

Editorial

Advances of the Semantic Web for e-learning: expanding learning frontiers

The Semantic Web for the e-learning context

The advent of Semantic Web and its relevant technologies, tools and applications provide a new context for exploitation. The 'expression of meaning' relates directly to numerous open issues in e-learning. In this special issue the focus is twofold: on the one hand to stress the importance of Semantic Web towards systems that provide value to learners, and on the other hand to reveal research opportunities that can initiate interesting research and projects in the forthcoming years.

In the World Wide Web Consortium (W3C) Semantic Web activity, a list of priorities set the major challenges for the realisation of the next generation web: the creation of a policy-aware infrastructure, the ontological evolution, the promotion of a 'web of trust', and the facilitation of information flow and collaborative life.

Over the last few years, the huge amount of work in the context of Semantic Web from several official bodies and research groups has lead the research community to a mature level concerning strategic views, implementation strategies, technologies and frameworks. According to Eric Miller, head of the W3C Semantic Web activity (in Gruber, 2004):

The WWW2004 Web conference had a strong Semantic Web focus and reminded me of the second web conference in Chicago. Chicago, it seems to me, was a turning point, as everyone who attended realized that the web was not a fad, but rather something that was going to revolutionize how we communicate. The WWW2004 conference had a similar impact on me with regards to the Semantic Web. The technologies and toolkits are maturing. Semantic Web applications are becoming far more prevalent.

In the same vein, Amit Sheth stresses that 'Semantic Web technology is here to stay'. However, the most critical aspect is to focus on Semantics rather than Web, because 'If SW is too narrowly defined, ruling out anything that does not involve formal representation and inferencing, then it may not be in vogue for too long' (Sheth, 2004).

In this context, this special issue of *The British Journal of Educational Technology (BJET)* intends to serve as a reference point for all the researchers interested in the challenges that Semantic Web poses to e-learning in particular, and to learning and knowledge technologies in general.

The ultimate objective is obvious. Semantic Web research 'targets the enrichment of life through a major shift from focusing on computing to focusing on improving the human

experience—not only through better ability to use heterogeneous content and apply knowledge, but also by incorporating human perception and pervasive computing’ (Sheth, Ramakrishnan & Thomas, 2005).

The exploitation of Semantic Web in the context of e-learning requires a deeper understanding of the relevant issues. In Figure 1, we have summarised some key research themes related to the convergence of Semantic Web and e-learning. More specifically, we have used a matching of key issues that play a significant role in Semantic Web and e-learning research, and we have presented a set of research priorities. Three circular areas summarise the current research in semantic e-learning. For their discussion, we have used the following pairs, where the first part relates to the Semantic Web key issue and the second one to the e-learning key issue:

1. Expression of meaning–Content authoring. The direct relation of Semantic Web and e-learning combines the traditional content authoring process with the critical objective of expression of meaning. Issues like semantic mark-up, semantic retrieval, personalised (semi-) structured annotation and content conversion are prominent parts of a big research stream, in which the main concern is the development of semantic e-learning content.
2. Ontological evolution–Adaptive hypermedia. The traditional adaptive hypermedia considerations in e-learning have been combined with ontological engineering, and a lot of flexible systems and accompanied methodologies have emerged. Issues like ontology construction, ontology integration, conceptual modelling and semantic

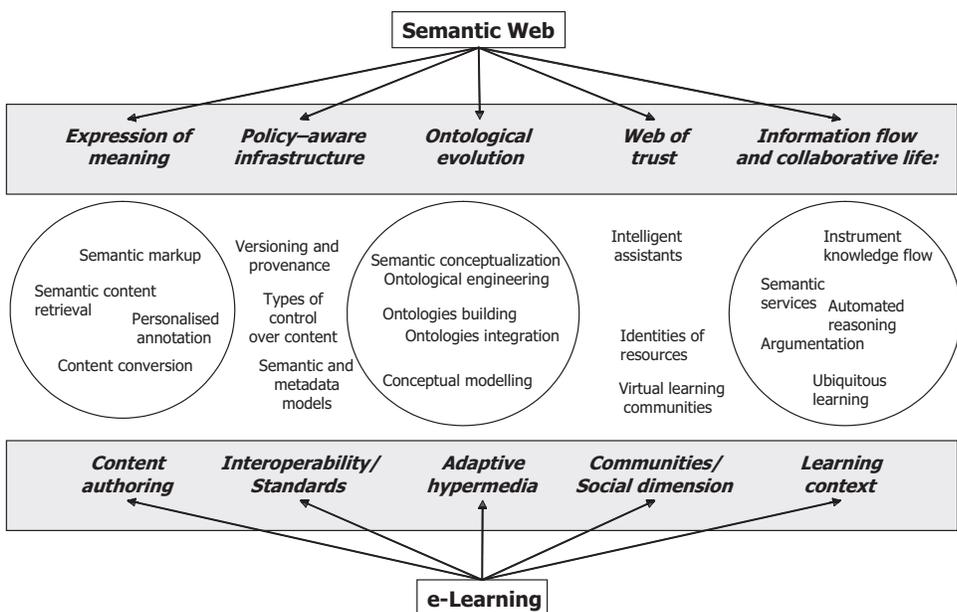


Figure 1: A Semantic Web–e-learning research issue correspondence map

conceptualisation reveal a new research agenda, in which the specifications of conceptualisations (ontologies) promote the performance of learning systems.

3. Information flow and collaborative life–Learning context. The instrumentation of knowledge flows has been included in the priorities of the W3C Semantic Web activity. According to Eric Miller, ‘one of the challenges we will meet is to strike a balance between on the one hand requiring authors to do more at the outset in order to make information machine processable, insisting that everything the machine could use to answer a question be recognized and identified by the (human) questioner, and, on the other hand, to leave large quantities of information inaccessible to the machine’. Within this area, semantic services, (semi-) automated reasoning and argumentation are critical themes on the semantic e-learning agenda.
4. Policy-aware infrastructure–Interoperability/Standards. The e-learning industry has demonstrated many achievements within the area of interoperability and standards, and from this perspective this industry recognises the need to secure a policy-aware infrastructure. The Semantic Web will only achieve its potential as an information space for the free flow of scientific and cultural information if its infrastructure supports a full range of fine-grained policy controls over the information it contains. The issues of different types of control over content, the compliance to semantic and metadata models, as well as the versioning and provenance of content, require extensive research.
5. Web of trust–Communities/Social dimensions. According to Eric Miller (2004): Trust in the human social context is based on constantly evolving and adapting information. Two parties may trust each other based on (1) a history of mutual interaction, (2) formal contracts that rely on other established systems (e.g. legal and legislative), and (3) risk analysis of a failure of any party to perform as agreed. In the e-learning industry this issue is of critical importance. The marketplaces of learning objects, the unique identification of resources and the development of intelligent assistants will require a Semantic Web language for describing trust. Within this area a lot of work has to be done over the next few years.

Presentation of the published papers

In the forthcoming years, Semantic Web will provide an interesting research context for the e-learning research community. The inevitable role of knowledge and learning in the knowledge society will be the driver of several Semantic Web-enabled services, tools and applications for citizens and learners.

Here, the e-learning research community has a critical role to play: it must create synergies and provide value systems for learning by exploiting the capacity of the Semantic Web. The maturity of the previous research in e-learning is the best enabler of research in this direction. Research in areas such as metadata and standards, adaptive hypermedia, learning communities, knowledge management, personalised delivery of content, and learning content annotation provide a significant level of readiness of the e-learning research community to exploit the benefits of the Semantic Web. A number of e-learning issues revealed over the past few years can be handled through Semantic Web practices, tools, methods and technologies.

In this special issue, we have invited submissions that fall into the following categories:

1. Preparation for semantic e-learning—semantic e-learning readiness. Within this category the main emphasis is on the conversion and the compliance of learning content to Semantic Web standards. In the current stage of the Semantic Web evolution this is basically pursued through the specification of ontologies and their use for e-learning. Typical themes include:
 - semantic annotation of learning objects: content/learner/context orientations;
 - methodologies for (semi-) automated conversion to semantic content;
 - semantic mining according to multi-criteria for learning performance; and
 - development of learner model ontologies.
2. Semantic e-learning. The realisation of semantic e-learning requires a multifold approach to vertical and horizontal issues. The international collaboration can promote such a goal, but it is evident that the success of the previous stage (semantic e-learning readiness) will influence the possibilities for successful and wide adoption of semantic e-learning. Some interesting research themes in this category include:
 - semantic e-learning portals: methodologies/frameworks/engineering;
 - semantic e-learning services: exploring resource identities for (semi-) automated value provision; and
 - semantic content repositories and intelligent assistants.
3. Next-generation e-learning. Undoubtedly, Semantic Web represents an important milestone towards our overall goal to support effective learning. Within the next years we think that the key challenge for the Semantic Web—as well as for e-learning—will be to develop infrastructures that are capable of exploring heterogeneously formatted learning content in an integrative way. This means that we will see a shift of focus, away from formalising and codifying learning content, and towards managing content in different formats through automated reasoning and delivering it through mobile and wireless networks, as well as through digital television channels. Some interesting research themes in this category include:
 - semantic multimedia content management: methodologies/frameworks/engineering, and
 - bridging semantic e-learning with ubiquitous and pervasive networks.

A tough blind review process (with about 15% acceptance rate) combined with a strategy of invited papers from well-known academics and practitioners within the field has resulted in a special issue that is of very high quality and relevance. We believe that the papers in our special issue tell the story of semantic e-learning in a way that highlights some of the most relevant issues of future research.

In the first paper, ***Semantic learning designs: recording assumptions and guidelines***, Miguel-Angel Sicilia from the University of Alcalá, Spain elaborates on the key theme of learning designs and provides new insights into relevant questioning. His main proposition is that behind learning designs, which are considered as representations of the results of the design process, there is a hidden but critical 'implicit design',

which concerns the theoretical standpoints, assumptions and guidelines that must be applied in order to come up with the concrete arrangement of learning activities. These latter elements are critical, not only for informative reasons, but also as a means towards the aim of connecting theories and hypotheses with actual practice, and analysing the resulting empirical data as a form of inquiry into the validity of theoretical assumptions. Using an ontological approach, this paper delineates the main aspects of a schema for the recording of such implicit design rationales.

In the second paper, ***An intelligent semantic e-learning framework using context-aware Semantic Web technologies***, **Weihong Huang, David Webster, Dawn Wood** and **Tanko Ishaya** from the University of Hull, UK present an excellent and novel context-aware semantic e-learning approach to integrating content provision, learning process and learner personality in an overall semantic e-learning framework. As the basis of this computational framework, a scalable and extensible generic context model is proposed in order to structure the semantics of contextual relations and concepts in various contexts, such as learning content description, learning model, knowledge object representation and learner personality. The corresponding technical and pedagogical developments of this framework also consider compatibility issues with respect to existing technologies (eg, XML/RDF) and specifications (eg, IEEE LOM) in order to achieve the best possible interoperability.

The third paper, ***Ontology mappings to improve learning resource search***, is written by **Dragan Gašević** and **Marek Hatala** from the Laboratory for Ontological Research in the School of Interactive Arts and Technology, Simon Fraser University Surrey, Canada. The authors provide an excellent approach to the subject. The present applications of ontologies in e-learning make use of various ontologies (eg, domain, curriculum, context, etc), but they do not provide a solution on how to interoperate e-learning systems based on different ontologies. The proposed solution uses a mapping ontology that is a part of a recent Semantic Web initiative called the Simple Knowledge Organisation System. In the paper, the authors describe two search algorithms that they have developed and implemented. They also present an evaluation of their solutions—in a system that helps students search for relevant learning resource using a local context (ie, course curriculum) ontology.

For the fourth paper, we have invited **Darina Dicheva** and **Christo Dichev**, from Winston-Salem State University, USA, who are well-known academics who conduct leading edge research in semantic e-learning. We are really very happy for their positive response. In their paper ***TM4L: creating and browsing educational topic maps***, they describe TM4L, an environment for building, maintaining and using standards-based ontology-aware e-learning repositories. TM4L is based on the idea that concept-driven access to learning material implemented as a topic map can bridge the gap between a learner and her or his targeted knowledge. One of the driving goals of this work is to increase the reusability of available educational resources by enabling the use of a developed subject ontology together with courses on the same subject that have a different structure. Another goal of TM4L is to support an efficient context-

based retrieval of learning content that is tailored to the needs of a learner working on an educational task. The paper focuses on three aspects of the TM4L environment: domain modelling, editing capabilities and the interface for exploring the learning collection.

In the fifth paper, ***Semantic-aware components and services of ActiveMath***, **Erica Melis, Giorgi Gogvadze, Martin Homik, Paul Libbrecht, Carsten Ullrich** and **Stefan Winterstein** from DFKI Saarbrücken, Germany provide a report on leading edge research from the ActiveMath project funded by the European Union (Framework Programme 6) on technology-enhanced learning. ActiveMath is a complex web-based adaptive learning environment with a number of components and interactive learning tools. The basis for handling the semantics of learning content is provided by its semantic (mathematics) content mark-up, which is additionally annotated with educational metadata. Several components, tools and external services can make use of that content mark-up, for instance a course generator, a semantic search engine and various user-input evaluation services. The components and services have to communicate, pass content and state changes, actions, etc, including mathematical semantics and educational mark-up. The novel event infrastructure of ActiveMath supports this communication. The paper focuses on the usage of the semantics of the content by different components and sketches the communication between them.

In the sixth paper, ***e-Learning for depth in the Semantic Web***, authors **Uri Shafir**, from the University of Toronto, and **Masha Etkind**, from Ryerson University, Canada, describe their Concept Parsing Algorithms, a novel semantic analysis methodology at the core of a new pedagogy that focuses learners' attention on deep comprehension of the conceptual content of the learned material. Two new e-learning tools are described in some detail: *Interactive Concept Discovery Learning* and *Meaning Equivalence Reusable Learning Objects*. These semantic technologies have been developed at the Ontario Institute for Studies in Education and at the Adaptive Technology Resource Centre of the Faculty of Information Studies at the University of Toronto. They have been tested since 2001 in several academic institutions in Canada and at the Russian Academy of Sciences. The authors describe the rationale for developing these instructional tools, their main characteristics, and the results of several evaluative implementations that demonstrate their potential to enhance learning outcomes and to provide authentic, credible, evidence-based formative assessments of learning processes.

The seventh paper, ***Towards a semantic e-learning theory by using a modelling approach***, is written by **Pertti Yli-Luoma**, from the University of Oulu in Finland, and **Ambjörn Naeve**, from the Royal Institute of Technology in Stockholm, Sweden. In this paper, a semantic perspective on e-learning theory is advanced and a modelling approach is used. This modelling approach is based on the four SECI phases of knowledge conversion: *Socialisation*, *Externalisation*, *Combination* and *Internalisation*, as introduced by Nonaka (1994), as well as on the SECI process framework developed by Naeve *et al* (2005) within the PROLEARN network of excellence for technology-enhanced professional learning. It involves two levels of knowledge—tacit and explicit. In the

Socialisation phase, the teacher–student–interaction activates the exploratory learning behaviour. This phase is emotionally and socially loaded. The Externalisation phase is partly emotional but a cognitive dimension is also needed, which requires creativity. Externalisation works optimally if it is collaborative in nature. In the Combination phase, an ability for hypothetical-deductive thinking is needed for the modelling approach. During the Internalisation phase, the learning process requires that students engage in seeking to understand and explain phenomena, which further demands testing of the theoretical concepts. The paper also includes examples of how these SECI knowledge conversions can be supported by different learning tools.

The eighth paper is ***A prototype semantic web-based digital content exchange for schools in Singapore***. Here **Paul Shabajee** and **Brian McBride** from the University of Bristol, UK, and **Damian Steer** and **Dave Reynolds** from the Hewlett-Packard Research Laboratories, Bristol, UK, contribute an excellent case study. Singapore has many large and educationally valuable digital collections and is planning to develop many more. These contain historical, cultural and scientific multimedia objects, along with various other learning objects. At present, schoolteachers and pupils find it hard to locate many of these resources using traditional search engines. This paper describes a research investigation into the design and subsequent development of a prototype digital resource discovery portal (Digital Content Exchange), based on Semantic Web technologies, and explores some of the educational issues raised. The presented research project has explored how the features of the Semantic Web could offer valuable educational benefits—beyond those based on existing information retrieval technologies.

Finally, as a concluding paper, two of the editors, **Miltiadis Lytras** and **Ambjörn Naeve** (Lytras & Naeve, 2006), provide a short essay entitled ***Semantic e-learning: synthesising fantasies***, where the monolithic approaches to technology-enhanced learning is criticised. They argue that semantic e-learning provides a critical challenge for the whole research community towards extended openness, exploitation of meaning and unforeseen opportunities for learning to the whole world.

The concluding remark is a call for a new learning generation primer. Synthesising fantasies is just a simple invitation to semantically define our commitment to collaborate and to agree on the technology-enabled services that bring learning to the forefront. The promotion of the knowledge and learning society requires an integration of the demand-and-supply side of knowledge and learning.

Epilogue

Addressing diversities of learners and in learning is one of the key research challenges addressed in the European Network of Excellence on Professional Learning PROLEARN, <http://www.prolearn-project.org>. The network integrates European research areas along four main topics: competencies and personalization, interoperability, collaborative learning, and business processes and learning. Knowledge representation is studied both from a human point of view—learning—and from a technical point of view—

learning support. Semantic web technologies play a central role for the latter. Knowledge integration and exchange have been studied for example in the context of smart spaces of learning (Peter Dolog *et al* 2004) or the definition of the Simple Query Interface (SQI) (Bernd Simon *et al* 2005) for learning repositories. Other work includes social networks, workplace learning, as well as advanced infrastructures for collaboration and knowledge transfer.

In a world that is increasingly depending on knowledge for its economic prosperity, the opportunities for learning are of strategic importance for our collective welfare. Although the overarching goal of life-long learning for all inhabitants of this planet is still far from being realized, we believe that the emergence of the Semantic Web provides real opportunities in this direction (Naeve, 2005). The challenge of using Semantic Web for the 'expansion of learning frontiers', alluded to in the title of this special issue, is therefore of critical importance for a globally sustainable future. Through the collection of papers presented here, we have tried to highlight some important technical achievements in this direction. However, although these advancements are quite impressive, technology alone will not be sufficient to achieve the planetary goal of an information society for all, a goal which requires us to deal with extremely difficult social, political and economic issues. The so-called 'digital divide' between the 'information-haves' and the 'information-have-nots' shows no signs of shrinking, and may in fact be widening. How to counteract this dangerous trend, and democratise the access to learning and knowledge, is therefore of utmost importance. Putting technology to use in creating equal learning opportunities for all, regardless of economic disposition, ethnic background or cognitive profile, would therefore be a very fitting theme for another special issue.

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