JIME Special Issue, Editorial and Introduction:

The Educational Semantic Web:
Visioning and Practicing the Future of Education

Terry Anderson and Denise Whitelock
Special Issue Editors

Terry Anderson, *Professor and Canada Research Chair in Distance Education, Athabasca University, #320 10030 107 St, Edmonton AB, Canada T5J3E4, terrya@athabascau.ca*

Denise Whitelock, *Institute of Educational Technology, The Open University, Walton Hall, Milton Keynes, MK7 6AA, UK, D.M.Whitelock@open.ac.uk*

1   Introduction

The "Semantic Web" is a term coined by Tim Berners-Lee to refer to a vision of the next dramatic evolution of web technology. He envisions forms of intelligence and meaning being added to the display and navigational context of the current World Wide Web (web). The Semantic Web is a long-range development that is being built in stages by groups of researchers, developers, scientists and engineers around the world through a process of specification and prototype instantiating these interoperable specifications.

Semantic Web based applications are being developed in all disciplines and professions, including education. Both formal and informal education are integral to all forms of human development. The information age, with its emphasis on knowledge growth and multiple forms of communication, is dependent upon citizens being able to learn effectively. The speed and incessant demand for change is forcing formal and informal educational opportunities to become more effective and efficient. Moreover, the social costs of neglecting education exacerbate schisms between those with opportunities for learning and those without. The "have" and "have not" effects are social costs that individuals, as well as society as a whole, can ill afford. The Semantic Web provides a long-term vision of opportunity for educational provision that is unbounded by geographic, temporal or economic distance. But is this vision attainable? If so, is the effort required to realize this vision commensurate with the potential gain?

I (Terry) first became interested in the semantic web from reading Berners-Lee's original works and following first generation developments of semantic web technologies in information science, e-business and health fields. I then began including the ideas in talks I gave at various conferences and forums in 2003. Naturally, I became curious about what other educators were doing with the semantic web and so Googled the term, "education semantic web". Much to my surprise and disappointment, I found that most of the references were to my own admittedly introductory and visionary comments made in these speeches. Where was the real work, innovation and actual prototype development? Fortunately, we were able to locate this type of work and we believe that most of the leading researchers in the area of the educational semantic web have contributed to this special issue. Of course, if we have missed your work, we welcome comments and URLs in the discussion areas of the special issue (see below).

2   Format of this Special Issue

The Educational Semantic Web provides a theme around which many futures and technological applications can be crafted. This Special Issue of JIME is an interactive, peer and public reviewed exposé, in academic terms, of the future of the Educational Semantic Web. The format of Special Issue builds upon the work of a 2003 JIME issue in which chapters from the book, "Reusing Online Resources: A Sustainable Approach to eLearning" were publicly reviewed by an international group of experts. The reviews sparked further commentary between reviewers, authors and the general readership.

This Special Issue will feature nine papers by invited, internationally renowned authors who have previously written about the effect of technology on education, learning and scholarship. Their interests and writing span distance education, higher education and lifelong learning. Each has shown capacity to write with vision and clarity that has garnered international attention. They were asked to create original articles that envision the future decade of education and learning based on their current work and interests in respect to the emergence of a global and intelligent Semantic Web.

The second component of the Special Issue is devoted to reactions to the articles written by some of the world's foremost educational practitioners with acknowledged leadership and competence in building educational systems based on the use of new technologies. Although the distinction between the two groups may not always be easy to discern, the authors of the commentaries were asked to review and comments upon one of the selected articles. The goal of the commentaries was to review the article with a critical eye towards practicality, training and support issues, cultural and economic barriers, implicit assumptions, and other issues related to the adoption of innovation

3   Visions of the Educational Semantic Web

The Educational Semantic Web is a developing and futuristic vision. As such, it has many enthusiastic proponents and an equal number of sceptics. In this introduction to the Special Issue, we highlight the promise of these technologies and conclude with the major arguments of the Semantic Web sceptics.

The Educational Semantic Web is based on three fundamental affordances. The first is the capacity for effective information storage and retrieval. The second is the

capacity for nonhuman autonomous agents to augment the learning and information retrieval and processing power of human beings. The third affordance is the capacity of the Internet to support, extend and expand communications capabilities of humans in multiple formats across the bounds of time and space. Advocates of the Semantic Web envisage its use to create very powerful new applications in nearly all disciplines, social and economic endeavors. However little has been written to date expanding on the promise and the current progress that applies these powerful affordances to educational contexts, challenges and opportunities. Thus, the rationale for this special issue.

3.1   Information Storage and Retrieval

We have rapidly become accustomed to a network in which search engines provide potential hits numbering in the tens or hundreds of thousands for many relevant and important terms. Daily, tens of thousands more web pages of information are added to the net. Yet, our capacity to find and retrieve, much less manipulate and organize this material is only at a very rudimentary state. The Semantic Web deals with this challenge by ostensibly allowing content to become aware of itself. This awareness allows humans and agents to query and infer knowledge from information quickly and in many cases automatically. Through the use of metadata organized in numerous interrelated ontologies, information is tagged with descriptors that facilitate its retrieval, analysis, processing and reconfiguration.

For example, a simulation could be created for the Semantic Web that tracks the cargoes of ships arriving with relief supplies for a famine-struck country. The cargo manifests are placed on the web as they arrive in a port. Linkages to daily commodity markets, consumption needs, transportation availability and other data can be read in real-time by development workers and students around the world. Different scenarios can be played out, informed by real-time interventions including environmental or political vagrancies. These scenarios then become artefacts of the Semantic Web themselves, providing content for future students of history, geography, development or logistics.

The capacity of the Semantic Web to add meaning to information, stored such that it can be searched and processed, provides greatly expanded opportunities for education, simulation and real-time action anywhere on the distributed network. Critics have argued that the creation of a single network of semantically related mark-up is foolishly ambitious, and unworkable beyond small and centrally coordinated communities – a characteristic that is anathema to the current web.

Work in this area requires the development of appropriately scaled ontologies, systems that relate and map different ontologies to each other and systems that learn and mine ontology connections through use and the development of working prototype systems.

3.2 Agents

Agents are Internet-based computer programs that are created to act relatively autonomously for extended periods of time. The Educational Semantic Web utilizes a variety of student, teacher and content agents to enhance the teaching/learning processes. For example, a teacher agent operating on the Semantic Web might undertake many of the routine administrative tasks that currently consume large amounts of teacher time. They communicate with individual student agents, tracking student progress, providing automated lists of resources such as tutorials, remedial help, and assisting scheduling and time allocation tasks. They schedule personal time between teachers and students to maximize the effect and affect of these interactions. Teacher agents will track professional interests of teachers relating to their field of subject expertise, developments in new pedagogies with active evaluation and testing of pedagogical interventions. Teacher agents will assist teachers in routine marking tasks, record keeping, and document control for assessments requiring manual effort. Student agents will assist learners in working collaboratively, finding sources of expertise and assisting students in documenting and archiving their learning products. A further capacity of the Semantic Web is realized when agents extract information from one application and subsequently utilize the data as input for further applications. In this way, agents create greater capacity for large scale automated collection, processing and selective dissemination of data.

However, these agents can only operate because the information on the web is endowed with semantic meaning in formats that can be read and processed by both agents and humans. Critics have noted that such personal agents have been "just around the corner" for over twenty years. Indeed, agents are the least developed of the three primary technologies of the Semantic Web, but continuous increases in processing power, coupled with increasingly automated tagging and organizing of content through information extraction techniques, gives promise for near future development of these technologies.

3.3   Communication

Despite the capabilities of agents, human-to-human communication will always be a major component of the educational experience. Proponents of the Semantic Web, argue that this communication will be even less constrained by barriers of time or place when the Educational Semantic Web is functional. We have had access to long-range and instantaneous communications since the invention of the telegraph in the 1850's. Further developments have added voice, video, and multi-point features to synchronous communications. All of these technologies have now converged on the web. Educational Semantic Web scenarios envisage the capacity to store, search, filter and otherwise process these human interactions. This allows interactions to be used and reused in a variety of educational applications. For example, students can process the content of commercial television advertisements to deduce strategic markers used to influence consumer behaviours. Furthermore, the Educational Semantic Web could add to our concepts of virtual presence by defining and structuring virtual reality environments and net-based enhancements to real work and study contexts. Developments referred to as "social computing" allow humans to make connections with others of like interest; coordinate activities, filter and recommend and otherwise assist fellow learners in acquiring and building new knowledge. Finally, semantic tagging of individuals and utterances will allow for shifting and sorting of appropriate individuals and content to filter and focus interactions.

Despite the capacity and promise of the Educational Semantic Web, there continues a debate regarding the capacity, efficacy and even desirability of using such technologies in educational contexts (Noll, 2002). Fears of privacy intrusions and questions of the value, costs and desirability arise. Questions relating to the pedagogical and necessity of extensive human interaction as a component of the educational process are largely unanswered or the subject of more epistemological debate than empirical research.

3.4   Challenges to the Educational Semantic Web

Like any expansive technological vision, the Semantic Web has attracted both valid criticisms and unsubstantiated denigration. These criticisms range from concerns with practicality and implementation to more fundamental challenges concerning the epistemological capacity of machines and humans to deal effectively with the same set of meaning-filled signs. Furthermore, concerns have been expressed relating to the interpretive power that can be shared across all human and machine cultures.

Beginning first with the practical issues, we note that the Semantic Web is much more complicated and difficult to implement than its HTML-based web precursor. I recall my first experience with web creation working with a group of gifted high school students during an afternoon in 1994. At the end of the session we had created and posted multimedia pages from a yearbook to the Internet, despite the fact that none of us had ever created a web page before. By contrast, after four years of work by the W3C (World Wide Web Consortium) and other global collaborations there are as yet no complete practical or commercial applications of the Semantic Web – much less a "killer application." The networked world of the 21st century is much more diverse than that to which Tim Berners-Lee presented the original web in 1994. Now, ventures in competing technologies such as web services and huge financial investments in systems such as .Net serve to fragment development efforts in competing systems and standards. Building the Semantic Web is much more complicated than just developing sites for the original display-orientated web. The comment found on a developer's discussion list that "either RDF is dumb, or I am" captures the frustration of many who see the vision but have not been equipped with the tools or techniques to allow them to exploit that capacity.

The means by which the Semantic Web will be created often spawns acrimonious debate and discussion. Harking back to Raymond's (2001) pervasive differentiation between construction of an emergent and self-organizing bazaar as opposed to an architected cathedral, Jack Schofield (2003) comments,

> For Microsoft and IBM, it's like designing a giant metropolis, laying out the roads, agreeing on traffic regulations, putting in plumbing, and so on. For the hackers, it's more like "let's build a city: everybody bring a brick."

Educators certainly no longer have the power or the will to create global information systems, and thus we are hostage to emergent technologies. However, it is unlikely that the Educational Semantic Web will be made useful unless and until it's end-user applications become simple enough to support useful learning experiences and activities controlled and created by ordinary teachers and students.

The vision of the Semantic Web is based on the capacity for machines to accurately locate, read, interpret and process data created by hundreds of thousands of different individuals and organizations. It has proven to be an extremely challenging task to develop data structures that impose enough structure to insure programmability without losing data or unduly confining the ways in which humans can express themselves. Prerequisite to the effective functioning of the Semantic Web is the existence of systems for defining, creating and deploying sets of identifies or tags that

describe and in some cases constrain the content on the Internet. These tags are organized and related to each other in the form needed for formally structured ontologies. The tags are used by both humans and agents to retrieve, process and otherwise manipulate information found on the Internet. It is becoming apparent from early work on large systems (such as Cyc) that it is unlikely that there will be a single unifying ontology under which all information can be classified. Fundamental questions related to cultural understanding, contextual variations, as well as semantic and ontological underpinnings of information, make the quest for such systems quixotical. However, work by groups such as the WC3's WebOnt group (http://www.w3.org/2001/sw/WebOnt/charter) to develop languages for creating multiple ontologies and systems to translate between systems based on common features of ontologies give promise to a workable system.

Beyond the technology is the human motivation for tagging and making knowledge accessible. In a scathing essay entitled "Metacrap: Putting the torch to seven straw-men of the meta-utopia," Cory Doctorow (2001) argues that people lie, are lazy, are stupid, have very little self insight and work in environments where there are many legitimate yet different ways to describe or tag anything. Thus, the challenge of tagging everything on the Internet in a set of coherent schemas is immense and obviously will not be done by professional cyber-librarians employed to catalogue books. Rather, systems are needed that allow tags to be acquired through use, that allow multiple tags to describe the same data and systems that harvest and capture schema and tagging systems automatically. Of course, this need is somewhat tautological in that a system of agents capable of doing this tagging, would need an existing Semantic Web in order to carry out their task. Thus, the Semantic Web is described and defended as a multi-year, if not a multi-decade, project. As hoped for, articles in this special issue (notably McCallum and Downes) point to ways that the meta-tagging problem may yet be resolved by increases in both automated and human input metadata.

For all the reasons cited above and others, there exists scepticism about the utility of the Semantic Web vision. This suspicion is especially pronounced in educational contexts where for many the educational transaction is an intensely human experience. For some, education is more accurately described as an artistic social interchange rather than one waiting for enhancement and possible substitution by a human-machine interaction. Nonetheless, the capacity to create powerful learning opportunities, accessible anywhere/anytime that maximize the use of content, social interaction and machine support is equally compelling to educators. Thus, this Special Issue was created to stimulate the debate and broaden the vision regarding the

role of advanced networking in education through the development of the Semantic Web.

Our hope is that educators around the globe will take the time to seriously read the articles and the responses in this special issue. Second, that you will take the time to respond with your own visions and concerns or post an appropriate question that will further our discussions. A final thank you to all the authors and the respondents for an effort that we believe is of critical importance on the road to creation of more accessible, high quality education and training opportunities for each of us.

4   Overview of the articles and commentaries

An overview of the semantic web and the special issue by Athabasca University's Terry Anderson and Denise Whitelock from the Open University of the United Kingdom.

Arthur Stutt and *Enrico Motta* Semantic Learning Webs: Stutt and Motta from the Open University of the UK begin their exposition of applications of the educational semantic web quite appropriately by detailing learner needs. Besides the obvious necessity for structure, authenticity and support they note the need for structural organization of the context of learning on the net. From there we move to explication of the critical role of argumentation that grounds both formal scholarship and informal learning. Can the semantic web help us make and defend our arguments? With the help of graphic knowledge browsers and other tools being developed at the Open University Stutt and Motta show us how global communities will build knowledge neighbourhoods and charts that document, share and stimulate their current and evolving knowledge base.

> Australia's Rod Sims focuses on the practical in his commentary – if (and when) we build the educational semantic web- will it make a difference? Sims notes that Stutt and Motta's knowledge neighbourhoods must do more than present knowledge- they must engage not only the highly motivated but the learner who is learning for a variety of reasons – many not directly associated with intrinsic interest in the subject. This variety of interest and engagement requires that we not assume that learners will create the type of knowledge communities that the technology can support. Sim's commentary ends with a warning to not just build systems that support and virtualizes the types of educational interactions and cognition that has defined education to date. Rather, we have to build for a world in which cognition and interaction with machines is fundamentally different from that which has marked our evolutionary history.

Gord McCalla: The Ecological Approach to the Design of E-Learning Environments: Purpose-based Capture and Use of Information about Learners   Gord Mcalla summarizes his extensive experiences and those of his colleagues at the University of Saskatchewan in creating artificial intelligence applications for educational use. In the article he presents a potential solution to the meta-tagging dilemma that confronts all those working with educational objects. Just how will all of the essential metatags be created and maintained and is there any way that these tags can be rich enough to meet the diverse and ever changing needs of thousands of potential users? McCalla's outlines an ambitious plan to create an 'ecological approach' to advanced e-learning applications in which content is tagged automatically in response to its use by users and furthermore how these 'evergreen' manifests can be matched to create personalized learning contexts. Creating McCalla's model will be complex and technically challenging, but it promises an educational semantic web that dynamically grows in response to practical uses and applications of real users. McCalla article provides an insightful introduction and vision of a semantic educational web that builds on the 30 years development of educational applications by serious computer scientists and maximizes the advantages of the emerging distributed tools of the web.

> In their response Leonie Ramondt, Tom Smith and Pete Bradshaw from the Anglia Polytechnic University's UltraLab describe how the type of living, ecological tagging and annotation of learning objects described by MacCalla needs the commitment and ownership of end users who add the necessary affective commitment to the learning process. This sense of collaborative and group commitment is seen as necessary to any sustainable vision of the educational semantic web. They also briefly describe the way human discussions can be re-used as learning objects using development tools for capturing and annotating discussion and classroom interaction needs.

Betty Collis and *Allard Strijker* Technology and Human issues in Reusing Learning Objects: Betty Collis and Allard Strijker, from the University of Twente, highlight two major issues, which they consider affect the reuse of learning objects. These not surprisingly fall into the realms of technological constraints and social or human interactions with learning object repositories. They suggest that discussions surrounding the wonders of the Semantic Web, as a change agent for teaching and learning, assume that the if the labelling or meta-tagging and other problems associated with the selection of learning objects is solved then real progress will be made. However they suggest that a number of other components in their 'life cycle' of learning objects merit attention as they too present a number of pedagogical

problems that can unwittingly be passed on to the user. Collis and Strijker welcome the development of intelligent agents which will enhance the automation of the Semantic Web but warn that learning objects are only a tool and that human sharing and collaboration take precedence in any meaning making process.

> Terry Evans who is key player in the current debate about the role of globalization, technology and distance education responds to the notion of object repositories as a form of 'instructional industrialism'. A notion he has developed with Darryl Nation which describes a 'behaviorist –inspired didacticism'. Evans suggests that learning objects may be viewed as the currency of this instructional industrialism. A sober thought but he does not go on to tell us where this leads us. He does warn of the dangers associated with the colonizing potential of new learning systems with their learning objects such as the Semantic Web. Perhaps this is an issue that should be debated in this Jime special issue?

Rob Koper: Use of the Semantic Web to solve some basic problems in Education. Rob Koper is best known for the ground breaking work he led at the Open University of the Netherlands in creating an educational modeling language that was incorporated in the IMS learning design specification. In this article he reviews seven of the most important technologies of the semantic web, thus providing a technical primer and overview of the technologies of the educational semantic web. He goes on to map these technologies with current problems (and opportunities in education) and finally overviews his current work that moves "beyond the course" to invision self organizing lifelong learning webs and communities.

> In his response, the University of Waterloo's Tom Carey challenges some of the promises (after all we've heard many before), and notes that a learning design needs to be more than a finished, static product, if it is to capture and express the dynamic knowledge of those create it. He also urges caution in overestimating the knowledge and understanding of learners that can be extracted by the tracings left by their progress through learning environments. It isn't quite as bad as interpreting the future by examining the entrails of birds, but both methods can produce error when we assume that actions equate to cognitions.

Stephen Downes: Resource Profiles. In this in-depth article Stephen Downes from Canada's National Research Council explores the manifold problems and at the same time the compelling need for metadata to help us find, annotate and effectively use

learning resources. Rather than taking the traditional tack of trying to standardize on a particular type and specification for metadata, Stephen argues for a much broader and more distributed system of meta-tagging in which a resource is described by many people for many uses. He also points to ways in which this distributed system of meta-tagging can and will be implemented across the web creating an organic and self-organizing semantic web. Regrettably, we were forced to reduce the length of Stephen's article to fit the format of a Journal article. Extensions to the ideas presented here are available at
http://www.downes.ca/files/resource_profiles.htm

> David Wiley from the University of Utah is perhaps the world's leading expert on the use, classification and re-usability of learning objects. He comments that Downes has done the field a favor by renaming learning objects (a term that continues to elude a consensus definition) as more general educational resources. Wiley also notes the inherent problems of reliability and falsehood that arise when multiple metadata descriptions are attached by multiple authors and users to any educational resource. As Downes notes one meta-description is far too few, but how we delete those that are obviously false, inaccurate or devised for selfish pecuniary reasons? Wiley also goes further than Downes in providing self-organizing examples, not from lower level activities such as neural cells, but providing examples from social organizations of humans in networked contexts. Finally, Wiley calls for IT efforts at creating human enhanced forms of semantic web education and not more sophisticated human less forms of automated training and education.

Heidrun Allert: Coherent Social Systems for Learning – An Approach for Contextualised and Community – Centred Metadata. Heidrun Allert, from the University of Hanover, continues the debate about metadata and the Educational Semantic Web. She proposes a new form of metadata, which is based upon the concept of a 'Learning Role.' This notion of role has been introduced to facilitate a dynamic modelling approach. Learning roles are indeed described as meta-roles, which in turn specify roles, together with the interaction between roles, and the properties that describe a role type. Allert's vision for the Semantic Web is based on a system that recognises the patterns and developmental pathways forged by these meta roles. She acknowledges that the learning Roles presented in this paper are 'far from complete' which leads to the question of what is a formal definition of a 'Learning Role'?

Paul Brna 's commentary on Alert's paper focuses on this very issue of a more formal definition for a 'learning Role'. Paul, from the University of Northumbria, calls for further clarification of this notion in order to understand whether a Learning Role does indeed have a recursive function. If it is recursive then which pathway can be identified through the learning roles by a model of this nature? Brna goes on to examine the strengths of Allert's model which he suggests lies in its diversity which is based on the acceptance that different communities of practice view events/things differently. He does however point out that the consequences of such a premise leads to a postmodern view of the world where we need many different ways of scrutinising events. This observation leaves us with his interesting deduction that the 'educational semantic web community may be following a path similar to that described by Perry (1970) on the development of students in higher education!'

Kendall, Clark, Bijan, Parsia and *jim Hendler*: Will the semantic web change education? In this article Jim Clark and his colleagues from the University of Maryland outline the way the Semantic web enhances the powerful hyperlinking of the original web to enhance both the research and the pedagogical functions of education systems. Many of us have heard the exuberant claims for the semantic web, but few of us understand just exactly how a machine can function to deliver these promises. The introduction to the semantic web technologies of RDF and OWL provide a technical yet understandable overview of the current tools being used to create the educational semantic web. The result, the authors, claim will be a techno-logical environment in which everyone can become a 'hyperkrep (hypertextual knowledge representation) hacker'.

In his response, notable distance education author and teacher, Greg Kearsley counters Clark et al.'s claims and notes that the average, very busy educator has many priorities beyond intrinsic interest in becoming a 'hyperkrep hacker'. He doubts that ordinary education systems will be changed by any technology that is more complicated than simple uni directional web links. In combination these two articles force us to look at the future, while at the same time noting how stuck in the past education systems remain – a dilemma that challenges this whole special issue and calls for continuing efforts to reduce this implementation gap and if we will live to see the educational semantic web in our life times..

Bernd Simon, Peter Dolog, Zoltán Miklós, Daniel Olmedilla and Michael Sintek Conceptualising Smart Spaces for Learning: Bernd Simon and his European

colleagues documents their work at building real applications of the semantic web – Smart Spaces for learning' in workplace learning context. In this context many educational services and resources must be made available to and customizable to the individual needs of diverse and distributed workforce. Such a challenge calls for interoperability across firms and learning designs (a common ontology) and a capacity for these diverse resources to respond to learners based upon their unique learner profiles. The result is a prototype personal learning assistant that attempts to search for and deliver electronic learning content and activities customized to a particular learner's needs and interests.

> Rory McGreal from Athabasca University notes that personal learning agents can not work in an environment which is not formally defined by a series of interconnected standards. He notes, with examples from his own work, the challenges yet the indispensability of common or at least commonly discoverable specifications for detailing activities critical to supporting online learning. These activities range from standards to identify and describe learning resources, to those that dynamically describe learner profiles and ways to adapt content display in response to unique learner needs.

Diana Oblinger: The Next Generation of Educational Engagement. Diana Oblinger's paper rounds off this special issue by drawing our attention to the young learners who will be using the Semantic Web. Diana Oblinger, the Vice President of EDUCASE, highlights the fact that the Net Generation is digitally aware and is exposed to a number of media that affects their expectations of e-Learning materials. In the United States playing computer games is part of college life but nearly two thirds of the cohort surveyed by Jones (2003) had little experience of the use of games as a teaching vehicle. Oblinger mentions the role of simulations in the teaching of Business Studies but there is also an increasing role for the use of simulations in the teaching of Science. One of the important features of gaming scenarios that she mentions is that they are performance based environments which she asserts stimulate the learning –by-doing approach which spills over into other fields of enquiry. So what fun and games should we expect on the educational Semantic Web of the future?

> Robin Mason from the UK's Open University notes that gaming builds on the skills acquired during informal learning. She encourages educators to capitalise on the growth of informal learning 'sparked off primarily by the Web' ' but warns against the costs of the development of high quality

multimedia learning materials. There is also a note of caution about the types of games the NetGen'ers are playing some of which are mindless and violent in nature. She does however make a strong claim for the skills and the approaches to learning that are acquired by the best game-users which she suggests reflects the new 'learning to e-learn framework' that will underpin the Semantic Learning Web.

5   References

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