Semantic Wiki: a collaborative tool for instructional content design

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Keywords: learning content design, collaborative learning, semantic wiki, semantic web

The rapid evolving of web technologies has brought to the increasingly diffusion of applications making the Web an interactive social network environment. The World Wide Web Consortium and several research centers are working on the integration of such technologies into the project of a Semantic Web. Consequently, e-learning systems and tools supporting instructional content design could take advantage of these advancements. In this scenario, according to a social-constructivist approach, the authors discuss the adoption of Semantic Wiki as a collaborative environment to design educational contents. The paper will outline the application perspectives and the strategies to adopt, in order to facilitate meaningful learning processes, and the potential advantages that Semantic Wikis would bring from the point of view of knowledge management, as well as for the re-use of learning resources.

for citations:
Coccoli M., Vercelli G., Vivanet G. (2012), *Semantic Wiki: a collaborative tool for instructional content design,* Journal of e-Learning and Knowledge Society, v.8, n.2, 113-122. ISSN: 1826-6223, e-ISSN:1971-8829

1 Introduction

Since the original idea lying behind the Web, as expressed by Berners Lee (2000), it was clear that the Semantic Web would be characterized by the preeminent role of users and their social interactions:

I have a dream for the Web […] In the first part, the Web becomes a much more powerful means for collaboration between people […] In the second part of the dream, collaborations extend to computers. Machines become capable of analysing all the data on the Web […] the Web will be a place where the whim of a human being and the reasoning of a machine coexist in an ideal, powerful mixture.

However, such a Social Web[1] is not yet completely implemented and the *World Wide Web Consortium* (W3C)[2] is working on the definition of relevant standards. In the meantime, twelve years after that dream, the Web has become the most extensive network of information ever. Nowadays, it can be regarded as a complex "social ecosystem", the so-called "Web 2.0", where people can interact and share their files, as well as their personal experiences and thoughts.

Contextualising the vision of Berners Lee, we can assume to live currently in the second part of his dream about the Web. Nevertheless, we have to wonder whether we are acting in a (*Social*) *Semantic Web* rather than in a *Social* (*Semantic*) *Web*. It is worthwhile to notice that parentheses make the difference: in the first case, the extension of proactive collaboration capabilities to machines can be considered as an evolution of ontologies in the direction of the social consensus; in the second case, it could be considered as the origin of a "Web 3.0" in which automatic reasoning is implemented into *social networks*. In both cases, the Semantic Web suggests new appealing perspectives for both technologists and educators.

In this framework, the term *semantic* recalls a formal and standardized representation of nature and meaning of digital contents, and their mutual relationships. The "social consensus on data" can be achieved by means of metadata, adopting commonly recognized schemes and categories, thereby creating an explicit and shared knowledge model with a well-defined formal representation. The key to such a representation is the use of ontologies, in other words terminological systems and conceptual schemes, which allow the definition of an exhaustive and rigorous representation model for a given knowledge domain.

[1] W3C Social Web Incubator Group - http://www.w3.org/2005/Incubator/socialweb

[2] The W3C is an international consortium whose mission is to lead the Web to its full potential by developing protocols and guidelines that ensure the long-term growth of the Web - http://www.w3.org/

Ontologies permit to express web data in a machine-understandable format, thus enabling their transformation into social shared knowledge.

Accordingly, several authors investigated the application of Semantic Web technologies to educational contexts (Aroyo & Dicheva, 2004; Sampson *et al.*, 2004; Bianchi *et al.*, 2010; Vercelli & Vivanet, 2012). Following this line of research and conforming to a social-constructivist approach, this work presents an analysis on the usage of *Semantic Wikis* to design learning contents in a collaborative way.

2 Semantic Wiki for learning

The foundational basics of wiki platforms are the "social consensus" and the active collaboration among users (Jung, 2012). Yet, they do not easily allow re-using the inner knowledge. Such a limitation is due to the fact that wiki contents are not easily *machine understandable*: even if they are text-based, due to the lack of a formal structure, they are not. As a consequence, with the aim of empowering Wiki functionalities, semantic structures have been adopted, transforming wiki platforms[3] in *Semantic Wikis*.

The main feature of Semantic Wikis is having Semantic Web technology embedded, while holding the classical Wiki interaction model (Cunningham & Leuf, 2011). In fact, Semantic Wiki enables the semantic annotation of Wiki contents within the single wiki pages and the definition of meaningful relations, in a machine understandable format (Krötzsch *et al.*, 2007). For instance, Semantic-MediaWiki (SMW, a semantic extension of MediaWiki) allows to formally and explicitly represent knowledge content in a simple way, by means of the following construct:

```
[[Property::Value | Display]].
```

Thus, if we want to state that *R.L. Stevenson* is the author of "*Strange Case of Dr Jekyll and Mr Hyde*" within the "*Robert Louis Stevenson*" wiki page, the syntax of the semantic relation will be as follows:

```
[isAuthorOf:: Strange Case of Dr Jekyll and Mr Hyde]]
```

(the machine-understandable *Value* could even be different from the *Display*, which corresponds to the human-understandable text).

Since their origin, Semantic Wikis drew the e-learning specialists' attention (Schaffert *et al.*, 2006). In particular, the use of such systems in both the *lear-*

3 The first Semantic Wikis have been developed only recently, between 2005 (Semantic MediaWiki) and 2006 (Ontowiki). In this year, there was the first international conference, named "SemWiki2006", about them.

ning process and the *content creation and reuse* has been investigated (Bichiri, 2011), illustrating that Semantic Wikis are valuable tools to support learning activities for many reasons. Specifically:

The semantic annotation process leads to think over the knowledge. Wiki pages can be augmented with semantic annotations, creating a better representation of the specific domain of knowledge, stirring up further reasoning on the learning content. The definition of a formal model requires structured contents. Consequently, learners are forced to redesign the wiki content organization after a deep analysis. Moreover, changes recorded in the chronology can support teachers in the assessment phase, to evaluate the achievement of learning goals.

Sharing different perspectives. Semantic Wikis give teachers and learners the opportunity to share their viewpoints, by participating to the collaborative construction of a common knowledge domain model. Thus, learners can greatly benefit from knowledge sharing, through the observation of a topic from different perspectives.

Reasoning and discovering. Semantic Wikis can support automated reasoning and inference capabilities, facilitating the emergence of new knowledge that is not directly encoded into the Wiki by authors.

Besides, semantic wiki platforms have some strengths from the point of view of the content management process too. Among the many advantages, we cite the following:

Ascribing a type to a link results in an added value to the collaborative content creation process. Semantic Wikis allow classifying wiki pages contents as well as their associations (ascribing a type to a link), resulting in a further level appended to the knowledge structure. As a consequence, contents are reusable in a more comfortable way and their creation process is more powerful.

Reusability. Semantic Wiki contents can be used to realize more complex learning objects, which can be further annotated using standardized knowledge models, such as *IMS Learning Design Specification*[4] or *IEEE Learning Object Metadata* (LOM)[5]. The availability of annotated objects enables instructional designers to reuse and merge existing contents for the definition of new learning modules.

Interoperability. Semantic Wikis use standardized languages and models defined by the W3C, in order to guarantee interoperability. Generally speaking,

4 http://www.imsglobal.org/learningdesign/

5 http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf

it is possible to import and/or export data, which are encoded in XML (*eXtensible Markup Language*) and/or RDF (*Resource Description Framework*)[6].

3 The instructional content design

Regardless the variety of learning content design models available in the literature, the instructional content design process is generally based on two levels of granularity (Trentin, 2001): *(i) macro*, which has the aim of defining both the domain of knowledge and the teaching units and modules; *(ii) micro*, which gives detailed definition about the content of single teaching module.

Consequently, and according to the model of social constructivism (Varisco, 2002), teachers and students can cooperate, at design-time, thus enabling the generation of meaningful learning processes (Ausubel, 1963). Besides, this can support students in defining their view on a given domain in a collaborative way. Starting from these premises, we discuss the usage of a Semantic Wiki system as a platform for the collaborative design of educational content.

As is well known, the definition of educational contents (key topics in a given learning path) is based on the preconceived learning objectives. These latter can be identified by the teacher (even in collaboration with students) following well-established hierarchical models such as, e.g., using a taxonomy (Bloom, 1956; Anderson & Kratwohl, 2001). Then, the organization of learning content will be specified (Fig. 1), based on the objectives scheme. A typical situation is having contents made of learning units and one or more levels of modules, so that every objective is associated with one or more contents.

Fig. 1 - The correspondence between learning objectives and contents.

With the aim of enabling a meaningful learning, the structure of contents must be defined conforming to established educational principles, also taking into account that the chosen taxonomy can lead to different learning paths (Auth *et al*., 2012). According to several researches such as, e.g., the work of Ausubel (1963), Novak (2001) and the National Academy of Sciences (NAS, 2000),

[6] XML: http://www.w3.org/XML/. RDF: http://www.w3.org/RDF/

learning is facilitated when relevant connections between newly acquired notions and the pre-existing knowledge are established. Moreover, a number of researches on memory strategies (in Legrenzi, 1997; Tulving & Craik, 2005) highlight that the capability of storing new information is enhanced when people transform complex data in simpler ones, also defining some categorization criteria to be used to retrieve information. Hence, from the educational point of view, a good strategy is organizing the content top-down, from abstract concepts, able to provide the *advance organizers* defined by Ausubel. These will be used by the students, to link their knowledge with newly acquired information. Then, they will be defined with more detailed concepts. At this stage, cooperation among students is crucial, since the activity is oriented to "anchor" the content structure to their own knowledge basis.

Within a semantic enabled working environment, the content taxonomy can be defined by means of an *ad hoc* ontology. With reference to a Semantic Wiki system, the hierarchy of categories[7] can be exploited to let students cooperate in building the desired content structure (Fig. 2). Accordingly, a draft schema of learning contents will be available.

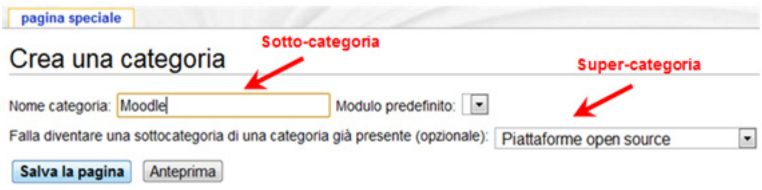

Fig. 2 - How to create categories and sub-categories within a wiki platform.

Next, after the *macro*-structure for the contents has been defined, cross-relations can be identified. To this aim, Semantic Wiki systems are well suited. In fact, they allow defining relations (property) between contents with an easy-to-use syntax, which can be compiled by people without technological expertise too.

As an example, figure 3 shows some properties (underlined) defined within a page describing the Moodle platform. Through this page one can find that: Moodle is acronym for *Modular Object-Oriented Dynamic Learning Environment*; Moodle is an e-learning platform; Moodle is released with the GNU General Public Licence; Moodle is inspired to social constructivism principles; and, lastly, Moodle has tools to create blog, wiki, and chat.

According to the above-cited relations, the Semantic Wiki system allows exploring contents, driven by concepts. Figure 4 shows how it is possible to

[7] This feature is available in "traditional wikis" too.

jump from the Moodle page to the social constructivism, by following the link *basedOnLearningTheory* as well as how to reach the GNU General Public License, via the link *hasLicense*. This way, the network of hypertext links permits to draw personalized learning paths, from different points of view.

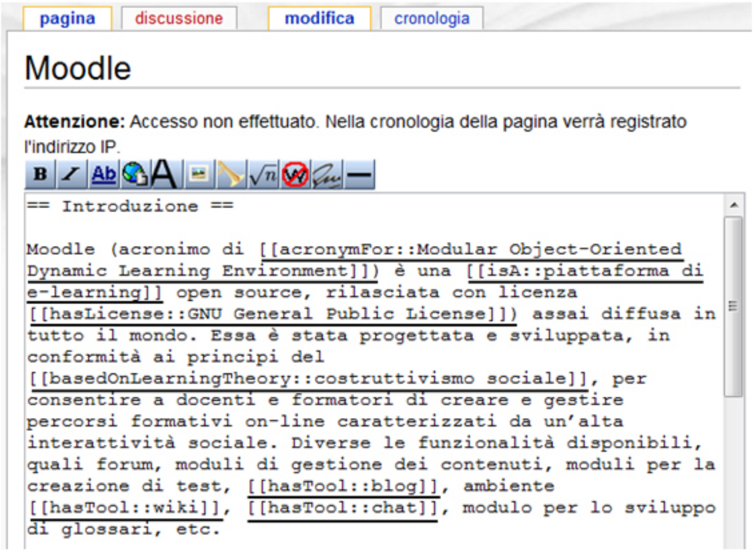

Fig.3 - The syntax of a semantic wiki page, describing the Moodle platform, with the underlined properties.

Fig. 4 - Exploring semantic wiki content by concepts.

In this perspective, we notice that the educational potential typical of the hypertext is at the basis of the Cognitive Flexibility Theory (Spiro *et al.*, 1988), since it can guarantee the instructional paths flexibility (Calvani, 1998). We underline that a Semantic Wiki is much more than a hypertext system. In fact, an underlying network of meanings drives navigation through concepts, aiming to enhance the comprehension ability on a given domain, rather than the mere storing of meaningless data.

Furthermore, the properties, properly defined, can be exported in RDF format enabling advanced search[8] capabilities within the Semantic Wiki pages such as, e.g., "*find the e-learning platforms released with GNU Public License, with a blog as a tool*". The "export ontology in RDF" feature enables the reuse of the ontology itself, which can even be modified, in different systems compliant with such a representation model.

As a final remark, we notice that results of a previous experimentation (Coccoli *et al.*, 2012) suggest finding a common vocabulary of the relations, prior to define the properties. This can prevent the risk of having to cope with the problem of non-uniform terminology at a later development stage. Besides, such a discussion is necessary to have a common view on the meanings of relations. The specific *discussion area* associated with every page of the Semantic Wiki is a simple and good tool to talk through and to negotiate common solutions on both contents and relations. In fact, every property definition triggers the creation of a related special page to describe its meaning and to start relevant discussions.

Conclusions

To conclude, we observe that Semantic Wiki systems have to be considered as a sound solution for educational purposes, mainly due to the fact that they support collaboration while designing and developing learning content. This allows the increase of knowledge and skills both cognitive and meta-cognitive, induced by the process of creation and sharing of concept networks, corresponding to a specific domain. Such a development process will be a work in progress, part of a continuous design activity, including negotiation of meanings, within a learning community.

These principles have been tested with groups of students in "Communication Science" at the University of Genoa and the published results have shown both positive elements and criticisms (Coccoli *et al.*, 2012). Discussing these results is out of the scope of the paper. Nevertheless, we point out that the majority of the participant students have put in evidence the easy way of

8 With this aim, the SPARQL Protocol and RDF Query Language (SPARQL) has been defined. URL: http://www.w3.org/TR/rdf-sparql-query/

collaborating to the co-construction of the educational content that was the subject of their work. However, to be able to perform a quantitative assessment, a new activity has been launched, in which a new team of students has the task of re-designing the above-cited contents, outcome of the previous experimentation phase. The teacher will be able to evaluate their degree of involvement and participation, their individual activity and the mutual characteristics of the proposed work.

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