Developing Learning Objects through Concepts and Contexts

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ABSTRACT

The Internet has promoted several changes in the world, including on education. People have been more interested in learning, which makes developing higher quality content material even more important. In addition, people want to satisfy their learning needs according to their personal characteristics such as knowledge background and learning style. Therefore, nowadays there is a great interest on reusable learning content material and adaptive systems. Learning metadata standards contribute to achieve such reusability through the idea of learning objects. However, there is no guidance on how to develop learning objects, but only on how to describe them. The work presented in this paper proposes a model for structuring knowledge (concepts, demonstrations and interactions) in learning objects according to their context, representation and composition. This approach enables increased reusability and adaptability while providing better structured material.

Keywords: E-Learning, learning objects, reusability, knowledge representation.

RESUMO

Neste mundo altamente competitivo, as pessoas estão cada vez mais cientes da importância da educação continuada. A Internet, que tem promovido mudanças em diversos setores, é discutida como uma das formas de possibilitar melhorias também na educação. Entretanto, desenvolver conteúdo de qualidade a ser disponibilizado na Web é trabalhoso e caro. Além disto, as pessoas querem satisfazer suas necessidades de aprendizagem conforme suas características pessoais tais como conhecimento já adquirido e estilo de aprendizagem. Portanto, atualmente há um grande interesse em materiais para aprendizagem que sejam reutilizáveis e sistemas adaptativos. De modo a promover a reusabilidade estão sendo criados padrões de metadados para aprendizagem baseados na idéia de objetos de aprendizagem. Entretanto, não há uma metodologia bem estabelecida para desenvolver tais objetos, mas somente definições de estruturas para descreve-los. O trabalho apresentado neste trabalho propõe um modelo para estruturar conhecimento (conceitos, demonstrações e interações) em objetos de aprendizagem conforme seus contextos, representações e composições. Este enfoque permite um aumento na reusabilidade e adaptabilidade dos objetos de aprendizagem e promove um material de aprendizagem melhor estruturado.

Palavras chave: E-Learning, objetos de aprendizagem, reusabilidade, representação de conhecimento.

1 Introduction

We are living on what has been called the Information Age. There is an overload of information that is getting more difficult to filter, manage and assimilate. As a consequence of this high amount of information readily available and easily accessible we want to be able to use it in an efficient and effective manner to pursue our goals.

The development of the Internet has accelerated this process. Not only, the Internet has become a great resource of information but also the access to this resource is easy and affordable. This is the main reason why the Internet has caused many changes on several business areas.

In parallel to all this revolution, Education has also been re-discussed. New theories and paradigms have been developed and new methodologies have been tested. The Information Age and its environment of rapid changes have increased the importance of life long education and the Internet has provided mechanisms for advancing techniques and methodologies. In addition, changes like personalization of services and content that the Internet has endorsed in the business area are also being propagated to education.

In order to provide education, it is necessary to develop learning content material. However, developing high quality material is expensive and time consuming. It has led to a demand for reusability in order to enable reduction of costs and time for material development.

The use of well-structured descriptions of the content material (metadata) has contributed to a better search of the desired material, thus facilitating content reuse. However, as these descriptions are not unique it is necessary to provide ways to enable interoperability among metadata structures. This is particularly important when considering that there is a movement towards globalization where organizations need (or want) to cooperate to each other,

To enable interoperability of learning content, organizations such as IEEE, IMS Global Learning Consortium and ADL have worked to develop technical standards, recommended practices and guides for learning technology. In general, their main focus is on describing learning content (e.g., [1], [2] and [3]).

Although these valuable efforts are being used worldwide and have proved their efficiency and efficacy, there are still some problems on how to structure learning objects. The general approach consists on having already developed several learning objects (i.e., learning content materials) and to define their metadata in order to allow their reuse on different educational and training programs.

The work described in this paper presents a conceptual framework that considers facts to be learned according to theory and practice, i.e. concepts, stories (knowledge experiences) and phenomena. In addition, a more critical view is also expressed through interactions. However, in order to use these concepts, phenomena and interactions in a learning activity it is necessary to place them into a context. Finally, an application enables representing such knowledge and it is possible to sequence/animate it. Therefore, besides improving content reusability and adaptability, our approach also provides guidance in the development of learning objects and activities.

This paper is organized as follows: Section 2 describes our proposed architecture of schemas for learning objects. Then, in section 3 we present the concept of Knowledge Manifold, which is reorganized and restructured to be used in our conceptual framework. In this section we also present the fact schema. Section 4 describes the context schema, which represents the environment in which learning occurs. Then, Section 5 presents other schemas and their integration to the overall architecture. Section 6 presents the relationships of the schemas, showing therefore how they are associated. Finally, Section 7 presents some final remarks.

2 The Proposed Architecture of Schemas

In order to improve reusability it is desirable to have high granularity in learning objects. However, breaking up content usually leads to losses in meaning. Considering these aspects, it was decided to adopt an architecture of schemas (or conceptual frameworks) in order to be able to define semantically richer learning objects although with high granularity. It was also seen as an important aspect to be able to apply underlying concepts of learning into the development of learning objects.

In our architecture of schemas (Figure 1) we consider as a "fact" everything that is to be learned, i.e., concepts, experiences and experiments. However, a fact is related to a context that represents the environment in which the fact occurs. Therefore, the interpretation of a fact is dependent on its context.

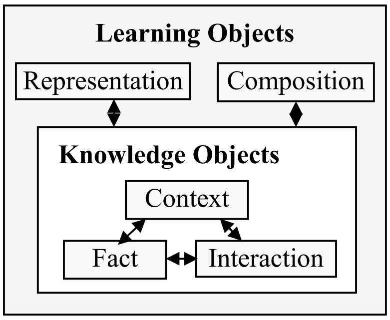

Fig. 1. Architecture of Schemas for Learning Objects

Facts and context are subject to interactions, i.e. in order to enable better understanding of facts according to their context it may be necessary to discuss over the facts and their environment. These discussions are represented through interactions that also allow the evolution of facts and contexts. Notice that this component is more important when a critical thinking approach of learning is considered. Thus it is not an essential component, but it has increased on significance over the years as education shift from teacher-oriented to student-oriented.

Learning occurs through the representation of facts, their context and respective interactions. Representation provides media representation so that it is possible to learn facts and interactions through an application. It is also an important aspect because it enables adaptability according to learners' styles and abilities. The representation component is the most affected by technology since it is the representation of application mechanisms that are used to present information (facts and interactions).

Finally it is possible to compose facts, interactions and contexts (knowledge objects). It allows a more sophisticated knowledge representation because we organize information into more complex units that will originate learning objects, i.e., the physical learning objects (content material files) and respective metadata.

We consider the fact and the context schemas the most important because they are responsible for describing concepts and experiments as well as the environment on which learning is going to happen. Therefore, they are going to be detailed separately in sections 3 and 4 respectively.

3 Concept of Knowledge Manifold and the Fact Conceptual Framework

For the fact schema, in our work we have adopted the concept of Knowledge Manifold. According to Ambjörn Naeve [4], an idea (concept) is a representation of a subjective experience. Knowledge Manifold (Figure 2) is the collection of such ideas within each individual that are constantly calibrated with their surroundings in a multitude of different ways. It is based on the fact that the mind works part deductively, by theorizing – part inductively, by collecting experiences. A theory creates expectations that often lead to experiments, the outcome of which in turn can verify or contradict the corresponding theoretical predictions, thereby influencing the conceptual evolution of the theory itself.

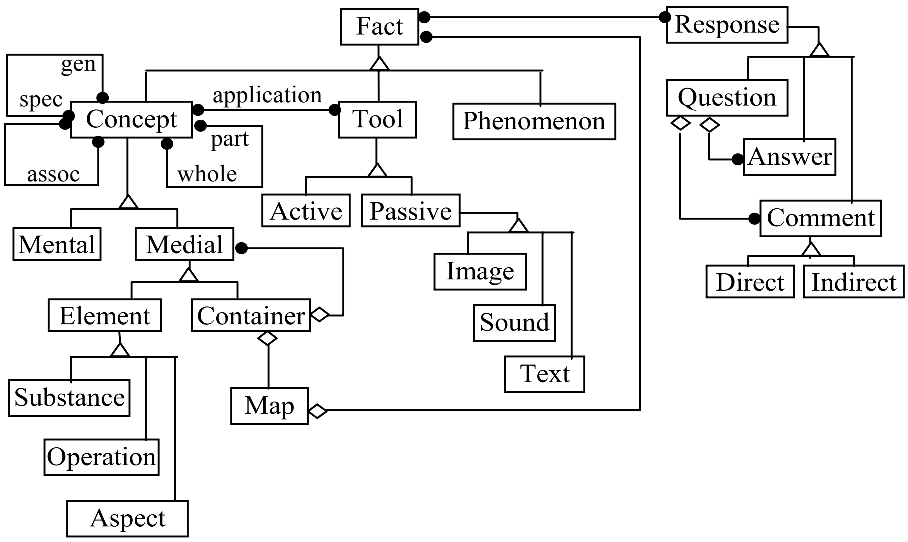

Fig. 2. Conceptual classification of a Knowledge Manifold

Facts can be theoretical or practical, hence involving concepts and/or can express experiences. Tools can present a concept.

Concepts can be inward ideas (mentally expressed) or outward ideas (medially expressed). There are different kinds of relationships among concepts: generalization/specialization, part/whole and associations.

A concept can be an element or a container (i.e., a set of medial concepts). An element concept can be a substance (i.e., describes something that remains unchanged during the transformational changes – just like a noun), an operation (i.e., describes a process of change/transformation – just like a verb) or an aspect (i.e., describes some type of invariant property of a substance – just like an adjective). A container concept has associated maps that are related to facts.

A tool is an application that presents facts. It can be passive in such a way that is expresses the idea through an image, a sound or a text; or active presenting a simulation or experience.

Facts are associated to responses that can be of type question, answer or comment, and a comment can be direct, i.e. expressed in multimedial form, or indirect, i.e. expressed in the form of a link (address).

Since we see the educational process as an application of the Knowledge Manifold, we use the structuring of facts to represent knowledge to be learned. We adapted the conceptual classification of a Knowledge Manifold in order to define the fact conceptual framework (Figure 3), i.e. the fact schema of the Figure 1. The extensions are represented through gray boxes and dashed lines.

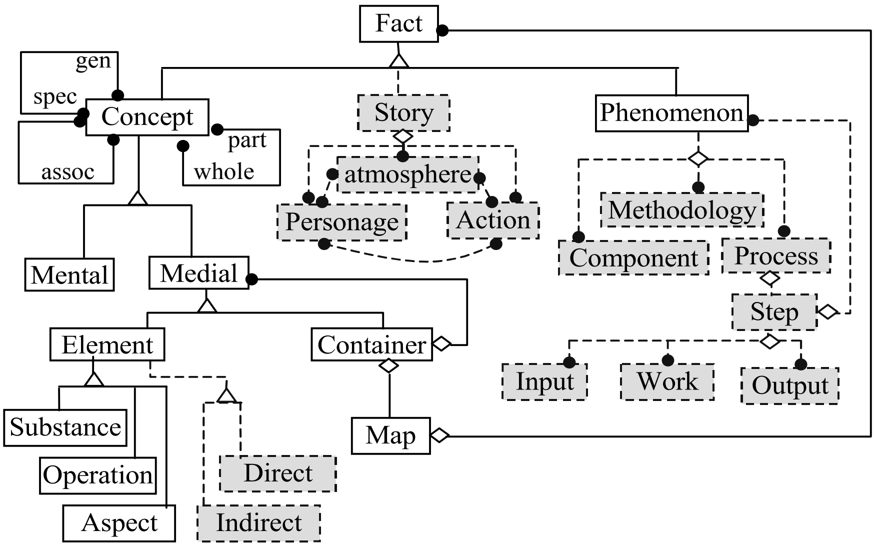

Fig. 3. Fact conceptual framework

We represent facts to be learned according to three different approaches: theory, story and practice, i.e., concepts, knowledge experience and experiments.

Story represents stories or cases. A story is composed of personages, descriptions of the environment (atmosphere) and actions. The personages execute actions that occur in a specific atmosphere.

Notice that interaction and representation aspects such as response and tool that are depicted in the conceptual classification of a knowledge manifold (see figure 2) are not represented in the fact conceptual framework (figure 3). They will be represented in other appropriated conceptual frameworks (interaction and representation conceptual frameworks). Therefore, this is the reason for response, questions, answers and comments or tool, active, passive, image, sound and text are not included here.

We extended the element concept in order to allow its representation directly or in the form of a link (address), i.e., indirectly. In addition, as presenting an experiment involves components that are processed according to a specific methodology, these are the extensions for phenomenon that we have defined in the fact conceptual framework (figure 3). A phenomenon is composed of component, methodology and process. A process is composed of steps that have input, processing/work and output. A step can be more complex, involving other phenomena.

In order to enable better understanding we present an example *in italics*. *We could represent the fact that a dog barks loud to a mailman in a house. The concept could be medially represented through a container of a dog (element substance), bark to (element operation), loud (element aspect volume), mailman (element substance), in a house (element aspect place). In this case we would have the (definitions of the) concepts dog, to bark to, loud, mailman, and in a house. However, it could also be presented through a story, with personages (dog and mailman), atmosphere (in a house) and an action (to bark). Finally, we could represent it as a phenomenon with methodology (observation of a mailman delivering mails in a house), components (dog and mailman) and a process (s1: the mailman is arriving and we look for the dog; s2: the mailman arrives and the dog starts barking; s3: the mailman deliveries the mail and the dog keeps barking; s4: the dog keeps barking and we measure the volume of the barking; s5: the mailman leaves and the dog stops barking).Other representations could also be possible, such as having the same story plus the concept mailman. It only depends on what it is going to be taught.*

4 Placing Learning Concepts and Experiments into a Context

After defining the fact conceptual framework, representing concepts, stories and experiments, it is necessary to define a conceptual framework for context.

Hawryszkiewycz [5] says that learning objects take a new meaning in their context and can better add to knowledge if they are placed in a context. Naeve [4] emphasizes this importance when he says that separating between knowledge-components and learning-strategies is complicated by the fact that any given answer implies a pre-judgement of the context within which the question was formulated. This creates a 'strong dependency' between what is being presented and under what kind of circumstances it is being presented, which represents a hardwired relationship between knowledge-content and learning-strategy.

According to the Webster's Dictionary, context is the environment in which an event occurs. Therefore, the learning context is the environment in which the facts to be learned occur.

We represent a learning context (Fig 4) through the knowledge area, learning goals, learning level, requirements/prerequisites, moments, places and experiences that are related to the fact.

A context can be simple or complex. The latter represents a composition of contexts.

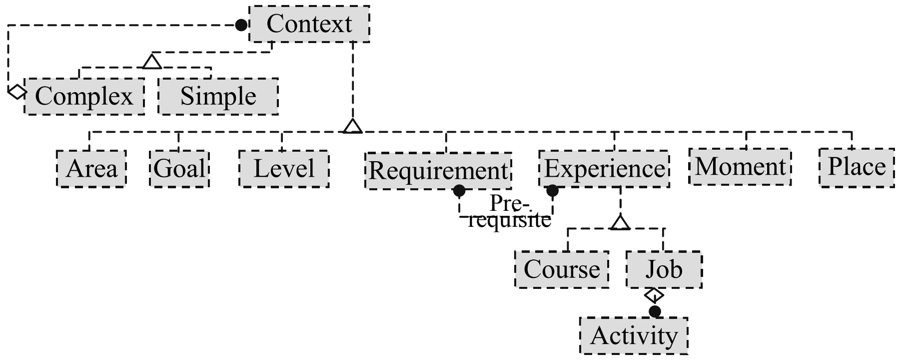

Fig. 4. Learning context conceptual framework

Area represents the knowledge area. Goal represents the learning goal. Level represents the learning level. Requirement represents the learning requirements or prerequisites. Moment and Place represent respectively temporal and spatial aspects related to the fact.

Experience presents academic and work experiences related to the fact. An experience can represent a course and/or a job. A job involves activities, some of which can contextualize the fact. The requirement for learning a fact can be a specific experience.

In order to enable better understanding we present an example *in italics*. *We could represent several different contexts. A simple context would be representing only one aspect such as level (novice, intermediate, advanced) or area (veterinary). A complex context could have an area (veterinary), a goal (to understand dogs reactions under mailman presence), a level (advanced), and requirement (to know concepts such as dog, mailman, barking, house, and that normally a dog barks; and previous experience on animals psychology). The learning will provide experience on working with mailmen to avoid bad reactions on dogs. The place is in a house while the moment is when the mailman is near the house. Notice that several variations of this context are possible.*

5 The Other Conceptual Frameworks

In this section we present the remaining three conceptual frameworks/schemas (interaction, representation and composition) of the proposed 5-schema architecture (section 2).

Interactions allow a better understanding of the concepts, knowledge experiences (stories) and experiments as they enable a critical discussion over the facts. Since facts are inserted into a context, these interactions must also consider the context. Figure 5 represents the interaction schema. Notice that it is part of the conceptual classification of a knowledge manifold. However, it was extended in order to express more semantic related to the messages.

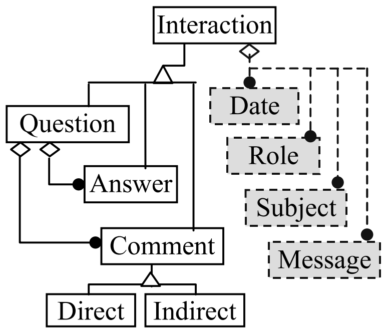

Fig. 5. Interaction conceptual framework

In order to enable better understanding we present an example *in italics*. *Questions over the example experiment in the second context (the complex one), could be: date = march 13th, 2003; role from = professor John; role to = all students; subject = specific case?; message = Is it a characteristic of a specific kind of dog?. Then student Mark could answer in the same day to the professor that he has made experiments with three races of dogs and they all behaved the same way, barking loud; while student Mathew could comment in the next day to all students that he believes that trained dogs do not have the same behavior.*

As described in section 3, the concepts, stories and experiments are expressed in the fact schema and are related to the environment in which learning occurs (expressed in the context schema – see section 4). The interactions allow the discussion over such facts, thus improving learning. However, it is necessary to represent all these components (facts, context and interactions) through a media. Figure 6 shows the representation conceptual framework.

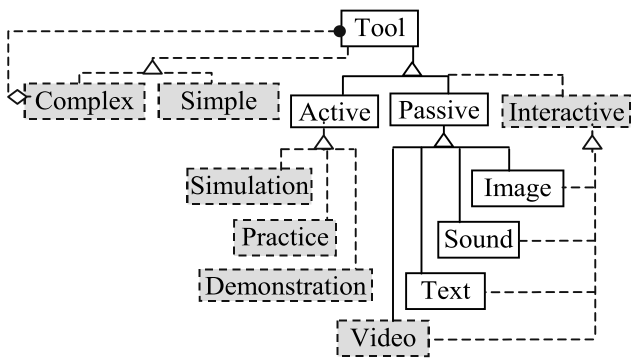

Fig. 6. Representation conceptual framework

A tool can be simple or complex. In the later case, it is composed of other tools. A passive tool conveys information through different types of sensing media, most often visual images, sound, text or video. However, through an active tool it is possible to perform experiments of different kinds, for instance simulations, demonstrations or practices. Finally, the representation conceptual framework also includes interactive tools that can be available in text (e.g., email, newsgroup, discussion forums and textual chats), sound (e.g., voice over IP and phone calls) and video (e.g., videoconference).

In order to enable better understanding we present an example *in italics*. *A simple tool could represent the concepts of the first example in the beginner level context through a video. The second context could have a complex tool to through practice enable the student learning the experiment and through a text interactive tool enable discussions.*

Finally, we need to enable compositions of the represented facts, interactions and their context. Figure 7 presents the composition conceptual framework. Composition is achieved through animation or sequencing of knowledge objects and corresponds to an ordered aggregate of facts, interactions and contexts.

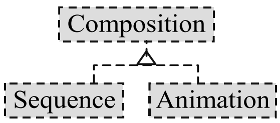

Fig. 7. Animation/Sequencing conceptual framework

In order to enable better understanding we present an example *in italics*. *Considering the second example of context, we could have the representation of the story through a video, which would give the motivation to the experiment. Then the sequence would be the experiment though practice followed by discussions. The next step could be defining the reasons for this behavior of dogs.*

6 Integrating the Conceptual Frameworks

Since we have defined the schemas (or conceptual frameworks), it is necessary to determine their relations.

A knowledge area (represented in the context schema) is defined through a concept defined as a fact or it can be defined through a direct description. It is related to fact and response, since they refer to a knowledge area. This area can slightly adapt a generic concept, so it is important in the definition of the context.

The learning goal can be expressed through fact-objectives, i.e., facts can describe other facts' goals, or through a direct description. By well-established and disseminated learning goals related to a specific fact or participating of a specific interaction the learner can feel more motivated. In addition, knowing the learning goal and objectives enables a better organization of learning as a whole.

It is possible to express requirements/prerequisites through facts or experiences, i.e., relations between fact and requirement define a fact that is prerequisite of other specified fact. Similarly, relations between requirement and experience define an experience that is prerequisite of a specified fact. In addition, the prerequisite facts and experiences allow better and easier understanding of what is to be learned.

The relation between fact and experience expresses how learning the fact can contribute to the learners' experience. Analogously, the relation between interaction and experience expresses how participating of the interaction can contribute to the learners' experience.

The relations between moment and place with fact and interaction represent temporal and spatial aspects of learning.

Facts and interactions are represented through the use of tools. Concepts and stories are passive tools while phenomena are active tools and interactions are interactive tools. The context can help in the choice of the best representation tool, for example the concept to bark can be represented by a image in conjunction with a sound for a little child while it is enough a text for a teenager (context level).

The learned sequence of knowledge objects (facts and interactions) defines what has recently been learned and what is to be learned, so that it makes learning the fact simpler and motivates the learner. The relation between animation and context as well as the relation between animation and representation allows better sequencing and animation through the same or complementary contexts or representations. Notice that animations generally occur when simpler concepts are considered (e.g., animation of pictures composing a story).

7 Conclusion

In this paper we presented a novel approach for developing learning objects based on an architecture where semantic aspects are emphasized. This architecture is centered on the idea of knowledge objects (concepts, stories and phenomena, plus interactions embedded in a context). These knowledge objects are represented and possibly composed in order to originate learning objects. The resulting learning objects allows better structuring of what is to be learned as well as better definition of related learning activities. Therefore, besides improving content reusability and adaptability, our approach also provides guidance in the development of learning objects and activities.

We started studying learning objects and their application in learning environments. Then we have seen that the development of learning objects could be better structured thus allowing more reusability and adaptability. Therefore, we initiate the process of defining the underlying concepts (hence defining the schemas).

The definition of the schemas was not only based on the concepts about knowledge manifold but also received an important input from the generalization of a previously proposed metamodel that was defined in the context of marketing activities [6] [7]. The generalization of the concepts for a generic environment allowed a deeper discussion on the schemas for developing learning objects.

In addition, a previous proposal of an architecture of schemas for learning objects based on the conceptual architecture of data warehouse systems [

8] enabled the perception about the need for more structured learning objects than the considered in the available standards proposals.

In [9] we proposed a configurable environment for e-learning systems that we are going to instantiate. The work described in this paper is part of the database schema definition for this e-learning environment, in which we try to apply a better knowledge-structured approach.

During the development of our proposal we have found some interesting works. Song [10] presents a metadata model for learning objects. Although it is related to the description of learning objects instead of knowledge that is embedded in learning objets, it considers some similar concepts, such as the need for structuring content, carrier (representation), neighbor (context and composition) and intensity (context).

Rodriguez, Chen, Shi and Shang [11] present the idea of open learning objects (OLO), in which it is considered an interface to export the results of learning objects-to-learner interaction and for learning object adaptation. It considers InnerMetadata that is the collection of layered metadata mechanisms that are used to describe the OLOs, their adaptive features, and the learning interaction tracing. It presents five layers for OLOs that look somewhat similar to our proposed architecture of schemas for learning objects. However, they do not consider learning context and their work is on describing learning objects to enable better learner interaction and learning object adaptation, while our work is based on the knowledge representation of what is to be learned so that better learning objects can be developed.

Hawryszkiewycz [12] presents how to integrate learning objects into learning contexts. This is a complementary work to our proposal, since besides considering the context of facts and interactions, it will be also necessary to consider the context of learning objects.

Finally, Elisabeth H. Wiig and Karl M. Wiig [13] describes the importance of conceptual learning, in which is emphasized the use of conceptual maps. We consider this is an important work that is related to the definition of facts and their sequencing in our proposal. Therefore, we consider it as a complementary work to our proposal and further study will be necessary.

We are just at the beginning of what we expect to be an important contribution for e-learning but a lot of work is still to be done. Some of the future works involve the detailing of the other database semantic components such as learner and course conceptual frameworks; the use of ontologies for improving the usability, efficiency and efficacy of the proposed schemas; the development of automatic behavior and intelligent guidance throughout the development of learning objects in order allow an easier and faster structuring; and more detailed tests of the proposed schemas.

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