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SEMANTIC WEB FOR SUPPORTING PERSONAL WORK AND LEARNING ENVIRONMENT CREATION

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The ARISTOTELE European project investigates the concept of Personal Work and Learning Environment (PWLE), an approach allowing workers, seen as "lifelong learners", to benefit from - and contribute to - collective knowledge within their organization. The PWLE is a personal digital environment assisting workers in their knowledge cycle. Specifically, the PWLE makes it easy to transform workers' tacit knowledge into explicit knowledge, and helps them to contribute to collective knowledge that they can exploit for learning and work purposes. By facilitating the modeling, representation and accumulation of collective knowledge, Semantic Web technologies support PWLE processes for continuous learning in enterprises.

Key words: Semantic Web, Collective Knowledge, Personal Work and Learning Environment (PWLE), Organizational Learning.

1. Introduction

The "knowledge society" needs to better support the development process of professionalism within organizations and companies with a view to continuing education that does not involve the transformation of lifelong learning in lifelong schooling [24].

The need for lifelong learning in so-called *lean enterprises* [19] brings to the fore the importance of facilitating and supporting the continuous professional development at all operative levels within the enterprise. This support justifies the use of active pedagogical approaches, such as action learning [21], able to anchor the training project to the working context, thereby promoting employment through special “educational treatments” a correspondence between individual learning processes and changes planned by the Organization.

To date, the majority of activities aimed at corporate training failed to:

- catch the skills developed during the informal learning activities;
- reuse the knowledge emerged during either work or learning activities (individual, collaborative);
- exploit, effectively (up-to-date) and efficiently (timely) the existing skills.

For these lacks, it becomes a challenge to prepare collaborative learning activities and provide mechanisms to respond at the same time to the individual (worker) learning needs and strategies and constraints of the Organization as explained in [5] and [25].

In recent years, different aspects of learning at the workplace have been subject of attention from various research actions. Projects like APOSDLE [20], MATURE [22], TEN-competence [18], approved under the sixth and seventh framework research program of the European Commission, can be considered "pioneer" aiming at the alignment of individual learning processes with business ones in order to enable the quick update of employee’s skills in relation to changing professional requirements demanded by the labour market.

The ARISTOTELE[a] project [12], co-funded by the European Commission under the Seventh Framework Programme, aims to take a step forward compared to the state of the art. Indeed ARISTOTELE proposes the definition of models, methodologies and tools to support and exploit, in a synergistic way, three types of processes - organizational processes, learning processes and collaborative processes - in order to improve the activities related to the management and development of human resources and maximizing the Organization's capacity to learn, innovate and evolve [27]. In particular the ARISTOTELE project it is targeted to knowledge workers operating in knowledge intensive organisations.

In this paper we present the results of one of the ARISTOTELE research lines, related to the development of a Personal Work and Learning Environment (PWLE), an environment providing a functional support to knowledge workers’ activities that are "self-regulated", "collaborative" and simultaneously "located". The support within the PWLE to the processes of planning, reflection and goal setting encourage continuous learning, sustained and constantly re-oriented by peers.

The paper is organised as follows: Section 2 provides an overview of the ARISTOTELE platform and the key features provided by its innovative tools; Section 3 introduces methodological and educational perspective for moving towards PWLE environment; Section 4 shortly recall how semantic web technologies helps in representing knowledge and how these technologies are exploited in the ARISTOTELE platform; Section 5, the core of the paper, presents the PWLE and shows how it

[a] http://www.aristotele-ip.eu

supports the SECI model; Section 6 presents the PWLE usability evaluation results; finally Section 7 draws the conclusion and the future work.

2. The ARISTOTELE Platform

The aims of this section is to provide a short description of the main features of the ARISTOTELE platform in terms of software architecture and advanced features provided by the innovative tools that have been integrated in.

The ARISTOTELE project has been focusing on the development of methodological and technological solutions for reinforcing links among individual learning, organizational learning and creativity within knowledge intensive organisations [15]. In effect, ARISTOTELE follows an approach that supports a joint exploitation of human resource management, organizational learning, knowledge management, and collaboration processes. The proposed approach allows to create a virtuous cycle where intangible assets (creativity, competences, and knowledge) are tracked, collected, and exploited through processes (organizational, learning, and social collaboration) whose central role is played by users, intended as knowledge workers supported by enabling technologies. In order to achieve this vision, the ARISTOTELE project provides the following key contributions:

- A new way of conceiving and enhancing the relationship among knowledge flows, organizational and learning objectives, work practices, and creativity within knowledge intensive organizations;
- A methodological and modeling ground consisting of conceptual Models representing, in a machine understandable way, key organizational assets and a set of business process patterns related to knowledge intensive organizations;
- Innovative methodologies and related software tools processing, managing and operating on semantic conceptual models to support the achievement of organizational and performance objectives;
- An innovative technological platform human centric, models & methodologies driven (in contrast with technology-driven), built on top of state of the art solutions (i.e. IWT – Intelligent Web Teacher and Microsoft Sharepoint 2010).

These challenging objectives, implies a complex software architecture whose design has been inspired by enterprise framework like MIKE 2.0 (Method for an Integrated Knowledge Environment - an open source methodology for Enterprise Information Management that provides a framework for information development). The figure below provides an overview of the overall architecture.

We leverage on already existing and well affirmed enabling technologies like Microsoft Sharepoint Server 2010 for the aspects related to content management and web based collaboration within enterprise, and IWT – Intelligent Web Teacher for supporting learning and training activities in an adaptive and personalized way.

The semantic layer consists of four Models and related technologies for their management (storage and reasoning):

- Knowledge Model (KM) – This model focuses on three aspects of knowledge:
  - Enterprise activity and strategy domain – Models enterprise knowledge, e.g. strategies, processes, activities, documentation, and, in general, all output generated by workers in

their activities, including social interactions with peers;
  - Organizational knowledge – The set of lightweight ontologies that are exploited to provide a shared classification of the organization's resources and entities;
  - Training domain – Models domain knowledge that is relevant for the learning activities and it is based on the IWT Knowledge Model.
- Competence Model (CM) – This model provides a representation of competences (expressed in terms of knowledge, skill and attitudes) and their relations to other models elements such as context, evidence and objectives.
- Worker Model (WM) – This model provides a representation of the worker including social, learning, working and personal goals.
- Learning Experience Model (LEM) – This model provides a representation of the learning experience needed to achieve a new competence or fill a competence gap.

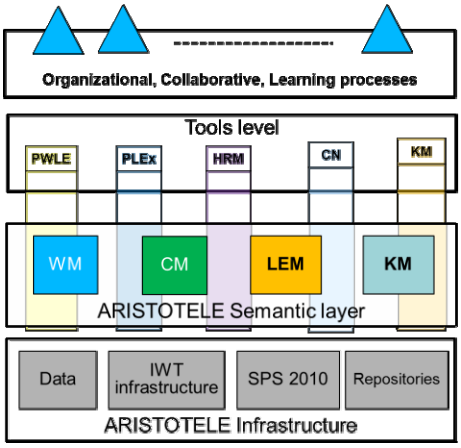

Figure 1: ARISTOTELE overall Architecture

All the ARISTOTELE models are formalized using RDFS/OWL and this allows a concrete enforcement of the models on semantic web stacks, interoperability among them, and easy linkage with other models emerging within the semantic web community. Indeed, we have integrated and extended a lot of semantic web schemas like SIOC, HR-XML, FOAF, DOAP, MOAT, RELATIONSHIP, REA, just to mention few. The models are managed using an Enterprise Liked Data layer that acts as business abstraction layer towards the triple-store where models instances are stored in.

The concrete support to the knowledge workers within the enterprises is provided by the tools. The tools implement advanced Enterprise 2.0 features that leveraging on the semantic models are able to deliver very innovative functionalities. The ARISTOTELE tools are:

- **Knowledge Management (KM)** Tool, provides functionalities for ontology extraction, matching and merging from structured and unstructured data sources (office document, PDF, blog and forum posts, etc.), document classification and annotation, competency extraction from document, tag suggestions, expert finding, Q&A.
- **Human Resource Management (HRM)** Tool, providing functionalities for project/activity

feasibility considering available competency within the organisation, competence gap analysis, team and group formation considering trust level among worker, relevance analysis [14] supporting decision making on the basis of the "relevance" of the human resources in the organization, analysis of curriculum vitae with automatic extraction of competency and personality traits supporting both recruitment campaign or activities like quick assessment of competency within the organisation.

- **Social Collaboration and Networking (CN)** Tool, aiming at supporting the innovation process within the organization. In particular, the tool provides recommendation (in terms of people, activities and contents) to group of workers for developing innovation (i.e. virtual product requirement definition).
- **Learning Experience Generation (LEG)** Tool, providing functionalities for recommending suitable contents and didactic approaches to the workers according to their learning needs, to generate, adapt and manage personalized learning experiences tailored to the organizational objectives or for filling a specific competency gap.
- **Personal Work and Learning Environment (PWLE)** tool, acting as a technological integrator for all the other tools. This tool helps knowledge workers to define and achieve their objectives (in terms of goals, objectives and tasks), supports learning and knowledge activities, support workers collaboration through the creation of dynamic workplace, and contributes to fuel the organizational knowledge base (populate the semantic models).

3. Towards the PWLE: educative perspectives and sustainable didactic process

Recover the good principles of interactionist with the convergence of constructivist [11] and socio-cultural [4] perspective, can lead to the development of innovative corporate learning environments.

The effectiveness of a learning environment within knowledge intensive organisations should be found in its ability to stage interactive and constructive approaches to respond to lifelong learning specific needs of the knowledge workers. Indeed in lifelong learning context the knowledge workers need to have greater control of their own professional growth including ways of learning both formal and informal. An environment like this should allow the creation of training spaces intended to:

- Lead workers to identify their own learning paths and to raise awareness of their learning needs;
- Allow workers to share their experiences and knowledge with experts within the community of interest, to produce new knowledge and perform group activities;
- Allow workers to show levels of knowledge and skills acquired within their profile, so that there is a continuously update of the degree of learning acquired during the training and working activities;
- Enable the development of transformative processes such as recruitment and selection of knowledge, their organization and their storage in meaningful way (within semantically described datastore).

In order to meet these new needs and contribute to the achievement of some of the future scenarios described in [3] (where learning technologies are seen as immersed in the workspace and social networks are conceived as a bridge between work and learning), as explained in section 2 we looks at

PWLE as socio-cognitive environment that integrates capabilities to support both execution of daily business activities and participation in formal and informal learning activities.

From the formal learning point of view of, the PWLE is based on the already affirmed (and commercially available) IWT (Intelligent Web Teacher) platform that enables the provision of personalized, contextual, dynamic and adaptive learning experiences. These features are made possible by explicit representation of knowledge about the disciplinary domains (using ontologies) and the learners' profiles (considering already acquired knowledge and preferred learning style) as well as the application of reasoning algorithms and optimization on the knowledge base (including ontology, metadata and contents) [6].

From the informal learning point of view, the PWLE, borrowing from Wenger [29] the concepts of participation and reification, provides to the worker more autonomy in organising his training activities within the working context. Moreover, PWLE emphasizes the "involvement" dimension as a decisive element for the investment in terms of cognitive and social capital, simplify the alignment of worker's development plans with respect to the strategies and objectives of the organisation.

The PWLE supporting the self-regulation practices, allow the worker on the one hand to increase his motivation and awareness through autonomous and progressive alignment of their educational goals, and on the other hand to maximize the involvement compared with business goals, enjoying the collective space, characterized by the collective knowledge [17], to retrieve information on the learning objectives of other members of the organization and their explicit knowledge.

From a functional point of view, the PWLE it is build leveraging on the Microsoft Sharepoint 2010 technology platform and helps the knowledge workers to:

- identify new objectives and to organize and align them with those of the Organization;
- receive (from their manager) and perform tasks (through the integration of productivity tools);
- organize their contents through mechanisms such as social tagging, search for content from external sources or from knowledge bases business, up and running their own co-operation, communication and learning;
- receive recommendations with respect to content and people considered "useful" to the context current
- manage their profile in the Organisation social network.

The PWLE supports four processes that, through the sustainment of the self-development of skills in social contexts, are essential for the enrichment of the personal skills and have, at the same time, to maximize the collective knowledge.

The **first process** involves the functionalities for self-regulation allowing the worker to organize and define their goals in terms of skills to be acquired (suggested by the system with respect to the tasks to be performed or with respect to the role to which it aspires, etc..) and monitor their learning curve in order to adapt their learning process accordingly. The PWLE allows users to view the competencies from different perspectives or view (tasks, roles, projects), each of which reflects a specific need for which it is necessary to reach a particular level and type of experience. The possibility to represent the competence objectives to be achieved, allows workers to move promptly

towards those competences that can be considered at that time, the most relevant (for the working activities) on which to plan training interventions.

The **second process** concerns with the ability of PWLE to support the workers with organizing and building their personal knowledge (mediating, integrating and enriching it with the collective one) or rather, eliciting tacit knowledge and share it with other organisation's workers. The use of shared ontologies (dedicated to classification) to annotate fragments of knowledge (e.g. user-generated content) within the Organization is a valuable mechanism to formalize and share, not only the results of the workers' activities, but also the process and the steps that led to these results. This approach allow to capitalize the experiences of the single worker enabling the creation of a collective knowledge for the whole organisation [29].

The **third process** concerns with the possibility for the worker to request a personalized learning path that match a personal training need expressed in natural language so to fill its competences gap. This flexibility allow to the workers to iteratively refine their educational goals, balancing them (in an assisted way) with the needs, the resources available and the objectives of the Organization, as well as with the objectives of colleagues with a similar profile. In addition, workers can constantly observe the evolution of their cognitive status and results of the Assessment.

The **fourth process** is centred on the social dimension. In particular, the process concerns with the ability for the worker to manage its own personal page within the Organisation's social network, to monitor the activities of some of its colleagues and, at the same time, to share with its network the personal progresses related to both work activities (like completed tasks, projects completed, etc..) and training activities (competences acquired, learning goals already achieved, etc.) [9]. Observing themselves in the organization social network helps workers to monitor their progress against specific goals, increase competitiveness and facilitate visibility within the organisation motivating them to improve their performance. These updates allow workers to have a constant monitoring on how competences, activities and learning resources have been used for achieving a specific learning objective and how these resources have been classified or commented by other members of the Organization, thereby increasing the social rootedness of the educational process.

4. The semantic web for knowledge modelling

The problem of how to represent knowledge coherently with its communicative function always accompanies the research and teaching practice [26]. In particular, in the e-learning field, the Semantic Web has the potential to enable new forms of interoperability through use of ontology for the conceptualization of large-scale integration of educational content.

The semantic annotation of the educational contents help to improve its retrieval (increasing precision and recall factors) according to specific user needs, preferences and prior knowledge facilitating the personalisation [1]. As described in [13] annotating semantically the content produced during collaboration sessions (e.g., instant messaging, forums, etc.) allows to share and reuse explicit knowledge.

As explained in section 2 we propose to model the different organisational assets using semantic web schemas leveraging on SKOS-based lightweight ontologies (we call them organisational

ontologies) and a linked data approach to correlate them [9]. Figure 2 conceptually represents these relations.

In particular, we defined organisational ontologies allow the definition of semantic correlations, not provided in advance, through the use of automated methods for the extraction of knowledge or through the application of methodologies for knowledge elicitation.

As we show in [7], the Semantic Web is a technology that can enhance knowledge management in enterprise especially in the enterprise 2.0 scenarios.

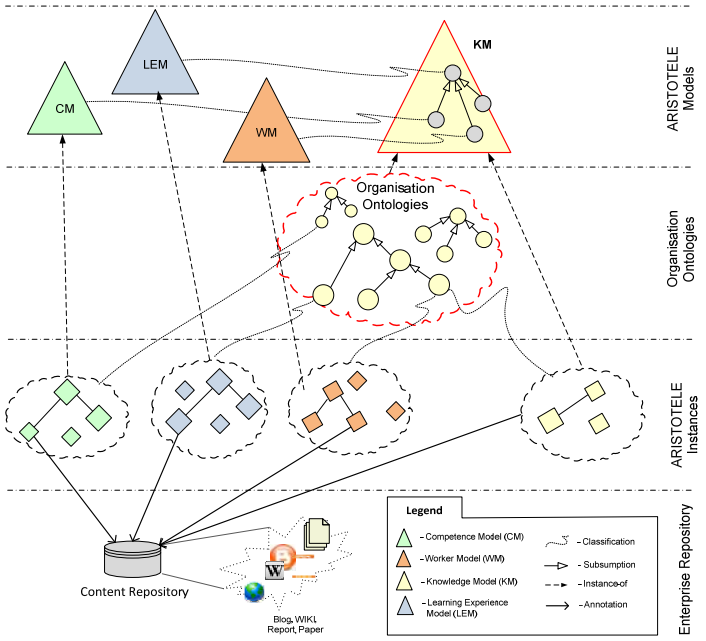

Figure 2: ARISTOTELE Semantic Models

5. How the PWLE enable the collective knowledge generation and sharing

In order to demonstrate the effectiveness of the PWLE in supporting contextualised knowledge generation and sharing, in the following we detail the second of the above mentioned four processes supported (the ability of PWLE to become a tool for organizing worker personal knowledge).

The way to transfer knowledge and operating skills are strongly related to the context in which they are processed. The context, in turn, is central to connote the relationship of the individual workers with the available knowledge. Nonaka and Takeuchi [23], in their dynamic model, identify four possible transformations of knowledge, from the perspective of the explicit/tacit couple. In their view, these are the ways ensuring organizations to increase circulation of immaterial elements like knowledge. We can show how these "knowledge conversion" could happen within the PWLE (Figure 3). In particular we will show the manner in which the PWLE instantiates the SECI model elements (Socialization, Externalization, Combination and Internalization) described in [23].

5.1 Externalisation

Consider the following situation. In the PWLE the worker A has to perform the task "State of the art on ontology schemas for the Semantic Web". The task results have to be collected in a document describing the most relevant ontological schemas for the Semantic Web. The task is part of the project X which aims to define a new semantic search engine.

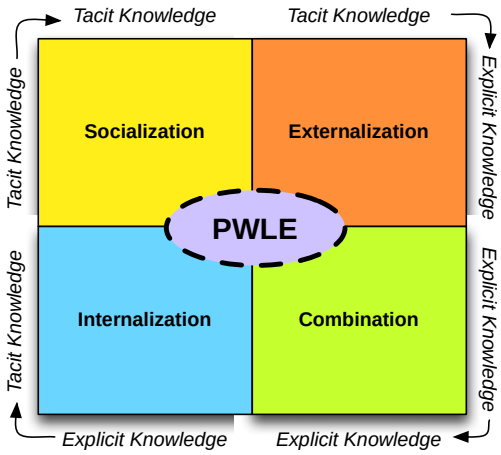

Figure 3. The SECI model in ARISTOTELE.

The worker A performs a web search and found the site http://semanticweb.org/ which leads to a list of ontological schemes. Worker A starts with reading the pages describing the different schemes, annotating those that he considers the most relevant. The scheme called SIOC (Semantically-Interlinked Online Communities Project)[b], which is used to model the semantic knowledge about the collaboration sessions and online communication with Web 2.0 tools, draws his attention, so he starts to "tagging" the pages to SIOC that seem most relevant. In particular, the Worker A found the scientific paper "*Reusing the SIOC Ontology to Facilitate Semantic CWE Interoperability*"[c]. Worker A recalled that, in short, his company will have to start the project Y that has the objective to integrate a Platform for Social Networking with an Idea Management System. Worker A perceive the usefulness of the previous article for the objectives of the project Y and book the paper URL, through a Semantic Social Bookmarking feature (available in the PWLE), with the element "Project Y" available within the taxonomy of corporate projects (already modelled using SKOS[d] as part of the organisational ontology).

The following pictures show how the PWLE supports the creation of the concept instances (worker, objective, task, document, etc.) of the ARISTOTELE models and how support tagging with several kinds of suggestions.

[b] *http://sioc-project.org/*
[c] *http://www.springerlink.com/content/45x6125434110702/*

[d] *http://www.w3.org/2004/02/skos/*

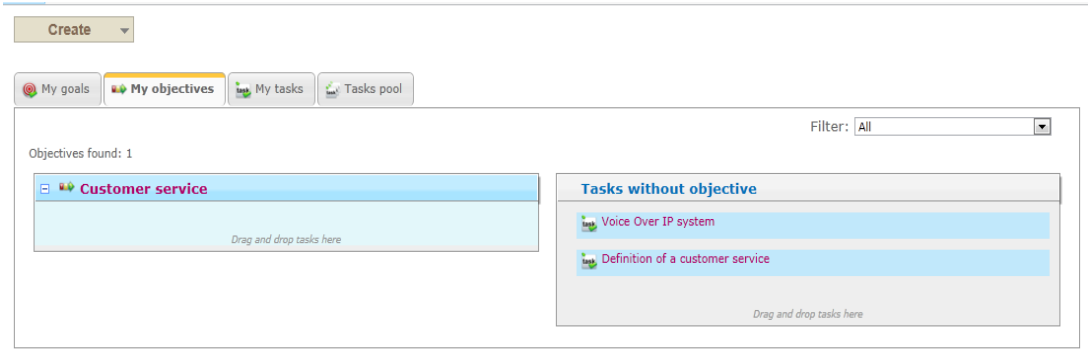

Figure 4: objectives/task creation

When a new objective/task is created this information is stored within the Enterprise Linked Data Layer of the ARISTOTELE platform helping to automatically define the working context. During daily activities, Worker A produces documents and stores them within the collaborative workspace. The worker can decide to tag the resources. The system helps the worker with tag selection suggesting:

- Tags that are relevant for the document among those already used by the worker
- Tags used for similar resources by other workers
- Tags used by similar workers

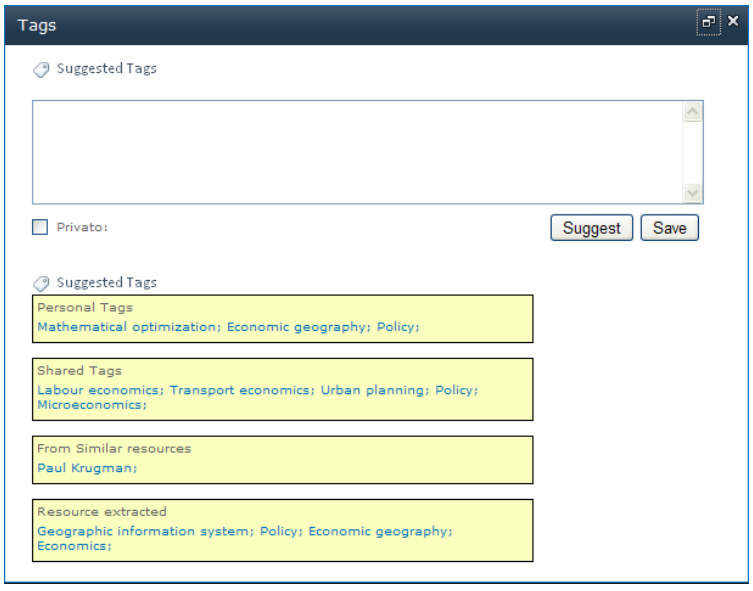

Figure 5: suggested tags for a the document

5.2 Combination

Even the combination phase is fully supported by the Semantic Web architecture of the PWLE. Indeed in the above mentioned scenario, the combination of explicit knowledge occurs, for example, through the use of the projects taxonomy represented using the models, whose elements are used as a mechanism to correlate content and information.

Two or more resources (such as documents, articles, blog posts, tasks, etc.) annotated independently by different workers, with the element "Project Y" of the project's taxonomy are automatically cross-related and become searchable, even starting from the above mentioned taxonomy. The use of multiple taxonomies (such as projects, contexts, topic, etc.) enables different forms of combination that could happen at run-time according to the specific workers or organisation needs.

It is worth to mention that the functionalities provided by the Knowledge Building tool are used for classifying and automatically annotate resources produced by workers through the PWLE. For instance as shown in Figure 4 associating a task to an objective, or an objective to a goal, or a document to a task, etc., within the PWLE the system automatically create instances of the models element within the semantic layer.

This means that when another worker start with working on Project Y and start with collecting info and organising its work (in terms of tasks, objectives, etc.) the system could suggest the Worker A as a worker with some knowledge about semantic web schema or as owner of a research paper that could be relevant for his tasks.

5.3 Internalization

Let us assume that two months later the project Y begin, and employee B, engaged in one of the first tasks of the project, access through the PWLE to the project Y collaborative workspace. In the PWLE area devoted to show the available material within the organisation relevant for the project it is suggested the reference to the Article "tagged" by the worker A. Worker B studies it, acquiring knowledge on the topic of interoperability in the Social Web. In this scenario, the PWLE (and its tools like the Semantic Social Bookmarking) supported the transfer of Worker A tacit knowledge into explicit knowledge, now represented by an RDF triple, which connects the scientific article resource to a specific element of the project taxonomy.

This RDF triple, has been added by the Enterprise Linked Data Layer as detailed in [9], and it is accessible within the organisation. Also through the PWLE, the worker B can access all the information related to the item "Project Y" taxonomy (also included in the Enterprise Linked Data Layer), and therefore also to the scientific paper reported from worker A. Worker B reading the article enables an individual process of learning and acquiring knowledge of an important aspect of the project Y. Explicit knowledge produced by the worker A, through the step of exteriorization, becomes, in this phase, tacit knowledge for the worker B.

The following snapshot shows how PWLE support the internalization by suggesting existing knowledge within the organisation to be exploited by the worker.

Starting from a task definition, the system extracts categories related to the task (e.g. VoIP, telephone) that are part of the organisational ontologies. Exploiting relations among instances created

during the externalization phase, the system suggests possible instances (tasks, workers, documents) that could be related to those categories.

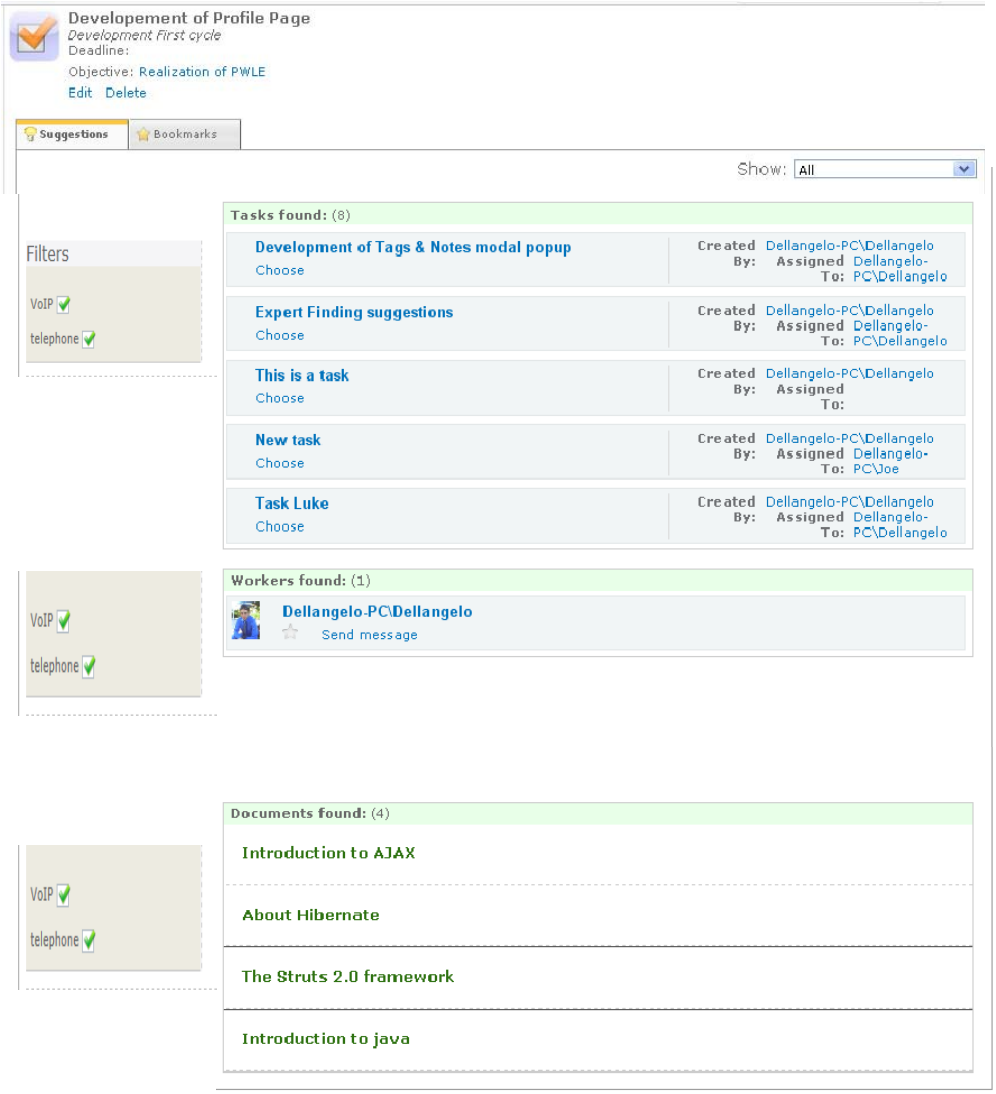

Figure 6: context-aware suggestions

5.4 Socialization

During the realization of the project Y, the worker B (together with his colleagues) takes part in brainstorming sessions (using the Social Collaboration and Networking tool) planned by the Innovation Manager of his company in order to generate and select promising ideas for new

products/services or for the improvement of existing products/services based on the project Y results. Participants are chosen through the Team Formation service (part of the HRM tool) that uses the semantic modelling of the worker profiles considering knowledge, skills, attitude and mutual trusts as described in [8]. In particular, the team formation builds the group of participants in a brainstorming session by choosing the workers with the right mix of technical and behavioural skills (e.g., problem-solving, critical thinking, reflection, etc.).

During the brainstorming session, that it is built on top of the PWLE where specific collaboration services are ad-hoc configured the worker B, in presenting his idea, describes what he has learned from the study of material related to the item "Project Y". The group brainstorming process enriches and describes in detail the idea of worker B, reaching a consensus around it. Brainstorming, in fact, support the socialization phase where knowledge remains tacit but is shared with colleagues.

6. PWLE evaluation

All the tools that are going to be integrated within the ARISTOTELE platform have been evaluated during the second project year both from usability, functional and users' perception point of view. In the third project year the same kind of evaluation, together with impact measurement within the pilot organisations will be executed. In the following section we report the main evaluation results concerning the PWLE usability.

6.1 Usability Evaluation

Concerning usability, 20 educated testers from both application partners (APs) evaluated the tools following a scenario based approach (4 out of 6 different scenarios where centred on the PWLE) using Cognitive Walkthrough (CW), a usability inspection method used to identify usability issues in a piece of software or web site, focusing on how easy it is for new users to accomplish tasks with the system.

With the results of CW we obtained information on the main quality components attributed to usability as follows: Learnability ("how easy is it for users to accomplish basic tasks the first time they encounter the design?"), Efficiency ("once users have learned the design, how quickly can they perform tasks?"), Memorability ("when users return to the design after a period of not using it, how easily can they re-establish proficiency?"), Errors ("how many errors do users make, how severe are these errors, and how easily can they recover from the errors?") and Satisfaction ("how pleasant is it to use the design?").

For all the quality attributes mentioned above we have identified a set of questions. The questions were organised in five sections (according to Nelson) in a semi-structured interview grid, always starting with an open question followed by the same question and a seven-point Likert scale (the reason for that order was the intention to first collect the impressions of the tester and then to wrap them up in an overall value; scale was from "1=difficult/less frequent/negative" to "7=easy/very frequent/positive").

The interview guides finished with questions for the evaluators about how the interview went and if they had the opportunity to make observations on the behaviour of the tester.

The next table shows the list of the questions:

Table 1: Questions of the semi-structured interview

Questions	
	Learnability
a)	How easy was it for you to accomplish basic tasks the first time you encountered the tool?
b)	How easy was it for you to navigate in the tool?
c)	How easy was it for you to find critical/relevant information?
d)	How easy was it for you to feel comfortable with the tool?
e)	Does the tool support a natural workflow?
	Efficiency
f)	Once you had learned the design, how quickly have you been able to perform basic tasks?
g)	How much time did you need to complete the task?
h)	How many steps were required to complete basic tasks?
i)	How efficient - compared to other applications - do you think is the tool?
	Memorability
j)	Imagine you would return to the design after a period of not using it, how easily could you re-establish proficiency?
k)	What do you think – would it be easy or difficult for you to remember the design afterwards or after periods of non-use?
	Errors
l)	Did you commit many errors?
m)	How severe were these errors?
n)	How easy was it for you to recover from the errors with the right information?
	Satisfaction
o)	How pleasant was it for you to use the design?
p)	How do you feel about the tasks completed?
q)	Would you describe this system to a friend as pleasant or unpleasant system to use?
r)	To what extent does the tool support organisations in aspects like learning?
s)	To what extent does the tool support organisations in aspects like collaboration?
t)	To what extent does the tool support organisations in aspects like communication?
	Questions for the evaluators
u)	Did you have the impression that the tester was satisfied with the CW?
v)	Was the tester willing and able to give detailed answers?
w)	How was your overall impression of the interview?
x)	Have there been any particularities worth mentioning?

6.2 Usability evaluation results

The data gathered from the cognitive walkthroughs have been analysed using as principal source of information the free-text answers given by the testers. Nevertheless, the quantitative data have served as a first indication of the results, followed by an in-depth analysis.

The overall number of cognitive walkthroughs was 43 (N=43);

14 out of 20 questions were almost fully completed by the testers (0/1/2 answers missing);

2 out of 20 questions had a relatively high number of missing answers (questions d, i); from the corresponding free-text answers it can be deduced that this is due to missing knowledge about similar applications – both questions ask to make a comparison between the PWLE with tools with similar functionalities; many of the testers that did not provide a rating value stated that they didn't know other or similar tools;

4 out of 20 questions had 5-9 answers missing:

- Question e): The question if the tool supports a natural workflow was partly seen as critical, because some testers did not know what exactly was meant by a "natural workflow"; some of the non-respondents said that the tools proposed a workflow structure of its own which was different from a natural one;
- Question m): This was asking for the severity of errors committed – it was based on the previous question ("how many errors…") and the non-respondents said that they did not commit any errors, so that this question was not applicable;
- Question n): If it was easy to recover from errors – similar to question m), non-respondents said that this question was not applicable;
- Question r): If the tools support organizations in aspects like learning – the non-respondents said that they could not answer this question because they did not know the answer; a sub-group said that their validation scenario did not tackle learning aspects, so that the question was not applicable.

As mentioned below the PWLE was central for 4 out of 6 scenarios. The picture below provides an overview of the mean scores achieved by those scenarios.

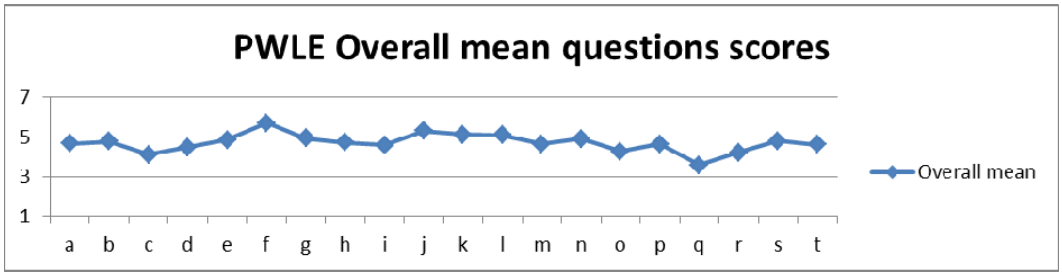

Figure 7: PWLE usability evaluation results

7. Conclusion and future work

The paper shows how the techniques of the Semantic Web can be used to enhance learning and collaboration, in line with an interactionist perspective matrix of socio-constructivist. The impact of the Semantic Web on learning is described by a scenario focused on the use of PWLE, an advanced socio-collaborative tool developed in the context of the ARISTOTELE EU co-funded project whose capacity enabled by the Semantic Web languages and patterns, allowing, among other processes involved, the instantiation of the SECI model of Nonaka and Takeuchi, which allows the activation of transformative processes that drive the transition from tacit knowledge than explicit.

In the next future (third project year), the PWLE will be fully integrated within the ARISTOTELE platform and connectors towards Microsoft worker productivity tools like Microsoft Outlook and MS Project will be developed and validated in real working environment provided by the 2 pilot organisations.

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