Workplace Learning - Providing Recommendations of Experts and Learning Resources in a Context-sensitive and Personalized Manner

An Approach for Ontology Supported Workplace Learning

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Abstract: Support of workplace learning is increasingly important as change in every form determines today's working world in industry and public administrations alike. Adapt quickly to a new job, a new task or a new team is a major challenge that must be dealt with ever faster. Workplace learning differs significantly from school learning as it should be strictly aligned to business goals. In our approach we support workplace learning by providing recommendations of experts and learning resources in a context-sensitive and personalized manner. We utilize users' workplace environment, we consider their learning preferences and zone of proximal development, and compare required and acquired competencies in order to issue the best suited recommendations. Our approach is part of the European funded project Learn PAd. Applied research method is Design Science Research. Evaluation is done in an iterative process. The recommender system introduced here is evaluated theoretically based on user requirements and practically in an early evaluation process conducted by the Learn PAd application partner.

1 INTRODUCTION

Change is given and an employee's working environment, his/her tasks and duties changes quickly and ever often. According to (Bureau of Labour Statistics 2014) the median number of years that wage and salary workers had been with their current employer was 4.6 years in January 2014. Already in 2012 Forbes has reported that, according to a survey ninety-one percent of Millennials (born between 1977-1997) expect to stay in a job even for less than three years (Meister 2012). However, not only 'job hobbing' requires (workplace) learning but also taking over new responsibilities within an organisation. In a survey conducted by Accenture (2014) 91 percent of the respondents consider the most successful employees to be those who can adapt to the changing workplace. As pointed out by Tynjälä (2008) workplace learning is different to school learning as it is mostly informal in nature, as - for example - usually no formal curriculum or prescribed outcomes exits, emphasis is on work and experiences, it is often performed collaboratively and no distinction is made between knowledge and skills. In our approach we aim to formalize workplace learning by defining learning goals that are related to business goals, objectives and strategies. Competencies, required to reach the learning goals and hence, the business goals, are determined and described in job, respectively role profiles. From this an employee's competence profile is derived in which the level of acquired competencies is reported, for example in an objective agreement. Collaborative learning is supported by using a wiki as learning platform.

For implementation we use a model driven approach (De Angelis et al. 2015). That is, we extended existing meta models, e.g. standard notations like Business Process Model and Notation (BPMN) (OMG 2011) and Business Motivation Model

(BMM) (OMG 2014) or created new ones, based on standards (for example the Competency Meta Model is deduced from the European Qualifications Framework (EQF) (European Comission n.d.)) to model collaborative workplace learning centred on business processes and their context. We then transformed the models and relations between them into an ontological representation for machine execution. We also transformed these models and relations into wiki pages and links.

With this approach we are able to integrate workplace learning deeply into daily business, i.e. we consider a learner's context regarding tasks he/she has to perform in business processes combined with organizational knowledge about his/her position in the organisation and, his/her working experience. Based on this context information, appropriate learning objects and learning material are determined and recommended to the learner according to his/her learning preferences.

Our approach is part of the European funded project Learn PAd (cf. http://www.learnpad.eu). Applied research method is Design Science Research (Hevner & Chatterjee 2010), complemented by the approach of Grüninger & Fox (1995) for ontology design and evaluation.

Application domain is Public Administration (PA) as this sector must support extremely complex processes in order to provide services to citizens and companies. According to our business partner, today it needs up to two years of learning to become fully operational.

In Learn PAd a learning platform is created to support Public Administration (PA) with workplace learning. PA's can access the platform via a wiki interface (see Xwiki, http://www.xwiki.com/en/). For learning information about the process and specific task(s) a learner has to perform is displayed. As depicted in Figure 1 in the left part of the wiki the properties of a process task as well as data input and output is provided to the user. In the right context-related and personalized recommendations are given.

We assess our approach in an iterative process as part of the overall Learn PAd project evaluation. A first evaluation was accomplished recently.

The paper at hand is structured as follows: In section two we will give an overview on related work. Then we will introduce an application scenario to illustrate our approach (section three). In section four we will give a specification of the recommender system, followed by a description of its implementation (section five). First iterations of evolution are described in section six. We conclude in section seven.

Figure 1: Recommender Interface

2 LITERATURE REVIEW

In our literature review we consider research on four aspects that are most relevant for our work: recommenders, competency frameworks, imparting knowledge and learning styles.

2.1 Recommenders

There is today a large agreement among researchers that e-learning content should adapt to the learner’s context and that learners should be guided through learning content based on such context. The recommendation of learning objects can be regarded as a special case of business-process oriented knowledge management. A wide array of recommenders have been proposed, all of which aim at recommending the next learning activity – very often interaction with a learning object – to a learner who is currently engaged with an e-learning system.

Such recommendation can be based purely on a history of learner activities, within the same or previous sessions. Some approaches use content-based filtering: they recommended learning items that have a content similar to that of learning objects in the learner’s current session (Ghauth & Abdullah 2010), (Khribi et al. 2009). Others are based on collaborative filtering or association rule mining (Zaíane 2002), (Khribi et al. 2009), i.e. they recommend objects that other learners (with similar interests) used together with the objects from the current history. A survey of further approaches of this kind can be found in (Sikka et al. 2012).

Other researchers claim that – besides the current activities of the learner – additional information is needed to make useful recommendations:

- A profile of the learner, including existing knowledge or skill levels, preferred learning style and current learning goal, in order to enable proper personalization of recommendations (Schmidt & Winterhalter 2004), (Yu et al. 2007)

- Meta information about the learning objects, including required previous knowledge, content type and interactivity level in order to match them against the learner profile – and enriched with knowledge from a domain ontology (Schmidt & Winterhalter 2004), (Yu et al. 2007)
- Information about the role of the learner and his/her position in the organization (Abecker et al. 1998, 2000), (Schmidt & Winterhalter 2004)
- Explicit information about the work context of the learner in terms of e.g. a currently executed task or business process (Abecker et al. 1998, 2000), (Schmidt & Winterhalter 2004)

The approaches mentioned above all use ontologies to model the required information and rely on the computation of similarities between a learner's profile (and possibly work context) and the metadata provided with learning objects. (Yu et al. 2007) additionally use the dependencies between learning objects to create a "learning path" through all recommended learning objects.

Our approach is similar to the one in (Schmidt & Winterhalter 2004), which relies on semantic modeling as described in (Abecker et al. 2000). We propose to model and use the same kind of information – i.e. we believe that all of the above listed information is indeed necessary to make didactically useful recommendations. We take that approach further by concretising the meta models and ontologies required for modelling that information and by proposing concrete matching procedures.

2.2 Competency Frameworks

In order to develop an appropriate competency model we carefully studied frameworks related to competency, like the RDCEO (The Reusable Definition of Competency or Educational Objective), TRACE (TRAnsparent Competences in Europe), DeSeCo (The Definition and Selection of Competencies) (Rychen & Salganik 2003), DIGCOMP (Developing and Understanding Digital Competence in Europe) (Ferrari 2013), e-CF (Anon n.d.), Bloom's Taxonomy (Forehand 2012) and EQF (The European Qualifications Framework) (European Commission n.d.).

Since our application partner in the Learn PAd project already uses the EQF framework, we decided to base the competency model on it.

The European Qualifications Framework (EQF) is envisaged as a meta-framework that allows positioning and comparing qualifications. It consists of eight reference levels which are described in terms of learning outcomes: knowledge, skills and competences. For instance EQF level 4 for knowledge is "Factual and theoretical knowledge in broad contexts within a field of work or study"; for skill is "A range of cognitive and practical skills required to generate solutions to specific problems in a field of work or study"; and finally for competence: "Exercise self-management within the guidelines of work or study contexts that are usually predictable, but are subject to change; supervise the routine work of others, taking some responsibility for the evaluation and improvement of work or study activities" (European Commission n.d.).

2.3 Imparting of Knowledge

One of the most important aspects imparting knowledge is the notion of a Zone of Proximal Development (ZPD), introduced by Vygotsky (1978). He defined the zone of proximal development (ZPD) as "*the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers*" (Vygotsky, 1978, p. 86). Vygotsky proofed that when a learner is in the ZPD for a particular task he is able to achieve it if appropriate assistance is provided.

Another important aspect imparting knowledge is scaffolding. Scaffolding was coined by (Wood et al. 1976) whose conceptualization of scaffolding was consistent with Vygotsky's model of instruction and emphasizes the teacher's role as a more knowledgeable learner to help learners to solve problem-oriented tasks (Kim & Hannafin 2011).

Quintana et al. stated, "the process by which a teacher or more knowledgeable peer provides assistance that enables learners to succeed in problems that would otherwise be too difficult" (2004). However, in workplace learning experts' involvement is not always feasible. As shown by (Boud 2003) one limitations of workplaces as learning environments is the "reluctance by experts to guide and provide close interactions with learners". Hence, other learning aids - i.e. learning material created with certain didactic considerations in mind, is to be recommended to support learners.

A rather young learning theory that builds also on the ZPD idea and that takes into account the role of technology for learning is the so-called connectivism (Siemens, 2005). Connectivism postulates that learning occurs when connections are made between nodes in a learner's network - where a node can be anything ranging from a piece of knowledge in the learner's mind to a digital artefact or another person. This implies that new knowledge must be connected to existing knowledge or experiences – which can be understood as a concretization of the ZPD – and that such connection can be mediated by links in the digital environment.

2.4 Learning Styles

The theory of *learning styles* describes a number of ways in which learning can be different between individuals and claims that hence, different ways for supporting individual learning must be developed and adapted to a learner's individual preferences.

The Dunn & Dunn learning style model (1978) describes several elements of learning styles: the environmental domain, the emotional domain, the sociological domain, the physiological domain and the psychological domain. People deal with information and ideas in different ways because of their preference. These learning styles influence the achievement of the learners. Using the right combination of learning preferences will help the learners to achieve their learning goals. An example of how e-learning systems can support these different learning styles is amongst others provided by Wolf (2002).

3 APPLICATION SCENARIO

The application scenario was developed based on a real case and as a result of several interviews conducted with representatives of our application partner in Italy, the Marche Region.

The application scenario provides all information needed to instantiate all kinds of meta model relevant for workplace learning, i.e. process models, business motivation model, organisational model, document model and competency model. We also introduced two personas: a PA officer called Barnaby, who joined the Public Administration of Monti Azzurri not long ago; and an entrepreneur, who requests a service from the PA, called Susan.

In our illustration we will focus on a complex task of business process Barnaby is about to perform and will show, what Barnaby must learn and how our approach supports him.

The business process, “Titolo Unico” that Barnaby performs provides a service to companies who want to start a business. The process can become rather complex and one of the most challenging tasks is the one about involving other PAs or private parties for contribution. To decide, who is to involve, declarations made in the entrepreneur's application must be carefully assessed. We use the term Public Administration (PA) to refer to those public administrations that hold an office dealing with such kind of process. A PA can be a single municipality or span a couple of municipalities providing a service together.

The task of identifying the appropriate organisational units to be involved while comply with the time constraints and taking the right follow-up decisions is of crucial importance for successfully delivering the service. That isn't as easy as it sounds as it requires comprehensive knowledge of the Italian law (i.e. national, regional, provincial and municipal norms and regulations) and, what is even more important: much experience. Since PAs can vary largely regarding number of organisational units and hence specialisation due to the size of a city or region and the nature of the PA, i.e. single or aggregated municipalities, and the law does not go so in detail to specify which organisational units to involve in a particular case, experience matter a lot.

Thus, an experienced PA officer knows the law AND the structure of the municipality to be involved AND the responsible officers in the respective organisational unit. Since direct contact may speed up a task (e.g. quicker responses to requests and less bureaucracy) this knowledge - although informal - is highly relevant.

3.1 Learning Support

In the business process, our application scenario is about, the entrepreneur Susan requests approval of building a chalet on the lake of Caccamo, which belongs to the municipality of Serrapetrona which is in the province of Macerata, Italy. Susan uses the application form provided at web-side of the PA and we assume that she filled it out correctly.

By submitting the form the business process at the PA of Monti Azzurri was started. The PA officer Barnaby took over the task to assess the form. Based on the type of request specific actions are to be taken In our case the type of request is *receptive tourism*; and Barnaby knows that type requires always the authorization of the municipality according to the Italian law (*norm 9 of 2006*). However, due to his little experience, Barnaby does not know the municipality of Serrapetrona and he is not sure of which organisational units should be involved. He needs an expert to advise him.

Recommending Experts

Barnaby enters the Learn PAd system, moves to the task “Identify Organisational Units” he has to perform and checks on the recommendation panel for help (see the right-hand side of Figure 1). In the panel contact details of two experts – Sarah Brown and Laura Cruciani - are displayed Sarah is a former PA officer of Monti Azzurri who now works for the municipality of Sarnano. The recommendation system still considers Sarah as an expert as she dealt with many cases concerning the municipality of Serrapetrona. Laura, is the boss of Barnaby, working for the PA of Monti Azzurri for many years.

Instead of searching internal phone books, asking around or applying the trial-and-error method Barnaby can contact one of the experts, who will suggest which organisational units to involve and to which law article it may refer. Additionally the contact details of the personnel could also be provided to start establishing a not too formal business relationship.

Recommending Learning Resources

After Barnaby got advice which organisational units to involve, he sends requests to obtain the opinion on the case of the involved parties. Responses are expected within 30 days.

However, Barnaby receives answers in time from all but one of the parties. Now he needs help in how dealing with this situation. The Learn PAd system has a section in the recommendation panel that refers to learning objects and learning material (see Figure 1). Basically all models represented in the wiki are considered learning objects since the learner needs to get familiar not only with a process, its structure and tasks but also with the involved roles, organizational units, business documents, IT systems and so on. For differentiation we call dedicated technical books, tutorials, learning audio and video file etc. 'learning material'.

Thus, Barnaby checks on the learning material provided by the Learn PAd system. As recommendations in Learn PAd are contex-sensitive and personalized the ZPD of a learner is considered. More in detail, Barnaby has an acquired competency EQF level of 3 in *"Manage Specific Admin Procedure"*. Learning material recommended in Learn PAd is also related to competencies it fosters. In our example the book *"Regulation of Titolo Unico"* - is related to the same competence (*"Manage Specific Admin Procedure")* but classified with level 4. The difference of 1 between the competency levels is considered conform to the ZPD of the learner. As a learner can also determine learning preferences (in Barnaby's case it is reading) the recommended learning material is ranked top of the recommendations.

Since no further challenge comes to light Barnaby finishes the assessment of the application and finally sends the approval to Susan for realizing her chalet on the lake of Caccamo.

4 RECOMMENDER SYSTEM SPECIFICATION

We learned from Vygotsky and others (1978) that mentoring is very successful in supporting individual learning. However, particularly in workplace learning experts might be too busy to provide the wishful support or spending their time with mentoring is simply too costly. Hence, an efficient solution is needed that provides a) alternatives, and b) guides to experts most capable of giving advice (with respect to expert knowledge but also regarding the Zone of Proximal Development (ZPD) of the learner.

In our approach for recommending relevant information supporting the user in learning we consider three modes of learning:

- simulation (in a simulation environment a learner can simulate to perform a business process task)
- browsing (a user can view and navigate through wiki pages, representing his/her business environment like business process, tasks, organisational charts, related documents, etc.), and
- execution mode (using the wiki as a front end to perform a business service; often called learning by doing).

Furthermore we differentiate between learning objects, learning material and experts. As all wiki articles correlate one-to-one to model elements they are regarded as *learning objects* related to these model elements. *Learning material* is information dedicated for learning, for example (training) books, audio and video files. Simulation and browsing is considered as interactive learning material.

Besides the characteristics of the wiki content (derived from the meta-model and the models), the recommender ontology also represents characteristics of the learning material as for example the EQF level of knowledge that is addressed. Furthermore the ontology contains profiles of the learner, i.e. the workers in the PA, including his/her EQF specification, learning preferences and individual learning goals. With this holistic view on learners, their working environment and organizational network it is possible to identify relevant learning objects, learning material and experts, appropriate for the ZPD of the learner and according to her learning style. An example of how the ZPD is addressed in our approach is provided in the previous section.

Most recommendations rely on rules. The left side of these rules (precondition) is defined in terms of the learner's context - i.e. his/her required and acquired competencies (including levels) and learning style, as well as the context and application data of the currently executed business process. The right side of rules (consequence) contains the recommended material.

4.1 Basis for Recommendations

We start from the premise that in an organisation business goals and objectives are defined. They can be modelled in a Business Motivation Model BMM (OMG 2014). We extended the BMM meta model by introducing learning goals as new Course of Action. Learning goals can be related to business goals and strategies that support them. To achieve a learning goal certain competencies are needed. Note, that we use the term *competency* to summarize the three learning outcomes (knowledge, skill, competence) defined in EQF. Hence, learning goals defined in the BMM are related to the Competency Model in which competencies are described according to EQF including their levels (1-8).

We further assume, that competency profiles are set-up for organisational units, roles etc. to specify a set of competencies *required* by this entity. We also maintain competency profiles of employees which contain the *acquired* set of competencies. The difference between the required competencies, e.g. by a role and the acquired competencies of a person who has this role, determines the *individual* learning goal. In addition we can model specific competencies needed for example to perform certain tasks and hence, related to an extended process model. In this manner we can identify the knowledge gap a learner has, the learning goals he/she is supposed to meet and his/her learning preference that is also captured in the learner's competency profile.

4.2 Making recommendations

Depending on the learning mode recommendation differ in range. Since the more is known about the learner's working context the better (filtered) the recommendation. Thus, most valuable recommendations can be provided in the execution mode. Here the recommender system knows exactly what task a learner is about to perform, what tasks are already done, what decisions have been taken during the business process so far and what application data is relevant. In best case within the simulation such context information can be 'faked', i.e. instead of real data fictional data is used but same kind of recommendations can be provided. Less accurate recommendation can be made within the browsing mode as the learner is free to navigate within one or more processes. Hence no information is available about former actions and application data.

Currently recommendations are given regarding experts and learning material. Future work is to recommend also similar cases (see Section 7).

In the following we will give two examples of how recommendations are determined.

Recommending Experts

The difficulty in recommending experts lies in identifying the *appropriate* expert. Obviously, the choice of an expert depends on the work situation - and hence the knowledge required - as well as on the level of knowledge of the learner and possibly existing relationships between the learner and the expert.

We consider three ways to determine experts:

1. line managers from the same organisation the learner belongs to
2. colleagues, having (had) the same role as the learner but having executed the very task the most times
3. persons, having the same role as the learner but belonging to another PA

In the following the recommendation of an experienced colleague is described in detail. As mentioned above for building the recommender we follow the approach of Grüninger & Fox (1995) for ontology design and evaluation.

First the informal competency question (CQ) is provided, followed then by its transformation into a SPARQL query.

<u>Informal competency question</u>:

Given a user logged in to the Learn PAd system and the role this user has in a task

AND

some constraints regarding task (e.g. the task a performer is about to execute) and work experience (e.g. a performer's work experience) *(cf. WHERE-clause of the SPARQL query)*

what internal experts can be recommended *(cf. SELECT-part of the SPARQL query)*?

a. *rationale*: the answer is used to recommend experts from the same organisation that executed the tasks most often.

b. *decomposition*: the name of the user, user is an actor, an actor has role in the task, role is assigned to more than one performer, performer has task log.

Formal competency question (SPARQL query):

```
SELECT ?experiencedPerformerName
   ?email
WHERE {
 {
   SELECT ?experiencedPerformer
   (count(?executedTaskInstance) AS
   ?count)
   WHERE {
        ?taskInstance rdf:type
   bpmn:Task .
        ?executedTaskInstance
   rdf:type ?taskInstance .
       ?executedTaskInstance
   emo:activityIsPerformedByPerform
   er ?experiencedPerformer .
        ?currentPerformer
   emo:performerHasEmailAddress
   "barnaby.barnes@fhnw.ch" .
        FILTER(?currentPerformer !=
   ?experiencedPerformer)
      } GROUP BY
   ?experiencedPerformer
   }
  ?experiencedPerformer rdfs:label
   ?experiencedPerformerName .
  ?experiencedPerformer
   emo:performerRepresentsPerson
   ?experiencedPerformerBusinessAct
   or .
  OPTIONAL {
      ?experiencedPerformerBusinessA
   ctor foaf:mbox ?email .
   }
} ORDER BY DESC (?count ) LIMIT 1
```

Result of the query is a colleague of the performer, working in the same organisation, having the same role and great work experience in the tasks the performer is about to execute. In the recommendation panel is name and contact details is provided.

Recommending Learning Material

For recommending appropriate learning materials the zone of proximal development of a learner must be considered. That is, the level of competency that the learning material fosters should be reasonably higher than the learner's current level of this competency (cf. application scenario described above). Furthermore, the learning material should support the learner's preferred style as, for example, the learning material that matches his/her preferred learning style is listed on top of the list and the link to it is presented in bold characters. It is also possible to completely filter out learning material that doesn't meet a learner's learning style.

Informal competency question

Given a user logged in to the Learn PAd system and her learning style

AND

some constraints regarding competencies (e.g. acquired and required, i.e. fostered competencies and their level) *(cf. WHERE-clause of the SPARQL query)*

what information material is recommended? *(cf. SELECT-part of the SPARQL query)*?

a. *rationale*: the answer is used to provide learning material (i.e. links to documents, video files, simulation) that are relevant to the learner, i.e. fosters one or more competencies she has to improve and the level of the fostered competency is exactly one level higher than the level of the acquired competency.

b. *decomposition*: the name of the user, user is an actor, an actor has a profile, profile contains acquired competencies and their level and the user's learning style, learning material, learning material fosters one or more competency at a certain level suitable for a certain learning style.

Formal competency question (SPARQL query):

```
SELECT ?learningMaterialTitle
   ?learningMaterialType
   ?learningMaterialURI
WHERE {
    {
```

```
    SELECT
?nextCompetencyLevelNumber
?aquiredCompetencyLabel
?learningStyle

    ?competencyProfile
emo:competencyProfileIsAquiredBy
Performer ?performer .

    ?competencyProfile
cmm:competencyProfileContainsCom
petencySet ?aquiredCompetencySet
.

    ?aquiredCompetency
cmm:competencyBelongsToCompetenc
ySet ?aquiredCompetencySet .

    ?aquiredCompetency
cmm:competencyHasLevel
?competencyLevelNumber .

    ?aquiredCompetency rdfs:label
?aquiredCompetencyLabel .

    BIND(?competencyLevelNumber+1
AS ?nextCompetencyLevelNumber) .

       ?competencyProfile
lpd:competencyProfilePrefersLear
ningStyle ?learningStyle .

 }

 ?nextCompetency
cmm:competencyHasLevel
?nextCompetencyLevelNumber .

 ?nextCompetency rdfs:label
?aquiredCompetencyLabel .

 ?nextCompetency
lpd:proposedLearningDocument
?learningDocument .

 ?learningDocument
elements:documentHasType
?documentType .

 ?learningStyle
lpd:learningStyleBelongsToDocume
ntType ?documentType .

 ?learningDocument
emo:documentRepresentsdocument
?foafDocument .

 ?foafDocument
elements:documentHasTitle
?learningMaterialTitle .

 ?foafDocument
eo:documentHasStorage
?documentNode .

 OPTIONAL{

      ?documentNode
lpd:xwikiPageRepresentsNode
?learningMaterialURI .

 }

 OPTIONAL{

    NOT EXISTS(?documentNode
lpd:xwikiPageRepresentsNode
?learningMaterialURI) .

      ?foafDocument
elements:documentHasSource
?learningMaterialURI) .

 }

}
```

After giving two detailed examples of how we build recommendations we describe the technical implementation of our approach.

5 RECOMMENDER SYSTEM IMPLEMENTATION

The recommender system is an integrated part of the Learn PAd system platform and incorporates mainly the modelling environments, the transformation component, the learning platform Wiki frontend and the ontology recommender component.

The core implementation part of the recommender system is the ontology and recommender (OR) component. The platform independent meta models and the conceptual meta models are represented in OWL (Bechhofer et al. 2004) and loaded at runtime by the OR component. The component is written in Java uses the open source library Jena (Dickinson 2009) which provides an API to work with ontologies.

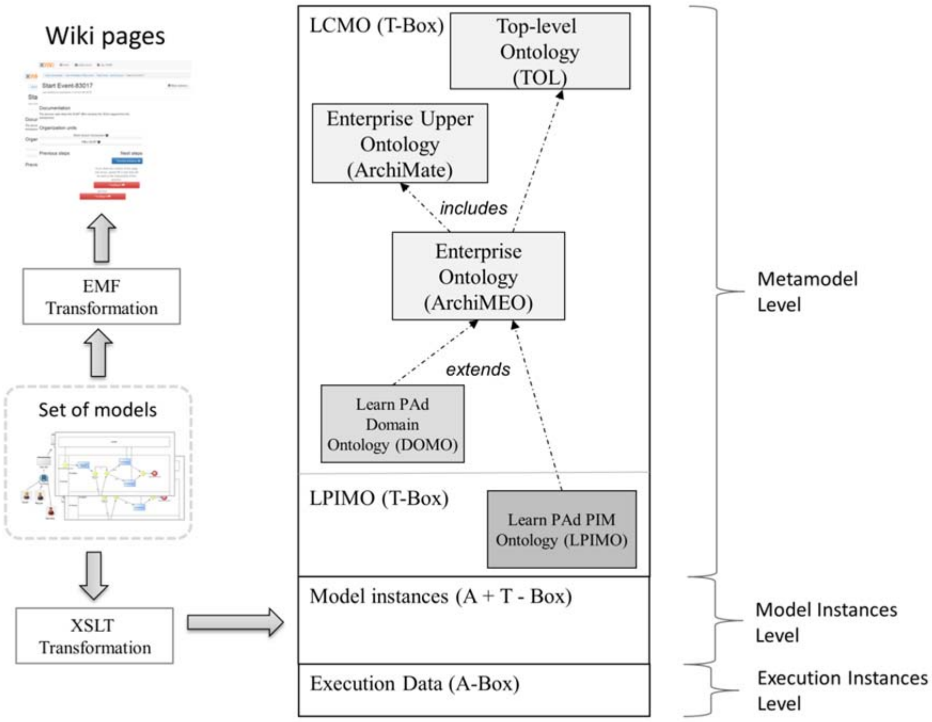

Figure 2 Ontology Levels and Transformations

A new set of models published via the modelling environment will be exported in a proprietary XML format. This exported of models are transformed in a generic way into Wiki page representations based on the Eclipse Modelling Framework (EMF) (Eclipse Foundation n.d.). The transformation into the ontology instances is using XSLT (W3C Working Group 1999) templates and an XSLT Engine. This approach has been chosen in a first prototype version since it allows a straightforward transformation directly into the specific target model and format of the ontology. The models are transformed into RDFS (W3C 2014) conform classes and are formatted in the Turtle format for a convenient work with text based version control systems.

In a second step a more generic meta - meta model based transformation will be evaluated.

After the transformation into the ontology, an inferencing step is applied to run SPIN (W3C n.d.) rules and infer relations to corresponding conceptual model classes and eventually already existing instance. Examples of such existing instances might be an organisation's employee directory received from a human resource system. The combination of the platform independent and conceptual models as well as the transformed model objects build the upper two levels in our OR component knowledgebase shown in Figure 2.

Valuable recommendation rules require context information besides the information from the enterprise models. Application data and logging information from process executions could provide such information. This extended information shall be made available for reasoning together with the ontology and model instances. But here, we face the problem of the missing support of multilayer ontologies by the ontology description standards, like OWL. If we add execution data to our ontology we have an instance of an instance problem, i.e. the execution data represents one layer, the process and other model instance the next higher layer and our PIMM/LCMM meta-models the highest layer. Fanesi (2015) and Fanesi et al. (2015) propose an approach with RDFS-FA respectively OWL-FA to overcome that problem and still keep it decidable by reasoners. Executed processes and tasks in our example are added as instances of the process instances. This allows applying a counting rule which suggests a performer as an expert, if the performer has executed the task most often.

6 EVALUATION

Before proposing the design of our recommender, we compiled requirements based on a) literature (see Section 2) and b) the results of a questionnaire that was filled in by 52 civil servants. In this section, we present a summary of how our recommender design satisfies these requirements. This is followed by a summary of results from a qualitative evaluation.

6.1 Requirements met

Regarding the **interplay of the recommender with the platform** that handles the execution of the business process and the necessary **context awareness**, the following requirements were satisfied:

- Questionnaire respondents had stated that, while receiving recommendations on a particular task, these recommendations should be detailed, but at the same time they would like to keep an overview of the whole process. This is satisfied by presenting a process overview in the main window of the prototype and displaying recommendations within a sidebar.

- Civil servants emphasized that they often do not know where the information contained in existing or new (learning) material should be applied. The recommender helps them in this because recommendations are context-specific (i.e. they get the recommendation where they need it). Context-sensitive recommendations are enabled by rules whose conditions are matched to the learner's current work context

Furthermore, requirements regarding the **competence-awareness** of the recommender are satisfied as follows:

- The choice to use EQF for the definition of learners' competence levels resulted in the adoption of an EQF-based meta model for modeling learner profiles
- Based on the definition of the zone of proximal development (ZPD) in (Vygotsky 1978), we formulated the requirement that the recommender should recommend learning objects aiming to teach the learner competencies at a level just above her current level. This is satisfied by describing learning objects with intended outcomes in terms of EQF competency levels and making sure that this level is just above the learner's current EQF competence level for each recommended learning object.

Another category of satisfied requirements concerned the adaptation of recommendations to the learner's **learning style**:

- Since questionnaire participants expressed the desire to get recommendations for a diverse range of content types, the recommender is able to suggest not only documents or multimedia learning objects, but also experts (see below) and historical cases.
- Based on the concepts proposed by connectionist learning (Siemens 2005) which imply the need to make connections with a learner's existing knowledge, the recommender creates such connections e.g. by proposing historical cases.

Finally, requirements regarding **expert guidance** are satisfied as follows:

- Since questionnaire participants stated the need to have quick access to recommended experts, the recommendations include contact information
- Based on the notion of ZPD (Vygotsky 1978) and scaffolding learning (Wood et al. 1976), we ensured that recommended experts have more advanced level of knowledge than the learner by making rules dependent on experts' EQF competence levels.

6.2 Qualitative Evaluation

The qualitative evaluation consisted in a workshop where civil servants interacted with a prototype of the Learn PAd collaborative platform, which included – among other functionality – the features of the recommender. The interaction was performed along the application scenario described in Section 3 and the corresponding application data and learner context were known to the system. The recommender was integrated into the prototype in the form of a sidebar where context-dependent suggestions were displayed.

Most of participants' feedback revolved around aspects of the recommender that were not yet implemented in the prototype. Thus, participants commented that there should be:

a) a registration form where a user's competencies can be assessed and then stored in a profile
b) more recommendations of multimedia content
c) recommendations also on the level of the whole process.

We consider this feedback as a confirmation that these features will be perceived as useful when implemented later.

7 CONCLUSION & FUTURE WORK

With our approach we could show how workplace learning can be improved by providing context-sensitive and personalized recommendations for learning in a collaborative environment. Next we will extend recommendations to similar cases. That is we will implement a Case Based Reasoning System to identify and recommend cases, similar to the one a learner is about to perform but have been accomplished earlier.

Furthermore we will work on key performance indicators for learning goals in order to assess learning progress. We intend to develop a cockpit to identify for example goals that are not satisfied and the reasons that causes this effect.

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