing PLE-PLN support tool.

Keywords: Personal Learning Environment, Learning Process Indicators, Cooperative Learning, Web 3D technologies, 3D representations, Semantic tagging, Virtual reality.

1 Introduction

In all debates about the future of the Internet, there is almost unanimity on the issue that more and more opportunities will be offered to users in term of participative, 3D experiences. The availability of ultra-wide band technologies will soon make it possible for all users, including those equipped with mobile devices, to access metaverses in such a way as it is now possible only inside research labs.

Today's challenge is to meet users' expectations in terms of interactivity, personalization and socially enabled experiences. This refers also to contexts like education and life-long learning. In such contexts, the evolution of learning strategies, and current tendencies in the fruition of learning opportunities, pose strict requirements to cope with: from the users' point of view, for instance, the provision of flexibility in learning, such as, for example, on-demand e-learning courses. From the tutors' point of view, a new requisite can be seen in the availability of meaningful tools for supporting learning activities, with respect to both the assessment of the role

[1] Corresponding author gabriella.dodero@unibz.it.

of social interactions among users and to creation and co-construction of a social knowledge.

The *traces* each user leaves behind while using such systems are many, and possible exploitations of such data is, today, under the attention of scientific community. A possible usage of these traces could be, for instance, to support the definition of *indicators* or specific metrics, that could provide insights for both users and tutors. Moreover, they could be valuable in order to *close the loop* of information with designers of such software systems, to refine and improve their implementations and to review their progresses with respect to the achievements of their design objectives. In previous works, for instance in [4], we proposed a sample of available data for a graphical 3D Learning Management System (LMS).

Our LMS, that we called DIEL [6], has the main goal to assist tutors by providing a set of metaphors for the creation of customized metaverses [2120], which can be seen as *virtual representations* of specific learning paths.

We believe that DIEL can be exploited to go one step beyond a traditional LMS, overcoming one of the big drawbacks of general LMSs, namely the *walled garden* effect. Because of such effect, students are unable to make *links* between topics they have approached in different courses and under different perspectives, thus avoiding the possibility to create a *big picture* in a unified knowledge. A discussion of such problems, and a proposal for its solution, have been highlighted, for example, in [5].

At the same time, a transition from teacher-centered tools (like standard LMSs) to a more *person-centered approach* is – today more than ever – imperative as perfectly inline with some recent researches on pedagogical theories such as socio-constructivism [14,15]. Support for a learner-centered view of educational resources is, in fact, better achieved when considering the establishment of a Personal Learning Environment (PLE) than within a traditional LMS, since inside the latter, content provision and aggregation is possible only to the teacher (tutor).

In this context, we developed an extension to DIEL, as a support for Personal Learning Environment [5] and also for its socially enabled evolution, namely the Personal Learning Network (PLN). The 3D metaphor, we adopted for DIEL extension of PLE&PLN, supports visualization of shared resources and interactions among users within a specific community. Therefore, users can organize their resources (and share them with other users) according to personalized and structured criteria.

The remainder of this paper is organized as follows. In Section 2 we introduce the definitions of Personal Learning Environment and Personal Learning Network we have chosen, discussing their perspectives and implications. Section 3 is devoted to a brief presentation of our DIEL e-learning environment, while Section 4 details our design of a PLE&PLN support to DIEL. In Section 5 we introduce the 3D space metaphor as a 3D representation of PLE&PLN and in Section 6 we outline indicators and metrics related to our topics. Finally in Section 7 concluding remarks and future directions are drawn.

2 Personal Learning Environment & Network

A precise definition of a Personal Learning Environment, PLE for short, is still in development. Limiting the discussion to a technical point of view, a PLE represents the integration of a number of "Web 2.0" technologies (like blogs, Wikis, RSS feeds, Twitter, Facebook, and so on) around the independent learner.

Using the term "e-learning 2.0," Stephen Downes [9] describes a PLE as:

> "*one node in a web of content, connected to other nodes and content creation services used by other students. It becomes, not an institutional or corporate application, but a personal learning center, where content is reused and remixed according to the student's own needs and interests. It becomes, indeed, not a single application, but a collection of interoperating applications; an environment rather than a system*".

In our work, we took into consideration this (enough broad) definition, first because it is one of the firsts officially provided, and second because it does not seem to prevent neither any application nor future developments. Thus, a PLE can be seen as a network of websites and/or services, that individuals – users, students – use to acquire new information and to deepen their knowledge on specific topics: in a word, to *learn*.

PLE users read, store and maintain precise contents and, at the same time, produce learning contents or reflections, also recording documentations about their particular and personal learning processes. In addition, PLE users aggregate data from their learning communities, using Web 2.0 technologies, RSS feeds or interesting Web logs (blogs). Fig. 1 shows a PLE, according to Weller [22].

Today, there is still no widespread use of PLEs, not so much for lack of available technologies for searching, storing, and annotating web based resources, but mostly for the difficulties experienced in the practical organization of these resources into a coherent and useful *learning space*. As presented so far, a PLE is tightly connected to the person whom it belongs; it is of course up to her to “run” and “maintain” the environment, i.e., to keep track of all different knowledge sources, and to monitor and access them periodically. These housekeeping tasks can be simplified to a certain extent using RSS feeders, nevertheless they shall require much effort and time to the learner. But obviously, at this stage of development, manual activities are necessary, thus requiring effort and concentration from the user.

As a further remark, the added value of many pieces of information, which originally were made available from non-related web sources, lies in establishing new, explicit relationships among them. This idea of linking together information, and tagging them as well as the respective links, is a central one in our system, and shall be further elaborated in the following Sections.

Personalization and freedom are sometimes criticized, because these forms of unstructured learning do not guarantee the quality of collected information. Therefore, absolute beginners in a topic may find a problem in using a PLE, given their difficulties to recognize authoritative information.

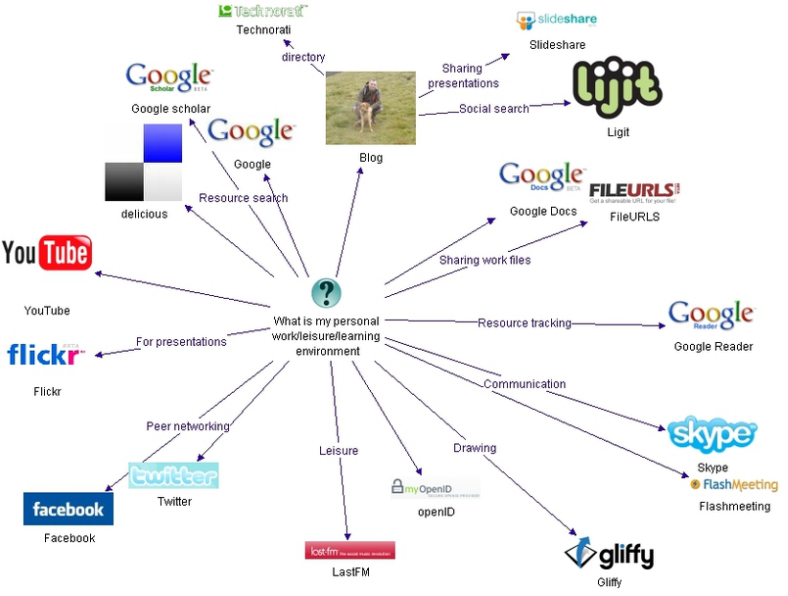

Fig. 1.. A set of tools for a Personal Learning Environment (PLE). These tools are all related to modern Web 2.0 Technologies and often adopted by standard students / users. [22]

To overcome in part such an issue, significant contributions to understand the trustworthiness of different knowledge sources may be provided by the observation of relevant resources, ranked as such by a majority of peers in a community, or by its relevant members. To this respect, it is of vital importance for a PLE to be *translucent*, as defined in [11]. *Translucence* is implemented by creating a graphical representation of a virtual space, containing the users of such application as well.

As a consequence, PLE visualization should help the learner to understand how his/her community is interacting at any given instant. The implications of translucence, and its extension to social translucence, in learning environments have been extensively discussed in [6]. Inside PLE, social translucence requires at least a part of each learner's PLE to be visible to peers, thus encouraging cooperation and knowledge sharing.

These considerations come from different requirements, just partially related to technical aspects of content fruition. Searching material on the Web is a complex activity, that involves various mental processes. PLE content selection is particularly relevant, because it implies an important reflection that leads to *meta-cognitive operations*, needed for understanding how to link a specific content to the existing knowledge background of a person. This topic is being investigated by various authors [12,18], that underline the value of *tagging* in self-directed learning as means for stimulating reflection on the tagged materials and their topics.

Combining and extending the concept of PLE, a Personal Learning Network, PLN for short, consists of the people (or better, the set of PLEs of the people) a learner interacts with and derives knowledge from in a Personal Learning Environment. The concept is new but promising and, somehow, related to the theory of connectivism

[10, 20]. In fact, learners in a PLN create *connections* and *develop a network* that contributes to their professional development and knowledge. In the last years, the concepts of PLE and PLNs are raising attention as possible important part of professional development in several fields. They have become common subjects in research for education and e-learning.

3 The DIEL E-learning Platform

DIEL is an e-learning platform providing new ways of user interactivity and data representation in a web based real-time environment [7, 8]. DIEL provides a dynamic and interaction-friendly virtual learning space for community portals in education. Its effectiveness was experienced in high schools, university courses, and in vocational training. DIEL supports educational strategies involving collaborative activities, as recommended by socio-constructivistic pedagogists, as well as individual and personalized learning strategies.

The organization of a learning activity is like the exploration of a set of virtual rooms, each of these rooms being dedicated to a specific activity. This metaphor mimics the real life, where there is a natural mapping between places and activities, like for example a library, a laboratory, or even a cafeteria. Available resources for the given learning objective appear as objects inside a room. The tutor decides room appearance and topology, by placing inside them, among possible objects, some doors, that lead to other rooms.

DIEL is web-based, built upon Moodle, and by design, its user interface, functional process logic ("business rules"), computer data storage, and data access, is developed and maintained as independent modules, thus as a three-tier architecture.

The Data Layer is responsible for storing and retrieving all the information needed for the e-learning platform and processes, as for example resources (multimedia data) and pre-defined learning paths. The Business Logic controls the application functionalities by performing detailed processing. The Presentation Layer, which is the topmost level of the framework, is devoted to displaying information by outputting processing results to any HTML5 browser/client [7].

The choice to develop DIEL as an environment for experiencing new technologies in education on top of Moodle responds to two main criteria: (i) the practical consideration that Moodle already has a huge community of users (as of Oct. 2011, more than 57000 registered sites offering more than 5 million courses, with more than 1 million teachers and 48 million learners, speaking 78 languages); (ii) the availability of an open source developers community around it, and the possibility to distribute our extensions back to the community itself.

4 PLE Support to DIEL and the Learning Experience

Our idea of a Personal Learning Environment in DIEL relies on the design and definition of environments – evolving in time – in which users can keep and organize their own resources, such as chat messages, documents, web links or other multimedia

and digital contents [5]. As shown in Fig. 2, the PLE layer in DIEL is built upon the central layer which includes the basic modules and implements the main functionalities of our system, as defined in [8]. The outermost layer is conceptually belonging to PLN, and its role shall be clarified later in this section.

The PLE layer upon DIEL core is also organized into different components, each of them delegated to specific tasks:

1) The *Bookmarks component*, mainly devoted to manage web links and personal bookmarks;
2) The *Feed Reader component*, related to the storage and the organization (using also semantic tagging procedures) of feeds from multiple web portals.
3) The *Communication component* responsible for instant messaging among different learners. This component is devoted to create and maintain interrelations among the users, *keeping alive* the learning network.
4) The *Recommender* component which is dedicated to maintain and refresh the recommended contents according to personal learner's needs, grabbing tham from other users – according to specific functions and weights – enduring the social dimension of the PLN

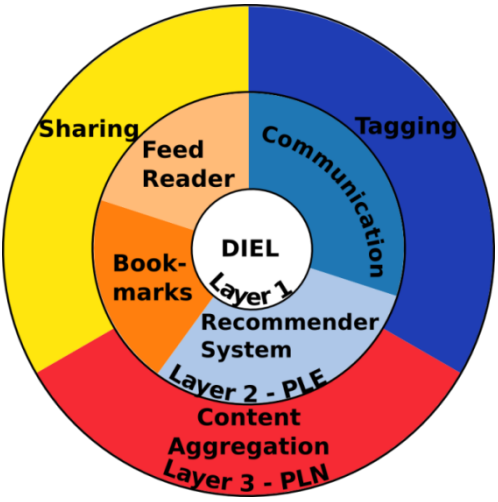

Fig. 2.. A schema presenting how Personal Learning Environment and Personal Learning Network cooperate in our DIEL System. The main components of DIEL live in Layer1, the PLE builds Layer 2 and the final layer combines all the functionalities for the PLN.

In this context, 3D visualization provides a natural metaphor for knowledge organization: every PLE element has an associated graphical representation, that can be arranged into a private space. An intuitive metaphor for a document is the corresponding icon (for example the familiar icons standing for PDF or DOC document types). Similarly the logo of a website (the so-called *favicon*) may be used

as icon for a link on that website (for example Wikipedia). More on visual metaphors shall be discussed in Section 5.

Thanks to the Recommender component, *social cooperation* with other DIEL users (namely, the PLN dimension) takes place in three different ways:

1. defining personal *contents aggregation*;
2. sharing such contents aggregation with selected users, or publicly with everyone;
3. visualizing *tag clouds* associated to contents aggregations made available by other users in the network.

Contents aggregations can be considered as *sets of connections* between elements (contents) in a PLE. For instance, an aggregation could encompass some blog entries, a Google Docs presentation and a portion of the slides from a specific course. The platform will then show a line that connects all resources icons together. Such links can be labeled, to highlight relationships among contents, and the aggregation itself can be attached a label, and an arbitrary number of tags, as for all PLE-managed elements. To simplify search and management of aggregations, they can be listed in a specific menu, while to avoid confusion, *links* can be selectively displayed or hidden.

Similarly, aggregations can be collapsed to one icon, or else, all their components can be expanded and shown in the 3D space, as described, later, in Section 5.

Sharing contents aggregations can be achieved as a one-to-one mechanism, or as a one-to many mechanism, respectively using the Communication or the Feed Reader component. What is actually shared is a link to the internal representation of the contents aggregation, a ReST URL.

In one-to-one communication, such an URL is *sent*, per chat or email, to another user, who will be able to view and eventually import it. In one-to-many communication, users can *share* a RSS feed (containing a set of such links), advertising all own aggregations; this mechanism will automatically update feed subscribers about new aggregations, thus allowing them to import newly created elements in their own PLE.

5 Visualizing and Structuring the knowledge of PLE and PLN in DIEL using a 3D space metaphor

According to the recent book of Kapp and O'Driscoll in [17], it's just a matter of time until 3D virtual immersive environments will be accepted as the learning mode of choice. Understanding the cognitive advantages underlying this idea is still under study. However, a 3D learning experience (3DLE), can be considered as rich interactive space in which the learner lives and interacts in real-time within an immersive virtual environment and community.

In a well-designed 3DLE, learning is transformed from a one-dimensional, directed and managed activity to a multi-dimensional *collaborative* activity. Through this approach, learners create *shared meaning* together. Thus, accomplishing a series of tasks in a virtual environment creates an ideal learning experience. It connects the

visual and mental cues that make the recall and application of the learning more effective [13,17].

Thinking about this, it's straightforward to understand why we have decided to adopt a 3D space metaphor in order to represent PLE and PLNs. We strongly believe that 3D virtual worlds can be as support in the personal learning processes, as also suggested by the very active research and business going on game-based and serious learning, as for example in [1,3,19]. Also, games intrinsically use a constructivist approach as students are meaning-makers and meaning-making results in production [16].

As hinted in the previous Section, we decided to arrange resources available in a PLE as 3D icons in a 3D space, with specific semantic meanings attached to icons themselves, to their visible links, and, as will be described in the following, also to their positioning. *Contents aggregations* can be collapsed inside one box, which contains all the resources, the relationships and the tags defined by the user in the learning process.

The graphical representation of the expanded content aggregation is a 3D hypergraph in which nodes represent resources and links represent the way in which these resources are connected each other. The corresponding syntax can be in the form of RDF triples "A in-relation-B-with C" where all the elements "A,B,C" can have semantic tags and specific meaning associated.

Tags attached to a resource or a link can be hierarchically organized and can be semantically enriched by the learner (*very important*, *read also*, *interesting*, and so on...) or simply devoted to statistical usage of the resource itself (number of accesses, last access, and so on...). The combination of the *values* of these tags automatically promotes the resource in the contents aggregation (box) as more or less relevant with respect to the other resources in the same box. The Recommender System, shown in Fig. 2 at Layer 2, is the PLE component that manages this process on behalf of the individual user. An avatar, representing the learner, can move freely in the space interacting with the resources or the boxes (contents aggregations) moving them from one place to another, thus associating specific importance (meaning) to the spatial position of an element. The learner can drag an interesting resource in the space, positioning it in one or more existing boxes, or creating a new box for a new contents aggregation.

The 3D environment supports a complete view of the learning space which can render complex inter-relationships among resources. Sharing contents aggregations, or portions of them, with other users is also implicitly achieved by moving their icons to a specific place. Once an element is shared, the learner collects feedback from colleagues, since they may enrich the tagging of the element; she may then accept or reject such suggestions from others. This way, social knowledge is created inside the PLN.

Thus, we decided to design the PLE view in DIEL as a portion of *sky* (see Fig. 3). The aim of this representation is to mark the difference between a structured learning environment, organized as a set of rooms belonging to a learning path, and a user-managed space, focused on personal interests. Choosing a sky as "container" of PLE resources and links is an intuitive metaphor of user's freedom.

In our current PLE implementation, and per default, PLE elements are placed along a spiral, in the middle of the sky. This disposition links to the time that passes by,

such that newer resources are arranged on top of older ones. The default spiral does not keep into account contents aggregations, as it is mainly aimed at focusing the person's attention to newer elements in PLE, that probably are the most interesting, and that deserve further study. By focusing on a particular contents aggregations, it is again rendered in PLE view as a distinguished spiral, like in Fig. 3.

It is convenient to employ translucence and proximity inside PLN with a semantic meaning. Translucence, as suggested by [11], can be used to explore peers PLEs and find out selected resources for extending own PLE. This mechanism is especially useful for the novices approach to new topics, to find materials made visible outside their PLE by peers. Translucence, however, would not be sufficient to gather the relevant materials, since the default arrangement inside PLE is based on temporal relationships. To this purpose, we need a further feature, namely, to be able to arrange icons in the 3D space based on tag matching.

Upon request, users can sort resources with same tags so that they can be naturally placed close to one another, and proximity may be used to approach resources collected by peers having similar tags. This spatial organization is based on the information collected by the Recommender component, that promotes (or demotes) resources that peers have chosen (or neglected) by showing them closer (or far away) from the user focus of interest.

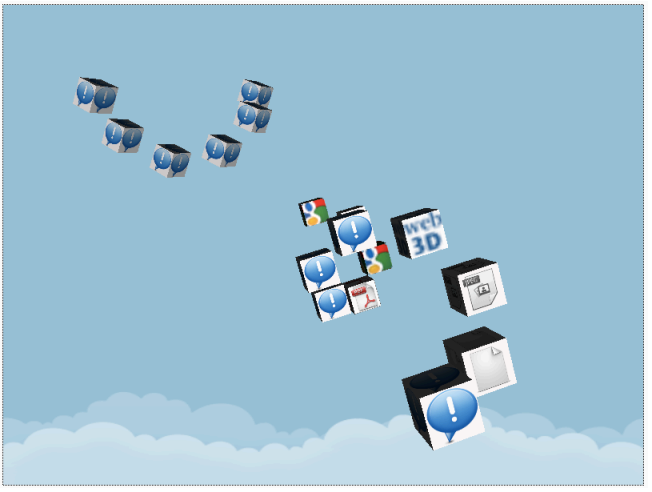

Fig. 3.. PLE and PLN view in DIEL. In the background, a content aggregation made available by another user

6 Indicators, Metrics and Feedback Exploitation

DIEL users produce different pieces of information, that are mainly used by the Recommender component. Some of them are directly connected with 3D visualization, others with contents, namely the use of tags and links that connect

them. Such indications can be a source of feedback for different subjects:

- *learners*, which can exploit the knowledge as the contents organization in other PLEs and can eventually suggest improvements or inherit interesting portions of the learning environments.
- *course designers*, which - by analyzing the learners behavior and by looking at the structures of the PLEs - can deduce new course design strategies.
- *PLE support tools development team*, which by considering the learners feedbacks can eventually improve the quality of the development and better take into consideration end-users needs.

For example, the concept of *proximity*, that has been already under investigation in previous works (see [4]), can be extended from proximity among users' avatars, to proximity among resources. Focusing on them, we can consider tags, links and their spatial position inside DIEL's PLE as orthogonal directions of an hyperplane, where different proximity relations might be identified. New similarities might be discovered between contents, in some cases suggested directly by users, in other by their proximity in one of the considered "dimensions".

This feedback can be exploited by users, that can consider more resources for specific topic; it also can be exploited by resource producers, to understand how and under which perspectives their contents are considered by users.

DIEL developers can exploit an aggregation of these indications for technical purposes (i.e., to refine their Human-Computer Interface, but also for refining recommender system's rules), but more interestingly for obtaining evidences on PLE usage, in an automatic and objective way, which is seldom investigated nowadays.

Automatic data collection has demonstrated to be particularly effective especially in process analysis - as, for example in [2] - therefore its application to the assessment of an educational process seems to be promising. Such lessons shall be used to better understand the user's point of view about PLE, and also to define new PLE support tool services, closer to user's educational needs.

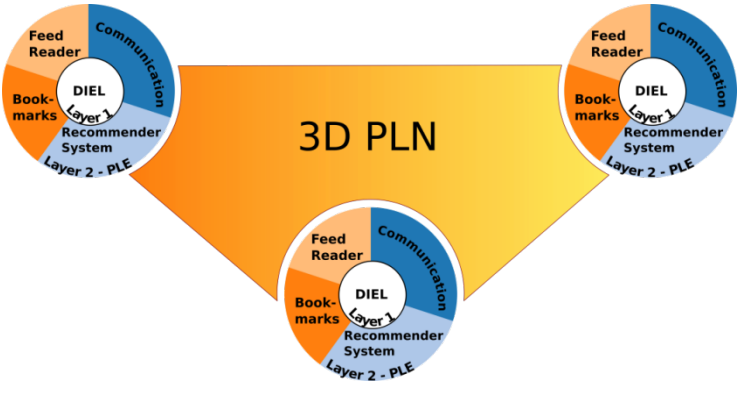

Fig. 4.. Relationship among PLEs and PLN in DIEL.

7 Concluding Remarks and Future Works

The paper has presented how a number of extensions that have been, and are still being developed, to the DIEL Learning Management System can be used to extrapolate indications about users' PLE support tool usage. The extensions address two main trends of learning methodologies and supporting tools:

- the Personal Learning Environment, as the place where non-structured learning can take place;
- the Personal Learning Network, that is the social dimension that is built by individuals that share and build knowledge, in a socio-constructivistic perspective.

The presence of a 3D virtual learning space allows us to argue on suitable metaphors to represent these new content aggregations, and how to explore them in non-structured ways. Various alternative spatial arrangements have been proposed, to better support non-formal and informal learning processes. Such processes involve the help of peers, and a recommender system to rank quality and interest in various aggregated resources.

Effectiveness given by a 3DLE lies in providing guidance as learners engage in discovery activities, that facilitate achievement of learning goals.Since individuals enter the experience at different levels, the guidance they are offered will naturally vary. Ultimately, effective learning is dependent on creating experiences that facilitate the learner's cognitive processing. Learning in an immersive 3D environment might yield advantages, but these will only be achieved if the designer is capable to exploit this innovative approach.

For the learner, the "closest" resources are those needing her attention that is the most recent ones (that she has still to examine) or those with higher rank from friends (when the learner is focusing on a specific tag). This user-centric view is what makes the system a valuable personal tool. However, the amount of data that DIEL and its PLE are collecting may also suggest objective rankings. It shall be possible to track resource usage by people, accompanying them with metrics to assess, for example, their popularity and reputation within a community. Data collection can be applied also to avatar movements in the virtual environment, as well as to resource organization.

Important lessons might be learned by observing the evolution of such graphical environments. The environment shall make it possible to highlight meaningful contributions, and to understand social dynamics: the feature is useful not only for tutors, teachers and content producers, but also for formal tuition contexts, as well as non-formal and informal learning experiences.

Of course, such indications will also be precious for the evolution of this system; being able to detect scarcely used features, as well as understanding how certain dynamics develops in DIEL can guide the future development of the system. Such feedback, as in the best Software Engineering practice, will come directly from stakeholders, and given that no perturbation to observed subjects will be made, no errors should come from the measurement process.

At present DIEL and its PLE have been implemented and are starting to be used inside our University. Each student can interact with other students, who have access to the same platform, so to discuss issues related to one specific course, or more generally to personal interests. It is foreseen to extend the current functionalities with the PLN features as explained above, better exploiting the 3D space navigation potential.

Two main directions appear as promising for the next future:

- an investigation on what metaphors better help the users in "finding their way" among the unstructured and social dimensions of PLE and PLN. The closed space versus open sky metaphor, being employed right now, could be superseded by hierarchical or other kind of organizations, once users have gained more familiarity with the tools;
- an extension of the current approach towards life-long and life-wide learning. The limitation of our current strategy is that DIEL is conceived to support mostly university students.

In the knowledge society, right now and more in the future, a person shall never stop learning, going periodically back, just to learn new trends in her profession, or changing their job altogether. These global, life-long learners shall need a corresponding global, life-long technological support, which at present no single university is capable of providing, at least for administrative reasons. In this sense, a better integration and interoperability with popular social media could be a solution for widening the learners community, suitably integrating the emerging and promising semantic web technologies.

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