THE SEMANTIC WEB IN TEACHER EDUCATION

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Abstract
The Semantic Web enables increased collaboration among computers and people by organizing unstructured data on the World Wide Web. Rather than a separate body, the Semantic Web is a functional extension of the current Web made possible by defining relationships among websites and other online content. When explicitly defined, these relationships can be interpreted by software including Web applications, online services and intelligent agents. Because it allows computers to understand the 'meaning' of Web-based information, the Semantic Web is sometimes referred to as the 'Intelligent Web'. This paper discusses the potential of the Semantic Web for teacher education.

WHAT IS SEMANTIC WEB?
The increasing availability and accessibility of information through the early years of the 21st century has had obvious benefits, but also poses a challenge to learners and educators. Sorting and evaluating information—rather than locating it—is now frequently a daunting task, requiring strong skills in information literacy and a significant investment of time and effort. The Semantic Web presents one solution to this information overload by organizing information meaningfully so we can retrieve what we want without getting lost on the Web.

Berners-Lee, Hendler and Lassila (2001) define the Semantic Web, also known as Web 3.0, as "not a separate Web but an extension of the current one, in which information is given well-defined meaning, better enabling computers and people to work in cooperation" (para. 8). Their early article drew attention to uses of the World Wide Web that were already a reality a decade ago, but were little understood outside of the computer science field (Czerkawski, 2012). According to Gutierrez (2008) "the difference between the World Wide Web and the Semantic Web relies on the integration and compatibility of information rather than just the interchange of files using the Web as the delivery system." (p.2).

For Maddux and Johnson (2011), the Semantic Web is "a proposal to use the existing Web to move data from place to place as it does today, but the data will be embedded in new and better markup languages" (p. 196). The evolution of markup languages such as HTML or CSS has been driven by the need to display increasingly rich media content to Web users. Newer versions of these languages focus increasingly on the structure, meaning and nature—the semantics—of the content being displayed.

Today, many educators (Maddux & Johnson, 2011; Morris, 2011; Anderson & Whitelock, 2004) are working to understand the significance of the Semantic Web. This paper presents arguments for the potential of the Semantic Web that can be applied to teaching and learning, and particularly to teacher education.

ADVANTAGES OF THE SEMANTIC WEB
Maddux and Johnson (2011) identify four innovative applications of information technology that will profoundly impact education. These are: computer and video gaming; social networking and Web 2.0; mobile and handheld technologies; and the Semantic Web. The first three technologies are increasingly well-understood by educators, but the Semantic Web is still "not well known outside of computer science and artificial intelligence circles" (Maddux & Johnson, 2011, p.195). The 2011 edition of the Horizon Report (Johnson et al., 2011) predicts that the Semantic Web will become more prevalent and prominent in educational settings in the next four to five years (Czerkawski, 2012).

The three advantages of the Semantic Web listed by Maddux, Liu, Li and Sexton (2011) are: "1) an aid to locating information, 2) an aid to data integration, 3) an aid to communicating and collaborating with others" (p. 3090). Anderson and Whitelock (2004) point out three similar affordances: "1) capacity for effective information storage and retrieval, 2) capacity to augment learning and information processing power, and 3) capacity to increase collaboration in multiple formats." The Horizon Report (2011) suggests several ways that the Semantic Web may be used in teaching and learning (Johnson, 2011, para. 2):

- Semantic portals that aggregate information from a variety of sources could facilitate research.
- A fully-developed semantic search tool could return results from a topical search with video, images, text, and other content aggregated and presented in a meaningful way.

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- As the amount of available information continues to grow, semantic tools that can deliver context-sensitive information will become key for research and sense-making (as cited in Czerkawski, 2012).

In other words, students will soon be able to locate, evaluate, manipulate, store and retrieve information more efficiently and effectively than ever before. This will in turn enable students to connect and collaborate with others based on shared interests in ways that were not previously possible. These analyses strongly suggest that Semantic Web has the potential to spur, and even require, innovative change in current educational environments (See Appendix for existing tools).

THE SEMANTIC WEB FOR TEACHER EDUCATION
Personalized knowledge retrieving and collaborative knowledge construction
One of the biggest advantages of the Semantic Web is its advanced search capability. The users can search the Web, retrieve easily meaningful information and sort out irrelevant data. This is made possible because the Semantic Web allows "its users to find relationships between tagged information using inference rules and data organizational tools called ontologies that provide logic and structure to the information embedded in web pages" (Ohler, 2008, p. 7). Greater organization of information—whether in simple hierarchies or more complex relational networks—will reduce the time and energy students spend sorting through unwanted information and resources.

The possibility of structuring data in this way does not mean that we are approaching a rigid or monolithic model for human knowledge. Indeed, the organizations most sophisticated with semantic metadata are technology companies like Google, whose business models rely on their ability to make information useful to people—and the clear trend among these companies has been toward personalization and customization (Liu, Yu & Meng, 2004).

Similar tailoring based on learners' interests, strengths and needs could be applied in teaching and learning environments. Teacher candidates arrive at teacher education programs from diverse backgrounds, with varying educational needs and learning capabilities. Semantic Web tools can give each teacher candidate or student the ability to process information at their own pace (Czerkawski, 2012). In this regard, Devedzic (2006) emphasizes that "learning modeling uses the learner's background knowledge, skills, aptitudes, motivations, learning and media preferences, mastery of content being taught, and learning progress to tailor the instruction to the learner" (as cited in Morris, 2011, p. 45).

Table 1: Semantic Web Tools for Teacher Education

Types	Programs	URL
Search Tools	ArnetMiner	http://www.arnetminer.org/
	Watson	http://watson.kmi.open.ac.uk/WatsonWUI/
	Hakia	http://www.hakia.com/
	Evi	http://www.evi.com/
Educational Repositories	Freebase	http://www.freebase.com/
	DBpedia	http://wiki.dbpedia.org/About
	MyExperiment	http://www.myexperiment.org/
	EPrints	http://www.eprints.org/
	DSpace	http://www.dspace.org/
Collaborative Databases		
	Semantic Wiki	http://semantic-mediawiki.org/
Data Visualization		
Social Annotation	Exhibit	http://www.simile-widgets.org/exhibit/
	GroupMe	http://groupme.org/GroupMe/
Scholarship Tools	AceWiki	http://attempto.ifi.uzh.ch/acewiki/
	MyMory	http://www.dfki.uni-kl.de/mymory/
	Talis	http://www.talisaspire.com/
Collaboration Tools	Debategraph	http://debategraph.org/home

Connected Content

The Semantic Web also has implications for what, and how, we teach future teachers. Learning objects are already richly tagged with precisely the kinds of metadata that the Semantic Web exploits. Carvin (2006) offers the example of "embedding metadata to content that connects it to specific education standards" (para. 10). This means that teacher educators or teachers can tag a resource as being connected to a specific academic standard, which itself can exist within one or more comprehensive taxonomies.

The Semantic Web makes it trivial retrieve this information when creating learning materials, enabling educators to find, use and even remix elements of multiple related learning objects. This flexibility can support large-scale repositories of pedagogy and teacher knowledge, as well as informal online spaces where teachers and teacher candidates can share and discuss learning scenarios.

Personal Learning Networks

Personal learning networks provide an entry point or gateway for users to learn from others with whom they share common interests. People connected through such networks point each other to learning opportunities, discuss ideas, and answer questions on an ad hoc basis that can be both synchronous and asynchronous. Participation in multiple overlapping or discrete learning networks frees up learners' time for thinking, creating and using relevant information rather than trying to find it. As Ohler (2008) points out "the objective is to spend less time searching for information and more time trying to understand, critically assess and creatively expand it" (p. 9).

The Semantic Web can facilitate personal learning networks both for students and teacher educators. The current Web is organized around services, rather than professional or learning goals. A teacher candidate who wants to share school-based experiences with his or her peers, or a first year teacher searching for answers to a question, must fit their needs to match the available information sources. The Semantic Web offers the inverse: information sources tailored to educators' needs.

Administrative Use

With the help of Semantic Web teacher educators can free up significant time, which can be used for instructional purposes. Anderson and Whitelock (2004) contend that intelligent agents will help faculty members to "track professional interests of teachers relating to their field of subject expertise, developments in new pedagogies with active evaluation and testing of pedagogical interventions" (p.4). More prosaically, such agents can assist in administrative tasks such as scheduling, student tracking, and advising.

CONCLUSIONS

The Semantic Web is in the early stages of development, and is not yet widely visible in teacher education programs (Czerkawski, 2012). Maddux and Johnson (2011) note that "[the] Semantic Web requires that developers construct Web 'ontologies'" (p.198); Stutt & Motta (2004) add that "[t]he Semantic Web will not be fully realized until a range of applications is built on top of these ontologies" (p. 10). Stutt and Motta go on to predict that the increasing semanticization of the Web will initially result in superficial products that do not reflect the potential of a fully Semantic Web.

Although one of the great promises of the Semantic Web is greater flexibility in identifying and accessing information, the ontologies underlying it are themselves quite inflexible. According to Devedzic (2004), the Semantic Web requires "information in a precise, machine-interpretable form, ready for software agents to process, share, and reuse it, as well as to understand what the terms describing the data mean" (p.40). In other words, "in order for this new technology to work correctly and efficiently, however, current methods of obtaining and structuring information must be standardized and available for access by a multitude of computer agents and people." (Gutierrez, 2008, p.2).

It is unrealistic to expect teacher educators to create time-consuming and highly technical resources, and so we currently exist in a holding pattern: waiting for these tasks to become faster, simpler and more immediately applicable to the needs of ordinary users.

In education, social interactions are critical to the quality of learning and teaching. No matter how promising, a poorly designed or implemented use of the Web will not enjoy an enthusiastic reception from teachers and students. The Semantic Web offers many possibilities, but in the area of teacher education, the path from possibilities to useful implementations can be long and winding. Faculty will wait for the technology and best practices surrounding the Semantic Web to mature before adopting them. On the bright side, as Ohler (2008) points out, for the first time we will see a foundational shift in technology before its actual arrival. "With the

Semantic Web being both inevitable and slow to develop, we can begin discussing possible learning scenarios that might emerge once it arrives" (p.9).

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