Elearning Systems Based on the Semantic Web

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***Abstract*— ELearning has been identified as a strategic resource that can be utilized as an increasing variety of venues such as homes, workplaces, and traditional institutions of learning, education, and training. ELearning systems are becoming technologically sophisticated and complicated, with regard to training management or course management. Their use does not always match well with traditional modes of teaching and learning and much care needs to be taken when considering the use of ELearning in educational institutions. The use of semantic web in eLearning has been explored with regard to two application areas: 1) software that supports teachers in performing their tasks in flexible online educational settings, and 2) software that interpret the structure of distributed, self organized, and self-directed ELearning and web-based learning. The resulting system will be used by learners to perform the tasks they are asked to do more effectively in the context of gaining knowledge out of the material presented by teachers. These two application areas and related tasks require a semantic representation of educational entities and pedagogical material, specifically the structure and the techniques of the teaching-learning process.**

In most eLearning systems users are able to manage and reuse learning contents according to their needs without any access problems. However the quality of learning is not guaranteed. This paper emphasizes the integration of the semantic web technologies with Elearning systems, taking into consideration the standards and reusable Learning Objects LO. The advantage to improve the descriptions of content, context and structure of the learning materials and the benefits of providing access to the learning materials are also presented.

***Index Terms*—Learning Objects, eLearning, Ontologies, Semantic Web, Web Based Learning.**

I. Introduction

It was for colleges and universities satisfactory enough to post course schedules and subjects syllabi online, but things have changed with the introduction of the Learning Management Systems (LMS), Web-based course tools like WebCT [15] and BlackBoard [4,5], Virtual Laboratory and the Live Meeting software. Elearning systems are becoming very popular and are being used by many educational institutions. The International Data Corporation (IDC) predicted in its January 2005 report that e-Learning will have $21 billion market in 2008, while was only $6.5 billion just two years ago [27].

The significance of computer-based learning is growing in all kinds of learning scenarios, and eLearning generally is seen as the chance to innovate learning. There are a lot of promises eLearning holds, for example that learning can take place anywhere, at the moment when it is needed. It can be individualized concerning time, place, duration, and learning style. Learning can be taken out of classrooms and formal education institutions, and be integrated into working and private life. However, a truly effective e-Learning solution must be provided to meet the growing demands for e-Learning by students, employee, researches and lifelong learners. Efficient management to the available information on the Web can lead to an e-Learning environment that provides learners with interaction with the most relevant material.

The current WWW is a powerful tool for research and education, but its utility is hampered by the inability of the user to navigate easily the vague sources for the information he requires. The *Semantic Web* is a vision to solve this problem. It is proposed that a new WWW architecture will support not only Web content, but also associated formal semantics. The Semantic Web, appears as a promising technology for implementing eLearning. It constitutes an environment in which human and machine agents will communicate on a semantic basis [3]. The Semantic Web is about two things. It is about common formats for interchange of data, where on the original Web we only had interchange of documents. Also it is about language for recording how the data relates to real world objects, that allows a person, or a machine, to start off in one database, and then move through an unending set of databases which are connected not by wires but by being about the same thing.

II. E-LARNING SYSTEM REQUIREMENTS

"eLearning is just-in-time education integrated with high velocity value chains. It is the delivery of individualized, comprehensive, dynamic learning content in real time, aiding the development of communities of knowledge, linking learners and practitioners with experts" [10]

The traditional learning process could be characterized with centralized authority (content is selected by the educator), strong push delivery (instructors push knowledge to students), lack of personalization (content must satisfy the needs of many students) and the static learning process (unchanged content). A detailed view on standard learning is given in Table.1. The consequences of such organization on the learning are expensive, slow and too unfocused (problem-independent) learning process. But dynamically changed business environment puts completely different challenges on learning process – fast, just-in-time (low in price) and relevant (problem-dependent) learning. This can be solved with the distributed, student-oriented, personalized, dynamic learning process – eLearning [25].

Table 1 shows the characteristics (or pitfalls) of the standard learning and improvements achieved using the eLearning environment. These are also the most important characteristics of eLearning.
The focus of eLearning systems is not only on education, but also on education without barriers of time and distance, and customized to user's and business' needs [10]. Key to success is the ability to reduce the cycle time for learning and to adapt "content, size and style" of learning to a user and to the business.
E-Learning system requirements involves both understanding the context and user's needs and identifying the system entities, the business rules and additional and non functional specifications such as usability, accessibility and scalability conditions. In the particular case of online learning systems design, we consider that it would be useful to add another step in the process: defining learning methodology. Figure 1 shows the steps that we recommend following in the identification process:
The first step is to understand the context where the system will operate. Several techniques, such as

TABLE I.
DIFFERENCES BETWEEN TRAINING AND ELEARNING [10]

Dimension	Traditional Learning	eLearning
Delivery	Push – Instructor determines agenda	Pull – Student determines agenda
Responsiveness	Anticipatory – Assumes to know the problem	Reactionary – Responds to problem at hand
Access	Linear – Has defined progression of knowledge	Non-linear – Allows direct access to knowledge in whatever sequence makes sense to the situation at hand
Symmetry	Asymmetric – Training occurs as a separate activity	Symmetric – Learning occurs as an integrated activity
Modality	Discrete – Training takes place in dedicated chunks with defined starts and stops	Continuous – Learning runs in the parallel loops and never stops
Authority	Centralized – Content is selected from a library of materials developed by the educator	Distributed – Content comes from the interaction of the participants and the educators
Personalization	Mass produced – Content must satisfy the needs of many	Personalized – Content is determined by the individual user's needs and aims to satisfy the needs of every user
Adaptivity	Static – Content and organization/taxonomy remains in their original authored form without regard to environmental changes	Dynamic – Content changes constantly through user input, experiences, new practices, business rules and heuristics

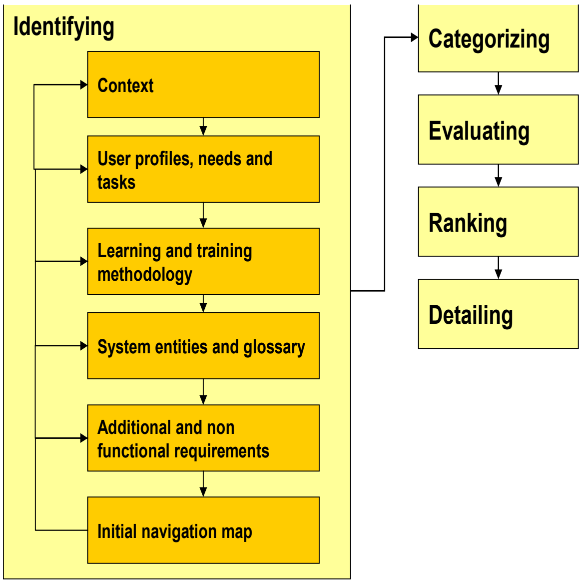

Figure 1. eLearning systems requirement identification process

Business modeling or Business Process Reengineering diagrams, can help to understand and explain business processes.

- *Identifying user profiles, needs and tasks*

Once the context is defined, the user profiles that will interact with the system must be identified, and so must their needs and the tasks that they should be able to perform. Use cases are a standard technique for gathering requirements in many modern software development methodologies. A use case is one of the ways of using the system. The sum of all the available ways of using the system constitutes the functional requirements (what things the system will do and how, independently of the technology it will be used in the development and the way the user–system interaction will be performed). Constantine [7] proposes some use cases description guidelines.

- *Defining learning methodology*

It defines the way the learning will be performed and how it will match the different learning paradigms and learner orientations. As a result, the main elements of the learning process must be identified as well as the main features of each profile environment.

- *Identifying the system entities*

The entities are all the items the user will take, handle, produce or use in his interaction with the system (i.e., an inscription, an exam, a chapter, a mail, etc.). Each entity is defined and described by a set of attributes and states. Apart from the entities identification it will be useful to elaborate a glossary with all the outstanding terms that appear in the requirements capture phase (i.e. validation date, setup date, etc.).

- *Identifying additional and non functional requirements*

These requirements specify properties of the system such as accessibility, availability, reliability, and so on. They can affect some or all the functional requirements.

- *Defining initial navigation map*

The navigation map is a view of the e-learning system showing how users will navigate in it. It can be represented in a hierarchical 'tree' diagram. Each level of the diagram shows the number of clicks that it takes to reach a screen / page. Keeping the most important areas of the system only one click away from the first screen / page will facilitate user tasks. Creating a system navigation map at the early stages of the project provides a valuable communication vehicle between stakeholders and the development team.

III. LEARNING OBJECTS (LO) AND E-LEARNING STANDARDS

There are several issues that need to be considered to decide when and how to integrate standards into e-learning content. Issues relevant to:

- The eLearning project
- Finished eLearning product
- Workflow process
- Reuse of components
- Standards identification and application

Currently, e-learning standards are being developed by four main organizations: AICC, IEEE, IMS, and ADL.

AICC (www.aicc.org) is an international group of technology-based training professionals that creates CBT-related guidelines for the aviation industry. AICC publishes a variety of recommendations, but its standards with the most impact on the e-learning arena are its computer-managed instruction (CMI) guidelines.

IEEE (www.ltsc.ieee.org) is an international organization that develops technical standards and recommendations for electrical, electronic, computer and communication systems. Within the IEEE, the Learning Technology Standards Committee (LTSC) provides specifications that address best practices, which can be tested for conformance. Basically, they wrote the standard on how to write standards. The most widely acknowledged IEEE LTSC specification is the Learning Object Metadata (LOM) specification, which defines element groups and elements that describe learning resources. The IMS and ADL both use the LOM elements and structures in their specifications.

IMS Global Consortium (www.imsproject.org) is a consortium of suppliers that focus on the development of specifications that focus on the use of metadata to address content packaging. The specifications are used to define how an LMS communicates with back-end applications and content objects or libraries. Several of its standards are made available on its website at no fee.

ADL (www.adlnet.org) is a U.S. government-sponsored organization that researches and develops specifications to encourage the adoption and advancement of e-learning. The most widely accepted ADL publication is the ADL Shareable Content Object Reference Model (SCORM). The SCORM specification combines the best elements of IEEE, AICC, and IMS specifications into a consolidated document.

The goal of standards is to provide fixed data structures and communication protocols for e-learning objects and cross-system workflows. This enables interoperability between applications, such as a Learning Management System (LMS) and third-party or in-house developed content, by providing uniform communication guidelines that can be used throughout the design, development, and delivery of learning objects. When these standards are incorporated into off-the-shelf products, developers can base their purchasing decisions on quality and appropriateness rather than compatibility.

Currently, most e-learning standards can be organized into some general categories:

Metadata: Many developers argue that metadata content is the heart of e-learning. Learning content and catalog offerings must be labeled in a consistent way to support the indexing, storage, discovery (search), and retrieval of learning objects by multiple tools across multiple repositories.

Content packaging: The goal of content packaging specifications and standards is to enable organizations to transfer courses and content from one learning system to another. This is crucial because content can potentially be created by one tool, modified by another tool, stored in a repository maintained by one vendor, and used in a delivery environment produced by a different supplier. Content packages include both learning objects and information about how they are to be put together to form larger learning units. They can also specify the rules for delivering content to a learner.

Learner profiles: These standards allow different system components to share information about learners across multiple system components. Learner profile information can include personal data, learning plans, learning history, accessibility requirements, certifications and degrees, assessments of knowledge (skills/competencies). In addition, systems need to communicate learner data to the content, such as scores or completion status.

A. Learning Objects (LO)

The concept of Learning Objects is grounded in the object-oriented paradigm of computer science [13]. The principle of Learning Objects is the creation of instructional components that can be reused numerous times in different learning contexts. A Learning Object is a unit of instructionally sound content centered on a learning objective or outcome intended to teach a focused concept. It is a fundamental building block composed of all the instructionally necessary components to comprise a self-contained instructional unit. These multimedia learning materials as described by Hiddink (2001), EDUCAUSE (2005), and Gallenson et al. (2002) include, but are not limited to, simulations, electronic calculations, animations, tutorials, text entries, web sites, bibliographies, audio and video clips, quizzes, photographs, illustrations, diagrams, grafts, maps, charts, and assessments combined for the purpose of presenting interchangeable examples, arguments, cases, and practical exercises, which can be instructor guided or based on learner self-interest and self determined need [20]

This is a new way of looking at curriculum in which content is broken up into discrete pieces or Learning Objects. Teachers and learners then go about the process of creating linkages between chunks in order to construct understanding [22].

These Learning Objects can be delivered over the Internet and can be accessed by a number of individuals simultaneously, with minimal effort, reducing the need for instructors to develop their own instructional components. They allow for increased speed and efficiency of instructional development and decrease faculty preparation time [13].

B. Benefits of learning objects

According to [26], the fundamental idea behind Learning Objects is that instructional designers can build small instructional components that can be reused a number of times in different learning contexts. Additionally, Learning Objects are generally understood to be digital entities deliverable over the Internet, meaning that any number of people can access and use them simultaneously.

Benefits to learners

• Learning Objects allow the creation of highly effective learning experiences for students [20] and enhancing the student learning environment [12].
• The choice of which Learning Objects to assemble into all collection can be a decision made in advance by an instructional designer or at the moment by a student; [9]
• Learning Objects allow experiences in problem-solving and exploration and collaboration with fellow learners; [9]
• Learning Objects allow universal access to online instructional materials [20].
• Learning Objects provide solutions for individualizing learning [20]

Benefits for instructors

• Learning Objects are highly interoperable and reusable modular building blocks or eLearning content based on widely shared specifications [8].
• Learning Objects promote better collaboration among developers [20].
• Learning Objects provide resources for instruction where they might not otherwise [20].
• Learning Objects can be combined in nearly infinite ways to construct collections that might be called lessons, modules, course or even curricula.
• Learning Objects allow for increased productivity among trainers and educators [20].
• Learning Objects provide value in terms of saving time and money in course development [12]
• Learning Objects allow for increases in the reusability of content [12].
• Learning Objects allow for sharing knowledge within and across disciplines [12].
• Learning Objects engage faculty in a dynamic community of practice [12].

IV. THE SEMANTIC WEB – ONTOLOGIES, XML, RDF, AND URI

The Semantic Web is a mesh of information linked up in such a way as to be easily processable by machines, on a global scale. You can think of it as being an efficient way of representing data on the World Wide Web, or as a globally linked database.

The term „Semantic Web” encompasses efforts to build a new WWW architecture that supports content with formal semantics. That means, content suitable for automated systems to consume, as opposed to content intended for human consumption. This will enable automated agents to reason about Web content, and produce an intelligent response to unforeseen situations. [25]

"Expressing meaning" is the main task of the Semantic Web. In order to achieve that, several layers are needed. They are presented in the fig. 2 [3], among which the following layers are the basic ones:

- The **eXtensible Markup Language (XML)** layer, which represents data;
- The **Resource Description Framework (RDF)** layer, which represents the meaning of data;
- The Ontology layer, which represents the formal common agreement about meaning of data;
- A global naming scheme **Uniform Resource Identifier (URI)**
- The Logic layer, which enables intelligent reasoning with meaningful data.

The top layers: Logic, Proof and Trust, are currently being researched and simple application demonstrations are being constructed. The Logic layer enables the writing of rules while the Proof layer executes the rules and evaluates together with the Trust layer mechanism for applications whether to trust the given proof or not.

A. Semantic Web and eLearning

ELearning systems and eLearning research areas can benefit from semantic web technologies. The Semantic Web technology has enabled by a set of suitable agents, which seems to be powerful enough to satisfy the e-learning requirements fast, just-in-time and relevant learning. The possible uses of Semantic Web technology for e-learning are [25,10]:

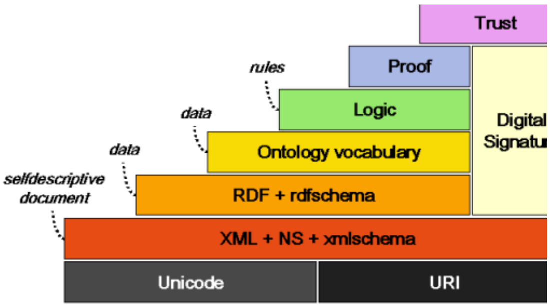

Figure 2. The Semantic Web layers [3]

• *Pull:* Knowledge items (learning materials) are distributed on the web, but they are linked to commonly agreed ontologies. This enables construction of a user-specific course, by semantic querying for topics of interest.
• *Interactive:* Software agents on the Semantic Web may use commonly agreed service language, which enables co-ordination between agents and proactive delivery of learning materials in the context of actual problems. The vision is that each user has his own personalized agent that communicates with other agents.
• *Non-linear:* User can describe situation at hand (goal of learning, previous knowledge,...) and perform semantic querying for the suitable learning material. The user profile is also accounted for. Access to knowledge can be expanded by semantically defined navigation.
• *Symmetric:* The Semantic Web (semantic intranet) offers the potential to become an integration platform for all business processes in an organization, including learning activities.
• *Continuous:* Active delivery of information (based on personalized agents) creates a dynamic learning environment.
• *Distributed:* The Semantic Web will be as decentralized as possible. This enables an effective co-operative content management.
• *Personalized:* A user (using personalized agent) searches for learning material customized for her/his needs. The ontology is the link between user needs and characteristics of the learning material.
• *Dynamic:* The Semantic Web enables the use of knowledge provided in various forms, by a semantical annotation of content. Distributed nature of the Semantic Web enables continuous improvement of learning materials.

B. *Ontologies for eLearning*

In a typical eLearning environment authors or trainers produce their learning material in a way to match the eLearning platform's architecture, this leads to a situation that authors use different terminologies, in which case the combination of learning materials becomes difficult. This problem affects the information and knowledge retrieval problem due to the fact that both instructors and learners have different knowledge backgrounds. Therefore, a mechanism for creating a shared-understanding and terminologies is required. Ontologies are a powerful mechanism for achieving this task [11].

Ontology provides a critical role for eLearning systems to formally describe a shared meaning of a vocabulary and a set of symbols through a set of possible mapping between symbols and their meanings. In eLearning systems the shared-understanding problem occurs on many ontological levels, in which the description of documents can be mapped in several aspects.
The most important issues to be considered when a learner searches for learning materials are [1]:

- Content of the learning material
- Context of the learning material (pedagogical issues)
- Structure of the learning material, to make sure that the learning material does not appear in isolation.

So there are three ontological levels to take in consideration content, context, and structure [11].

content ontology describes the basic concepts of the domain in which learning takes place (e.g., history or computer science). It includes also the relations between these concepts, and some basic properties. For example, the study of Classical Athens is part of the history of Ancient Greece, which in turn is part of Ancient History. The ontology should include the relation "is part of" and the fact that it is a transitive property of an element. In this way, an automated learning support agent can infer that knowledge on Classical Athens can be found under Ancient History. The content ontology can also use relations to capture synonyms like ('creator' and 'writer'), abbreviations such as 'World Wide Web' and 'WWW'.
Contextual (pedagogical) issues can be addressed in a *pedagogy ontology*. Learning material can be presented in the various learning contexts, like, as lecture, tutorial, example, figure, walk-through, exercise, solution, and so on. It helps in context-relevant searching for learning material as per user needs. For example, if you are searching for detailed explanation of a topic, obviously we would have material which has given more examples.
Structure ontology is used to define the logical structure of the learning materials. E-learning is often self-paced environment, so training needs to be broken down into small bits of information, which can be tailored to meet individual needs and skill gaps. But these chunks of knowledge should be well connected to create the whole course. So, greater attention should be given to design the structure of e-learning materials. Typical knowledge of this kind includes hierarchical and navigational relations like *previous, next, hasPart, isPartOf, requires*, and *isBasedOn*. Relationships between these relations can also be defined; for example, *hasPart* and *isPartOf* are inverse relations. It is natural to develop e-learning systems on the Web; thus a Web ontology language should be used.

C. How to Build-up Ontolgies

The main part of ontology based eLearning systems are the users or specifically learners and instructors, the first issue to be considered when developing ontologies is the capture and documentation of the most basic functional requirements from readers' viewpoint. The steps involved in building-up ontologies are [23]:

- Identification of the aim and the scope of the ontology
- Reuse existing vocabularies
- Enumerating the most important terms in the ontology
- Defining the classes and their hierarchy
- Defining the properties of the classes
- Defining the features of the properties
- Creating instances

V. CONCEPTUAL E-LEARNING BASED ON THE SEMANTIC WEB

In order to be able to develop semantic eLearning architecture that provides high-level service for users looking for appropriate online courses, one must consider technical concepts and issues such as a ***knowledge base***, which is the core of the architecture. It plays the role of a repository where ontologies, metadata, inference rules, educational resources and course descriptions, user profiles are stored. The metadata may be placed within the document itself or in some external metadata repository (e.g. an RDF repository) [16]. Here the metadata are stored externally in the knowledge base. The advantages of external storage are: 1- it is easier to scan a separate meta-description stored in a database and it takes less space to store it, and 2- the point of view may vary according to different authors who reuse the same learning material. It means that it is possible to have different descriptions of the learning material according to the different contexts [23].
Search Engines which is another concept that needs to be considered. For it provides an API with methods for querying the knowledge base. Next is the ***Inference Engine*** which answers queries and is responsible for inferring new facts by an intelligent combination of facts already have in the knowledge base.
The ***Access Interface*** part provides an integrated interface through which readers as well as authors/ administrators of academic institutions can access, upload or modify the data with particular authority. And finally personalized searches, notification service, course annotation, etc. which all lies under the ***services*** criteria concept.
The above-mentioned concepts and technical issues can all be integrated and considered when developing semantic eLearning architecture to form the conceptual eLearning system based on the semantic web as shown in fig. 3.

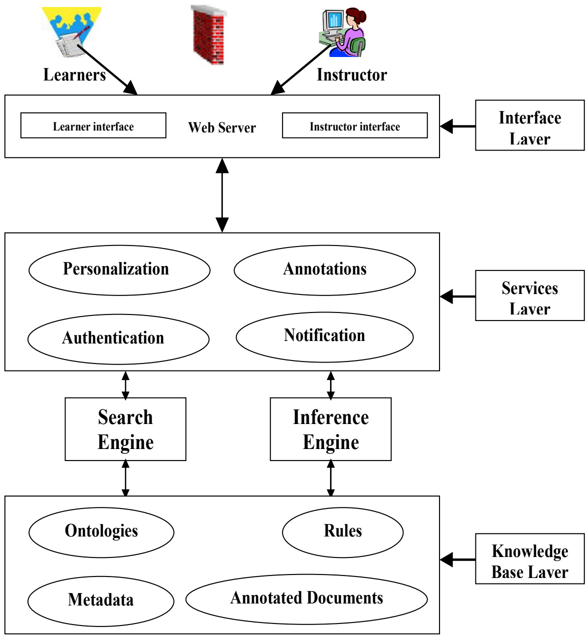

Figure 3 Conceptual eLearning architecture based on the Semantic Web [11]

VI. CONCLUSION

The Semantic Web is the emerging technology aiming at web-based information and services that would be understandable and reusable by both humans and machines. One of its primary component is ontology, generally defined as a representation of a shared conceptualization of a particular domain. It is expected that semantic web technologies will influence the next generation of e-learning systems and applications.
This paper discussed how the semantic web can help develop an eLearning platform which provides a common interface for learners, instructors, authors/administrators of academic institutions for accessing learning materials.

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