Social Computing Solutions for Collaborative Learning and Knowledge Building Activities in Extended Organization

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***Abstract*—The research presented aims to support Learning and Knowledge Building (LKB) activities of adult learners that act under specific contexts within Extended Organizations. Under Extended Organization is understood a community that emerges as a temporal integration of two or more different business, educational communities and organizational cultures (industrial, research and educational) and leverages ICT technologies to support LKB activities. The objective of the research is to explore supportive social computing based technologies for (cross-)organizational collaborative LKB activities. The technological developments are embedded in a pedagogical framework that puts a special focus on the harmonization of individual and organizational objectives. The proposed extended organizational concept and SW services developed to support such concept were investigated within two different cross-organizations: one including a large industrial company and a research institute and a university and the second one including a small industrial company and a department of a university. The results of testing and evaluation are presented and key lessons learned are discussed.**

Keywords-collaborative learning; social computing; cross-organsiational learning; organizational learning; ontologies; semantic wikis

I. INTRODUCTION

An organization aiming to be an intelligent learning organization faces a key problem of how to motivate the employees for continuous learning and knowledge building (LKB) activities to engage them in an active innovation process. The research approach presented in this paper is based on a new and developing paradigm of Extended Organization (EO). The model proposed emphasizes two types of creative cross-over conditions for LKB – vertical and horizontal within a single organization a, and horizontal between different organizations [2]. This represents the paradigm of an Intelligent Learning Extended Organization (IntelLEO) which constitutes a temporal alliance among different organizations (industrial, research, educational etc.) in order to share resources, skills and costs in supporting LKB activities [3]. The responsiveness of a learning environment within such a complex learning organization is crucial and can be strengthened by different means, e.g. by: better supporting collaborative learning with an extended offer of learning content, assuring better harmonization of the individuals' (members of the organization) and the organizational LKB objectives, providing more personalized learning paths directed to the organization strategic objectives, effectively combining learning and knowledge management approaches and systems within the organizations, etc. While each of these means has been subject of intensive research, their combination and synergy has not been sufficiently investigated.

In order to effectively support both collaborative LKB and harmonization of individual and organizational objectives within dynamic, flexible (often geographically distributed and international) IntelLEOs, efficient technology for management (i.e. access, delivery) of content within such an IntelLEO is 'conditio sine qua non'. The research presented aims to investigate how such a technology may bring added-value regarding overall responsiveness of the LKB environments in an IntelLEO. This concept of IntelLEO requires technologies to support sharing, harmonization, building, and extension of knowledge among individuals, industries and universities, and effective combination of content and organizational knowledge systems (at both universities and industries).

The paper is organized as follows: Section 2 provides a brief overview of the state-of-the-art of the technology relevant for a support of the LKB activities within EOs. Section 3 explains the basic concept, while Section 3 provides a brief description of the implemented social computing services. Section 5 is dedicated to the testing of the concept and technology within two real EOs, where lessons learned are discussed as well. Section 6 includes conclusions and indications of the future research activities.

II. OVREVIEW OF THE RELEVANT STATE-OF-THE-ART

As explained above, the proposed concept of an IntelLEO requires technology aiming to motivate employees to actively take part in collaborative LKB activities. Several topics are identified as being of key relevance for such technological support [3].

Extensive research and technology development has been performed in last decade to support the collaborative work of learners which may be applied also for an EO. However, since cross-organizational collaborative LKB activities are much more complex than collaborative work within single departments/organizations, more powerful technological support is needed. Current solutions are not context-sensitive and related to explicit models and ontological frameworks allowing for e.g. context sensitive recommendations of people appropriate for collaborative LKB within an EO etc.

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Another relevant area is Monitoring of Human-Computer Interaction (HCI) to derive possible meaning and relevance of information to the learner. Although such monitoring services have been subject of several research initiatives (not only within technology enhanced learning domain) the solutions to effectively extend contextual data user profiles through monitoring of active & passive interactions with explicitly & implicitly interacted data to build/deduce a possible relevance & meaning of data to user, and thus improve performance of other services are not available to support LKB activities within an EO.

Ontologies for formal representation of knowledge objects, learning activities and resources are available, but they are not well integrated to support LKB within an EO. There is no widely accepted model for representing competencies. The complexity of the existing models makes them difficult to apply in real world settings.

A relevant area for the presented research is also services to support definition of organizational policies for LKB activities. Existing organizational policy tools are typically focused on only one of the aspects such as organizational structure, access control policies, and intra-organization competency management and do not provide support for LKB activities within an EO.

ePortfolio software (e.g. Elgg) provides learners with a Personal Learning Environment (PLE) and social networking tools to focus on their individual learning and participate in collaborative LKB activities. Current approaches assume that the learning process happens in one system only, which does not correspond to the nature of workplace learning and does not respond to the needs for integration of informal and formal learning. There is no support for personal learning planning which stimulates harmonization with organizational competencies, and allows for managing and sharing learning activities/experience happening in different systems. The existing research considers a competency gap-analysis approach; however, it relies on a list of available defined competences and does not act as a learning organization in this regard. Competences are tied a specific context-of-use within one organization. In existing solutions, learning paths are static and cannot be adapted based on the dynamics of users' context and/or learning objectives [3].

Social software tools, Semantic Wikis (e.g., Semantic MediaWiki) enable seamless semantic annotation for 'regular' users [5]. However, knowledge that these tools capture is typically unstructured and encoded in proprietary formats, not allowing effective sharing of learning and knowledge objects within an EO.

III. MOTIVATION

As explained above, the aim of this research is to elaborate and provide technology to support the new paradigm of IntelLEO (Fig. 1). An IntelLEO leverages intelligent technologies to support LKB activities of a community that emerges as a temporal integration of two or more different business and educational communities and organizational cultures. Various technical solutions to support university/industry collaboration, as required within an IntelLEO, are developed. However, the key problems of how to motivate learners at both 'sites' to share learning objects and knowledge resources are still not solved, especially taking into account complex issues of different learning contexts, organizational objectives and IPR issues. Portfolio software that can be used both in industry and in higher education is of a key importance. An IntelLEO model emphasizes that the creativeness of organizations, and motivation of individuals to contribute into organizational knowledge and proactively learn, depends on the possibilities of creating and sharing tacit knowledge across various boundaries, externalizing such knowledge and grounding it in collaborative groups, and reusing it for organizational and individual growth. Shared organizational vision and rules among individuals guarantee the directed development and enable to keep organizational identity. The continuous harmonization of organizational and individual rules, values and objectives is the prerequisite to simultaneous co-building of organizational knowledge and keeping the individual motivation to proactively learn. Theoretical models of IntelLEOs, the activities and processes in these, and the means of achieving responsiveness are still in the phase of intensive development and investigation. By investigating the assumed increase of IntelLEOs' responsiveness by providing appropriate ICT services, the research actually explores how technology creates conditions for effective IntelLEOs.

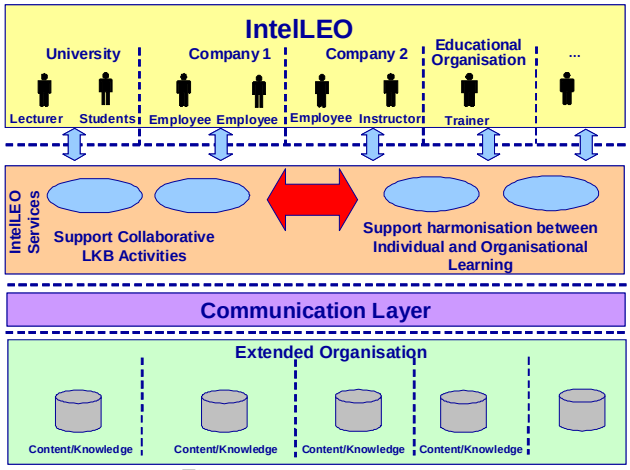

Figure 1 IntelLEO concept [3]

IV. PROPOSED CONCEPT

The presented research aims to enhance cross-organizational LKB practices at the workplace, where under LKB practices are understood activities that involve the Knowledge building process (the individual and social constructive process of creating new cognitive artifacts, which result in the formation of various forms of Knowledge) as well as Learning activities. It aims at increasing motivation towards LKB in organizations, externalization of tacit knowledge individually for personal development, participation in collaboration and knowledge

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combining practices in EO, and frequent harmonization of individual- and organizational objectives when planning, conducting and reflecting about work practices.

To support such EO concept the following methodological and technological means are developed:

• A new Implementation Framework on how to use technology to motivate employees to take part in collaborative LKB activities in an EO, taking into account the best social constructivist and situated learning practices in collaborative LKB,

• Ontological framework for LKB context representation,

• Generic and widely applicable so-called core services, fitting SOA principles, for managing collaborative LKB activities and contents in an IntelLEO.

The proposed ICT environment (Fig. 2) [6] consists of several layers,focused around the Core Services (CS) and the Ontology Framework. The different layers are the following:

• The layer 'Knowledge Resources' represents the resources and communication layer in an EO. It serves as resource basis for e.g. Process Knowledge, Portfolios, etc.

• The CS layer consists of several services: Organizational Policy (OP), Learning Planner (LP), Content Knowledge Provision (CKP), Human Resources Discovery (HRD), Working Group Composition (WGC), User Monitoring & Collaborative Traceability (UMCT).

• The Orchestration layer serves as the service integration environment. It combines the CS within Application-specific Services needed by the different collaborating organizations and users. Specifically, this layer links the CS and application specific SW solutions used within an EO to ensure Application-specific services which support the users in LKB activities. It is to distinguish that CS comprise the generic set of services, while Application-specific Services comprise services for the organizations in an EO (e.g. services to support new-comers in an EO).

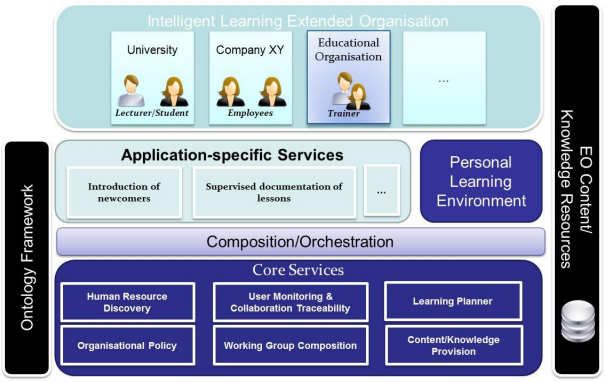

Figure 2 – Proposed ICT environment [6]

The Ontology Framework spans over the whole environment and serves as a model foundation and common base structure for specific knowledge. The IntelLEO ontology set consists of eight ontologies: Learning Context, Activities, User Model, Workflow, Competences, Organization Structure, Annotations, Competence Management ontology.

To guide the cross-organizational LKB within an EO, models that integrate self-regulated learning (reflecting, setting/monitoring learning goals) with collaborative knowledge sharing activities is investigated. The innovative approach is to use the so-called SECI-Model [7] as pedagogical framework - Socialization (implicit to implicit knowledge), Externalization (implicit to explicit knowledge), Combination (explicit to explicit knowledge) and Internalizations (explicit to implicit knowledge). Although SECI model is initially the model for organizational knowledge management, enabling knowledge conversion in organizations, this model has been effectively used for organizing learning at workplaces. Therefore, approach applied to the creation of the concept is that all segments of the solution focus around the SECI model. While intuitively attractive, there has been limited empirical investigation of the SECI model in practice, with this being especially true within the context of multi-organizational projects [8].

V. IMPLEMENTATION

The solution has been implemented as a generic system thanks to the ontology framework [9], making it easy to adapt it for different organizations and contexts. For this, different knowledge base could be produced to adapt the system usability in a specific context. Specific tools can be connected to the CS to respond to the specific organizations' needs, e.g. Semantic MediaWiki and Elgg can be used as a collaborative tools and PLE. Then, the solution can be deployed in different contexts.

Organization Policy CS is used to specify the context and priorities at the organizational level. OP CS is consisting of five functional modules. One of the aims is harmonization of individual learning goals of employees with the goals of organization. OP is a tool that is meant to be used by managers of organization, in order to define and promote contextual settings, policies and priorities of the organization. These settings, policies and priorities will then be utilized by other CS [8].

The Learning Planner (LP) CS allows users to have ubiquitous access to their personal learning spaces. Through this service, users can manage and attain their learning goals harmonized with those of their organization, by receiving support from the social context of their EO, and also contributing back to it through sharing their learning experiences. Managing Learning Goals functionality supports users in planning and managing their personal learning goals, choosing/creating the competences to be acquired and building learning paths to acquire each specific competence. It also helps users to harmonize their learning goals with organizational objectives. Contrary to other competence-based approaches, here users are not limited to choose their learning goals from only a set of predefined goals provided by their organization; they can create new competences which they desire to achieve or browse the list of available competences within their EO and choose the ones that they find relevant to their goals [9].

Based on the contextual data about a user's tasks, learning goals, competences and other relevant information, this functionality recommends learning paths for achieving a

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certain target competence to the user. A LP is comprised of a sequence of LKB activities along with descriptions (metadata) of assets required for performing those activities.

Analytics functionality is responsible for processing and analyzing the data about users' learning activities and their interaction with diverse kinds of learning resources (e.g., learning goals, target competences, activities and knowledge assets). It makes use of the interaction data stored in the RDF repository to provide users with feedback, primarily through different kinds of visualizations, to support them in planning and monitoring their learning process. Browsing the Analytics of a certain available competence, updates the managers of an organization on how frequently this competence has been used within the organization, in the context of which learning goals, by users of what organizational positions, and what the main issues regarding this competence are. This allows managers to apply any necessary modifications in the definition of the competence itself or learning paths associated with it. Social Wave receives information about the events occurring in the LP and other connected tools, e.g. MediaWiki, and updates the social (activity) stream of users who might be interested in those events. Semantic annotation and indexing of learning resources provides two types of annotations: manual and automatic. Semantic Search aims at enabling effective retrieval and reuse of stored learning resources, i.e. learning goals of other users, competences, LPs, learning activities or knowledge assets [10].

Content/Knowledge Provision (CKP) service aims at locating and retrieving appropriate learning and knowledge objects and making them accessible either to members of an EO or to other services, taking into account the specifics of the user's learning context. CKP offers the web browser-based user interface. It provides three major functionalities: (a) bookmark/upload knowledge objects into a designated repository, (b) manage uploaded knowledge objects, c) perform semantic search of knowledge objects repository.

Human Resource Discovery and Working Group Composition CS offer several functionalities related to context sensitive finding human resources and establishing temporal working groups with them. These CS offer search for persons, working groups or organizations, based on several criteria. CS provides contextual recommendation of people. CS can select relevant person for collaborative LKB, where the recommendations are based on algorithms computing the similarities between different kinds of resources.

The User Monitoring and Collaboration Traceability (UMCT) service implements functionality to monitor user interaction, in particular over MediaWiki. The UMCT service works in the background of the legacy system, in this case MediaWiki (or Elgg), and does the monitoring of a specific set of interactions that the user has with the MediaWiki in question. These interactions include: open a page, create a page, edit a page, upload a document, bookmark a page, delete a page or performing a search. This set of interactions may be extended and may vary according to the system being monitored and the use of the monitored data. The information is collected by an extension installed on the MediaWiki side and passed to the UMCT web service where the activities performed by the user are then saved in the ontologies repository. The main objective of these services is to extend user profiles through the monitoring of active and passive interactions with explicitly and implicitly interacted data to build and deduce a possible relevance and meaning of data to a user, and improve performance of other core services by making the monitored information available to these services. The functionality that monitors the main activities records certain events occurring during the use of other services, such as the creation of a learning goal, addition of a competence to a learning path or the creation of a learning group by a certain user. The monitored data may be visualized in different ways: in the social wave panel in the LP or in the end-user environments, MediaWiki. This functionality has as a main objective to build and deduce a possible relevance and meaning of data to a user. It is possible for the user to define in a fine-grained way what information the service is allowed to collect.

The integration of all developed services was included in the conception and implementation of the services and Ontology Framework by basing the ICT concept on service-oriented architecture principles. This principle was applied by implementing a set of CS, as explained above. At the same time – adhering to SOA's principle of loose coupling – the ICT concept allows for integrating/orchestrating one or more of CS – and optionally external systems from the existing learning environment – into Application Specific Services that provide the combined functionalities to implement a specific use case. This integration/orchestration is facilitated through the well-defined interfaces, which allow each service (as well as external tools) to synchronously invoke another service's functionality – in some cases extended to the according user interfaces – e.g. a user requests forming a learning group for a particular competence in LP, which causes the corresponding user interface of WGC Service to open. This synchronous integration between services was complemented by an extensive event model allowing services and external systems to asynchronously notify each other of pre-defined events. This event system was especially used when integrating the services with existing tools of the learning environment – MediaWiki, e.g. (a) When a user starts acquiring a competence in the LP this competence is automatically added to the user's profile page in MediaWiki, including information about how far the user has progressed in acquiring the competence, (b) Creation of a working group triggers the creation of a corresponding page in MediaWiki, which contains links to the profile page of each user. All services work on a central shared data repository, modeled through the Ontology Framework. Universal and transparent access to this shared data repository is realized through the services of the Ontology Framework.

VI. EXPERIMENTAL VALIDATION

As the research was following a participatory design based research approach an active involvement of all actors and especially the future core users is being pursued. Based on this approach, the user requirements and scenarios for use of the developed services within specific EOs were defined

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[11, 12]. The users were involved in intensive testing and evaluation of the results. All test-participants were provided with the same set of IntelLEO services during the test-period, while the scenarios for the usage of these services were adapted to the specific needs and requirements of each EO. All test participants were provided with the same set of quantitative (pre- and post-evaluation questionnaires) and qualitative (focus-groups, expert interviews) evaluation instruments to collect their feedback.

The first case is settled within the big multinational corporate in the automotive sector. The specific instances are located within the product development department. External research cooperation and education/training partners such as a RTD institute and University were involved in the cross-organizational activities. The main challenge in this case is related to the issue of motivating employees to document and share their experience within and across the departments and organizations. In addition, time to competence is of high importance for the company, especially in the case of the involved department, where there is no specific formal educational program for obtaining the specific knowledge, skills and competences needed in this department. One of the main requirements is the integration of any solution with MediaWiki and Semantic Wiki, which is used for LKB.

The second case is involving an SME providing IT services especially for the e-Engineering and e-Manufacturing sector, and its collaboration partner, a University department dealing with software engineering. The cross-organizational activities in this case are focusing on the specific innovation-driven demands of the SME and the relevant scientific expertise at the University department. Current cooperation activities between the two organizations have been carried out in a rather non-transparent one-to-one exchange between staff members. With a more transparent approach, supported by ICT, to knowledge exchange and collaboration the individual as well as the organizational benefits shall be considerably increased.

The objective of this evaluation was to test and validate the prototype of services and implementation framework, collect feedback concerning the usability and usefulness of the services and to test how these services increase the individual motivation for LKB activities, a pre-requisite of organizational responsiveness. Both quantitative (and qualitative evaluation has been carried out. The analysis comprises detailed comparison of the results of evaluation in the two different cases. Due to the lack of space, here the conclusions made based on these evaluations are briefly presented. More detailed results can be found in [6, 8].

Based on the thorough testing of the services a number of improvements in the services were proposed by the users. The required improvements have been carefully analyzed, lessons learned regarding the developed services have been identified and the actions to improve the services to assure effective use of the services in the future have been carried out. A number of useful conclusions regarding pedagogical aspects have been identified as well.

The results show the importance of collaboration services for an increased motivation for learning and knowledge building (LKB) activities. The participants who got involved in collaboration activities often were amongst the most motivated for LKB and showed also the highest self-efficacy. This result was confirmed by the correlation analysis of data on learning and knowledge sharing attitudes, which highlighted the relationship between collaboration and the motivation to learn, the willingness to share knowledge and also the self-efficacy for LKB. A strong positive correlation between the motivation to learn and self-efficacy for LKB is found, meaning that the more self-confident a person is with respect to LKB the more motivated s/he is to actually learn. Thus the studies confirm outcomes from existing studies on self-efficacy & learning motivation [12].

The acceptance of the developed services in real-life environments depends very much on the organizational context of the test participants. Participants from the large company coming from a very competitive work-environment are not used to work with prototypes. Thus, feedback is more critical than the feedback from the second case. The willingness for the further usage of the services for promoting LKB after the testing period in the EOs appeared to be influenced by the initial organizational LKB culture differences. The high motivation to learn, as well as to share knowledge with partner organizations in the second case, remained high. On the other hand, despite the fact that participants in the first case have a high individual motivation to learn from other organizations, this motivation was extenuated by organizational barriers in form of existing policies that impeded e.g. sharing of knowledge.

The evaluation of the services revealed several interesting and useful insights concerning the most important drivers and barriers for cross-organizational learning. Cross-organizational learning in such a continuous and structured way, as it is supported by the services, was seen as an important benefit from managers and employees in research institutions, while users involved in the industrial organizations reflected critically on this approach. The main potential barriers to apply this approach were the privacy regulations of large companies, which constrain the transparent use of individual competencies across department and organizational borders. The fear to lose intellectual property and knowledge-able workers through an increased transparency and cross-organizational learning cooperation were mentioned as relevant obstacles [12].

The participants identified several benefits of the developed services for workplace learning: The requirement to structure and document one's work-relevant knowledge and learning processes has been highlighted. The important requirement was that the services should support learners to stay on the learning track. Therefore, the Social Wave was one of the most important features. This functionality helps learners to quickly be informed about the latest activities involved, the most urgent learning goals, new resources, and latest resources book-marked/stored to the system for a later enhancement. The challenge for learners is to know which of the huge amount of available learning resources are relevant at a specific time point to continue one's learning process towards successful achievement. From an organizational point of view one of the main contributions was the process of documenting the competency needs of the involved

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organizations. The services are perceived as especially useful for newcomers, as they replace a "mentor" [6].

VII. CONCLUSION

The proposed approach, including the pedagogical framework and developed services, offers a novel perspective on supporting LKB in organizational settings: it brings together elements originating from and necessitated by the social, organizational and informal context of organizational learning, along with motivational and self-regulatory aspects that aim for the individual learning of knowledge workers. The services were designed to not only support and promote organizational learning in terms of all the aspects set forth by the pedagogical framework, but also to integrate the various tools and services that employees often interact with during their everyday practices. To address this challenge, the tools relied on a network of ontologies as their common (linked) data model. These ontologies provided a basis for all the functionalities of the tools, as well as a ground for data linking and exchange among the tools integrated. The network of ontologies, in particular, facilitates formal representation and seamless integration of data about individuals' learning experiences (i.e. learning activities and their context), the knowledge being shared, as well as different kinds of annotations that capture either individual or collective reflections on the shared content/knowledge. Moreover, in the last few years the affordances offered by the Social Web, i.e. Web 2.0, paradigm have affected the existing learning pedagogies, bringing forth the concept of Social Learning, mostly in formal educational settings [5, 13]. The evaluation of the developed services (and accordingly the pedagogical framework) reconfirmed the role and importance of social learning in informal organizational learning.

It may be concluded that the main innovation is the approach to align (cross-) organizational LKB policies with personal user-centered goals, applying social computing approach. Although the research addressed a wide spectrum of RTD topics relevant for collaborative LKB activities within an EO, many aspects are open for further research. Attention in future RTD work will be given to e.g. quality of TEL services for collaborative LKB activities in EOs, privacy and security issues, further aspects relevant for context modeling, etc. Especially privacy issue from technical point of view will be addressed in detail (e.g. as the Ontology Framework is defined in the OWL language, it has to be investigated how such a formal nature of ontologies can be leveraged to reason over the various security/privacy policies within EO, etc.). The implemented services and the Implementation Framework support further use of the proposed concept and services. Since the services are developed to suit very distinct EOs, it can be assumed that the Framework is applicable in various organizational settings, not only in EOs but also in complex single organizations (e.g. large manufacturing companies for collaborative LKB activities among departments/ subsidiaries) or smaller organizations (where appropriate selection of the services and aspects relevant for an SME could be made).

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