Ontology-Based Competency Management: Infrastructures for the Knowledge Intensive Learning Organization

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Abstract

Learning activities can be considered the final outcome of a complex process inside knowledge intensive organizations. This complex process encompasses a dynamic cycle, a loop in which business or organizational needs trigger the necessity of acquiring or enhancing human resource competencies that are essential to the fulfillment of the organizational objectives. This continuous evolution of organizational knowledge requires the management of records of available and required competencies, and the automation of such competency handling thus becomes a key issue for the effective functioning of knowledge management activities. This chapter describes the use of ontologies as the enabling semantic infrastructure of competency management, describing the main aspects and scenarios of the knowledge creation cycle from the perspective of its connection with competency definitions.

Introduction and Background

The "Semantic Web" vision described by Berners-Lee, Hendler, and Lassila (2003) has recently fostered research on the use of formal ontologies to support "intelligent" behaviors for a variety of Web applications. These applications include Web-based learning in a broad sense, which is commonly referred to as "e-learning" (Lytras, Tsilira, & Themistocleous, 2003). Nonetheless, the perspective of most of those current applications does not consider organizational needs as the essential driver for the elaboration and delivery of learning activities, but focuses on other aspects regarding technical, social, or usage issues from the perspective of the individual learner or informal communities of learners (Anderson & Whitelock, 2004).

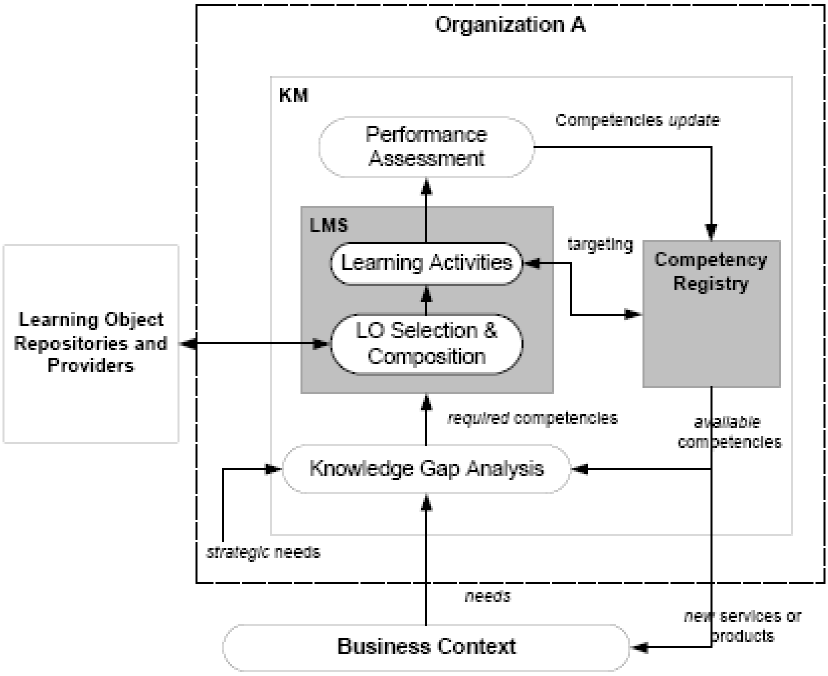
An organizational perspective to Semantic Web-enabled e-learning should focus on the role of learning activities in the broader framework of organizational learning (i.e., on providing a semantic account to existing learning processes). But in addition, the implications of the semantic approach to organizations should be explored as a source of new ideals and business designs for *learning organizations* (Örtenblad, 2001). According to this latter view, the Semantic Web can be considered as the enabler for a new model of a *semantic learning organization* (SLO) in which ontologies are the technological backbone for intelligent activities and semantics-enabled artifacts.

A first step toward the definition of the concept of SLO is the analysis of the essential roles of ontologies in organizational learning. Since learning can be considered as an outcome of the need to acquire new competencies, it is worth first sketching the main components that surround such activities. Figure 1 provides an abstract, idealized view of such components. *E-learning* can be considered an important component of the *knowledge management* (KM) function, as described by Wild, Griggs, and Downing (2002). In fact, even some architectural guidelines for this integrated view have been described elsewhere (Metaxiotis, Psarras, & Papastefanatos, 2002), and the use of reusable *learning objects* in that context has also been analyzed recently (Lytras, Pouloudi, & Poulymenakou, 2002). This perspective puts an emphasis on Web technology-based *learning activities* inside the organization as enablers of knowledge acquisition activities. In consequence, e-learning becomes part of a more complex organizational *conduct*, in which lacks of required competencies trigger the search for appropriate contents or activities (i.e., learning objects), in an attempt to acquire knowledge and abilities that fulfill the contingent or strategic need. It should be noted that this approach does not preclude that other kinds of useful informal or incidental learning take place inside organizations (Matthews, 1999), but rather complement them with a more organizational goal-directed activity. In fact, recommender systems for exploiting employee interests like the one described by Lindgren, Stenmark, and Ljungberg (2003) could be built as a complement within the architecture described, also taking advantage of the richness of the underlying ontological structures.

As illustrated in Figure 1, the process of acquisition (usually) starts from a business need emanated from the context of the organization, or eventually from strategic management (Rainer & Kazem, 1995). Such needs trigger the process of assessing if the organization is in place to deal with them. Such assessment is commonly referred to as *knowledge gap analysis* (Sunassee & Sewry, 2002) and essentially consists on matching the competencies required for the incoming needs with the available ones. Such competency management facilities are usually part of the human resources function (Soliman & Spooner, 2000), but this is not relevant for our present discussion. If the result is not satisfactory, the process of searching for available resources should start. This process may entail the selection of learning objects in external or internal repositories and the composition and delivery of the appropriate learning activities. After these activities take place, some kind of assessment would eventually end up with an update of the registry of available competencies. Finally, the newly acquired competencies could change the position of the organization to offer services or products, this way closing the "knowledge acquisition loop."

The cycle depicted in Figure 1 can be expressed in terms of knowledge management (KM) activities and products. According to the recent Holsapple and Joshi (2004) ontology of KM, competences can be considered as capabilities attributable to *processors* of knowledge representations (KR), and the final learning activities can be considered as a specific type of knowledge manipulation activity (KMA), consisting on *knowledge* acquisition or eventually, transformation. Furthermore, processors are considered to

Figure 1. The competency-guided organizational learning cycle



have some capabilities, which are the focus of analysis in this chapter. This direct mapping of the essential concepts described in this chapter and H&J ontology of KM enables an effective integration of ontology-based KM and organizational e-learning, providing a concrete mean to the integration framework described by Sicilia and García (2004). This will be the point of departure for the rest of the discussion provided in this chapter.

In this chapter, an organizational view of learning processes enabled by Semantic Web technologies is provided, and the essential cornerstones for such semantic learning organization" are considered to be competencies and learning objects. The discussion focuses on competency management and its relationship to the description of learning concepts. Concretely, the second section provides an overview of existing work in ontologies and schemas for competence description. The third section deals with the use of ontological schemas to assess "knowledge gaps," in terms of the "difference" between required and available competencies. Then, the connection of such knowledge gap with learning object metadata is described in the fourth section. Finally, some conclusions and a future outlook are provided in the fifth section.

Existing Schemas and Ontologies for Competency Description

Previous research and standardization activities have resulted in a number of data schemas aimed at describing competences. Among them, the *competency* format specified by the HrXML consortium (Allen, 2003) is of a special relevance for practical purposes, since it is the result of an industrial effort in the direction of interchanging data about competencies in a common format. Competencies in HrXML are defined through XML fragments like the following one, extracted from Allen (2003):

```
<?xml version="1.0" encoding="UTF-8"?>
<Competency xmlns="http://ns.hr-xml.org"
   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
   xsi:schemaLocation="http://ns.hr-xml.org Competencies.xsd"
   name="Clerical"
     description="Knowledge of administrative and clerical procedures and
    systems such as word processing systems, filing, and records management
    systems, stenography and transcription, forms design principles, and other
    office procedures and terminology">
   <CompetencyId id="2.C.1.b"/>
   <TaxonomyId id="O*NET" idOwner="National O*Net Consortium"

           description="Occupational Information Network"/>
   <CompetencyWeight type="x:Importance">
   <NumericValue maxValue="100" minValue="1">92</NumericValue>
   </CompetencyWeight>
   <CompetencyWeight type="x:Level">

   <NumericValue maxValue="100" minValue="1">74</NumericValue>
   </CompetencyWeight>
   <Competency name="MS Office Proficiency"

      description="Proficiency with Microsoft Word, Excel,
     Access, and other components of MS Office"
     required="true"> <CompetencyEvidence required="true"
     name="Acme Corp MS Office Proficency Test"
     typeDescription="A standard test of MS Office
     proficiency for the administrative employees of Acme
     Corp"> <NumericValue minValue="0"
     maxValue="100">85</NumericValue>
     </CompetencyEvidence> </Competency> </Competency>
```

In that fragment, the main characteristics of HrXML competencies are illustrated: The competency is identified and a textual description is provided. External taxonomies of competencies can be referenced through the TaxonomyId element. Weights and importance levels for the competency can be stated through the CompetencyWeight element. Competency definitions can be recursive, that is, nested, by embedding the Competency element inside another one. This way, a competency can be expressed in terms of other(s). Evidence for competences can be recorded in a variety of ways, such as scores in some standard tests, licenses, or qualifications.

As can be appreciated in the example, HrXML provides a flexible and adaptable schema for describing required and desired competencies. Nonetheless, its scope currently does not address some details that would be important in approaches to automated or semi-automated competency handling in the framework depicted in Figure 1. Some of these missing elements include:

1. The notion of competency itself is not detailed and is considered explicitly as a "placeholder" for knowledge, skill, abilities, and "other characteristics" (KASOC). While this could be considered a good modeling option for the sake of maximum flexibility in data interchange, it appears as an excessive oversimplification of the many facets of the use of the term "competency" (Hoffman, 1999), so that at least one further level of detail could be useful in KM applications. Particularly, the emphasis in observable performance (Boam & Sparrow, 1992) should be clearly separated from the underlying attributes of the person that are put into play in the work context of the competency. For example, having knowledge about the internals of a plane might be considered a necessary requisite for the complex competency of driving a plane, but by no means is a sufficient condition.
2. The composition of competencies requires additional refined semantics to express the kind of relationship between the embedded and the embedding competence. For example, a distinction about "part-of" and "is-a" relationships has been addressed elsewhere (Vasconcelos, Kimble, & Rocha, 2003; Sicilia, García, & Alcalde, 2003).
3. Measurement scales can be of any type, and the same holds for types of evidence. Although using a single, unified measurement scale for any kind of competency is far from being realistic, it would be desirable that at least the scales or criteria used be described formally, as part of the competency definition schema, so that automated tools could understand a "reason" about them to some extent.
4. HrXML is not concerned with developing specific competency taxonomies, since this is the work of other organizations like the O*Net[1]. Nonetheless, a single language and logical format for competency taxonomies and competency description schemas would be desirable in order to achieve a higher degree of interoperability.

It should be noted that this cannot be considered a list of flaws of HrXML, since the specification clearly delineates that these areas are outside of its scope (at least in the current version). The IMS consortium[2] also provides a specification for competencies called "Reusable Definition of Competency or Educational Objective (RDCEO)," but its underlying model provides similar capabilities to that of HrXML. Although RDCEO is explicitly intended to be integrated in the description of "learner profiles" and "learning objects," the same problems described still remain, so that we will not discuss it in detail.

Ontologies can be used as the infrastructure for supporting the extended requirements just enumerated, since their underlying description logics formalism (Baader, Calvanese, McGuinness, Nardi, & Patel-Schneider, 2003) provides a rich set of modeling elements capable of expressing subtle details in competency schemas. For example, different *role types* can be used to model different kinds of competency relationships (2), several measurement scales can be modeled as part of the ontology (3), and modern ontology description languages can be used to represent both the concepts but also the instances (i.e., the concrete taxonomies) (4). In addition, the diverse concepts that surround the notion of competency (1) can be modeled through logical, precise definitions, ready to be used in intelligent applications. This is especially important if competencies are intended to be connected with learning materials and activities, since such surrounding concepts include the required knowledge or attitudes (and even the learning "style") for achieving a given degree of performance in a competency (Hoffman, 1999), which are in many cases the elements used to describe learning contents.

In the next section, we describe a formal ontology for the concept of competency that extends the current HrXML model, in an attempt to provide a richer model for the competency facets described so far.

Organizational Needs and Knowledge Gap Analysis Based on Ontological Competence Descriptions

In this section, the proposed competency schema and its use for knowledge gap analysis is described. First, the fundamental components of the schema are described and then a possible competency gap analysis is provided.

Integrative Ontological Schema for Competency

The notion of competency is linked to the concept of human performance, which according to the model of Rummel (Rothwell & Kazanas, 1992) encompasses several elements: (1) the work situation is the origin of the requirement for action that puts the competency into play, (2) the individual's required attributes (knowledge, skills, attitudes) in order to be able to act in the work situation, (3) the response which is the action itself, and (4) the consequences or outcomes, which are the results of the action, and which determine if the standard performance has been met. Finally, individuals usually receive some kind of feedback depending on the success or failure of their action. In what follows, the main ontological definitions for this notion of competency are provided, using informal descriptions. The formal ontology was edited with OILEd, producing a DAML file, which can be found in the Web page of the author. Here, we use UML diagrams (OMG, 2003) as a more visual and easy to understand notation.

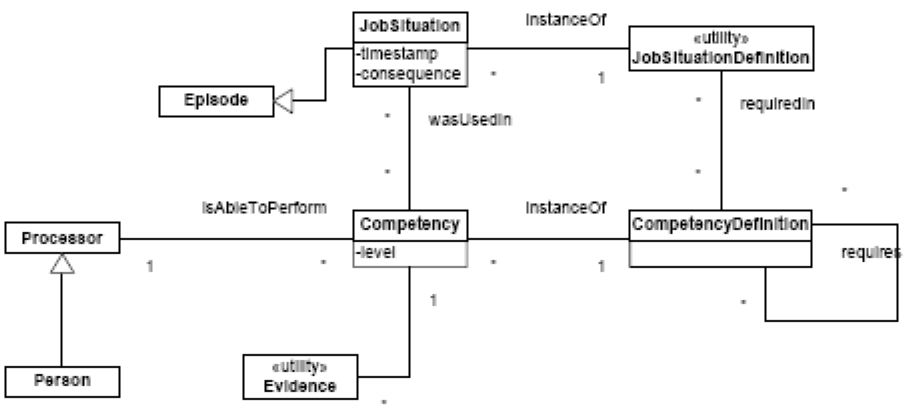
First, it is required to delineate the difference between actual competencies, which are performance capabilities of individuals, and competency definitions, which are stereotyped descriptions of competencies. Figure 2 provides the basic modeling elements for that situation. The competency class represents a discrete competence of an individual (represented generically as processors to provide room for software systems that are able to exhibit some competencies). It should be noted that competencies are a characteristic of a processor, so that the isAbleToPerform relationship can be understood as a composition. The level attribute in competencies is used to denote that some kind of measurement scale is required for competencies, and the utility class Evidence is used to denote that some facts or indicators about a competency can be declared, although the details about such descriptions are not provided. Competencies are put into play in concrete job situations, which can be considered as a kind of episode in the life of the organization that occurs at a concrete moment in time. The consequence attribute in the class JobSituation simply represents the outcome of the episode, which can be used as a source of assessment for various purposes, including the revision of the beliefs the system has about the competencies of the participants.

Competencies and job situations in Figure 2 are connected to their respective "definition" elements. These definitions are used to represent stereotypical competencies and job contexts, so that they can be used to describe, for example, job position characterizations in human resource selection processes, or as a way to state the needs of a project.

Each job situation definition in Figure 2 requires a number of competencies as defined in competency definitions. This is a way to describe work situations in terms of required competencies. In addition, each competency definition may require a number of other competency definitions, which can be used to model the concept of nested competencies in HrXML.

The model in Figure 2 describes the core elements in a competency ontology that allows both the recording of the actual competency model of employees as well as stereotypical definitions of competencies that can be used to drive search or calculation processes based on competency types. Nonetheless, the ontology does not cover the points (1) to (4) as missing points in existing approaches. In what follows, more elements are introduced to explicitly cover them.

Figure 2. Basic elements of the ontology of compentency

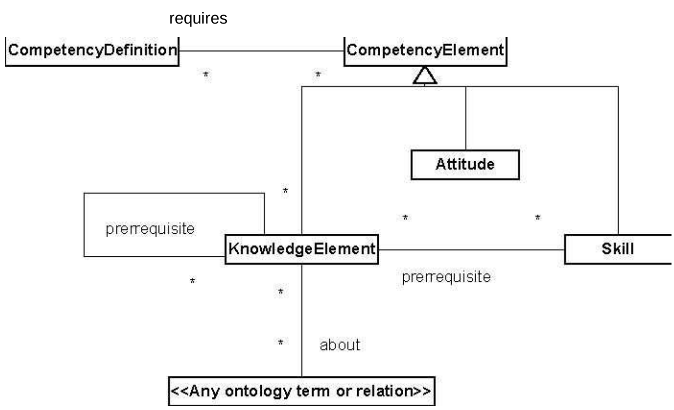


at

The elements influencing competencies are of a various kind, including knowledge, skills, abilities, and also attitudes. The problem with those terms is that they do not have a widespread clear definition, so that it is necessary to define them in advance before putting them into the ontology. Here we will only deal with knowledge, skills, and attitudes with the following senses. Knowledge is defined as "what is conveyed by usable representations" (Holsapple & Joshi, 2004), referring to some discrete mental structures that can be represented in information artifacts like books and Web pages;

skills are considered here as "an ability that has been acquired by training," following the definition in the WordNet dictionary. Finally, attitudes are considered "a complex mental state involving beliefs and feelings and values and dispositions to act in certain ways," also obtained from WordNet. Although these definitions may be subject to controversy, they allow for a clear separation about three types of traits that represent different aspects of competency. For example, an employee may have the knowledge about the internal components of a certain machine or peripheral, since he or she has studied some diagrams about it. This is different than having the skill of using that machine efficiently. In fact, the knowledge about the internals of the machine may not be necessary for its proper usage, and on the contrary, knowing the internals does not guarantee that the employee is able to use the machine efficiently. In addition, attitudes represent elements that are not necessarily connected to specific knowledge or skills. For example, having good negotiation skills does not always entail that an employee would have the attitude to reach a consensus in meetings. Figure 3 depicts the essential elements of this simple decomposition of the concept of competency.
It should be noted that from an ontological perspective, attitudes are mostly domain independent, while knowledge items and skills are not. Examples are "service orientation" or "attentive to details" attitudes that are equally applicable to employees, irrespective of the industry. Some skills are also of a generic nature, like "persuasion" or "negotiation," but many others refer to concrete elements or artifacts that are specific of the industry. Typical examples are "Java programming skill," "Oracle database administration," "repairing Seat Cordoba engines," and the like. Knowledge elements typically can be structured in knowledge trees, as it is done in many adaptive tutoring systems (e.g., Weber & Brusilovsky, 2001). This is represented in Figure 3 through the association prerequisite. The defined knowledge elements can be linked to any domain ontology term or relationships, so that the knowledge element is clearly

Figure 3. Modeling elements influencing competencies



classified inside a given knowledge structure. Skills can also have knowledge elements as prerequisites, and they could be considered to be composite also, but we will not deal with this here.

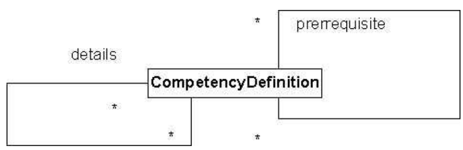
In addition, skills can be "parameterized" for ease of definition. For example, for any programming language *P*, we can define a skill "programming in *P*." This structure has the advantage that several skills that only differ in the parameter(s) can be grouped together, which eases browsing and search for competencies.

Relationships between competencies can be of a diverse kind. Perhaps the most common kind of relationship is "contribution," which represents the fact that one competency is made up of a number of other, simpler competencies. This is a "part of" relationship that entails a concrete given semantics that will be described later. The

problem with competency relationships is that they should have a clear interpretation in terms of the actions that they entail in the context of the cycle in Figure 1. This is why we only deal with "prerequisite" (i.e., "part-of") and "details" relationships here. The latter is conceived as a form of "specialization" in the sense that a competency provides a more detailed description to an existing one. For example, "Administering Oracle databases in large installations" stays at a higher degree of abstraction than "Administering Oracle
9.0 databases in large installations." The specialized competency usually requires more specific knowledge elements. Both the "prerequisite" and "details" relationships entail some form of prerequisition, but the semantics are not exactly the same. For example, the $C_1 \equiv$ "relational database design" competency is a prerequisite for $C_2 \equiv$ "Administering distributed Oracle databases in large installations," but it is not a detail, since it reflects only a previous component of knowledge. In other words, the competency C cannot be considered as a specific kind of competency C.

Some other simple competency relationships are "equalTo" and "similarTo." The former is a simple way to state that two competencies are the same, while the latter is a way to express different strengths of correlation or resemblance between competencies.

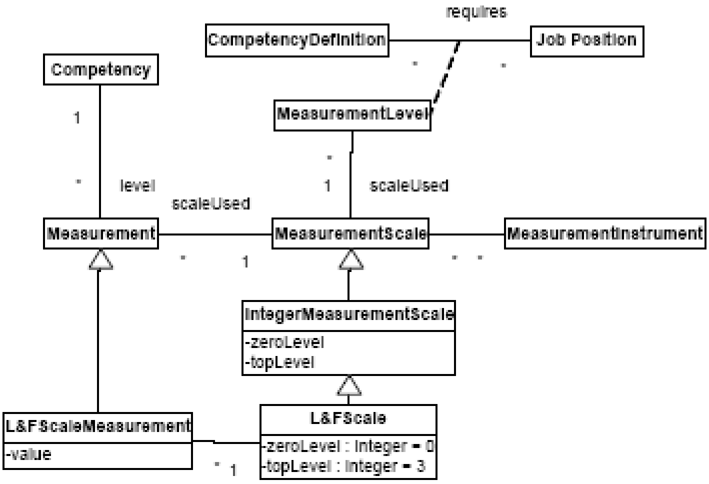
Figure 4. Modeling competency relationships



Measurement scales for competencies — point (3) in the list — can also be of a diverse nature. Although the development of simple integer scales is common (Lantz & Friedrich, 2003), other kind of scales could also be allowed. Figure 5 depicts a model in which measurements are connected to competencies, as an elaboration of the simple "level" attribute in Figure 2. Measurements are always related to a given MeasurementScale, and usually some instruments associated to such scales are available (e.g., questionnaires or interviews). From this basic level, several types of scales and their associated measurements can be defined. For example, Lanz and Friedrich's scale can be defined as a subclass (or alternatively, as an instance) of IntegerMeasurementScale. Each scale must provide some definitions that act as constraints on the description of the measurements.

In Figure 5, job positions are described in terms of competency definitions by specifying a given measurement level as an association attribute, connected to the scale in which the level is expressed. This is an example of how other elements different from processors can be described using the ontology. The elements in Figure 5 could be complemented with other ontology terms that better describe each measurement instrument, and also with "conversions" from one scale to another, when available.

Figure 5. Modeling competency measurement scales



The model just described can be extended for specialized uses, and its current form as a DAML file edited with OILEd provides a format that can be used for developing Semantic Web and other kinds of applications, and that provides a logic-based form that can be easily flattened to simple XML schemas like HrXML. This covers the point (4).

An Approach to Competency Gap Analysis

The measurement of competency is a difficult problem, due to the multi-faceted nature of the concept. For the sake of illustration, we will use a concrete approach to competency measurement based on the evidence provided by Lantz and Friedrich (2003). According to the ontology described, a set of instances inside the ontology could represent the elements in Figure 1 as detailed in Table 1.

Abstract element	Ontology elements	Purpose
Competency registry	All of the elements described in the previous section.	Describing existing employee's competencies (and competency descriptions) in detail.
Needs/strategic needs	Needs can be expressed as triples (c:CompetencyDescription, l:level, i:intensity).	Describing required competencies. An alternative expression may consider job situations instead of competency descriptions.
Available competencies	These are modeled by the extent of the Competency class.	Having a detailed record of employee's competencies.
Required competencies	A subset of the needs after matching them with the competency registry.	Describing the needs that are not covered by the existing competencies.
Knowledge gap analysis (or better, competency gap analysis)	An algorithm that takes as input a collection of needs and a competency registry and returns the required competencies.	The process or algorithm used to obtain the required competencies.
Competencies update	The creation or update of Competency instances, possibly including update of level and/or Evidence (depending on the form of assessing the acquisition of competencies).	Keeping the competency registry up-to-date.
Learning activities, learning object selection, and composition, learning object repositories.	Covered in the following section.	The selection and targeting of learning experiences directed toward the computed required competencies.

Table 1. Mapping the conceptual competency-guided lifecycle to the competency ontology

The inputs to the process of competency gap analysis can be considered as a logical formula instead of a collection of required competency levels and intensity. This enables the specification of *alternatives* in competency acquisition. For example, strategic directions inside the company may require new competencies in Product *X* or Product *Y* to face forthcoming technological challenges. Needs are described in terms of competency descriptions, so that for a given need, a triple (cd_i, $level_i$, int_i) is defined with the following three components:

- The CompetencyDescription itself, as an expression of the required competency.
- The level desired for that competency, expressed as an overall aggregate level, which will be mapped to the levels of individuals inside the organization.
- The intensity required, that is, the "volume" or "quantity" of the competency. This is an estimation of the required part of the workforce that is desired to have the competency. For example, if specified in percentages, a level of 80% indicates that most of the employees should have the given competency.

From the just described definitions, a very simple process of competency gap analysis can be described through the following pseudocode:

```
algorithm CGA(needs:List<Need>,
          registry:Collection<Competency>)
          returns required: List<Need>
begin
 for each element n_i=(cd_i, level_i, int_i)  in needs do
   begin
     (level_e, int_e) := searchCompetency(cd_i)
      if level_e< level_i or int_e < int_e then
       begin
         add(required, n_i)
       end
   end
 return required
end.
```

In the pseudocode, Need refers to the triples described, and List and Collection are respectively ordered and unordered containers of elements of the type put into the angle brackets. The simple algorithm described becomes much more complicated in the presence of diverse forms of measurement, but comparing levels and intensities should clearly be considered as important modeling elements in ontological approaches to competency management. It should be noted that computing $level_e$ and int_e requires an aggregation scheme that obtains an overall figure of the availability of the competency from the individual competencies of the employees.

The algorithm just sketched does not consider the importance or degree of preference of needs, which is useful in case a sacrifice is required due to budget or other practical constraints.

Required Competences as Structured Metadata for the Selection of Learning Activities

Learning objects are considered the building blocks for learning activities in current learning technology practice. A learning object can be defined as "an independent and self-standing unit of learning content that is predisposed to reuse in multiple instructional contexts" (Polsani, 2003). As such, learning objects are described through metadata records that define the intended context of use, which has been connected to the notion of reusability (Sicilia & García, 2003). In practical terms, this entails that learning objects can be annotated to define their intended outcomes or purpose. In the framework of the existing LOM standard for learning object metadata (IEEE, 2002), the competencies connected to a learning object can be expressed through the element

Classification (number 9 in LOM) that is intended to "describe where the learning object falls within a particular classification system." Concretely, in sub-element Purpose (9.1) we can use the competency value to state that the purpose of the classification is defining the competency or competencies that are the intended outcomes of the learning object (although the interpretation of this value as an outcome is not in the standard, it can be accommodated as an annotation practice without breaking the semantics of LOM).

This simple connection enables the search of learning objects as a reaction to the required competencies computed by the CGA. Nonetheless, this requires common and precise semantics in the ontology of competencies, and also a consistent annotation practice for learning objects to properly describe intended learning outcomes. While the latter is the focus of existing approaches like learning object "design by contract" (Sicilia & Sánchez, 2003), the former is inherently dependant to the ontology used and to the interpretation given to competency relationships and competency constituents. In what follows, a basic form of such interpretation, using the concepts described above in this paper, is provided as one of the possible design options.

A possible basic learning object selection and composition approach is sketched in the following pseudocode fragment:

```
 algorithm selectLO(n_i: Need,
              repository:Collection<LearningObject>)
          returns selected: Set<LearningObject>
begin
  selected:= search(repository, cd_i, level_i)
  if cd_i.prerequisite<>null then
   begin
     for each cd_j in cd_i.prerequisite do
      begin
        selected:=selected ∪ selectLO(repository, cd_j, level_i)
      end
   end
end
```

The selectLO algorithm takes as inputs a collection of instances of LearningObject and returns a selection of them. The input collection is an abstraction of possible practical scenarios in which several external or internal repositories of diverse characteristics can be available, possibly with different access interfaces. For each given need, the competency description is used to retrieve relevant learning objects, for example, by inspecting the LOM Classification element. In addition, the prerequisite relations are used to trigger the search of more learning objects that may be eventually required when targeting specific employees, using the level desired for the original competency as a requirement. Since selected as a set, duplicate requirements are avoided. The consideration of other kinds of relationships may lead to more complex selection algorithms, skills, and attitudes connected to the required competencies can also be used as a source of requirements for LO selection, in a similar way to prerequisites.

Once the learning objects are selected, the process of composition should merge them according to their relationships, and give them a specific pedagogy. The Learning Design specification (IMS, 2003) could be used for that purpose, but its description is out of the scope of this paper. Finally, the targeting of the learning objects to the "right" employees and in the "right" number (to take the intensity into account) again requires the examination of the competency registry. This election can be driven, for example, by a concept of minimum effort, so that the employees that require fewer (or no) prerequisite learning objects would be selected first. Of course, in this phase, the calendar of the company plays a role, since employees are currently "busy" in projects, for example, are not eligible for the learning activities. This introduces a new component in Need tuples, that is, the ideal "time frame" in which the need should be covered. We have omitted this component for simplicity in this chapter.

The algorithms described here serve as an illustration of the uses and importance of ontological structures in crafting consistent and shared approaches to competency management. Although they are not intended as design blueprints for the direct implementation of systems, they can be used as the scenarios to devise more detailed options of a diverse complexity.

Conclusion and Future Research Directions

Competency management can be seen as one of the foundations of learning activities in knowledge intensive organizations. As a critical point in the functioning of KM, competencies require a representational framework that is rich enough to support effective and efficient processes of competency search, matching and analysis. In addition, competency definition frameworks should ideally be integrated with reusable learning activities, enabling the full or partial automation of location and delivery of learning to the appropriate employees.

Formal ontologies (Gruber, 1993) have been proposed elsewhere (Sure, Maedche, & S. Staab, 2000; Vasconcelos, Kimble, & Rocha, 2003; Sicilia, García, & Alcalde, 2003) as the supporting framework for competency management. Nonetheless, more work is required in the clarification of the concept of competency and also in providing integrative schemas for competencies. One possible integrative schema has been described in this chapter. In addition, such schemas must be prepared for knowledge (or competency) gap analysis, so that they can be used to assess the changing knowledge needs of the organization.

Once the needs in terms of competencies are properly assessed, some action is required in an attempt to overcome them. One such possible action is the selection, composition, targeting, and delivery of learning activities. This raises the need for the integration of competency descriptions with learning object metadata, as the way to connect needs with knowledge representations that have the capacity of catalyzing the required competencies. Some directions about how to integrate competencies in learning object descriptions have been provided.

The competency-based framework for organizational learning described in this chapter is far from reflecting the complexity and richness of organizational learning, since it was only dealt from a generic perspective. Much work is still required to obtain a more detailed account of competency relationships, and also of the ways to properly describe competency descriptions to a level that is useful for organizations. Some of the aspects that require further work include the methods of assessing competences, the representation of tacit or social elements, and also the composition of learning activities to fulfill complex competency requirements. But this is a long way ahead for research, and some practical directions could be stated just to advance in the most straightforward direction. Among these directions, the most urgent is possibly the development of large competency description ontologies. The O*Net and other existing repositories provide the ideal point of departure for this effort of refactoring competency descriptions into richer ontological forms. In addition, some standard and consistent knowledge gap analysis algorithms could be formulated according to such ontological schemas. These algorithms could serve to motivate further debate, and also as a tool for refinement of competency schemas and databases, fostering at the same time the adoption of ontological tools in practical scenarios. We hope that this chapter had served to delineate the road for richer competency-based systems that rely on Semantic Web technologies to better serve organizational management.

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Endnotes

[1] *http://online.onetcenter.org/*

[2] *http://www.imsproject.org*