
# Competence Management in e-Learning Systems: a possible approach

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## Abstract

The need expressed by the single individual in a lifelong learning context is to have a personalized training able to facilitate the reaching of specific competences, to take into account not only the knowledge but also the sector-based skills. This explication has led the Polo di Eccellenza L&K research group to define an innovative Competence Management model. This model has been obtained from an extension of the Knowledge Model used by the e-learning platform Intelligent Web Teacher. It is, in fact, the result of the combination of the Domain ontology, underlying the IWT Knowledge Model, with an Application ontology according to the meaning used by Paquette (2007) in his vision.

## 1 Introduction

The European Union, indicating the year 2010 as the deadline for making the knowledge based economic system the most competitive and dynamic in the world, has placed emphasis on the Competence Society paradigm, meant as an evolution of the so called Knowledge Society (Nussbaumer *et al*., 2007).

In order to direct Knowledge Society changes, we need to support as well as possible the competence acquisition process in a lifelong learning context.

It is necessary to have adaptive and flexible learning systems, obtained defining learning personalization models based on the assessment of specific individual competences.

Therefore, this paper aims at introducing a model of Competence Management defined starting from the Knowledge model, used in the Intelligent Web Teacher (IWT) e-learning platform.

The first part of the paper provides the state of the art of the different innovative models with the representation of the various competences, in order to retrieve the existing material and extend its vision. In the second part of the paper we focus on the studies carried out so far; this is then followed by a specific case study. The final section contains some remarks about the approach employed.

## 2 State of the art and motivations

The representation of Corporate competences is a basic condition for the start up of a virtuous process which, on the basis of target topics of Competence, allows us not only to go back to human resource profiles in possession of certain Skills and Knowledge, but also to arrange learning paths able to maximize possible gaps related to specific competences and provide tools for the management and the nurturing of competence repositories.

The need to make an organized memory of paths characterized by a high level of Competence (DienG Kuntz, 2000) available for the user pushes the scientific community to take a step forward in the Pedagogical Engineering sector (Frauenfelder, 2007).

A systematic review aimed to the critical assessment of the outcomes of the primary researches carried out in this sector has been helpful in identifying the best evidences available on the basis of reliability, pertinence and significance criteria (DeKetele & Maroy, 2006)

The studies conducted have led, over the years, to consider Competence Modeling (Paquette *et al*., 1994; Paquette, 2002a, 2003) as essential for any Pedagogical Engineering process (Schmidt and Kunzmann, 2006).

The scientific theses have led to the development of Models (Sicilia, 2005)

which, basically, converge on the definition of Competence as a concomitance of Knowledge, Skills and Attitudes, and avail themselves of ontological schemes not only to describe the elements of a Competence in terms of nodes and relations with various granularity, but also to link this Competence to classes and sector-based domains of action (Mentzas, 2006).

Leading models such as MISA (Paquette, 2007) avail themselves of studies aimed to the classification of the typologies of Generic Skills implied in the exercise of a Competence (e.g. receiving, reproducing, producing, self-managing,…), associated to learning domains (e.g. cognitive, psychomotor, affective, social)

The need to obtain personalized learning paths able to lead to the acquisition of competences has made it necessary to associate the formalism and the exhaustiveness characterizing the taxonomic modeling with an organization based on dependence and order, specific of reticular modeling.

The taxonomic modeling allows us to define, in a formal way, the classes of membership of a Generic Skill and the corresponding levels of specificity. An ontological reticular representation, for example, even when it includes the definition of the concepts and the bearing conditions among them, as in the taxonomy, it also systematizes their relations.

Therefore, in the following section, we introduce an original approach aimed at answering to the needs emerged in the research sector, in which the integration of the taxonomic and the reticular representation becomes a strategic choice capable of managing in an optimal way the competences according to a specific sector of membership.

## 3 The definition of a Competence Model

According to Paquette's definition (2007), a Competence represents the ability to apply a Generic Skill to a specific Knowledge with a certain level of performance.

The goal of the present work is to investigate how Paquette's vision could be extended and concretized through the use of the Knowledge Model of the e-learning platform Intelligent Web Teacher - IWT (Albano *et al*., 2007), which offers the possibility to model, through the use of ontologies, the Knowledge concerning specific disciplinary domains, in order to support the definition (semi-automatic) of Units of Learning personalized in accordance with the cognitive state and the learning preferences of a specific learner (Mangione *et al*., 2008).The ontologies used within IWT (Gaeta *et al*., 2009) are built through the definition of Concepts representing the topics relevant for the domain to be represented, and through the definition of the relations between them.

The usable relations are the following: Has-Part(*c, c1*), Is-Required-By(*c1,*

*c2*) and Explain(*l, c*) which indicates that the learning object *l* deals with topics concerning the concept *c*. With regard to the semantics associated to the relations Has-Part and Is-Required-By it is necessary to notice that:

- in order to learn the Concept *c* it is necessary to learn all the son Concepts of *c* in respect to the Has-Part relation;
- in order to learn a Concept *c* it is necessary to learn, before, all the Concepts propaedeutic to it, according to the Is-Required-By relation.

To extend the above-mentioned Knowledge Model, in order to support the Competence management, we introduce a new ontology where the types of Skill are classified on the basis of a progressive domain complexity (e.g. reproducing, creating, self managing) and organized, first of all, through the Is-a relation, which allows to classify Generic Skills into more specific Skills or into subclasses (e.g. quoting Paquette, "intuition", "planning", modelling" are linked through the Is-a relation to "producing/creating") and through the Has-Part relation which allows us to define a Skill developed starting from Skills with a finer grain.

Future works will investigate the possibility to use also an order relation. The two ontologies considered, that we can call Domain Ontology and Application Ontology (Lenne *et al*., 2005), allow us to offer a training intervention centered on competence.

In the proposed model a learning object *l* is associated to a couple *(c,s)* where *c* belongs to the set of Concepts used to model the Knowledge concerning the disciplinary domains and where *s* belongs to the set of Skills used as vocabulary in the ontology of the skills.

At this point, the Explain relation is defined as Explain (*l*, *c*, *s*), whereas *l* indicates the learning object thanks to which it is possible to acquire the Skill *s* with regards to the Concept *c*. The Units of Learning will be defined starting from a Target of Competency – ToC (the final goal of the Unit of Learning will be the acquisition of one or more competences) made up of *N* couples ($c_i$,$s_i$).

For each couple *(c,s)*:

- if *c* is an atomic Concept (not further decomposable according to the Has-Part relation), then the Unit of Learning will include only one (the choice is made on the basis of the learning preferences of a specific learner) among the *l* learning objects linked to *c* and *s* through a relation of Explain(*l, c, s*) type, if necessary preceded by $l_i$ learning objects such that Explain($l_i$, $c_i$), where the $c_i$ Concepts are propaedeutic to *c* in respect to the referential ontology;
- if *c* is not an atomic Concept, then the Unit of Learning will include all the $l_i$ learning objects which "cover" the $c_i$ atomic Concepts included in the subtree with *c* as root, obtained considering only the Has-Part

relation on the selected ontology;

- If $s$ is not an atomic Skill (e.g. it is further decomposable respect to the Has-Part relation), then it is necessary to consider all the atomic Skills reachable in the subtree with $s$ as root, obtained considering only the Has-Part relation on the ontology of the Skills; in this case the Target of Competency will be redefined as $ToC = (c,s) = \bigcup_{i=1}^{N} (c,s_i)$ For each $(c,s_i)$ couple a $U_i$ Unit of Learning will be arranged according to the rules previously indicated. The final Unit of Learning will be the result of the composition (at present we consider the simple sequential composition) of the single $U_i$ Units of Learning.

## 4 A case study

The aim of this section is to instance, using a specific scenario, the model proposed in the previous section. The referential context examined is a University Course of Mathematical Analysis. The following figure shows a fragment of the Domain ontology concerning Mathematical Analysis.

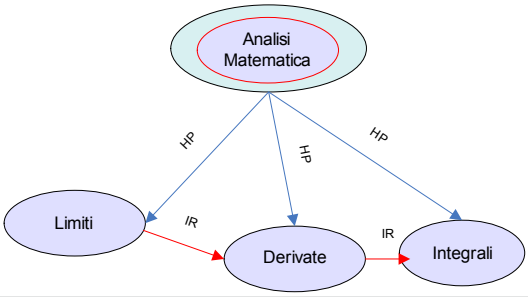


Fig. 1: Domain ontology

In Figure 3 we show a fragment of an Application ontology including only a few of the possible Skills that a user can acquire in the referential learning context. In particular, taking into account the Limits Concept, we can suppose to have the following Skills:

- Exercises: they refer to the the ability to solve the exercises concerning the Limits Concept
- Demonstrations: they refer to the ability to demonstrate theorems, formulas, concerning the Limits Concept
- Applications: they refer to the ability to apply the notions concerning the Limits Concept also in other fields, such as, for example, the Physics

one.

The above-mentioned Skills could be considered as specifications belonging to the "Reproducing" class of the taxonomy used by Paquette.

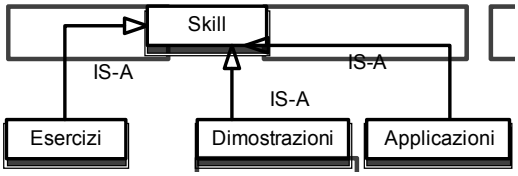


Fig. 2: Ontologia di applicazione

In the light of the considerations we have made in the previous section, a learning object is associated to a couple (*c,s*). Let us consider, in particular, the (Limits, Demonstrations) couple and, therefore, the learning object aimed to the acquisition of abilities in performing Demonstrations about the Limits Concept.

The explication of an ability is obtained inserting in the meta-data of the resource associated to the Concept, a particular label (in this specific case the label is "Demonstrations").

It is necessary to observe, however, that if a user wants to acquire Competences concerning a particular demonstration technique, for example a Reduction to the absurd, the examined results of the resource are not really able to satisfy the specific request. Therefore it is necessary to proceed with a refinement of the Application ontology.

This will imply a modification of the Domain ontology concerning the explication of all those concepts that can be associated to the considered Skill. Let us describe in detail the Application ontology and in particular the Demonstrations Skill, taking into account the various types of demonstration techniques:

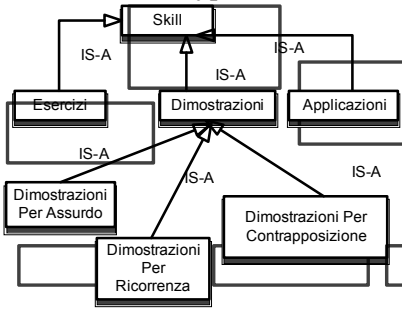


Fig. 3: Application ontology in detail

Such a detail requires a refinement of the Domain ontology

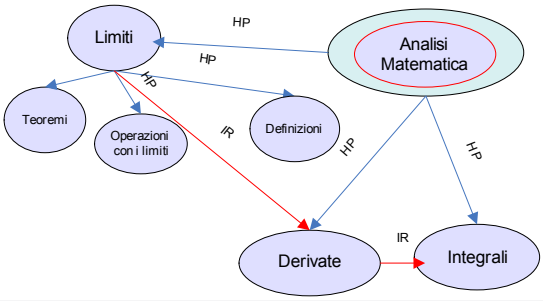


Fig. 4: Domain ontology in detail

The acquisition of abilities concerning the "Reduction to the absurd" technique is obtained through those learning objects associated to the couple (Theorems, Reductions to the absurd). Now let us see how the above-mentioned approach varies considering a different referential domain: e.g. The Programming Languages.

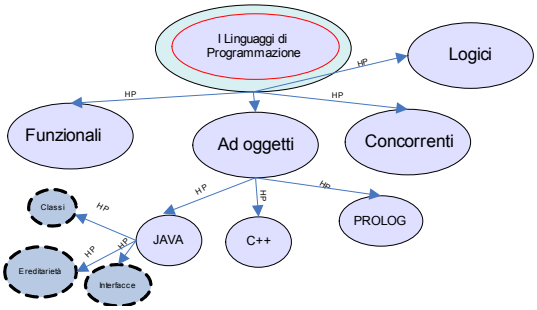


Fig. 5: Ontologia di domino relativa ai Linguaggi di programmazione

In this case the Application ontology will present specific Skills (e.g. "Coding") necessary to the acquisition of a Competence within the knowledge Domain examined.

## 5 Conclusions

The analysis conducted on the Competence representation models already existing in literature, has focused its attention on the possibility to characterize a Competence management system through Paquette's taxonomic representation, according to which a Competence is obtained applying a generic Skill to

a specific Knowledge.

The need to obtain personalized learning paths not only aimed to the acquisition of knowledge but also of specific competences, has made it necessary to concretize the vision adopted by Paquette through the Knowledge Model of the IWT e-learning platform.

The model proposed is based on the synergic use of two classes of ontologies (the first regarding the generic training domain, the second regarding its application to a sector-based training which requires specific skills) and is aimed to the arrangement, in a semi-automatic modality, of personalized Units of Learning, aimed at acquiring one or more competences in an efficient and effective manner.

Then, the model proposed has been applied to a case of study in order to understand which level of detail must be used to model Knowledge and Skills. Analyzing the results of the case of study obtained, it results that in order to support at best the personalization processes of Units of Learning it is necessary to define learning materials characterized by a fine granularity.

This choice sensibly improves the personalization process, since it becomes possible to easily orchestrate learning objects characterized by little dimensions, but it also produces an impact on the level of detail of the ontologies. With regard to this, the arrangement processes of domain and application ontologies are not standardized but the abstraction level depends a lot on the referential domain.

The examples examined have explicated the added value provided by the proposed model: the effective representation of a Domain is obtained through an interdependent management of the two ontologies. The variation of the Knowledge Domain, in fact, requires the sector expert to revisit the Application ontology in order to define the couples (*c,s*) best responding to the Goal Competence.

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