Semantic Web and Linked Learning to Support Workplace Learning

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ABSTRACT

In the last few years, the Social Web has offered new affordances for how learning is conceptualized and supported. Supporting workplace learning, however, faces specific challenges, some in particular due to its informal, contextual and social nature. The informal nature of workplace learning requires knowledge workers to be supported in their self-regulatory learning processes, whilst the social side draws attention to the role of collective in those processes. To address these challenges, in this paper we present Learn-B, a workplace learning environment. We also present how we developed and applied a common ontological foundation for the integration of our proposed learning services and existing tools in this environment.

Categories and Subject Descriptors

K.3.1 [Organizational Impacts] Computer-supported collaborative work

Keywords

workplace learning, organizational learning, self-regulated learning, linked data, semantic web technologies

1. INTRODUCTION

The proliferation of social software tools, on the one hand, and modern learning theories arguing for learners' autonomy, self-direction, high level of engagement and knowledge co-construction, on the other hand, have led to the wide acceptance of the notion of Personal Learning Environment (PLE) by the technology enhanced learning community. Although the notion of PLE is based on the assumption that learners are motivated and self-directed, unless provided with some structured learning scenarios and/or guidance, most people are reluctant to indulge in a learning process.

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Self-regulated learning (SRL) [18] contains the motivational elements to address this challenge and invoke high intrinsic motivation, high task persistency, and high self-efficacy beliefs in people [4]. To be intrinsically motivated for SRL in organizational settings, learners have to align their learning activities to (i) the organization's goals, (ii) learning activities of other organization's members and (iii) their own learning goals [11]. Further, individual and organizational incentives are needed to motivate employees to take part in knowledge building and sharing activities [12].

Looking from the 'technology support' perspective, Semantic technologies and the Linked Data paradigm could provide the required technical backbone for the realization of such a workplace PLE. Specifically, their contributions could be:

Integration of (interaction) data and knowledge originating from disparate and often heterogeneous sources (tools/services). Today's knowledge workers often use diverse tools and services in their everyday working and learning practices; therefore, the traces and outcomes of their activities are dispersed among different tools/services that often lack the capability of interchanging and/or integrating user's data. If properly applied, the Linked Data paradigm and the associated semantic technologies would enable meaningful data integration and knowledge structuring.

Semantic annotation and interlinking of data and knowledge items. Linked Open Data (LOD, http://lod-cloud.net/) Cloud integrates numerous knowledge bases comprising either general purpose or domain specific knowledge. These knowledge bases (i.e., their resources) can be used for unambiguously annotating data and knowledge items used in or resulting from learning activities, thus allowing for their semantic interlinking.

In this paper, we introduce the Learn-B environment, our attempt in supporting workplace learning by addressing the above challenges. Learn-B stands for Learning Biosis ("biosis" meaning a way of life), i.e. learning as a way of life. Being aware that the technology has to be complemented with a proper pedagogical and motivational framework, in the following, we first elaborate on the pedagogical foundation of our work (Sec. 2) and describe our approach via a usage scenario (Sec. 3). Then, Learn-B is explained in details in Sec. 4. After presenting the results of the initial evaluation of Learn-B (Sec. 5), we conclude the paper by comparing our work to the related work (Sec. 6) and by outlining directions of the further research (Sec. 7).

2. PEDAGOGICAL FRAMEWORK

Social software applications have allowed for new pedagogical affordances, and thus enabled a new perspective(s) into how learning happens and/or is supported. Such a perspective is characterized by more participative and social-based conceptualizations of learning, in which users are exposed to higher levels of autonomy, creativity and social-embeddedness [8][16]. This emergent conceptualization of learning is especially important in the context of workplace learning [5] where learning is not an isolated process; it is social, it affects and is affected by the social context and the collective knowledge available. Moreover, learning in the workplace is commonly informal and autonomous [5][15]. The "on-demand" approach to learning requires contemporary knowledge workers to have SRL skills in identifying their learning needs and conducting appropriate learning processes to attain them. Any solution aiming to support workplace learning, thus, should try to address the challenges inherent in this particular domain. The pedagogical approach we pursue in our research is based on a well-known organizational knowledge building model proposed by Nonaka and Takeuchi [9]. This model highlights the harmonization of individual and organizational learning, but does not incorporate motivational elements for starting and carrying out individual learning processes. Most people are not proactive enough to initiate a learning process or simply do not know how to learn; moreover, the lack of motivation for sharing personal knowledge and learning experiences, and contributing to the collective knowledge is a common problem in organizational settings [17]. To allow for supporting users in initiating their individual learning processes, we extend the above knowledge building model with SRL practices [13]. Further, to address the challenge of motivating users to share their personal knowledge and experiences within their organization, we incorporate a set of individual-level incentives and inhibitors for knowledge sharing within an organization into our pedagogical approach [12].

3. SCENARIO OF USE

To better illustrate the functionalities of Learn-B, in this section, we walkthrough a sample scenario involving a newcomer, who we call John, in a large organization.

A typical scenario for learning at workplace with the Learn-B environment assumes a goal-oriented learning approach with organizational support. Accordingly, John knows about the project(s) he is involved in and his responsibilities, but he is not aware of his learning needs, i.e. the competences he is lacking, or does not have at the required level. Our previous research [12] shows that lack of familiarity with organizational needs, expectations and policies, is one of the major challenges that newcomers face in large organizational settings. The *Knowledge Building Service* of his Learn-B environment (see Sec 4) enables John to browse the competences valued by his organization and required for accomplishing his duties (Fig. 1.A) and thus, better assess his learning needs, harmonized with those of the organization. Also, John can benefit from the personalized visual hints which indicate those competences of higher importance for him, considering his current state of expertise w.r.t. the duties he is responsible for (Fig. 1.B). Moreover, John has access to a diverse set of *Analytics* about available resources. Being derived from the social context of the organization and linked via the underlying ontologies, this feature allows John to probe into the usage of a resource by the collective, for instance, the number of users who have acquired a certain competence and their positions in the organization (Fig. 1.C). After John decides upon the competences to include in his new learning goal, for each of his target competences he chooses a learning path from a set of recommended learning paths (Fig. 1.D), provided to him by the *Learning Path (LP) Recommender*. At this phase of his learning process, John engages in learning activities by following the selected LP. He can choose to document his reflections on the performed learning activities and/or used knowledge assets in the wiki or the social network that are part of the Learn-B environment. Thanks to the use of ontologies and Linked Data principles, these reflections will be attached to his LP and accessible to him from any tool of the Learn-B environment (and even broader if he decides to make his data publicly accessible). John can also use *Semantic Search* to look for relevant learning resources that exist in the Learn-B environment. Via the *Knowledge Sharing Service*, John can share a learning goal with recommended colleagues, so they collaboratively work on it, or recommend them one of his competences, learning paths or other relevant knowledge resources. The updates brought to John by *Social Wave* enable him to better manage his learning process (Fig. 1.E). Specifically, for each of his targeted competences and its respective LP and accompanying learning activities/assets, John can receive the latest updates of that resource in his *Social Wave* on how the collective makes use of it and/or what actions have been performed on it in the context of other users' learning goals. In addition, *Social Wave* increases John's awareness of the utility of a shared knowledge item (e.g., a knowledge asset recommended by John being used by a colleague) or learning experience (e.g., his comment regarding certain learning activity being the seed of a productive discussion). This can act as an incentive for him to further share his learning reflections. In addition, John can also select colleagues whose Twitter updates he wishes to follow in his *Social Wave*. The stream of events in a *Social Wave* can soon become very long and crowded. Thus, John can personalize his stream of updates by defining his preferences in terms of domain topics and the resources he is most interested in.

4. THE LEARN-B ENVIRONMENT

The Learn-B environment is designed to support workplace learning and integrate the different tools that employees often interact with during their everyday (working and learning) practices. So far, we have integrated a wiki (MediaWiki), a social networking and collaboration platform (Elgg), a micro-blogging tool (Twitter) and a bookmarking tool (Tagging tool – implemented within this research as a bookmarklet). Fig. 2 illustrates the multi-layer architecture of Learn-B which can be adapted to and applied in a wide range of organizations. There is no strong boundary between the layers and components defined within each layer. In what follows we give a brief overview of each layer and its functionalities.

IntelLEO ontologies. Learn-B relies on an interlinked set of ontologies as its common (linked) data model. It provides the ground for the data linking and exchange among the tools integrated in Learn-B. Being developed within the IntelLEO project (http://intelleo.eu/), the ontologies are named after the project. They have been developed by following a combined top-down (review of existing work in the field) and bottom-up (requirements elicitation from IntelLEO business cases) approach. By following the recommended practices in ontology engineering [1] and publishing Linked Data on the Web [6], when developing the ontologies we relied on and linked to the vocabularies and ontologies already available and in use. The ontologies are designed to be modular and extensible. Detailed specifications of all the IntelLEO ontologies are available at :http://goo.gl/gt3cM.

Data Layer integrates two repositories: an RDF repository (Fig. 2A) and the Learning Resources Repository (Fig. 2B). The IntelLEO ontologies serve as the data model for storing data in the RDF repository and exchanging data among the Learn-B components. To facilitate the use of data from the RDF repository, Data

Layer provides a set of services which hide the specificities of working with ontologies, RDF, SPARQL and other related technologies from other Learn-B components. The Learning Resource Repository is used for storing learning resources created by Learn-B users. Data Layer provides services for storing, updating, sharing and retrieval of these resources in compliance with organizational policies defined by the organization.

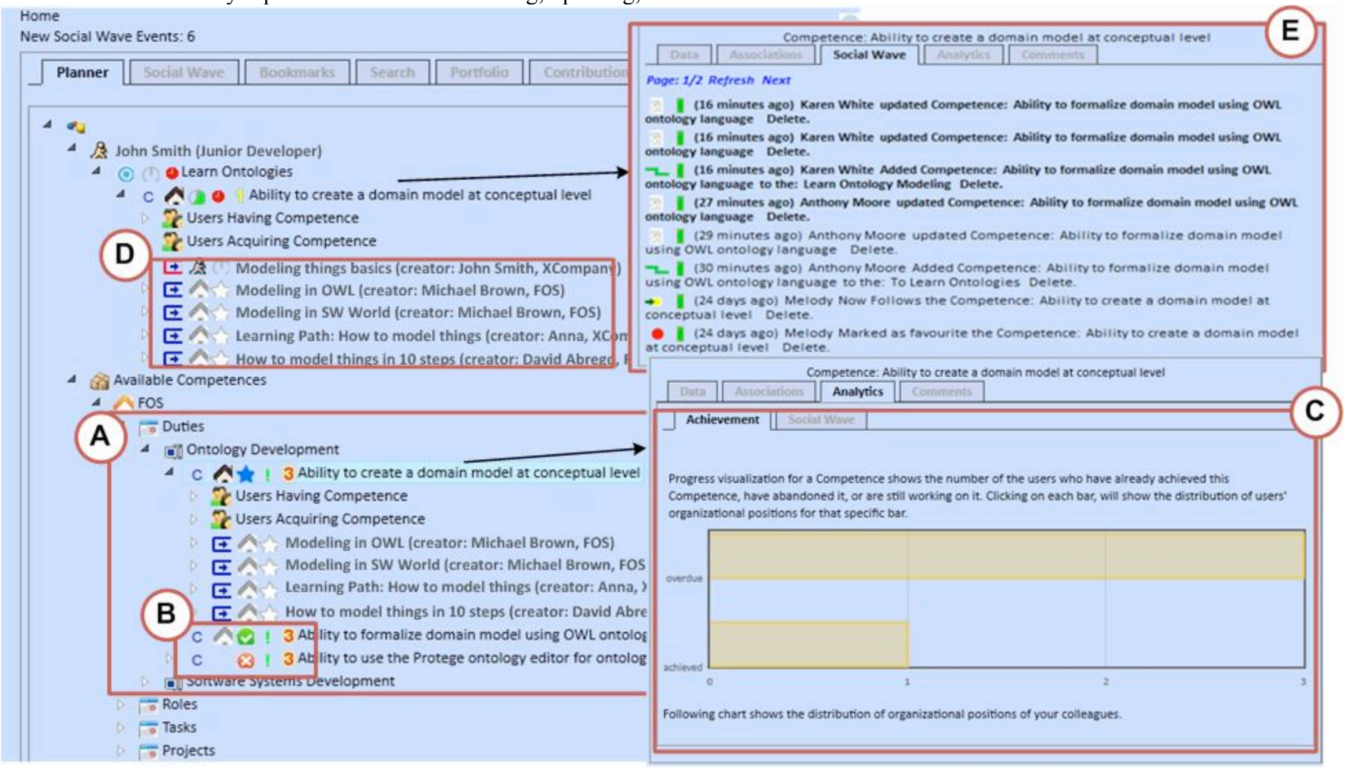

Fig. 1. A snapshot of the Learn-B environment in use.

As a part of Data Layer, the *Data Publishing* component (Fig. 2C) is aimed at making public data (from the RDF Repository) accessible on the Web as Linked Data. Currently, we are publishing the annotations of public learning resources as we consider these data potentially useful to other learning systems/tools that want to add a personalization/recommendation layer on top of their standard set of functionalities. The data is presently exposed through a SPARQL endpoint, whereas access through Linked Data API (http://goo.gl/EzwuW) is a part of our future plans.

Knowledge Management Service Group offers:

Knowledge Building Service (Fig. 2D) supports users in planning and managing their personal learning goals, specifying the competences to be acquired within a learning goal and creating a learning path for each competence. In addition, it helps users to harmonize their learning goals with organizational objectives and norms by giving them an overview of what competences are valued within the organization w.r.t. the existing duties, projects and tasks. Also, it provides users with personalized visual hints which indicate the importance of each competence or its required level for a certain user w.r.t. the duties the user is responsible for.

Knowledge Sharing Service (Fig. 2E) helps users in documenting and sharing their learning experiences and reflections over the learning process (including, e.g., the activities taken, the knowledge assets being used, and the colleagues who provided some guidance/help). These services are strongly related to the services in the *Recommendation Layer*, as they provide the data required for generating recommendations for knowledge sharing.

Semantic Annotation and Indexing Service (Fig. 2F) assists users when annotating semantically their learning resources (e.g. web pages and documents). When adding a new learning resource to a learning goal, a user can describe it using tags and/or domain-specific concepts. This service supports users in this activity by suggesting concepts related to the content of the learning resource. Tagging Tool (Fig. 2G) also leverages this service to support users when annotating online resources they find while browsing the Web. This service makes use of the Stanbol's content enhancement service (http://incubator.apache.org/ stanbol). The annotation is done both with the concepts from DBpedia and a domain specific ontology. The annotation data are stored in the RDF repository for later use by other services.

Semantic Search (Fig. 2H) aims at enabling effective and easy retrieval and reuse of stored learning resources. It allows one to search for resources based on a given domain concept or tag. This service makes use of the services of the Data Layer to search the data and learning resources repositories. If none of the available resources directly matches the user's request, the Semantic Search service will check for semantically related domain concepts or tags, find resources annotated with them and suggest those as potentially useful resources for the given user. To find similar domain concepts we use existing ontology relations (e.g. skos:broader, skos:narrower), as well as, domain concepts and tags used often in the same context.

Recommendation Service Group. Based on the contextual data about a user's tasks, learning goals, competences and other relevant information, *Learning Path (LP) Recommender* (Fig. 2I) recommends to the user learning paths for achieving a certain target competence. An LP is comprised of a sequence of learning activities along with descriptions (metadata) of knowledge assets required for performing those activities. To recommend the most appropriate LPs to the users, the LP Recommender first exploits cosine similarity measure between the vector of concepts and tags representing the user's personal preferences and the vector of concepts and tags related to an LP to find how similar each LP to the user's preferences is. In order to provide a more accurate recommendation of LPs, this service further considers users who had previously used the candidate LPs, and checks their similarity with the current user. The rationale for this comparison is that those LPs followed by users with similar interests and background are likely to be better adopted than those used by users with whom the given user has very low or no similarity.

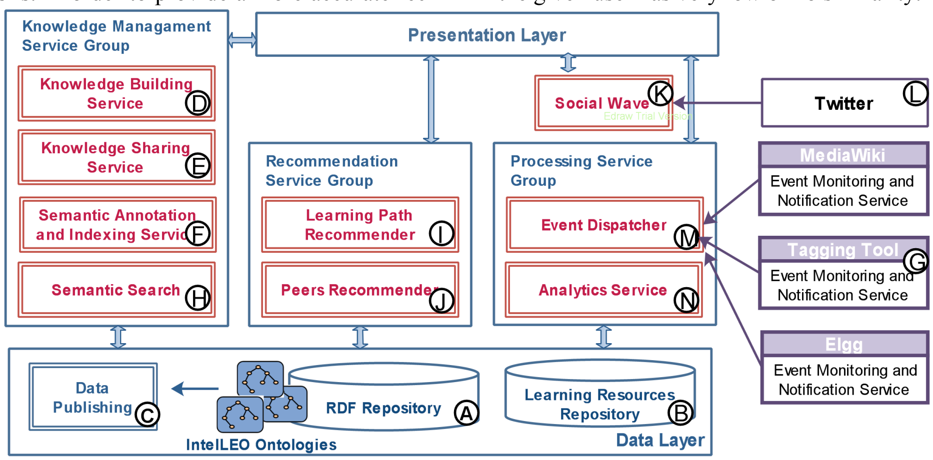

Fig. 2. The architecture of the Learn-B environment

Peers Recommender service (Fig. 2J) recommends peers who are likely to be similar in their interests and other preferences. To find their similarity, we make use of cosine similarity to compare vectors comprised of domain concepts and tags related to two different users. *Peers Recommender* uses four different vectors of domain concepts and tags: 1) one defined by the user as their personal preferences, 2) one attached to the user's learning goals (i.e., a set of competences each goal consists of), 3) one found in the user's learning history, and 4) one attached to the competences the user has already acquired. The user can define how each of these elements shall influence the peers' recommendation (e.g. personal preference have the highest influence, while ignore the learning history). It is based on this information that the *Knowledge Sharing Service* recommends whom to share learning resource with or to whom to recommend these resources to.

Social Wave (Fig. 2K) receives information about the events occurring in Learn-B (through the *Event Dispatcher*) and updates the social (activity) stream of users who might be interested in those events. This component also receives status updates from Twitter (Fig. 2L). In order to receive updates related to any particular user and their activities in Learn-B, one has to follow that user. Moreover, a user might decide to follow certain competences and in that case, they will receive updates about all the events related to those competences. New events are sent to the user's Social Wave inbox, and initially set as unread, sorted by the date happened. Each event contains information about how relevant it is for the given user. For specific learning resources (e.g. learning goals and competence), Social Wave performs filtering of events, so only those events that are related to a given learning resource are shown in the Social Wave inbox of that specific resource.

Processing Service Group. Learning events in Learn-B are captured and represented as a structured collection by the *Event Monitoring and Notification* service. This service is responsible for tracking all events that happen in Learn-B and sending the respective information to the Event Dispatcher (Fig. 2M). Event Dispatcher is responsible for processing of all events occurring in the Learn-B environment, storing them into the RDF repository and distributing them to other services.

Analytics Service (Fig. 2N) analyzes the data (from RDF repository) about users' learning activities and their interaction with diverse kinds of learning resources (e.g., learning goals, knowledge assets etc.) in order to generate feedback for users. The feedback, provided primarily through different kinds of visualizations, is aimed at supporting users in planning and monitoring their learning process. This service is further described in [14].

Presentation layer provides a transparent and adaptable interface for presenting knowledge and information to users.

The Learn-B Implementation. We have implemented Learn-B as a Java-based web application. The implementation leverages several open-source solutions for communication with external services as well as Semantic Web frameworks. To exchange data and communicate with external services used within Learn-B (so far MediaWiki, Elgg, Tagging Tool and Twitter), we rely on RESTful services implemented using the Jersey framework (http://jersey.java.net). The RDF repository of the Data Layer is implemented using Jena SDB (http://openjena.org/SDB/) which enables scalable storage and query of RDF data using relational databases. To enable effective manipulation of triples from the RDF repository within our Object Oriented (OO) application, we use the Jenabean framework (http://goo.gl/jfvCW).

5. EVALUATION

An early prototype of Learn-B was evaluated in February 2011 with end-users from three different business cases participating in the IntelLEO project. In this evaluation, the end users were asked to complete a series of learning tasks in the context of a learning scenario, authentic to the specific organizational context of each business case. The tasks themselves, however, were the same across the business cases, in order to allow for the comparison of results between the three different organizational settings. The objective of this evaluation was to investigate the perceived usefulness of each task for users' learning at the workplace and also to examine how useful and relevant the developed services and functionalities are in performing the tasks, especially w.r.t the motivational and pedagogical challenges of learning in the workplace. Due to their later delivery schedule according to the project plan, some functionalities of Learn-B such as Social Wave, Semantic Search and Peers Recommender were not a part of this evaluation.

Overall, 30 users participated in the evaluation: eight from the first (a leading car manufacturer), twelve from the second (an SME) and ten from the third business case (a teacher professional association). Majority of the participants had university degrees (83.3%). There were 23.3% users with 10 or more years of working experience, and the rest had less than four years of work experience in their current organizational positions. The evaluation was conducted on site of each business case. At the beginning of each evaluation session, the participants were familiarized with the learning scenario, phrased in a manner specific to each target business case. The learning scenario consisted of five tasks; we only report the results related to the first three tasks which are most related to the research presented in this paper.

The users' first task in the learning scenario was to create a new learning goal in Learn-B and choose from the available organizational competences to include in their learning goal. In task two, the participants were asked to browse the existing learning paths and choose one per competence included in their new learning goal from Task 1. In task three, they were asked to add new learning activities and knowledge assets to the chosen learning path(s) from Task 2. After finishing each of the above tasks, the respondents were asked to fill in the corresponding questionnaire, where they were provided with screenshots of the Learn-B functionalities and a related statement for each of the screenshots, asking them about the perceived usefulness of a specific function in performing that task. Answers were in form of a 5-point Likert scale (5: strongly agree, 1: strongly disagree). The question responses were grouped into Not-Agree (Likert-scale responses 1, 2 and 3) and Agree (Likert-scale responses 4 and 5).

Results from the users' answers show that the majority of the participants (58.6%) found that the creation of a learning goal, comprised of competences chosen from the existing ones, is useful to their personal learning (n=29, M=3.55, SD=1.088). In particular, almost all of the users agreed that seeing the available competences within their organization is useful when they are creating their learning goals (M=4.62, SD=0.56, 28 out of 29 users). When it comes to choosing competences to include in their learning goal(s), 76% of the users (n=29, M=3.93, SD=0.75) found it useful to see all the available and recommended learning paths (*Learning Path Recommender service*) for that competence. More individualized information about each competence (*Knowledge Building Services*) such as its priority w.r.t the user's organizational position (n=29, M=4.31, SD=0.81), its expected level to be acquired by the user (n=29, M=4.03, SD=0.94), and the prerequisites for achieving it (n=29, M=4.17, SD=0.81), were the other factors which users mostly found useful when planning for their learning goals. Moreover, users commonly agreed that seeing comments from their colleagues concerning a given competence (*Analytics Services*) is useful when deciding which competence to choose (n=29, M=4.14, SD=0.86); however, most of them did not agree that having positive comments from the colleagues was the reason for them to choose a given competence (n=29, M=2.83, SD=0.96). Seeing the roles of the employees who have already achieved a given competence (*Analytics Services*) is another piece of information coming from the social context of the organization that was found useful by nearly half of the users (48%), when they want to plan their learning goals (n=29, M=3.28, SD=1.192). However, a noticeable number of users, i.e. 76%, did not agree that being accomplished by many of their colleagues was a reason to include a certain competence in their learning goal (n=29, M=3.05, SD=0.93); nor did they find it useful to know the number of employees who have already achieved or are working on a certain competence, when they are in the process of creating their learning goal (n=29, M=3.10, SD=1.01).

Overall, 65% of the users stated that Task 2 (selecting one's learning paths) was useful to their personal learning (n=25, M=3.60, SD=1.080). Almost all of the users agreed that seeing all the available learning paths, learning activities and documents within their organization is useful when they want to choose a learning path (M=4.44, SD=0.583, 24 out of 25 users). Seeing their personal progress in completing a learning activity (*Analytics Services*), was one of the functions perceived noticeably useful by the users, for when they were about to choose a specific learning path (n=25, M=3.88, SD=1.09). In addition to the keywords accompanying the learning activities/documents a learning path is composed of, colleagues' ratings of and their comments about these resources (*Analytics Services*) were the other functions that users majorly found useful while performing Task 2 (M=3.68, SD=0.90; M=3.60, SD=0.76; M=4.0, SD=0.76, respectively, n=25). Similar to choosing competences in Task 1, most of the users did not agree that having positive comments or high ratings from the colleagues were necessarily the reasons to choose a specific learning path in Task 2 (M=3.24, SD=0.831; M=3.04, SD=0.841, respectively and n=25). Again, neither being completed by many of their colleagues, nor knowing the number of colleagues involved with/working on a learning activity were considered as the reasons to choose a learning path by a good number of the participants (M=2.92, SD=0.997; M=3.00, SD=1.190, respectively and n=25). Interestingly, this time 64% of the users did not consider seeing the roles of the employees who have already completed a given learning path (*Analytics Services*), as useful when they want to choose their learning paths – contrary to the similar case in Task 1.

A notable 70% of the participants found Task 3 useful for their personal learning (n=24, M=3.92, SD=0.974). Setting the visibility of their newly added learning activity/document and adding keywords to it were perceived as useful functions by nearly 80% of the users (M=4.13, SD=0.741; M=4.17, SD=1.274, respectively, n=24); followed by a 62% of the users agreeing that being able to also rate the new learning resource(s) is useful when trying to adapt the learning paths (n=24, M=3.67, SD=1.007).

6. RELATED WORK

Our research and the resulting Learn-B environment presented in this paper are related to two current dynamic research fields: supporting workplace learning, and leveraging Social Semantic Web and Linked Data paradigms in enterprises. Although extensive work has been done in both research fields, to our knowledge there are very few attempts in developing environments that support workplace learning, with the use of Social Semantic Web technologies, and are based on strong pedagogical foundations.

The APOSDLE project (http://www.aposdle.tugraz.at/) aimed at enhancing users' productivity in informal self-directed workplace learning by making individuals aware of available knowledge sources for a task at hand in the context of their everyday work processes. The main focus was on supporting individual learning in the workplace, while harmonization of individual and organizational learning and the effect of the social nature of workplace on learning were not addressed. Utilizing the Knowledge Maturing model, the MATURE project (http://mature-ip.eu/) examines how informal knowledge matures in organizations, networks and communities of practice through collaborative activities. To provide the required support for this maturing process, the MATURE project relies on the Social Semantic Web technologies, tools and services such as semantic wikis, semantic tagging and common vocabulary (i.e. ontology) building tools. In this project, however, the main focus is on (knowledge) maturing as an organizationally-guided learning process that emerges at individual or community level and moves towards an organizational level, and SRL and social-embeddedness of workplace learning are not investigated.

The SemSLATES approach makes use of Semantic Web technologies and Linked Data principles to provide support for knowledge integration and re-use, and efficient information retrieval in Enterprise 2.0 information systems [10]. Instead of creating a new knowledge management suite of tools, the aim is to integrate various existing tools in a transparent manner, and to re-use existing models and data already available on the Web. Obviously, this approach bears a lot of similarity to our work; however, it does not address the challenges of workplace learning; neither the social nor motivational issues relevant for the deployment of the new technology in Enterprise 2.0 settings. The OrganiK project (http://www.organik-project.eu) aims to develop an organizational knowledge management system for small knowledge-intensive organizations by combining elements from the domains of Enterprise 2.0 and Semantic Web technologies. The proposed solution here is also based on the SLATES framework [2], which is rather oriented toward supporting knowledge management in organizations and less attention is paid to workplace learning.

7. CONCLUSIONS

As shown in the evaluation of our research, semantic technologies can offer important advantages to workplace learning, once they are applied on top of sound pedagogical and motivational principles. While knowledge capturing and sharing are typically challenging tasks, our empirical insights revealed users' willingness to contribute to those tasks provided that: there is some recognition of/feedback about their contribution by peers/organizations; and the organizational expectations are explicitly stated. For users to demonstrate their contributions (i.e., their competence), the use of semantic technologies can play a crucial role, as products of both their work and learning can easier be documented, retrieved and integrated regardless of the tool in which the contribution was produced. However, an open question is how to further foster users' contributions and motivate them to provide higher quality inputs to the system. In our on-going activities, we are investigating open learner modeling [3], as a means that has already provided some empirical evidence in motivating users to improve the quality and amount of information in their learner models. We will also report on the results of a larger scale evaluation ending in late February 2012, in which users have used Learn-B in the period of three months in their day-to-day work activities.

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