e-Learning System Overview based on Semantic Web

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Abstract: The challenge of the semantic web is the provision of distributed information with well-defined meaning, understandable for different parties. e-Learning is efficient task relevant and just-in-time learning grown from the learning requirements of the new dynamically changing, distributed business world. In this paper we design an e-Learning system by using a semantic web and show how the semantic web resource description formats can be utilised for automatic generation of hypertext structures from distributed metadata. It is primarily based on ontology-based descriptions of content, context and structure of the learning materials and thus provides flexible and personalised access to these learning materials.

Keywords: e-Learning, semantic web, ontology, education hypermedia.

1. Introduction

> *"e-Learning is just-in-time education integrated with high velocity value chains. It is the delivery of individualised, comprehensive, dynamic learning content in real time, aiding the development of communities of knowledge, linking learners and practitioners with experts" Drucker 2005).*

E-Learning aims at replacing old-fashioned time/place/content predetermined learning with a just-in-time/artwork- place/customised/on-demand process of learning. It builds on several pillars, vis. management, culture and IT (Maurer and Sapper, 2001). e-Learning needs management support in order to define a vision and plan for learning and to integrate learning into daily work. It requires changes in organisational behaviour establishing a culture of "learn in the morning, do in the afternoon". Thus, an IT platform, which enables efficient implementation of such a learning infrastructure, is also needed. Our focus here lies in IT (Web) technology that enables efficient, just-in-time and relevant learning. Table 1 shows the characteristics of the standard training and the improvements achieved using the e-Learning approach (Maurer and Sapper, 2001). e-Learning has its origins in computer-based training (CBT), which was an attempt to automate education, replace a paid instructor, and develop self-paced learning. But the focus of e-Learning is to extend and improve the users and business' needs (Barker, 2000). Key to success is the ability to reduce the cycle time for learning and to adapt "content, size and style" of learning to the respective user and their business environment.

Technologies have been enhancing education all the time and new technologies have always been utilised firstly by education, especially with the emerging of computer related information technology (Devedzic, 2000). Network education (including distance education, distance learning), or e-Learning with the growth of computer networking. Wireless and mobile computing have resulted in mobile education or m-Learning. With wireless and mobile technologies, it is possible to realise anytime, anywhere, anyway, any device for learning and educating. Implementation of the m-Learning involves adding mobile computing technologies into the old e-Learning system. Modifying old systems needs a lot of work: redesigning architecture and re-implementing the m-Learning system. In the meantime, a large number of universities will update their systems and many more educational resources will be ported to new systems.

Table (1): Differences between training and e-Learning (Maurer and Sapper, 2001)

Dimensions	Training	e-Learning
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 to business tasks and never stops

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Dimensions	Training	e-Learning
Authority	Centralised – Content is selected from a library of materials developed by the educator	Distributed – Content comes from the interaction of the participants and the educators
Personalisation	Mass produced – Content must satisfy the needs of many	Personalised – Content is determined by the individual user's needs and aims to satisfy the needs of every user
Adaptivity	Static – Content and organisation/taxonomy remains in their originally authored form without regard to environmental changes	Dynamic – Content changes constantly through user input, experiences, new practices, business rules and heuristics

2. e-Learning benefits

> *"The biggest growth in the internet, and the area that will prove to be one of the biggest agents of change, will be in e-Learning."*
> By:John Chambers, CEO, Cisco Systems

Many of the benefits of e-Learning derive directly from the drivers themselves, e.g., global reach consistency of message and ability to learn anytime, anywhere. But e-Learning in the corporate environments offers other benefits as well. First, e-Learning enables companies to update materials and information across the entire enterprise, keeping content fresh and relevant. This is especially important as product-development cycles continue to diminish, product modifications become more frequent, and company organisations and policies become more volatile. Second, online training also creates a personalised learning experience. Instead of daylong or weeklong programmers, the typical e-Learning course can be broken into one-hour modules, offering flexibility around training. Employees can adapt training to their own lives and learning styles, accessing material whenever it is convenient to review course material.

Third, e-Learning is ideal for global corporations with people in multiple time zones, there is no need to coordinate travel and delivery schedules. Global companies, however, do need to address language and localisation issues. Fourth, Internet-based training can reduce costs, with housing and travel costs accounting for the majority of the savings. Lost productivity and revenue from classroom training can actually be higher if one considers time spent away from the office. Finally, there is evidence that e-Learning benefits corporate operation. e-Learning on the whole, appears to offer many improvements, both in the tangible as well as the intangible world. Some of the other benefits can be summarised as shown in Table 2 (Rosenberg, 2001).

Table 2: Benefits of e-Learning

Benefits of e-Learning	
Information is consistent or customised, depending on need	Everyone gets the same content, presented in the same way. Yet the programs can also be customised for different learning needs or different groups of people
Content is more timely and dependable	Because it is web-enabled, e-Learning can be updated instantaneously, making the information more accurate and useful for a longer period of time. The ability to upgrade e-Learning content easily and quickly, and then immediately distribute the new information to users is extremely time efficient.
Learning is 24/7	Students can access e-Learning anywhere and at any time of the day. It's "just in time – any time' approach makes the learning process ubiquitous.
Universality	e-Learning is web-enabled and takes advantage of the universal Internet protocols and browsers. Concern over differences in platforms and operating systems is rapidly fading. Everyone on the Web can receive virtually the same material in virtually the same time.
Scalability	e-Learning solutions are highly scalable. Programs can move 10 participants to 100 or even more participants with little effort or incremental cost (as long as the infrastructure is in place).
Builds communities	The Web enables students to build enduring communities of practice where they can come together to share knowledge and insight. This can be a tremendous motivator for learning.
e-Learning lowers costs	Despite outward appearances, e-Learning is often the most cost effective way to deliver instruction or information. It cuts travel expenses; it can also reduce teaching time, and significantly reduces the need for a classroom/teacher infrastructure.

3. Learning theory

e-Learning associated with any learning that incorporated any form of technology. E-Learning used synonymously in dialogue concerning flexible distance learning. However with the recent surge to incorporate more computer technology into classrooms, at all levels.
e-Learning can be defined as all that activity utilising information transfer and knowledge utilisation during the learning process with particular attention to computer-based technology involving learning activities in relation to primary school classroom environment. Research on flexible learning has been driven by what many are calling the "information revolution". Research on Flexible learning is becoming increasingly more visible as a part of the higher education family. But the research and literature reviewed for this study indicate that the higher education community has a lot to learn regarding how and in what ways technology can enhance the teaching/learning process. The recent work on social cognition . . . has shown clearly that information is processed in wondrous ways, few of which are replicate of the original information . . . the gist of this more recent work is roughly that individuals, alone or in organisations, transform and use research in highly selective and strategic ways (Huberman,1987).

The perspectives on knowledge use described by Huberman draw from a learning theory known as constructivism, which has moved to the forefront of educational theory in recent years (Huberman, 1987). A learning environment begins now to look more like a mix between the teaching strategies based in a critical inquiry and the teaching conditions, which are thought to support the goals, which these strategies hope to achieve. While no learning environment is ever complete, therefore the sense of its completion must derive less from a necessity to deliver all that learners need and more from its ability to allow learners to integrate various models of reality in ways that enable their meaningful management (Checkland, 1991).

4. Information technology and knowledge

Knowledge cannot be stored in computers; it can only be stored in the human brain (Davenport and Prusak, 2000; Lytras, et al, 2002), knowledge is what a knower knows; there is no knowledge without someone knowing it. Knowledge is information combined with experience, context, interpretation, reflection, intuition and creativity. Information, which can be stored in computers, becomes knowledge once it is processed in the mind of an individual. This knowledge then becomes information again once it is articulated or communicated to others in the form of text, computer output, spoken words, or written words or other means. Six characteristics of knowledge that distinguish it from information:

1. Knowledge is a human act
2. Knowledge is the residue of thinking
3. Knowledge is created in the present moment
4. Knowledge belongs to communities
5. Knowledge circulates through communities in many ways
6. And new knowledge is created at the boundaries of old.

Knowledge acquisition must be viewed as a cyclic process where old information is taken on board, combined with new information and the user's experiences to create newer updated knowledge. This then in turn reduces the old knowledge to the information level, and the previously utilised information could eventually be even further rescinded - to the data level (Colbeck, 2003). Information technology can play an important role in successful knowledge management initiatives. However, the concept of coding and transmitting knowledge in educational organisations is not new: training and employee development programs, organisational policies, routines, procedures, reports, and manuals have served this function for many years. What is innovative in the knowledge management area is the potential for using modern information technology (e.g. the internet, intranets, extranets, browsers, data warehouses, data filters, software agents, expert systems) to support knowledge creation, sharing and exchange in an organisation and between organisations. Modern information technology can collect, systematise structure, store, combine, distribute and present information of value to knowledge workers (Nahapiet and Ghoshal, 1998).

The successful information technology can be integrated by the following four stages;

1. General Support; the first stage is general IT support for knowledge workers. This includes word processing, spreadsheets, and email. End-user tools are made available to knowledge workers. At the simplest stage, this means a capable networked PC on every desk or in every briefcase, with standardised personal productivity tools (word processing, presentation software) so that documents can be exchanged easily throughout an organisation.
2. Expand Accessible Information Sources; an information system stores information on who knows what in the organisation and outside the organisation. The system does not store what they actually know. A typical example is the company intranet. Information about who

knows what is made available to all people in the organisation and to select outside partners.

3. Advanced Information Sources; the system stores what knowledge workers know in terms of information. A typical example is databases such as Lotus Notes.
4. Expert Systems; information system uses information to simulate expert opinions. A typical example is the expert system: 'Knowledger'. Artificial intelligence is applied in these systems. For example, neural networks are statistically oriented tools that excel at using data to classify cases into one category or another.

5. e-Learning and semantic web

The great success of the current WWW leads to a new challenge: a huge amount of data is interpretable by humans only; machine support is limited. Berners-Lee suggests enriching the Web by machine-processable information, which supports the user in his tasks. For instance, today's search engines are already quite powerful, but still return too often too large or inadequate lists of hits. Machine-processable information can point the search engine to the relevant pages and can thus improve both precision and recall. To reach this goal the semantic web will be built up in different levels: Unicode/Unified Resource Identifiers, XML, RDF, ontologies, logic, proof, trust (http://www.w3.org/DesignIssues/Semantic.html).

The important property of the Semantic Web architecture i.e. (common-shared-meaning and machine-processable metadata), enabled by a set of suitable agents, establishes a powerful approach to satisfy the e-Learning requirements. The process is based on semantic querying and navigation through learning materials, enabled by the ontological background. In Semantic Web can be exploited as a very suitable platform for implementing an e-Learning system, because it provides all means for (e-Learning): ontology development, ontology-based annotation of learning materials, their composition in learning courses and (pro) active delivery of the learning materials through e-Learning portals. Table 3 shows the suggested advantages to the possibility of using the Semantic Web for realising the e-Learning requirements.

Table 3: advantages of using Semantic Web as a technology for e-Learning

Requirements	eLearning Semantic Web	eLearning Semantic Web
Delivery	Pull – Student determines agenda	Knowledge items (learning materials) are distributed on the web, but they are linked to commonly agreed ontologie(s). This enables construction of a user-specific course, by semantic querying for topics of interest.
Responsiveness	Reactionary – Responds to problem at hand	Software agents on the Semantic Web may use a 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 personalised agent that communicates with other agents.
Access	Non-linear – Allows direct access to knowledge in whatever sequence makes sense to the situation at hand	User can describe the 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.
Symmetry	Symmetric – Learning occurs as an integrated activity	The Semantic Web (semantic intranet) offers the potential to become an integration platform for all business processes in an organisation, including learning activities.
Modality	Continuous – Learning runs in parallel to business tasks and never stops	Active delivery of information (based on personalised agents) creates a dynamic learning environment that is integrated in the business processes.
Authority	Distributed – Content comes from the interaction of the participants and the educators	The Semantic Web will be as decentralised as possible. This enables an effective co-operative content management.
Personalisation	Personalised – Content is determined by the individual user's needs and aims to satisfy the needs of every user	A user (using its personalised agent) searches for learning material customised for her/his needs. The ontology is the link between user needs and characteristics of the learning material.
Adaptively	Dynamic – Content changes constantly through user input, experiences, new practices, business rules and heuristics	The Semantic Web enables the use of distributed knowledge provided in various forms, enabled by semantically annotation of content. Distributed nature of the Semantic Web enables continuous improvement of learning materials.

Ontology

An interesting clarification of the philosophical term ontology is provided by Guarino and Gitareta (1995). They summarised several common definitions of ontology is a specification of a conceptualisation, as depicted in figure 1.

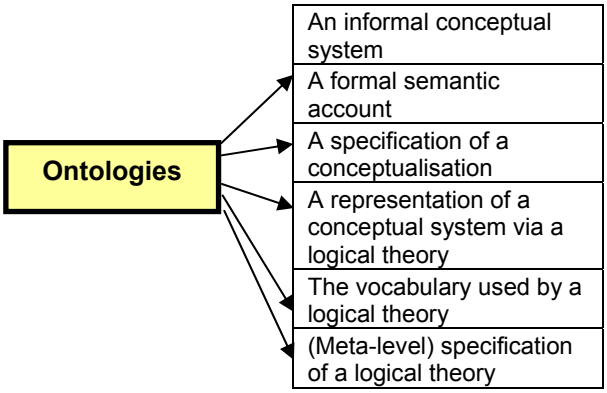

Figure 1: A basic classification of ontology

- An informal conceptual system
- A formal semantic account
- A specification of a "conceptualisation"
- As a representation of a conceptual system via a logical theory
    - Characterised by specific formal properties
    - Characterised only by its specific purposes
- As the vocabulary used by a logic theory
- As a (meta-level) specification of a logical theory

The ontology is to formally describe shared meaning of the used vocabulary (set of symbols) (Stojanovic, 2004; Noy and Klein, 2003). In fact, ontology constrains the set of possible mapping between symbols and their meanings. But the shared understanding problem in e-Learning occurs on several orthogonal levels, which describe several aspects of document usage, as sketched in figure 2. From the student point of view the most important criterions for searching learning materials are: what the learning material is about (content) and in which form this topic is presented (context). However, while learning material does not appear in isolation, another dimension (structure) is needed to encompass a set of learning materials in a learning course. The shared-understanding problem in e-Learning occurs when one tries to define the content of a learning document in the process of providing learning materials as well as in the process of accessing to (searching for) particular learning material.

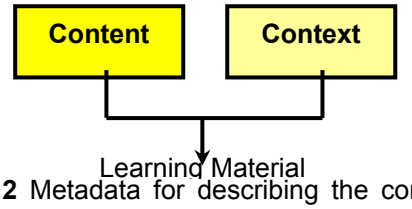

Figure 2 Metadata for describing the content of learning materials

Ontology as an informal conceptual system, figure 3 in the context of e-Learning means that we admit the presence of an (unspecified) conceptual system, which we may assume to underlie a particular knowledge base.

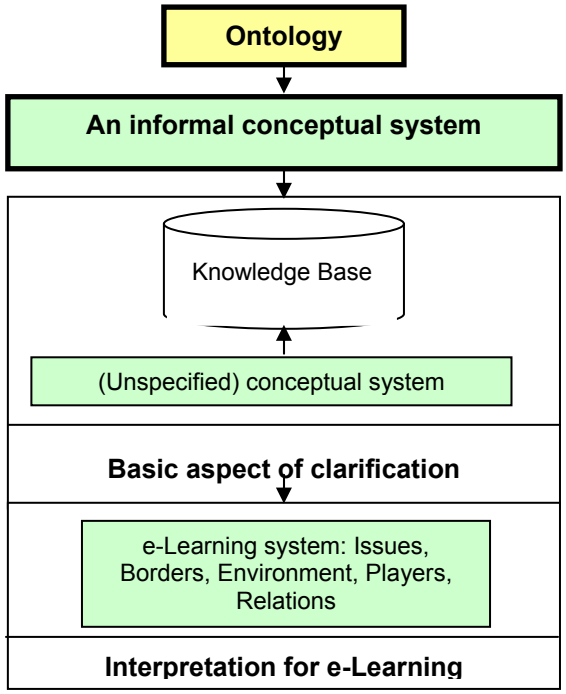

Figure 3: Ontology as an informal conceptual system

This is the common hypothesis in e-Learning implementations. An ontology as a formal semantic account, see figure 4, means that we analysed the phenomenon of e-Learning and we have concluded several semantic that formulate a value layer capable of exploiting knowledge sources semantically. The major problem concerning this interpretation of ontology is the complexity of e-Learning.

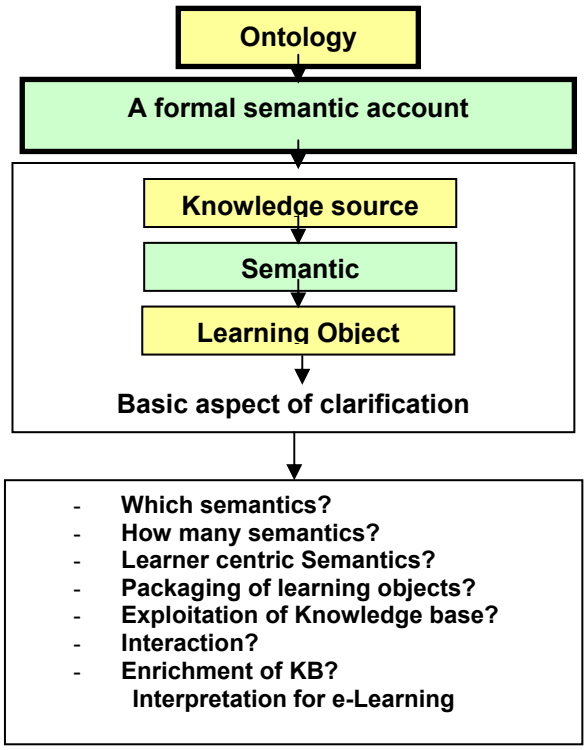

Figure 4: Ontology as a formal semantic account

6. Metadata

Metadata is structured information system describing resources, created to help in the task of discovering, managing and using them without the need to be read, viewed or explored in some way. Metadata is the total sum of what one can say about any information object at any level of aggregation, considering that an *information object* is anything that can be addressed and manipulated by a human or a system as a discrete entity (Gilliland-Swetland, 2005). Metadata enable effective search of resources across multiple repositories, since dealing with descriptive surrogates of resources is easier than dealing with the resources themselves. The use of a certain object by different communities can be facilitated by the existence of different metadata records describing it according to metadata schemes tailored to the needs of each community.

The e-Learning Hypermedia System envisaged to achieve adaptability needs to have not only the Hypermedia repository, also called Hyperspace, containing the HTML and XML, pages of e-Learning content, but also a repository containing knowledge about the domain to be taught, i.e., the Knowledge Space composed of the description of each elementary subject that conforms the knowledge space to be covered by the e-Learning content. The Content Knowledge Ontology is a structure of knowledge concerning the actual pieces of e-Learning content, capable of providing composition rules represented in a principled way to enable the configuration of complex learning objects tailored to the student's structure is based on standard metadata to enable interoperability and is encoded in a formal Web ontology capable of supporting reasoning services. The system must have a Student Model representing the knowledge concerning the profile of each individual learner which will be used at run time to decide which goals and preferences must be covered by the e-Learning content that the system provides to the learner. Such a student profile is also object to changes over time because of the student's activities. The student model was modelled and implemented as application ontology.

7. e-Learning system implementation

Figure 5 shows the block diagram of the e-Learning system implemented. Circles indicate activities while rectangles indicate obtained results. Arrows indicate the input or output results of activities. The Conceptual Model containing both the Student Model and the Knowledge Space Model was designed. Based on the Student Conceptual Model, the Student Ontology was designed in order to maintain a machine understandable repository with the student's profile. Based on both the Knowledge Space Conceptual Model and the Metadata Standard Specification, a Metadata Application Profile was designed intended to address the metadata needs for the e-Learning context of the particular project. Based on the identified Adaptability Requirements, the Content Knowledge Ontology was created to maintain the knowledge of each piece of the e-Learning content of the system. Also, the Domain Ontology was created based on the defined application profile and the scope and structure of the domain to be taught. Lastly, the process that automatically generates metadata instances describing the hypermedia repository elements in terms of the Knowledge Space Model was implemented and a procedure to augment the system's metadata by edition was also proposed and used.

8. Conclusion

Making content machine-understandable is a popular paraphrase of the fundamental prerequisite for the semantic web. In this paper we have presented an e-Learning system that exploits it in three ways, for describing the semantic (content) of the learning materials (this is the domain dependent ontology), for defining the learning context of the learning material and for structuring the learning materials in the courses.

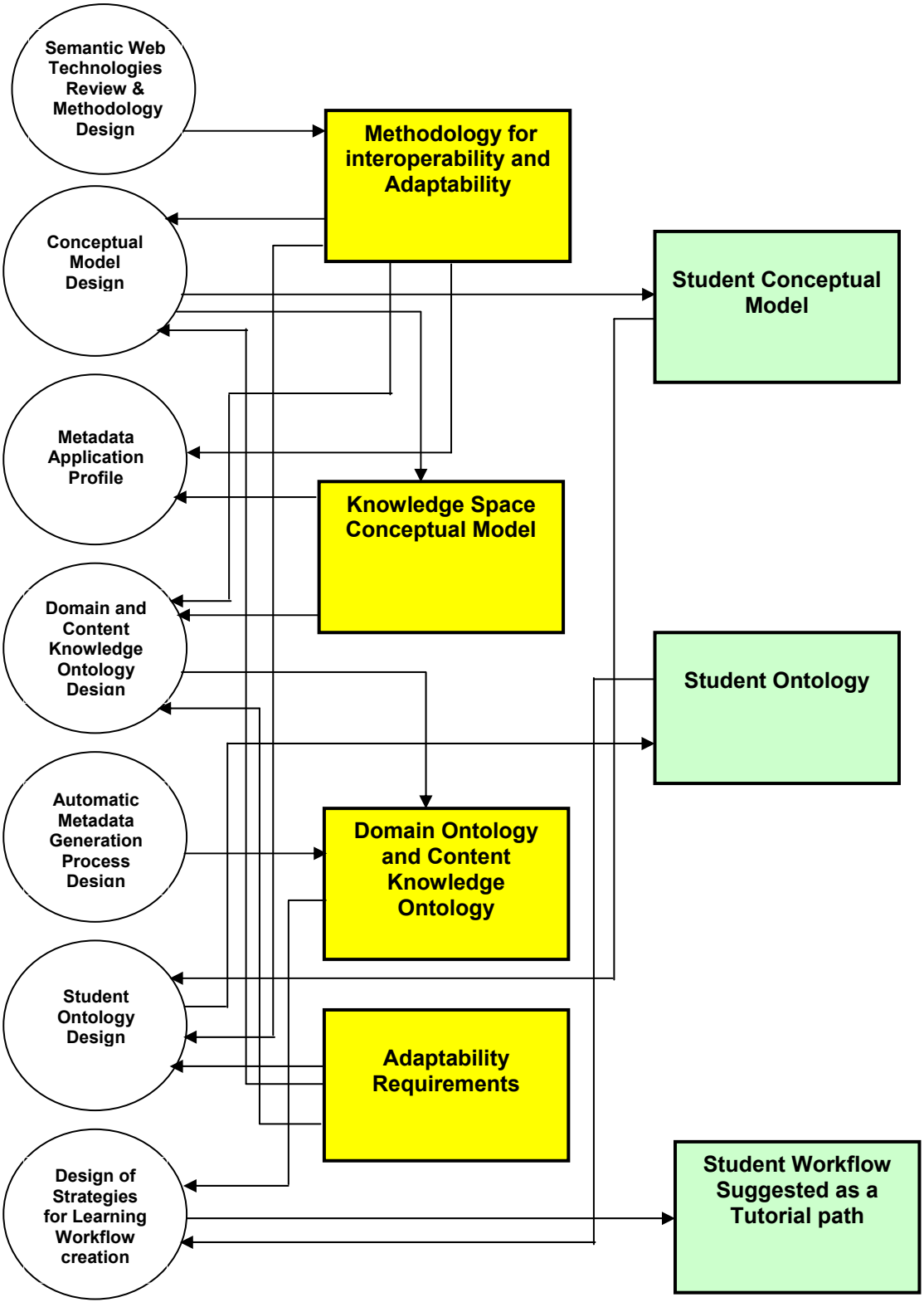

Figure 5: block diagram of the e-Learning system

The three dimensional, semantically structured spaces enable easier and more comfortable search and navigation through the learning material. Semantic Web is the backbone for e-Learning; a Semantic Web-based learning process could be a relevant (problem-dependent), a personalised (user customised) and an active (context-sensitive) process. These are prerequisites for realising efficient learning.

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