

Design of a Learner Model Based on the Competency-Based Approach Ontology

¹Abdelkrim Khartoch, ²Adil Hachmoud, ³Lahcen Oughdir, ⁴Salaheddine Kammouri Alami

Sidi Mohamed Ben Abdellah University (USMBA), Engineering Sciences Laboratory (LSI), Fez, Morocco

¹Orcid: 0000-0001-9113-8547, ²Orcid: 0000-0002-7450-1583,

³Orcid: 0000-0003-0151-863X, ⁴Orcid: 0000-0002-3231-8203

Abstract

Intelligent Tutoring Systems (ITS) have been subject of an effort of standardization in different aspects. Among these are the actors of the learning process. We are particularly interested in modeling the learner in order to better adapt their learning to today's ITS. A number of architectures of the learner model (LM) have been proposed from different points of view. However, few works have integrated the aspect of competency. In this work, we propose a learner model based on the ontology of the competency-based approach (CBA) comprising two main specifications, a learner-competency centered model and a dynamic model that adapts to different learning contexts.

Keywords : Intelligent Tutoring Systems ; learner ; Model ; Ontology ; Competency-Based Approach.

INTRODUCTION

In an e-learning context, Intelligent Tutoring Systems (ITS) promote access to resources and enable exchange and collaboration remotely. Work on ITS is mainly focused on content, instructional design, assessment, and the description of learning objects. The purpose of the learner model is to provide ITS with relevant information to customize and adapt learning to the learner traits and preferences. Generally, this modeling is developed within the classical instructional framework that takes place in a predefined context and in which the learner subsequently takes part.

Different types of adaptation and customization have been suggested (adaptation of presentation, adaptation of browsing, customization of context, customization of prerequisites...etc.) However, in today's communities, the learning process is continuous, can spread throughout a learner's lifetime and can take place in a variety of contexts (initial training, in-service training, etc.). The question that rises in this respect is how we can ensure customization in such a dynamic and evolving context.

The competency-based approach seems to be will adapted to these types of constraints. Indeed, this approach puts the

learning into context, allows the integration of learning within an overall logic which is privileged, and the knowledge which is deployed is transformed and recontextualized. In addition, knowledge can be organized through ontologies.

Our goal is to create a learner model based on the ontology of the competency-based approach in order to provide an adaptation during the learning process, an update of the learner's competencies and learning in a variety of contexts.

After a review of the literature concerning the modeling of the learner, we will go over the main features of the competency-based approach (CBA) and finally we propose an LM adapted to the CBA.

MODELING THE LEARNER

A. The Learner Model in the ITS

The purpose of ITS is to help the learners in their learning process, which requires a capacity of the system to perform an automated reasoning through the development of artificial intelligence techniques in order to adapt to the needs of its users [1]. Increasingly, researchers are focusing on a learner-centered learning as an essential component of the system and a learner model (LM) that allows the ITS to better adjust to the latter's needs.

The LM is a structure that allows the integration of a set of information on the learner into the system. This information is in the form of personal data, knowledge, preferences and other parameters facilitating the customization of learning. Several LMs are proposed for the various ITS in various fields. The question that rises at here is what essential information to include in the LM and how it will be used.

B. A Classification of Learner Models

According to a study by Yuan Fan Zhang in 2010 [2], LMs can be classified into several categories. Thus, it is difficult to assign to these categories rigid and absolute boundaries. Some

LMs belong to several different categories. These LM categories are:

- **Dynamic Model:** Information about the learner is collected in real time. Depending on the interaction between the learner and the system, this information could be modified or updated dynamically.
- **Cognitive Model:** The Learner’s cognitive aspects are considered in the modeling (attitude to learning, memory capacity ...etc.)
- **Model with mistakes:** Frequent errors, causes or explanations of these errors are saved.
- **Open / interactive model:** The model is built jointly by the system and the learner. It allows learners to have some control over the diagnostic inspection and the modification of the model.
- **Collaborative Model:** The learning context is collaborative. For example, the success of a learner could help the success of other members of the group.

- **Uncertain model:** the descriptions of knowledge or knowledge levels are often inaccurate in real situations. Knowledge modeling makes it possible to represent, shape and update this uncertain knowledge.
- **Distributed Model:** the environment is often distributed. A learner’s knowledge is distributed among the agents who communicate with him.

C. Features of the Learner Model

A LM can have several features. The customization of learning and the assessment of the learner’s knowledge are integrated into most ITSs. Although there are others, Figure 1 illustrates the main features [2].

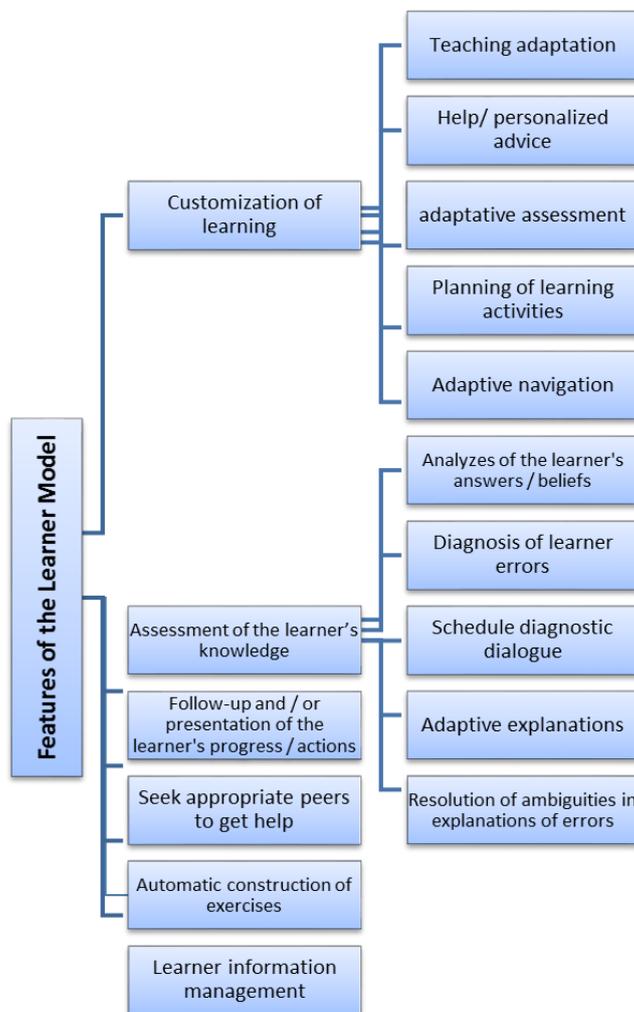


Figure 1: Features of the Learner Model

D. Components of the Learner Model

An LM can consist of several components presented in figure 2. It is rare that all these elements are incorporated in the same model and the choice of the parameters to take into account makes it possible to implement certain features.

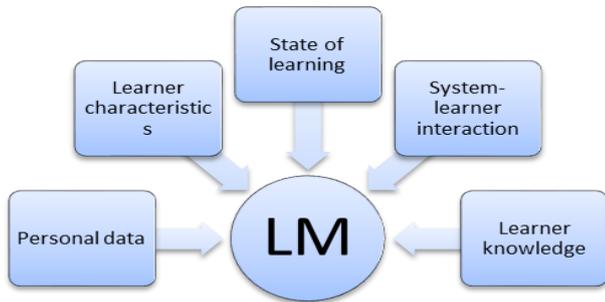


Figure 2: Components of the Learner Model

- Personal data: Contains general information about the learner (name, age, experience, training ...etc.)
- Learner characteristics: Contains the general or psychological traits of the learner such as learning purpose, personal type of learning, learning style preferences and level of concentration.
- State of learning: Contains present or past state of learning. This information is then used to analyze and keep a record of the learner's situation.
- System-learner interaction: At any appropriate time, the system infers the learner's knowledge or learning state according to the recorded data.
- Learner knowledge: This category may include the learner's level of knowledge, test scores, error patterns, learner beliefs and their degree of accuracy, explanations of errors, knowledge of prerequisite concepts, knowledge of sub-domains, knowledge to be validated, acquired knowledge, etc.

The majority of the works and concepts mentioned above use an objective-based approach, a traditional method that is dominant in the 20th century school world, which breaks down the knowledge to be transmitted within disciplines into as many objectives to be attained at each level of schooling. This approach suffers from several shortcomings that will be listed in the next section.

FROM THE OBJECTIVE-BASED APPROACH (OBA) TO THE COMPETENCY-BASED APPROACH (CBA)

A. Characteristics of the OBA

The objective-based approach (OBA) is an educational technology. Cuq [3] states that "OBA is the pedagogy that consists of linking the objective which is set to its operational mode and to the means of its achievement. An overall objective is set and broken down into sub-objectives, all of

which contribute to the achievement of the overall objective. Then, a set of pedagogical activities is considered necessary and sufficient for the realization of the sub-objective. The OBA results in a particular breakdown of the learning time that takes place in successive and compact blocks corresponding to each sub-objective."

Thus, three essential concepts are related to this approach: observable behavior, overall objective and specific objectives.

- Observable behavior: OBA focuses on observable and measurable behaviors and rejects reference to consciousness (behaviorism). It is based on behaviorism that is coupled with disciplinary contents broken down into very small units [4].
- The overall objective is defined as "a statement of pedagogical intent describing in terms of the learner's abilities one of the expected results of a learning sequence" [5].
- The specific or operational objective results from the breakdown of a general objective into as many statements as are necessary [6].
- According to Hameline [5] for an objective qualify as being operational, it must meet four conditions that are:
 - Its content should be stated in the least ambiguous possible way.
 - It must describe an identifiable learner activity through observable behavior.
 - It should mention the conditions under which the expected behavior should occur.
 - It must indicate the level of requirement at which learning is to be placed, and the criteria that will be used to assess this learning

B. Limitations of the OBA

Several criticisms were levelled at the OBA:

- Generally, the OBA sets goals but does not say how to achieve them.
- The OBA has been confined within a behaviorist operationalism, which has greatly distanced it from the pedagogic act and transformed it into an act of conditioned reflexes that abstract away all creative thinking in the learner [7].
- Being subject to the objectives set by the teacher, the learner is not always at the center of the learning process.
- The OBA is blamed for splitting the knowledge to be learned to the point where the student loses the ultimate aims behind learning [8].
- The inability of pupils to deploy knowledge spontaneously in situations for which it would be relevant.

C. The Concept of “Competency”

We will now deal with the concept of “competency”. This concept is central in the CBO.

In the literature, several definitions of the notion of competency have been suggested [9]. The following table sums up these definitions.

Table 1: Definitions of the notion of competency

Source	Definitions
Chomsky	Linguistic competency is an innate capacity that allows a speaking subject to produce and understand an infinite number of sentences. This competency is linked to the lexicon, phonetics, syntax and other domains of a language system. It is virtual and it is actualized in performance [9].
Richer	<ul style="list-style-type: none"> The vocational world borrowed the notion of competency from Chomsky's linguistics for its sense of creative adaptation to the demands of complexity. It has been used to designate the capacity of employees and businesses to adapt to increasingly complex, unstable and event-related professional situations. [10] Association of knowledge, procedural and cognitive vocational know-how skills, and life skills that are realized not on the basis of addition but on the mode of deployment, combination, and interaction [11].
Zarifian	The power to act, the capacity to make sense, and the engagement of the subjectivity of those who daily compete in professional situations [12].
Le Boterf	<ul style="list-style-type: none"> The actualization of what one knows in a singular context marked by work relations, an institutional culture, risks, temporal constraints, resources, is a sign of the transition to competency. The latter is realized in action. It does not pre-exist. There is competency only of competency in action [13]. Strategy and deployment skills emphasize both the dynamic aspect of competency, which is no longer an addition of knowledge, know-how skills and life skills, but an activation of

Source	Definitions
	these different instances of knowledge [13].
CECRL	<ul style="list-style-type: none"> Competencies are knowledge, skills, and dispositions to act [14]. Production strategies involve deploying resources and seeking a balance among different competencies - by exploiting strengths and minimizing weaknesses - in order to match the potential that is available to the nature of the task [14].
Belgian Decree	Ability to implement an organized set of knowledge, know-how skills and attitudes that allow the accomplishment of a number of tasks [15].
Training Program for School in Québec	Complex action-knowledge based on an efficient deployment and use of a set of resources [16].
Common Core of Knowledge and Competencies	It is to be able to deploy one's acquired knowledge in complex tasks and situations [17].
Gillet	A competency is "a system of conceptual and procedural knowledge organized into operational schemes and which allow the identification of a task-problem and its resolution through effective action within a host of situations." [18]

The Common European Framework of Reference for Languages (CEFR) defines knowledge in the following terms, "Knowledge or declarative knowledge is knowledge resulting from social experience or more formal learning. Skills and the know-how are more a matter of procedural skill than declarative knowledge, and are accompanied by forms of social skill. Social skills are attitudinal devices that affect the introvert or extrovert character in social interaction. Learning skills mobilizes social skills, knowledge and know-how and rest on different types of competencies".

We retain the following definition of competency:

"Competency is the implementation of a diverse but coordinated set of resources by a person in a given situation and in a given context. This implementation is based on the choice, deployment and organization of these resources and

on the relevant actions they can take to successfully deal with this situation "[19].

D. Characteristics of the CBA

The CBA developed by De Ketele, Roegiers and the BIEF group is primarily meant to be a break objective-oriented pedagogy. The CBA seeks to develop the possibility for learners to mobilize an integrated set of resources in order to solve a problem-situation belonging to a family of situations [20].

This approach therefore sets learning into situations. The integration of learning in an overall logic is privileged and the knowledge mobilized is transformed and recontextualized. It is in action that competency must be inferred, hence the importance of assessment through appropriate situations.

In the school system, according to Roegiers [21], CBA aims at three main objectives:

- Focus on what the student should master at the end of each school year rather than what the teacher should teach. Its role is to organize the learning in the best way in order to bring its students to the expected level.
- Make sense of learning by showing students the use of what they are learning at school, setting learning in relation with situations that make sense to them and using what they have learned in these situations.
- Certify the students' achievements in terms of resolving concrete situations, and not in terms of a sum of knowledge and know-how skills that the students hasten to forget, and which they do not know how to use in real life.

Despite some criticism levelled at the CBA, this approach is interesting to better adapt education and training programs to professional practice situations.

TOWARDS A LEARNER MODEL BASED ON CBA ONTOLOGY

A. Why an Ontology

Generally, an ITS manipulates a complex knowledge database on which we would want to implement some processing. This database lists the concepts of the modeled domain and can be organized in an ontology.

An ontology is a representation of general properties of what exists in a formalism that supports rational processing. This is the result of an exhaustive and rigorous formulation of the conceptualization of a domain. This conceptualization is often said to be partial because, in the state of the art, it is illusory to believe that it can, in a formalism, capture all the complexity of a domain.

An ontology defines concepts (principles, ideas, category of object, potentially abstract notions) and relations. It usually includes a hierarchical organization of relevant concepts and the relationships that exist between these concepts, as well as rules and axioms whereby they are constrained.

The introduction of an ontology in an information system aims at reducing, or even eliminating, conceptual and terminological confusion and moving towards a shared understanding in order to improve communication, sharing and interoperability [22].

B. General Design Procedure

In our work, we will design an LM so as to take into account the learner's "competency" dimension, based on the CBA ontology. Indeed, it is a hierarchical organization of the concepts and relations resulting from the formal analysis of the literature of the CBA domain and the pedagogies that have been developed around this approach, in particular the pedagogy of integration [23].

Figure 3 shows the overall architecture and the main elements of which it is composed: the pedagogical model, the domain model and the learner model.

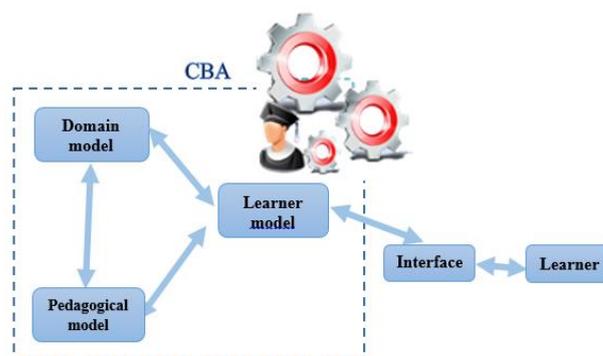


Figure 3: Global architecture adapted to the CBA

Concerning the LM in the context of the CBA, we need to model the learner's effective competencies. To do this, we will look at the possibilities of representing the learner's capacity to deploy his / her various resources (internal resources, external resources, contextual resources ...) for a successful resolution of problem situations. More than a frozen model of the learner, we seek to represent a learner profile in terms of competencies (Figure 4). This profile could have several uses (apart from pedagogical uses: customization of courses ...), it could be used for professional purposes within companies for the management of human resources.

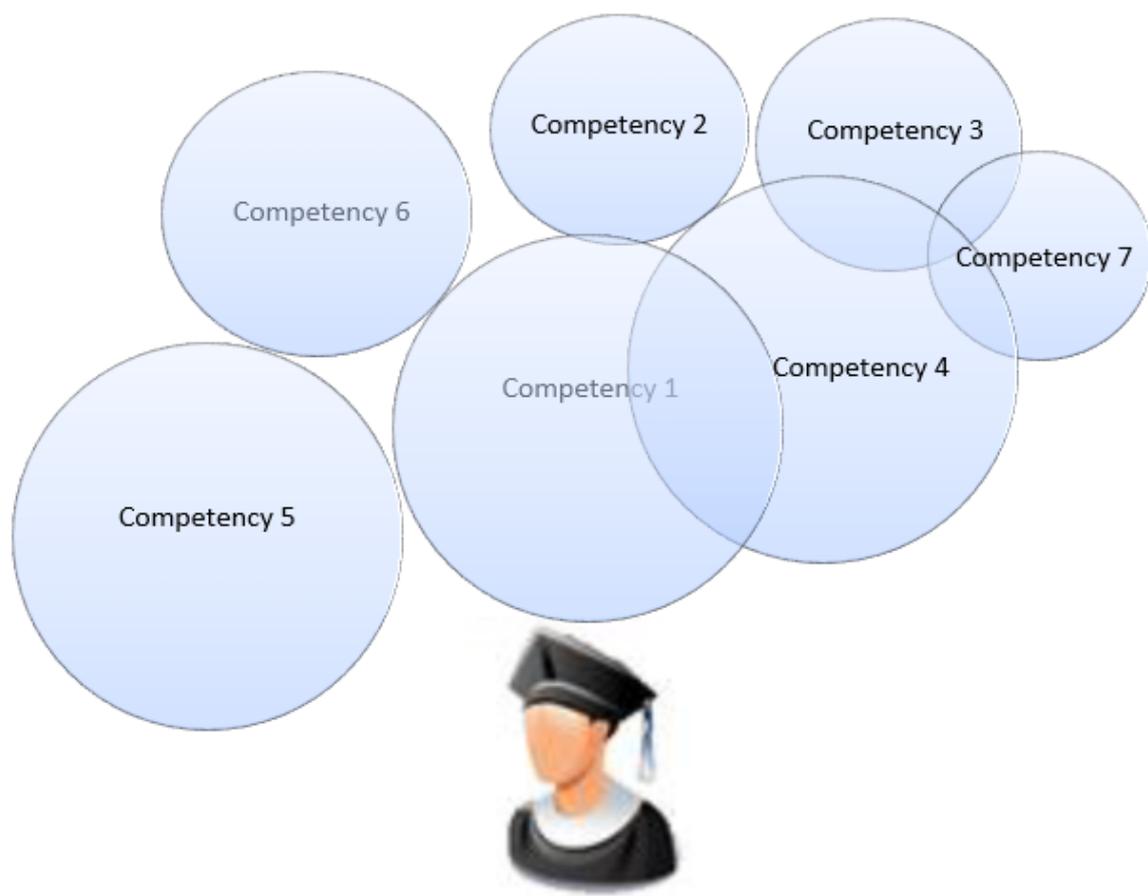


Figure 4: Learner's competency profile

C. Our conception of the LM based on the CBA ontology

In our conception of LM (Figure 5), a set of resources of different kinds is available to the learner. The classical view is content to represent the knowledge of the latter, whereas the CBA is interested in all of the cognitive resources of the learner including competencies.

Competencies are integrated according to different dimensions:

- Prescriptive Competency: This dimension allows us to structure curricula and define target profiles.
- Potential Competency: This dimension allows us to estimate the learning profile in order to customize its course and to best serve it. This profile is the result of assessing the achievements made during the training or previous professional experiences. This dimension can also be inferred from a conventional correlation between the learners' competency profiles and the certificates (badge, portfolio...) available to them or their occupation activity.
- Actual (or integrated) Competency: This is the dimension that we try to approach by defining potential competencies. Actual competency occurs in time. It is

hardly perceptible on the occasion of the performance of an actor in the context of a problem situation. This performance is not necessarily reproducible.

- Explicit competency: This is the dimension according to which competency is transferable and of which the learner is aware of the process of its development.
- Moreover, the learner is associated to a profile that can be expressed in a classical way in terms of a portfolio that combines the professional experiences and certificates of the learner.

Thus, it is important to establish the correspondence between the classical representation and the CBA representation in order to guarantee interoperability with what exists already and to allow an evaluation of the learners' achievements throughout their course.

It is also necessary to identify the various internal resources deployed by the learner. These resources can be intrinsic to the learner such as his physical and mental abilities. They may also be cognitive such as knowledge (theoretical knowledge, know-how skills, life skills). Skills are part of the learner's cognitive resources. Concerning conative resources, they can be of different sorts such as aptitudes (motivation as an

example), values and beliefs. The learners' experiences and in particular their failures are part of their internal resources.

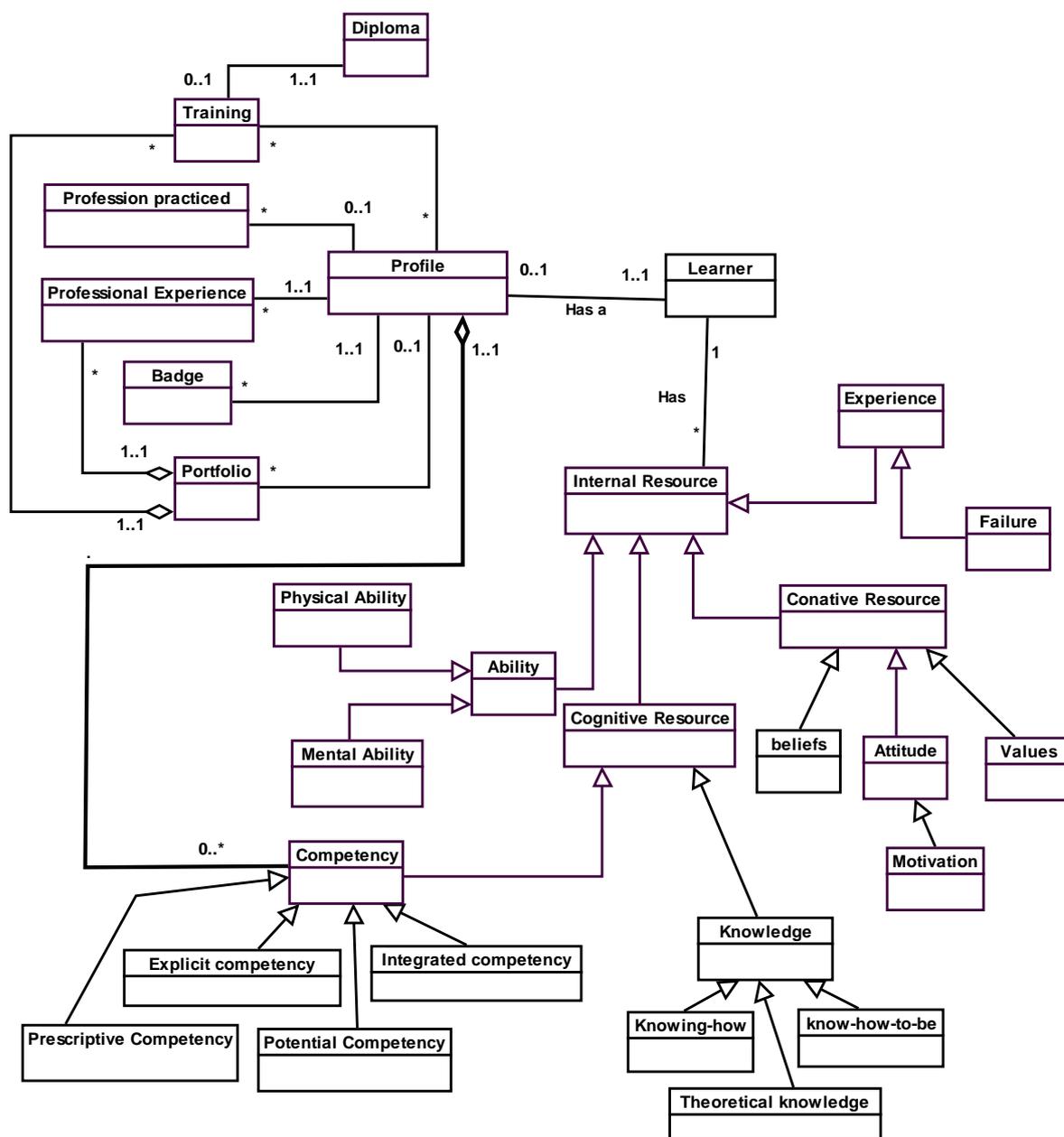


Figure 5: LM based on the CBA ontology

CONCLUSION AND PERSPECTIVES

The LM is a central component representing the characteristics of the learner that the system needs in a learning adaptive process. We are interested in modeling based on ontologies as a solution for the definition of concepts and properties related to the learner. This modeling is adapted to the competency-based approach, which offers a richer framework than the objective-based approach. In our forthcoming work, we will focus on the operationalization of this approach in the overall context of an ITS adapted to the CBA.

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