

Nuggets of Knowledge on the Semantic Web

A Story of Fusion in Contemporary Knowledge Building Environments

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Declaration

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work and has been submitted not as an exercise for a degree at this or any other university.

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Acknowledgments

Abstract

Collaborative knowledge building stresses the importance of interactions and discourse among learners in the construction of knowledge artifacts. Such students are not just socialising or swapping views, but are involved in the development of theory, model or conceptual maps about the subject matter, requiring the exercise of high level cognitive activity. Contemporary Knowledge Building Environment (KBE) design theory stresses a focus on foundational issues such as group cognition and knowledge negotiation.

The Semantic Web is an extension of the current World Wide Web, where marked up content is descriptively tagged so that applications as well as humans can understand it. There is an interesting parallel between Semantic Web technologies and knowledge building activities. Both are efforts to create new meaning or understanding of a knowledge domain, allow connecting between information resources based on relatedness, include the principles of sharing knowledge and formally representing knowledge in lasting representations.

The purpose of this study is to investigate whether a fusion of these technologies, through the implementation of Semantic Web concepts in KBE, can realise the goals of contemporary best-design theory for effective knowledge building environments.

An initial case for utilising Semantic Web technologies to enhance KBE is reviewed in the literature and such a KBE was designed and implemented. A case study into a small-group knowledge building activity was conducted, finding that signs of knowledge building and group cognition emerged, indicating an effective best-design KBE. Other unexpected findings are recounted and it is recommended that design of future KBE should take these into account.

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Introduction

The goals of knowledge building stress the importance of interactions and discourse among learners, involved as they are in the construction of some kind of knowledge artifact. Students properly engaged in this endeavour are not just socialising or swapping views, but are involved in the development of theory, model or conceptual maps about the subject matter, requiring the exercise of high level cognitive activity. To achieve effective knowledge building requires that the group must think together to produce a shared group artifact. Contemporary Knowledge Building Environment (KBE) design theory stresses a focus on foundational issues such as group cognition and knowledge negotiation.

The Semantic Web is an extension of the current World Wide Web, where marked up content is descriptively tagged so that applications as well as humans can understand it. There is an interesting correlation between the use of semantics on the Internet and knowledge building activities. Both are efforts to create new meaning or understanding of some knowledge domain. Common to both is an ability to allow connecting between information based on relatedness, and both include the principles of sharing knowledge and formally representing knowledge in lasting representations.

The present research study attempts to answer the following question:

“Can a fusion of Semantic Web and KBE technologies realise the goals of contemporary design theory for effective knowledge building environments.”

The design of such a KBE should facilitate emergent group cognition. An investigation of the resulting KBE should explore indicators of effective knowledge building and group cognition, and examine whether Semantic Web

technologies further enhance or diminish these activities. To satisfactorily answer the above question it is therefore necessary to consider two related sub-questions:

1. *“Are there indicators of emergent group cognition from the use of such a KBE”*
2. *“In what ways do Semantic Web technologies enhance or diminish knowledge building and the emergence of group cognition”*

These sub-questions will be central to an analysis of the success or otherwise of a Semantic Web based intervention in the design of KBE. The following sections illustrate the outline of this thesis.

Literature Review

This chapter reviews the literature relating to KBE, KBE design, the Semantic Web and related technologies, and suggests how the Semantic Web may be utilised in contemporary KBE. The importance of knowledge representation, cognitive models and metacognitive benefits are considered as is their relationship with group cognition. Potential benefits are considered in the fusion of the technologies, and how Semantic Web technology may enhance KBE design features.

Artefact Design

After an introduction to Semantic Web technologies is discussed, issues relating to the design of the KBE are considered. Each component of the KBE and how they map to related design features are explained. Finally the inferencing engine of the system is described.

Implementation

A small group study is argued for. Factors such as experience of the participants, the choice of the knowledge domain, the opt-in approach to recruitment for the study are considered along with the implementation duration.

Methodology

A case study as the most appropriate methodology for analysis is explained. Various approaches to analyse data, as well as the sources of data are discussed. A second phase of qualitative analysis of semi structured interviews is considered to support the findings and examine participant experiences.

Evaluation and Findings

This section describes how the data was analysed. Findings are recorded and observations are outlined. Positive outcomes are posited as well as some surprising findings.

Discussion, Conclusions and Recommendations

A discussion outlining some of the interesting findings and a future vision for Semantic Web and KBE on the Internet precedes concluding remarks and recommendations for future work.

Appendices, including references, complete the dissertation.

Literature Review

Introduction

This chapter reviews the literature relating to KBE, KBE design, the Semantic Web and related technologies, and suggests how the Semantic Web may be utilised in contemporary KBE. It begins by reporting on some contemporary theories (especially that of group cognition) which may be applied in the design of KBE technology. Cognitive models, metacognitive benefits and learning benefits of the Internet are discussed. Reasons for co-opting newer technologies of the Semantic Web into KBE are considered. The importance of knowledge representation (such as cognitive maps) to the area is examined. Technologies of the Semantic Web are looked into in more detail and how there exists a parallel with knowledge building activities. Potential benefits are considered in the fusion of the technologies, and how they might Semantic Web technology may enhance KBE. A reflection of the meaning of group cognition for KBE and a query as to whether such group cognition can be analysed completes the chapter.

Methods

Books, conference papers, reviews and articles were accessed through a mixture of online library resources (such as online databases and e-journals), online academic communities and academics' personal web pages, in-press publications, the TCD library and off-the-shelf.

Knowledge Building Environments

'Knowledge Building' can be thought of as the activity of advancing the perceived frontiers of knowledge. These perceived frontiers may be personal or communal. Knowledge building results in the creation or modification of real-world knowledge artifacts, available to be worked on or used by other

people (Scardamalia & Bereiter, 2003). In a communal setting it can be thought of as a collaborative activity by which conceptual artifacts and shared knowledge are developed (Lipponen 2002).

Stahl (2000; 2006) promotes a social approach to knowledge building in his design theory for collaborative knowledge-building environments (KBE). KBE have been an interest for Computer Supported Collaborative Learning (CSCL) researchers for sometime with CSILE/Knowledge Forum an early influential model (Scardamalia & Beireter, 1996). A contemporary research interest for Stahl in the area of (CSCL) is that of group cognition (2006). It is suggested that meanings, created within small group collaborations, are not cognitive properties of individual minds but rather characteristics of group dialogue. Group cognition or meaning is not just some statistical average or overlap of internal representations among learners, but is constructed by and because of the interactions of individual participants, not by the express intentions of individuals themselves. It is emergent from the discourse itself, each 'utterance' implying and requiring a set of references from others to complete their meaning.

What might a 'group cognition' informed KBE look like?

A KBE, designed with this theory of group cognition in mind, would facilitate the exchange of beliefs, the differentiation of ones own and adoption of others perspectives, negotiate shared knowledge or understandings, clarify knowledge domains through glossaries and formulate resulting artifacts in lasting representations. Collaboratively building such domains should also result in the formalisation of knowledge representations. Thus cognitive models should be linked with others to realize a community dimension, i.e. group cognition. Stahl has also suggested that KBE should provide search facilities, heuristics, critique a knowledge base and facilitate intelligent and timely delivery of information when required (Stahl, 2000). These requirements

support a model of collaboratively constructing knowledge domains by incorporating a level of semantic representation and relatedness.

Group Cognition – Metacognitive Benefits

It has been argued that relying too heavily on experts' cognitive models (for example learning from some website designed by some domain experts) tends to encourage passivity rather than learner inventiveness and imagination (Fisher 1988). Where learners attempt to internally assemble their own mental models of a domain, connecting new knowledge to prior knowledge, effective learning can take place (Fisher 1992; Fisher, Hoffman 2002). A group of learners embedding knowledge in cognitive models, where relatedness of concepts is made explicit, facilitates learners in identifying "main points" or "core ideas". Moreover, sharing models of knowledge reveals to learners that there are many ways to organize the same knowledge set, and that some are more elegant or more informative than others – in effect that there are "main relationships" or "core interactions" defining knowledge domains (Fisher and Hoffman, 2002).

It has been argued that the metacognitive process is important for problem solving and effective thinking (Davidson, Deuser, Sternberg 1994). Metacognitive skills are useful when constructing explicit (e.g. visual) representations of knowledge domains. Conscious thinking can thus be concentrated on the matter at hand, rather than dividing thinking time between metacognition and domain concepts. Stahl maintains that a group can be considered a 'thinking' unit (2006). It may be suggested that groups benefit from metacognitive advantages, in an environment where the group facilitates regulation of group cognition or understanding. Environments where group cognition emerges could therefore benefit where metacognitive processes of selection, comparison and combination are engaged in (Davidson, Deuser, Sternberg, 1994).

CSCL Knowledge Fragments

It has been suggested that the click and go paradigm of the hypertextual World Wide Web is lacking in terms of learning objectives (Dzbor, Stutt and Motta 2005). The questions of understanding and relatedness can be supported by focusing on the relatedness between knowledge fragments, rather than through the context of hypertext pages (Stutt, Motta 2004). This can be realised using technologies of CSCL, especially those of KBE, where use is made of recent concepts from Semantic Web technologies. This could benefit KBE as Semantic Web technologies are well suited to implementing some of the features identified by Stahl as core to KBE (namely facilitating exchange of beliefs, differentiating between perspectives, negotiating shared knowledge, clarifying knowledge domains by using glossaries and formalising resulting artifacts).

A collection of knowledge fragments using similar concepts and language, overlap to form knowledge neighbourhoods. Participation in knowledge neighbourhoods facilitates learner engagement with cognitive (and metacognitive) processes (Dzbor et al. 2005). Such knowledge neighbourhoods use formal relationships of concepts to cooperate and differentiate. On the Internet these knowledge neighbourhoods can now be defined by the formal specification of the Semantic Web.

Some Other Design Considerations – Knowledge Representation

Stahl sees learning or knowledge building design in terms of group cognition. In his design some factors need careful consideration. Knowledge representation can be described as the process of embodying knowledge so that it is tangible, can be acted on and is lasting. Knowledge representation can be effected in terms of cognitive mapping. Cognitive mapping, elsewhere described as knowledge mapping and semantic networking (Jonassen, 2005; Fisher, 2000), may be defined as textual, diagrammatic or visual representations of the structure and relationships between concepts within a knowledge domain (Stoyanov, 1997). Cognitive mapping acts as a cognitive mirror for an individual to perceive his or her own organization and structure of knowledge. Such a cognitive mirror leads to an explicit awareness of representations and relationships between items in a knowledge domain, an awareness which is an essential component of the metacognitive process.

Good knowledge representations have been shown to be effective learning aids (Fisher, 2000). For example, the periodic table or the chromosome map in biology are used in virtually every science classroom and have been shown to help students understand interactions between chemical elements and analyzing inheritance patterns. In any problem space, learners use mental representations to problem solve, whether the problem is analytical or to comprehension of a knowledge space. The way in which learners problem solve depends on how the domain is represented internally. Jonassen (2005) contends that a more efficacious way of affecting internal mental representations is to give learners access to knowledge representation tools, such as those described above by Stoyanov (1997) and Fisher (2000, & Hoffman, 2002). Jonassen claims that problem solving usually fails because learners inadequately represent the knowledge available to them.

Collaborative knowledge building may suffer something similar if the group also has inadequately represented knowledge.

Semantically enabled KBE may provide cognitive aids to a group of learners. Where the group is presented with cognitive representations of knowledge domain by semantic agents, the benefits to cognitive and learning strategies of users may be considerable (Stadtler & Bromme, 2005). A problem may occur, however, where providing such explicit metacognitive prompts leads to learners not developing these skills, which is at variance with many educational aims. To offset such a possibility Ford (2004) argues for the usefulness of building in a high degree of transparency and explanation, so that users are aware of what the system is doing for him or her. The development of transferable metacognitive abilities would require such transparency.

The Semantic Web and Knowledge Building

The existing web was constructed to be understood by humans. It has not been designed for meaningful manipulation by computer programs (Berners-Lee, Hendler & Lassila, 2001). Today the World Wide Web is largely a syntactic web, where resources are formally linked using the simple syntax of hypertextual references. Each link is an embedded address for another web page, contextualised by the author of the page. The Semantic Web replaces these simple syntactic links with semantic relationships between Internet resources (Hendler, Berners-Lee & Miller, 2002).

In figure 1 a syntactic web is contrasted with a Semantic Web. The links in a syntactic web are usually in the form of 'href' links, which are clicked by a user of the web resource, who understands the context of the link. In a Semantic Web, resources are formally related and contextualized using semantic metadata (a collection of which describes a knowledge domain and is called

an ontology). Users of a Semantic Web will use agents to ‘read’ the metadata on the web, pulling together material inferred in the context of the knowledge requirements from a user or community.

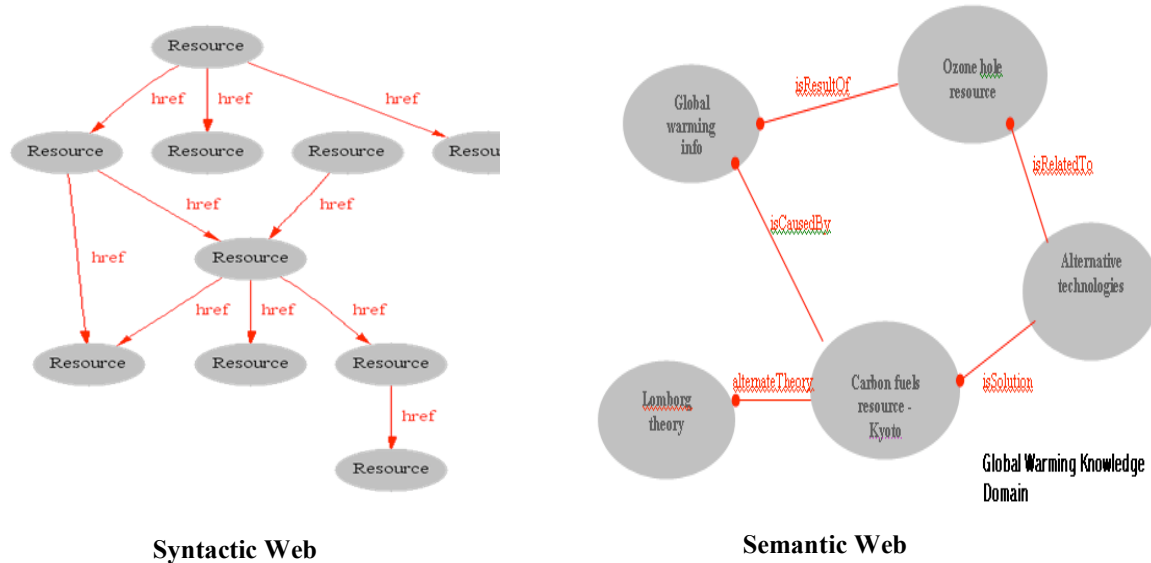


Figure 1. A syntactic versus a semantic web.

The Semantic Web improves on the present web by bringing a representational and relational structure to the content of web pages and other Internet resources. Each fragment is embedded not within the context of a web page, but within the context of a knowledge domain. Searching within a Semantic Web means bringing inference rules or logic to the web.

Constructing the Semantic Web requires annotation (called metadata) of resources, from which contextual content is gathered by the logic crunching of software inferencing agents (Ardissono et al., 2004). This may bring about an improved Web architecture enhanced with formal semantics, enabling engagement with more intuitive content and improved navigation through knowledge domains (Stojanovic, Staab & Studer, 2001). The process of annotating these chunks of knowledge facilitates engagement with structure, relatedness and interpretation, and makes possible reasoning about the web

providing educational services such as summarization, interpretation and support for argumentation (Stutt, Motta 2004).

Essentially, the task now at hand is one of expressing meaning and relatedness on the Internet. If there exists an opportunity for learners to engage in this process, if learners can connect with this aspect of building the Semantic Web and not just become more advanced passive consumers of a more intelligent web, the cognitive learning advantages could be considerable (Stutt and Motta, 2004; Davidson, Deuser, Sternberg 1994; Dzbor et al. 2005; Fisher & Hoffman, 2002). Of course the task at hand in KBE is also of expressing meaning and relatedness between diverse concepts and ideas. An opportunity thus arises to marry these technologies to achieve what Stahl describes as core to ideal KBE.

Building the Semantic Web

There are a number of technologies available today which, when combined, provide an underlying architecture for the Semantic Web. While W3C (www.w3c.org) describe a solution to the Semantic Web through the use of RDF (Resource Description Framework) related technologies, there are other technologies available to create semantics on the web. Rod Koper (2004) inventories seven core technologies: UML (Unified Modelling Language), XML (eXtensible Markup Language), RDF and RDFS (RDF Schemas), OWL (Web Ontology Language), LSA (Latent Semantic Analysis), Topic Maps, and Software agents that can read and process coded semantics.

A technology based on RDFS called OWL (Web Ontology Language) is currently recommended by W3C as the standard for the Semantic Web. OWL is used to represent the explicit meaning of Internet resources, knowledge fragments expressed as URI (Universal Resource Indicators), and relatedness

between them, so that they become interpretable by machines. (Bechhofer, Horrocks & Patel-Schneider, 2003; Stojanovic, Staab & Studer, 2001).

As it is constructed in the future, Internet content should be mapped to existing and evolving knowledge domains. Users (or rather participants) on the Internet will have to take on fluid and dynamic roles associated with groups, and may view domains from alternating perspectives (Brna, 2004; Allert, 2004). Especially in a collaborative learning context, such as those interacting in knowledge neighbourhoods, a community of content authors could benefit from a symbiotic relationship with the Semantic Web they are helping to build (Richardson, Agrawal, Domingos 2003).

Knowledge Fusion

There is an interesting correlation between the use of semantics on the Internet and knowledge building activities. Both are efforts to create new meaning or understanding of some domain of interest (Stahl 2000; Berners-Lee, Hendler & Lassila, 2001). One feature common to both is the ability to allow linking of information nodes not explicitly linked through hyperlinks (Scardamalia, 2002; Stahl, 2000). Scardamalia's CSILE/Knowledge Forum environment provides mechanisms for formally linking knowledge nodes together, including annotations and semantic fields. Stahl (2000) would include the principles of sharing knowledge and formally representing knowledge in lasting representations in the design for collaborative KBEs. One problem with CSILE/Knowledge Forum is that its knowledge building facilities are available only when using the Knowledge Forum environment. Knowledge representations will last only as long as versions of Knowledge Forum are used. On the other hand the Semantic Web may enhance KBE as it is an open project and a way to formally represent knowledge in a lasting and useful way.

In a real sense Stahl's design theory of KBE is ideally situated to incorporate Semantic Web technology. In fact, Semantic Web based languages could provide enhanced architectures for such KBEs. Implementing OWL, for example, may provide a framework for building important component devices required by Stahl and Scardamalia for collaborative knowledge building environments. OWL provides a semantic language for linking diverse knowledge domains together. OWL is a growing ontology language and has many ways of juxtaposing knowledge fragments together using an extensive set of inferencing rules, which could facilitate various knowledge building permutations. If the Semantic Web succeeds as expected, other future KBE systems will also undoubtedly utilise its features, providing portability for knowledge domain artifacts.

Designing KBE

Any collaborative participation in the building of Semantic Web knowledge domains is fundamentally an engagement with other people and their 'ideas'. Stahl would be fundamentally aligned with this position (2006). Bogdan (2000), in his work on the origins of *metamentation* (essentially '*metacognition*' from a phylogenic or ontogenetic perspective) maintains that human minds think reflexively because they interpret each other. Thinking about thoughts requires understanding thoughts as mental structures that represent and relate to other thoughts; and the ability to recognize these inter-thought relations. And because these abilities originate through the interpretation, interaction, manipulation, representation and relatedness to other minds, any process where minds collaborate leads to some degree of inter-group metacognitive activity.

Stahl goes further to state that any resulting artifact constructed through this collaboration is in itself an embodiment of meaning (2006) and therefore characterises group cognition. Collaboratively constructing knowledge

domains using Semantic Web enabled KBE may indeed create opportunities for developing group metacognitive strategies, because “minds mind minds” (Bogdan, 2000). Stahl argues that meaning exists in the intersubjective world of the artifact and that it is only then interpreted from individual perspectives. The idea of a thinking group is an intriguing one, and one that may lead to best-design KBE. Building KBE based on Semantic Web technologies could lead to an environment where this group cognition emerges. What remains, however, is whether resulting KBE can be constructed using technologies discussed above and whether there exist methodologies for identifying the existence of group cognition in knowledge building activities.

Conclusion

This chapter discussed the area of knowledge building and design of KBE in terms of group cognition. Technologies of the Semantic Web were suggested as useful in the implementation of best-design KBE. Cognitive models and metacognitive benefits were considered and reasons for the importance of knowledge representation (such as cognitive maps) to the area were examined. The Semantic Web was considered in more detail as were potential benefits in the fusion with KBE. The chapter finished by discussing the meaning of group cognition for design of KBE and a query as to whether a research methodology exists which could analyse such group cognition.

Artefact Design

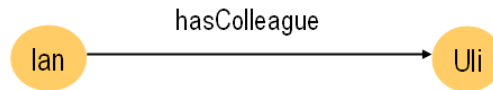
Introduction

This chapter begins with an introduction to the Semantic Web, which gives some further explanation of the technology. Issues relating to the design of the KBE are discussed. Stahl's design theory for KBE features as the rationale for many components. The rationale for implementing Semantic Web is discussed, and the five stage user implementation of the system is described. In phase one of the design, each of the components of the KBE and how they map to related design features are explained. Finally, in phase two the inferencing engine of the system is described.

Semantic Primer

Of the core technologies available for building the Semantic Web (Koper, 2005), Tim Berners-Lee and teams (2002, 2001) and Staab (2001) describe a layered approach. XML allows for the annotation of web pages by creating tags. This allows page designers to include a semantic structure around web page content. RDF (Resource Description Framework) uses XML to provide for a substructure of meaning on a web page. In figure 2 statements on web pages are defined using grammar-like statements, such as x has Property y, in a subject predicate object relationship. RDFS (RDF Schemas) is a set of formal specifications for structuring and sharing metadata on Internet resources. Machines can read RDFS statements and make inferences on them based on semantic logic (Stojanovic, Staab & Studer, 2001).

- **Statements are <subject, predicate, object> triples:**
 <Ian, hasColleague, Uli>
- **Can be represented as a graph:**



```

<Description about="some.uri/person/ian_horrocks">
  <hasColleague resource="some.uri/person/uli_sattler"/>
</Description>
<Description about="some.uri/person/uli_sattler">
  <hasHomePage>http://www.cs.mam.ac.uk/~sattler</hasHomePage>
</Description>
<Description about="some.uri/person/carole_goble">
  <hasColleague resource="some.uri/person/uli_sattler"/>
</Description>

```

Figure 2. The building blocks of the Semantic Web (Bechhofer, Horrocks & Patel-Schneider, 2003). RDFS statements define web resources.

A technology based on RDFS called OWL (Web Ontology Language) is currently recommended by W3C as the standard for the Semantic Web. OWL is used to represent the explicit meaning of Internet resources, knowledge fragments expressed as URI (Universal Resource Indicators), and relatedness between them, so that they become interpretable by machines. OWL enhances RDFS with a greater number of formal specifications but also with relational ontologies (Bechhofer, Horrocks & Patel-Schneider, 2003; Stojanovic, Staab & Studer, 2001). Ontology is a term used in philosophy for the theory of the nature of existence or of being. The term has been co-opted into Artificial Intelligence and Web research to describe formal, shared concepts of a particular knowledge domain (Stojanovic, Staab & Studer, 2001). Ontology can be defined by the vocabulary set and grammatical structure used to describe a knowledge domain.

As discussed in the literature, Rod Koper (2004) inventories seven core technologies: UML, XML, RDF/RDFS, OWL, LSA, Topic Maps, and Software Agents that can read and process coded semantics. The artefact associated

with this dissertation uses the latter Software Agent approach modelled on OWL concepts. This means that concepts detailed by W3C for the OWL language have been implemented, but not through the use of RDFS statements. The resulting system is therefore used as proof of concept, utilising server based database technologies to store knowledge fragments and associated tagging (instead of marking up these on Internet resources), and server and client side application scripting to implement the semantic agent.

Design rationale

Ideally a KBE should provide a space where ideas and beliefs can be expressed and can come into contact with alternative ideas from multiple viewpoints, and should be a space which can approach consensus. The KBE should be able to formulate, represent, communicate and preserve resulting ideas to provide for review, reflection and continuation from anytime or place (Stahl, 2000). It should also facilitate clarifying knowledge domains through glossaries (Stahl, 2006) and allow relating knowledge fragments not explicitly related through hyperlinks (Scardamalia, 2002). Further, there would be a use for building in a high degree of transparency and explanation, so that the user is fully aware of what the system is doing for him or her (Ford, 2004). Stahl (2000) describes phases of social knowledge building and their respective knowledge building supports:

Articulation: A text editor should be a minimal instance of supporting the process of idea articulation. **Perspectives:** An ability to support multiple perspectives from which statements arise. **Comparison perspective:** The ability to view alternative perspectives and adopt ideas from someone else. It should allow for easy comparison of various ideas and group perspectives. **Discussion:** Provides for the ability to correspond and exchange notes on any

matter pertaining to the knowledge building activity. **Argumentation and rationale:** Providing an argumentation structure where notes can argue or provide evidence for other notes. **Clarify:** Glossary discussions can make known how different people understand the terms they use. **Shared understanding:** Provides a repository for agreed upon definitions. **Negotiate:** Provide negotiation support helping different perspectives to converge on shared knowledge. **Collaborative knowledge:** The resulting collected negotiated knowledge. **Objectify or formalise:** Bibliography discussion facilitating the transferability of shared knowledge into other domains. **Cultural artifacts and representation:** A provision for formally accepting shared understanding as established.

It is envisioned that a KBE environment can be developed with these design considerations. Here it is intended that those elements which can appropriately achieve these aims by using Semantic Web technologies will be the main component parts to the resulting KBE system. There will be an attempt to integrate other elements as required by Stahl and others (such as discussion), but it is not the aim here to investigate the benefit of using a completed system (which is beyond the scope of this dissertation), but whether Semantic Web technologies can be successfully utilised to form and enhance some of the core components in contemporary KBE design.

Overview of the resulting KBE

One of Stahl's key design principles is that resulting artifacts should be available from anywhere and at anytime. What is intended is a KBE which can apply semantic tags to user authored knowledge nodes, and once this stage of authoring and tagging has been completed a mediating agent 'presents' similar nodes to proximate users, and provides a mechanism for instantiating formal semantic links and initiating communication and collaboration. What

remains is a cultural artifact, built through the KBE, resulting from the understanding of a knowledge domain by a community of learners.

Essentially the user goes through a five steps in knowledge building.

1. Users open a browser and type in the address for the online KBE. They then logon with a username and password.
2. Users articulate and build knowledge nodes, which can be a concept within the domain of knowledge defined and described by a user. The users can then semantically tag these nodes from an ontology (or glossary/dictionary) contributed to by the community of knowledge builders.
3. Users contribute to how the system 'thinks'. Users can influence how the system relates pieces of knowledge together (resulting in more abstracted indirect possibilities for knowledge building).
4. Users check to see if the system 'presents' proximate nodes from other users.
5. Users decide on whether to formally link knowledge nodes together from their perspectives or collaborate through communication. If users formalise a link to another node, that link becomes available as a hypertext link within the resulting hypertext space (which is the cultural artifact available to be searched and navigated across by users of the system, and perhaps future semantic agents).

Putting it together

Because the resulting KBE would be web based, web server and web client technologies were researched and PHP, MySQL, JavaScript were used. The application server (a recent version of PHP) was installed on an IIS 5 machine alongside MySQL. JavaScript was scripted as necessary on the source PHP pages, and interaction between the languages was used to achieve the

concepts behind the Semantic Web, particularly OWL. Using these server and database tools over actual marked up OWL was for reasons of access to technologies. What follows is a description of the KBE components and how they are related to design theory as found in recent literature, but in particular that of Stahl.

Phase 1 – Knowledge Authoring

Logging in

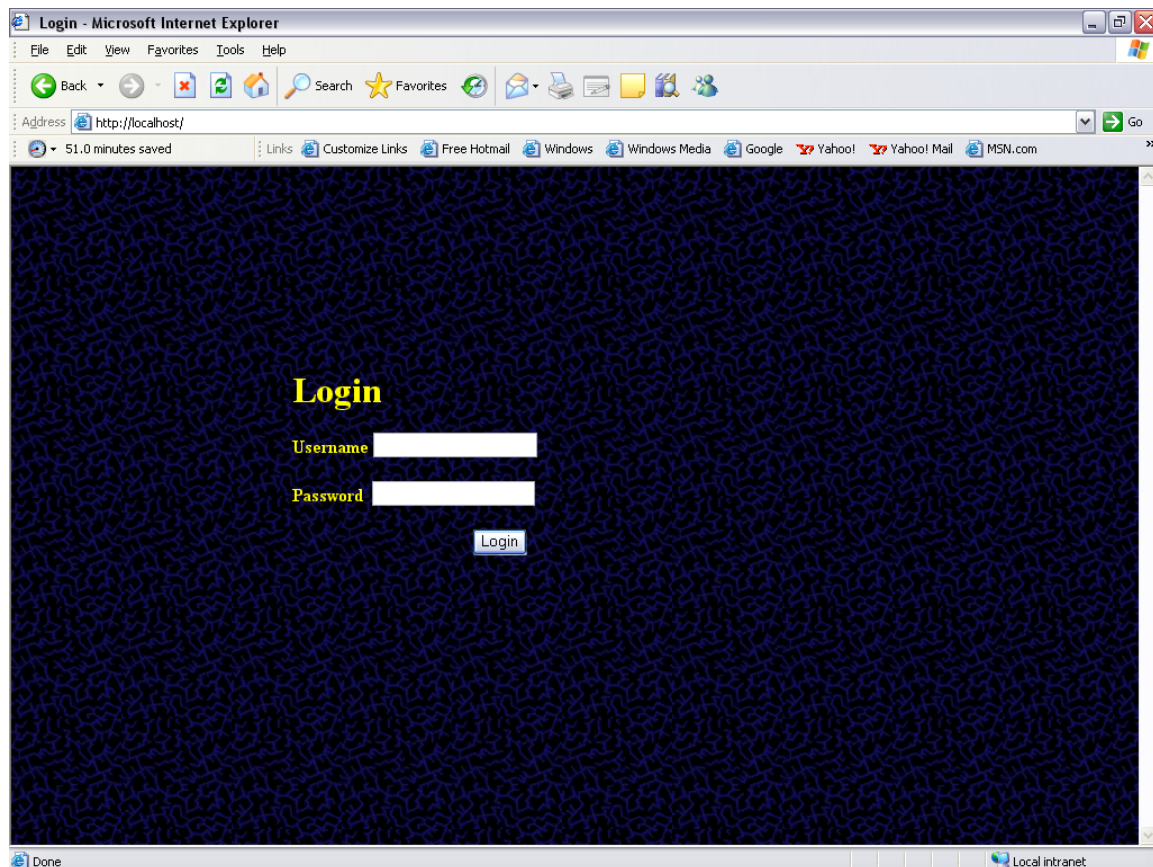


Figure 3. The Login home page.

Rational

An ability to support multiple perspectives should be integral to a KBE according to contemporary design theory. Using individual accounts ensures users contribute from their own perspective.

Component Design

In figure 3 we find the login screen for the KBE. Using usernames and passwords ensures user perspective integrity. Once a user logs on, they are passed through to the opening area where they can view available knowledge building projects that they are working on (as in figure 4). Here they can create new projects (see figure 5), open up existing projects or move into the 'Manage Semantics' component, which allows communities of users to build ontologies and influence how the system thinks.

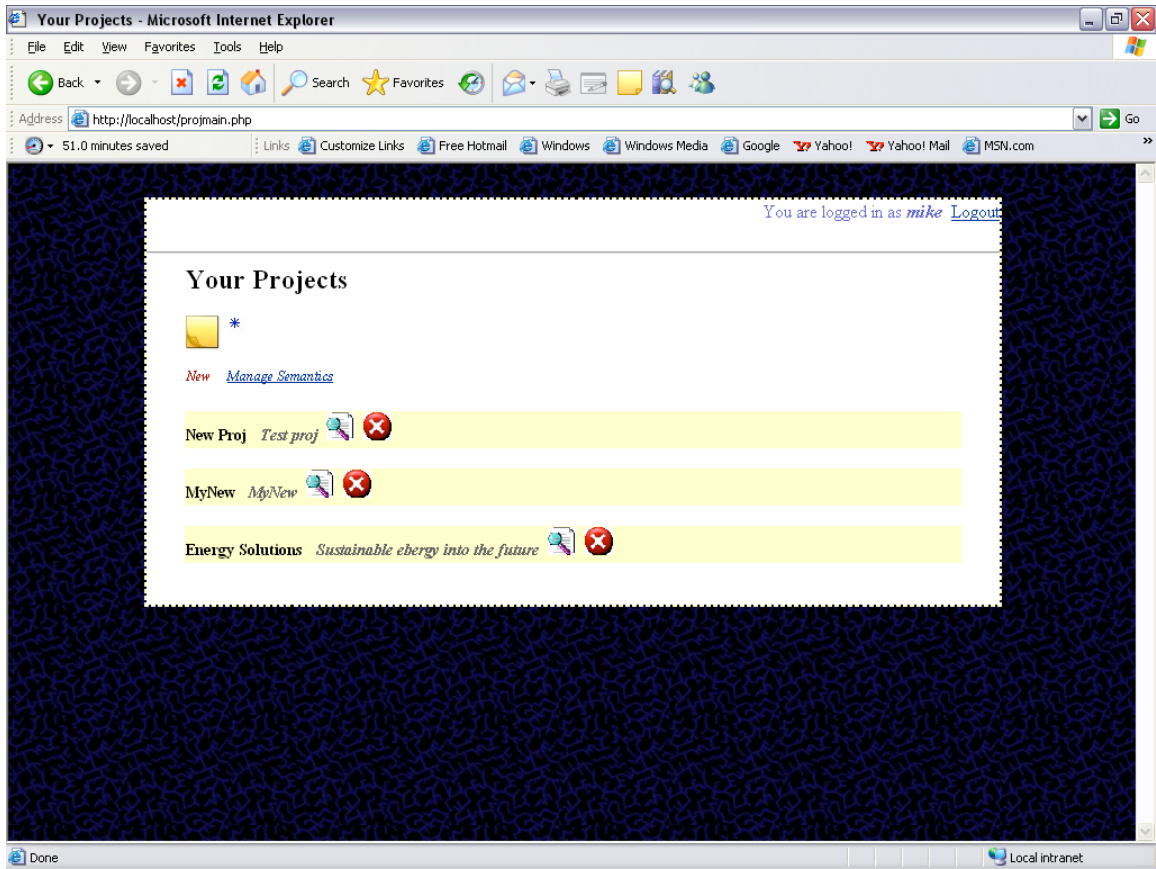


Figure 4. The home page once the user has logged on.

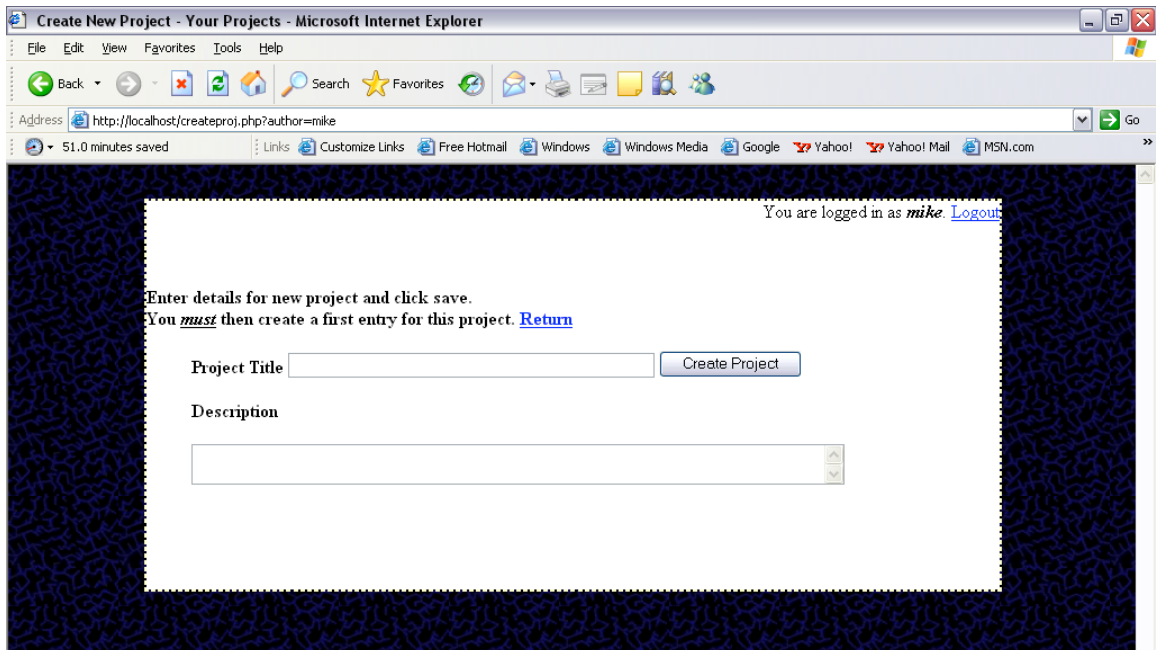


Figure 5. Create new Projects component.

Project Creation and Knowledge Node Authoring

Rationale

Articulation is of importance to allow knowledge builders contribute their understandings and ideas to a knowledge building community. There should be tools to provide for categorisation of ideas (such as into projects and knowledge nodes). An online text editor provides for the anywhere, anytime requirements for KBE.

Component Design

Figure 6 shows the screen on opening an existing or newly created project, where the user is presented with the Project home page for that user. Here users can create new nodes (knowledge fragments), enter Manage Semantics and logout. The edit component of the system (see figure 7) allows users to build rich text content using an online word editor. The nodes have their own sub-controls as shown in figure 8.

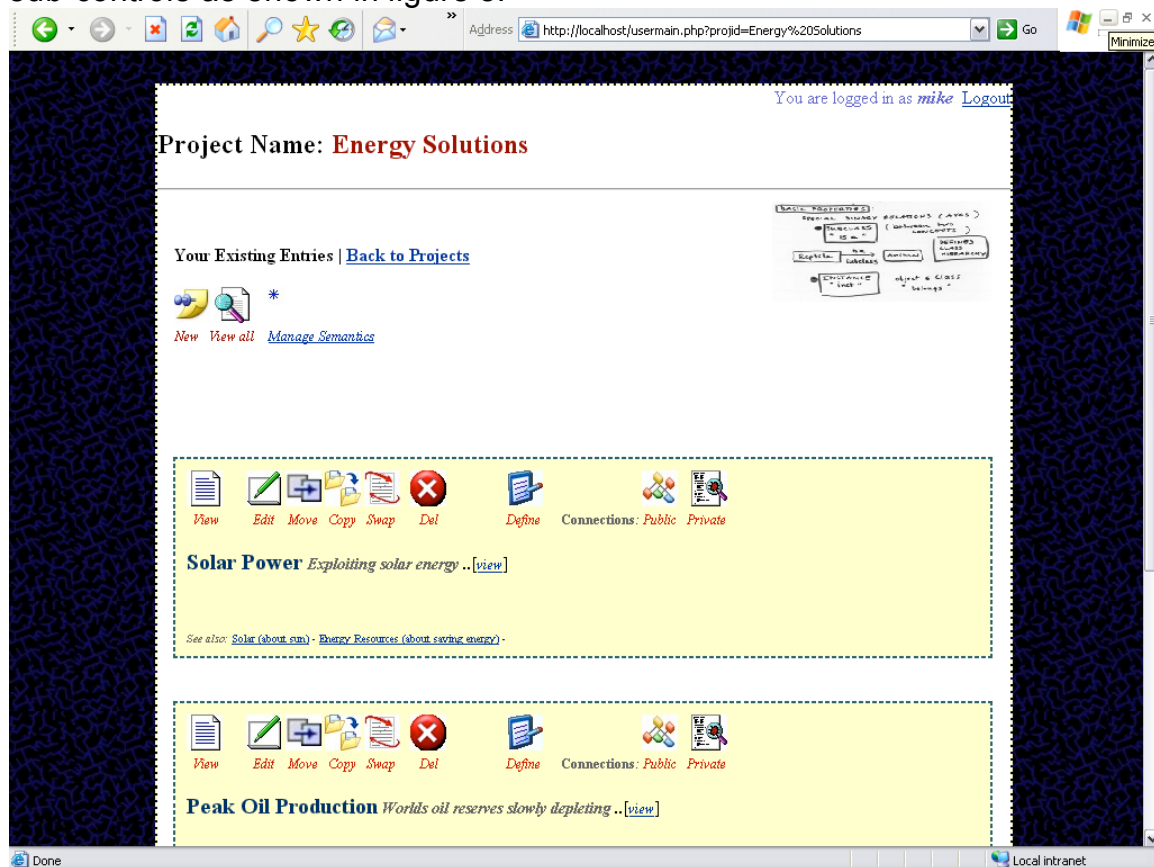


Figure 6 This is the home page for the Project just opened for the user.

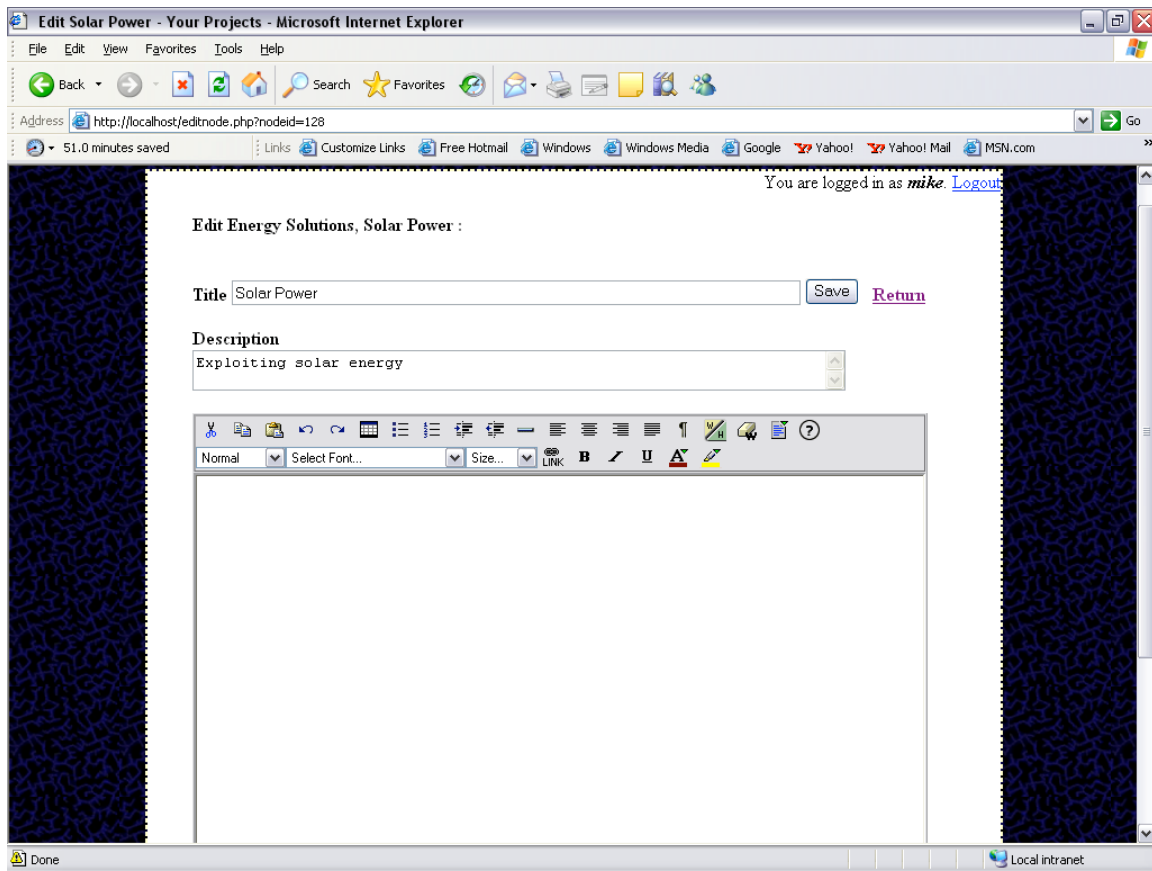


Figure 7. The edit page is an online word editor which allows users to author rich html content.

Controlling Knowledge Nodes – Adding Semantic Tags

Rationale

Argumentation allows for knowledge builders to place concepts in context, opposition or support for other concepts.

Component Design

Figure 8 shows the controls for each node where we can delete, view, edit the content of a node or swap the place of the node in the project. We can even move or copy the node to another project achieving a reusability feature within the system. We can also semantically define the node using the 'Define' control button.



Figure 8. Each node has its own individual set of controls.

This opens a pop up box, as in Figure 9, which adds semantic keywords in the form of 'class' or 'property' attributes. 'Class' and 'property' keywords are used to structure the knowledge domain by placing metadata on knowledge fragments as it is being created by the community of knowledge builders. The 'class' keywords define the node as an instance of a major topic within the domain whereas the 'property' keywords can place attributes on the node (W3C).

Only one 'class' can be chosen per node. The 'property' keywords can be used to further describe the knowledge node to the system. A user can place unlimited properties on a node, and must use the descriptor types. For example a node authored by a user has content describing Energy Crisis, which contains material about the problems with carbon based fuels and present peak oil conditions. A user might make such a node an instance of the class *Peak Oil* and place property symbols on them such as 'isDefinedBy carbon emissions' or 'isAbout oil depletion'.

A user can view the current ontology by going into the 'Manage Semantics' component and choosing 'View Current Ontology'. He or she can therefore see if someone else has already used tags that closely resemble the node.

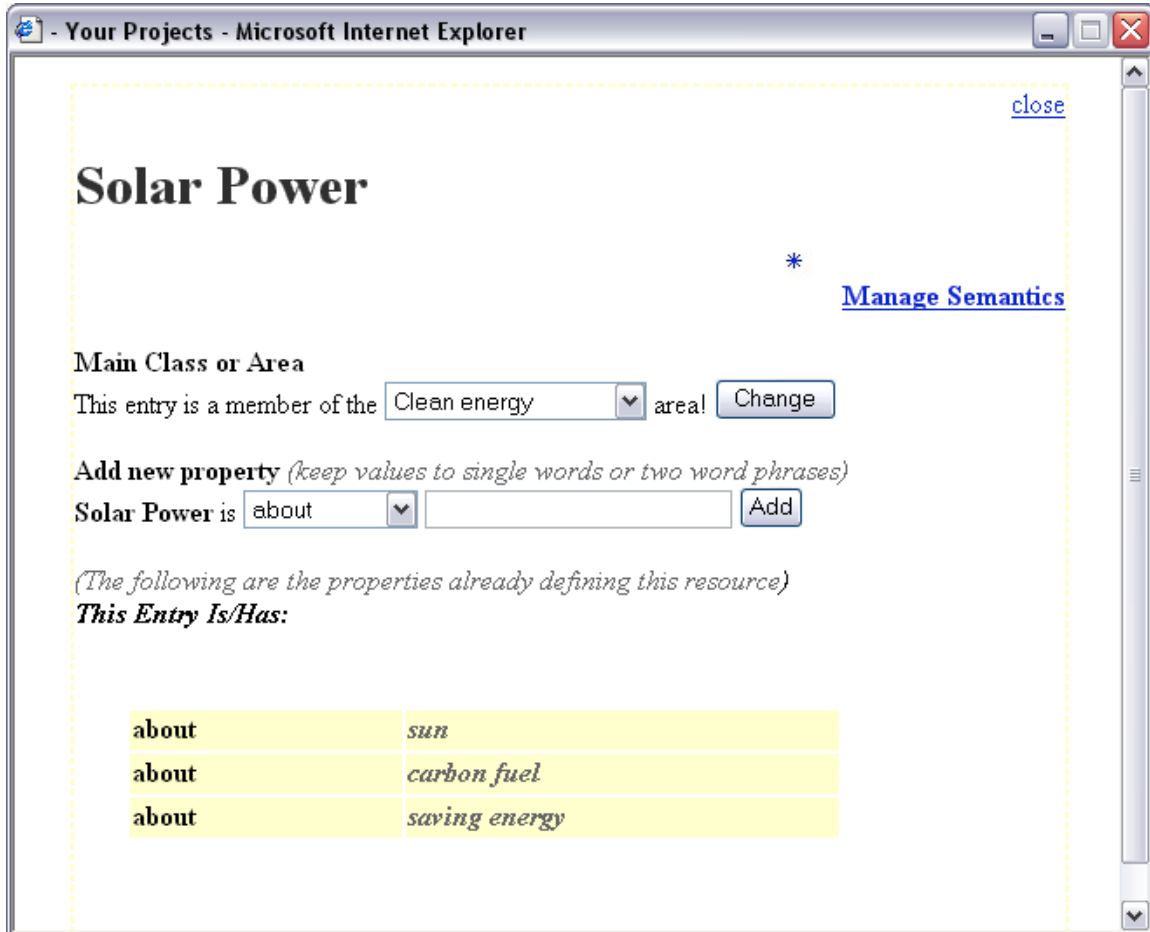


Figure 9. The Define pop-up box, which allows us to semantically tag our knowledge node.

Managing Semantics

Rationale

Clarification, negotiation and shared understanding are necessary for any knowledge building exercise.

Component Design

When entering the 'Manage Semantics' component we are presented with a screen as in figure 10. Managing the semantics of the system has two main parts to it. First the user can view and add new 'classes' and 'property types'. Here users can view definitions or explanations for given 'classes' and 'property types' and can also add to the 'class' and 'property' lists, giving definitions as they create.

The 'Manage Semantics' also allows users to relate class and property types together, to make some major topics sub classes of others, and likewise with property identifiers. For example, the 'Ozone' class could become a subclass of 'Global Warming', and any instances of these would therefore become related. This allows the system to inference the available knowledge domain for suitable links.

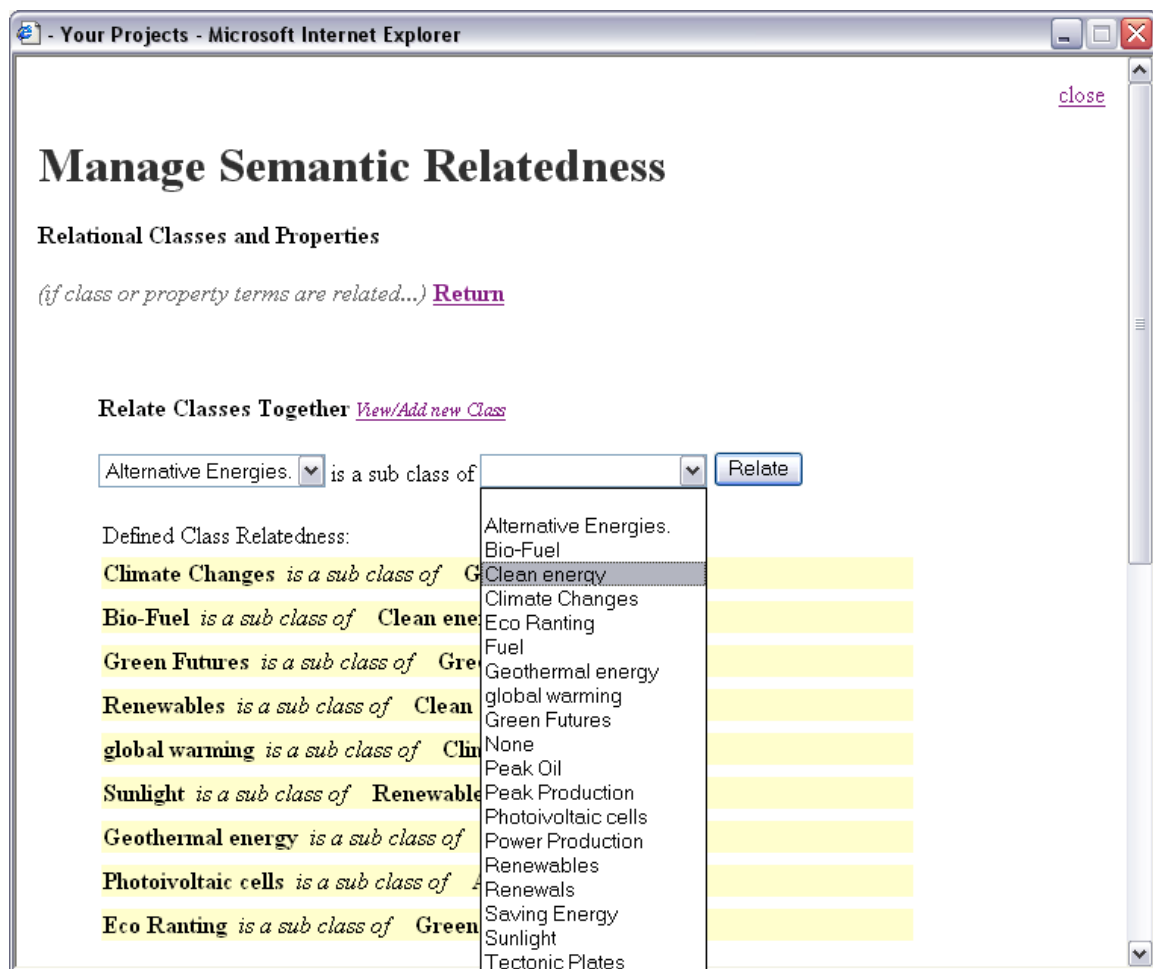


Figure 10 Managing Semantics allows us to influence the way the system inferences.

Phase 2 – Knowledge Building with Semantically Tagged Knowledge Nodes

The Inferencing Agent

Rationale

The presentation of collaborative knowledge in context with the whole knowledge domain can be achieved where an inferencing agent can search the space and present relevant finds based on negotiated and shared understanding (domain ontology).

Component Design

Once this stage of authoring and tagging nodes is completed, users can go on to connect, collaborate and knowledge build with other users. As shown in figure 11, using the 'Public' control calls on the system inferencing agent to find interesting direct or indirect matches for the node in question. The inferencing agent achieves this in a number of ways. It will search the set of knowledge fragments for available matching classes. If another node from another user is found the system presents it as a 'class' match, where the nodes are instances of the same class. The user can then choose whether to view the node in the context of the other author's complete project, or whether to collaborate with the author.

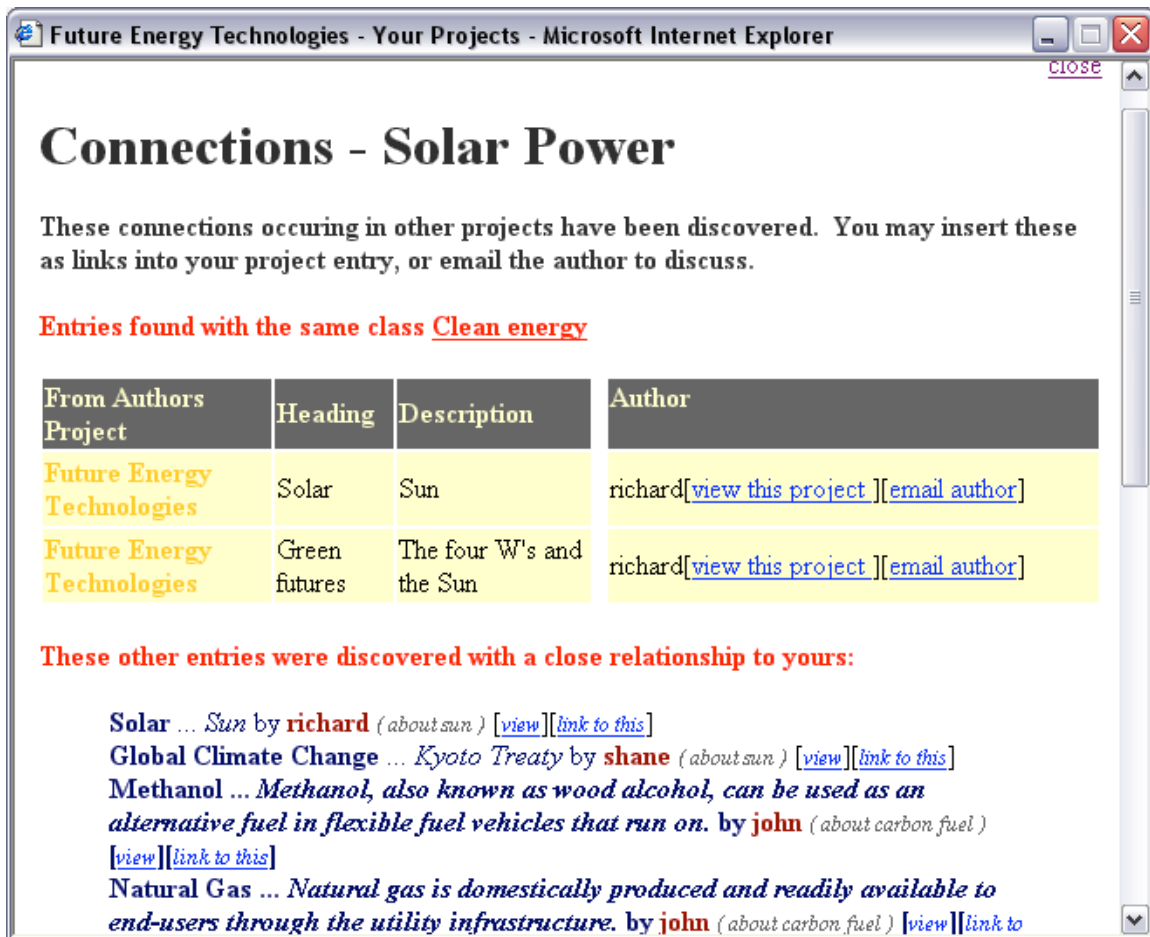


Figure 11. The system semantic inferencing agent 'presents' proximate knowledge fragments to each other.

Formalising and Building a New Hyperspace

Rationale

Once shared understanding has been established and nodes are formally linked, what may result is a semantically built and organically grown hyperspace or cultural artifact, which is available to be worked on in the future. Transparency can be achieved by getting the system to show how it came to conclusions, which could be saved, adding an additional layer of understanding to the resulting hyperspace.

Component Design

The semantic agent checks to see what property matches there were and presents these proximate nodes to the user, with the node title, description, and author and how the agent made the match. There are then facilities which allows user to view the node or formally link to the node. This last feature contributes to the building of a new hyperspace, which is the resulting cultural

artifact. When a formal link has been made, a href link is placed at the bottom of the node along with the semantic reason for the link (see figure 12).

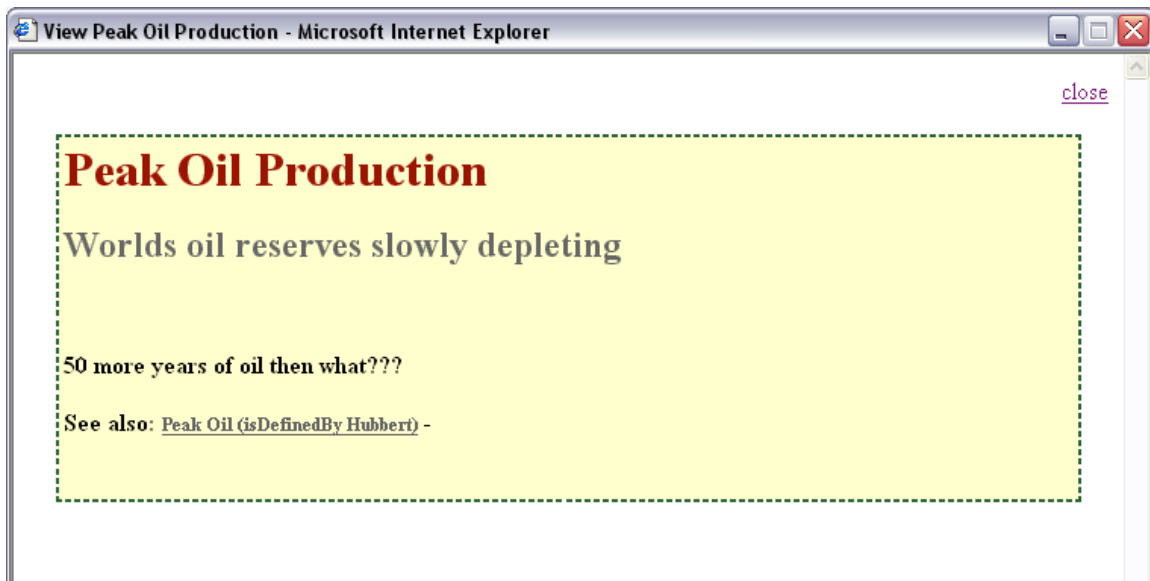


Figure 12. Links are placed at the bottom of knowledge nodes once they are formally chosen.

Inferencing with Extended Semantic Base

Rationale

Using Semantic Web principles allows the machine do much of the presentation of content to the user, allowing for interesting comparison perspectives and collaborative knowledge building opportunities to arise.

Component Design

The system can go further and find more indirect matches. This is dependant on how users have collaborated in the 'Manage Semantics' component to relate and build on classes and properties. The system will present discovered nodes as more indirect matches, again giving information on node title, description, author and the logic used to find the matches (see figure 13).

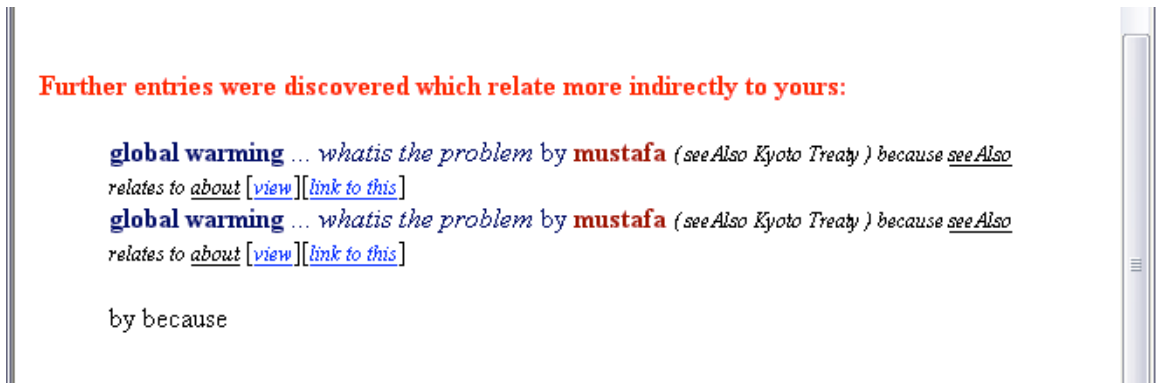


Figure 13. The system can do more abstract inferencing using the contributions to the 'Manage Semantics' component.

Conclusion

This chapter began with an introduction to Semantic Web technology. Stahl's ideal KBE features and how they relate to the stages of knowledge building was shown. The five stage user implementation of the system was described and how each of the components of the KBE mapped to design features in phase one of the build. The chapter ended with a description of the inferencing agent's design and usage.

Implementation

Introduction

After arguing for a small group study, the implementation of the artifact is discussed. Factors such as CSCL experience of the participants, the choice of the knowledge domain, the opt-in approach to recruitment for the study are considered along with the implementation duration and post implementation interviews.

Small Group Implementation

Stahl states that small groups are the engines of knowledge building and his vision for KBE are based around small groups. Infact, the paradigm used is that cognition is firstly and essentially group cognition, and that individual cognition emerges as a secondary effect (though individual cognition later seems to be more dominant in introspective narratives). Others have stated that minimising psychological distance between participants, thereby facilitating an environment where a community can emerge, requires that the number of participants should be small. Students then become meaningfully engaged in activities such as discussions or collaborative learning groups (Rovai, 2002). The current study examines the use of Semantic Web technologies to enhance and achieve the criteria in contemporary design theory of KBE, and we must thereby assess the effectiveness of the resulting KBE. Stahl's design theory deals with KBE based around small groups, and any investigation of such a KBE must be at the small group level.

A readily available small group has been available to this researcher. A group of students from the College of Further Education Dundrum are studying a blended learning delivery for a Cisco Networking Academy program. These students have prior experience of using CSCL environments, using Wikis and other features of Learning Management Systems. It was felt that taking a case

study of this small group would be an appropriate methodology for investigation, thereby reducing the time required in training in the environment, and perhaps over the novelty of collaborative learning.

The Knowledge Domain

A number of knowledge domain areas were considered and the 'Future Energy Solutions' knowledge domain was chosen, namely for its general and topical nature. As the system is an asynchronous tool, the group of 13 students spent 4 weeks in the KBE, contributing to and collaborating in the area. 'Future Energy Solutions' was the umbrella topic, and students were free to go and concentrate on any sub domain they wished, or be more general if they wanted. The reason a single domain was chosen was because of time constraints and that the present KBE allows for one 'ontology' in this implementation.

Participants were notified that their work was part of a research project and that there was an opt-in decision. After a short training session and some practice the participants began. As the course was a blended delivery of face-to-face tuition and online delivery there tended to be a mix of synchronous in-class and asynchronous out-of-class sessions. The system could easily accommodate this mixed usage. Users could use the environment in any way they wished, as long as it was representative of their understanding of the area. It was agreed that as long as the information was representative of their understanding content from the web could be copied (images, material etc.).

Participants consented to further surveys or interviews. After extensive analysis of the resulting knowledge domain, a sample was selected and a structured interview was conducted. This completed the implementation stage of the artefact.

Conclusion

The implementation discussed issues such as CSCL experience of the participants, the choice of the knowledge domain, the implementation duration and post implementation interviews.

Methodology

Introduction

This chapter begins by explaining the choice of a case study as the most appropriate methodology for analysis. Various approaches to analyse data (such as a novel use of video analysis and quantitative analysis techniques) are discussed, as well as the sources of data. A second phase of qualitative analysis of semi structured interviews is considered as an appropriate triangulation method to support the findings and examine participant experiences.

Case Study Design

The constructed KBE was built with CSCL based design theory in mind to examine the research question “*can a fusion of Semantic Web and KBE technologies realise the goals of contemporary design theory for effective knowledge building environments*”. In answering whether such an approach results in an enhanced knowledge building environment it was necessary to consider a methodology for analysis. Yin (2003) describes case study as a strategy to be preferred when appropriate, as useful when investigating contemporary phenomenon in their real life context and especially where the boundaries of context and phenomenon are blurred. Stahl (2006) recommends a case study approach to investigating contemporary best-design KBE. It has been suggested that case studies are too anecdotal, or that they are merely exploratory techniques that could only be used for initial investigation. However, such conceptions are based on an understanding of the case study as a methodology trying to make a universal generalisation or a ‘participant-observer’ strategy alone (Yin, 2003; Stahl, 2006; Bell, 2005).

Traditional sociological methods attempt to specify typical (or atypical) events, then to require large number of cases be analysed in laboratory or strict conditions, and then compute statistical analysis which can be applied to populations. Case studies are not used to ‘prove’ the effectiveness of interventions statistically, but to investigate what could happen or did happen in a ‘real-world’ context. Here, we wish to investigate whether knowledge building practices emerge in the KBE due to the intervention of Semantic Web technologies. ‘Relatability’ or ‘fuzzy generalisations’ (where a qualitative measure of the likelihood of what was found in a single case may or may not be found in other similar situations) can also be found from case studies, which may be more beneficial in areas such as sociology or education (Bassey, 1999; Bell, 2005). Two sub-questions are related to the study of a Semantic Web intervention in KBE. They are “*are there indicators of emergent group cognition*” and “*does Semantic Web technology enhance or diminish knowledge building and the emergence of group cognition*”. If knowledge building practices emerge within this study, then it may be suggested that at least with parallel knowledge domains (of similar fuzziness to ‘Future Energy Solutions’) the KBE could be successful. However, it is not possible to make a general statement of success for the use of such a KBE, and neither is it the study’s intention.

Data Collection

Data sets for such case studies can use a mix of quantitative and qualitative, to converge in a triangulation fashion (Yin, 2003). As this was a small group implementation and the KBE was used for one domain only and for a short period of time a case study was thought to be an appropriate methodology. Stahl makes an interesting use of video analysis methods, based on ethnomethodological studies (which are an analysis of how participants make sense of their own and others social actions). Video analysis is an extension of conversation analysis and can be used in KBE case studies to examine the

extent of group meaning or knowledge building. Stahl takes video analysis and extends its scope to any episodic data that allows fine grained analysis. It is not necessary that the data be audio visual and observational, but rather any episodic data such as chat, discussion boards, digital video, negotiation etc.

It has been suggested that in a knowledge building community there are usually present different ‘thinking types’ (Hewitt, Scardamalia, 1998) and this should be considered in the analysis of knowledge building. In this study, participants have not explicitly categorised themselves into ‘thinking types’, and therefore an analysis of participant contributions would be required in order to match them to identifiable types in the domain area. During the initial exploratory investigation of the knowledge domain area, it was found that the area can be separated into a number of key themes, and that these themes seem to fit into specific knowledge types, namely theory, explanatory and descriptive (or practical).

This study will use these techniques in attempting to analyse the main research question in relation to the two related sub-questions. The analysis first attempts to answer the research question “*does group cognition emerge?*” and then “*how does Semantic Web technology enhance or diminish knowledge building and group cognition*”. The analysis of emergent group cognition examines:

- the way in which group members construct group meaning
- themes of meaning making practices
- group strategies
- interpretive perspectives
- and group awareness

The analysis of Semantic Web intervention in knowledge building and group cognition examines:

- Attempts to clarify and organise
- Comparative, selective, combinatory strategy, and explanation
- Knowledge relatedness
- Recognition of and preference for knowledge building in this way

The first phase of analysis will use a quantitative analysis to address this question, where factors such as nodes per user, semantic tags per node, relations between properties and classes, numbers of formalised links making up the hyperspace, relationships between formally linked nodes and users will produce a picture of how and if group cognition emerges. Also examined are 'types' of nodes that link to similar nodes in an attempt to explain or be explained by these fragments, which may point toward knowledge building practices and resulting in intersubjective meaning.

This data will be collected from the KBE database and the cultural artifact (the resulting hyperspace) over a period of time, taking snapshots of episodic activity. This data will be captured and represented as cognitive maps, as it is felt a visual feel of the data will be more intuitive to analysis using this methodology (Jonassen, 2005). The benefits of collecting in this way are that the data is stable, unobtrusive, exact, and retrieved over a long period of time. It is also precise and quantitative. Disadvantages may be that the author/researcher is biased in selecting if the data is not complete (Yin, 2003).

Qualitative Analysis

A second phase of analysis will follow the semi structured interviews of participants. This will be used as triangulated support for or against the questions raised above in the quantitative analysis findings. Use of interviews

are an important source of case study data and have the advantage that they are targeted and insightful and tend to be fluid in pursuing a consistent line of inquiry, appearing as guided conversations rather than queries (Yin, 2003). Interviews must be properly designed and it is important that bias or prejudice doesn't play a part (Creswell, 2000).

The interview (see Appendix) was constructed as conversational and open ended in nature. Interviewees were asked on general experiences, knowledge building strategies, use of the system (tagging and linking), and learning styles. Questions about community awareness, group cognition, identity and the cultural artifact followed, juxtaposing the personal and group understanding of knowledge building. Dislikes, improvements and other thoughts complete the interview.

Conclusion

A case study was chosen as the most appropriate methodology for analysis in this particular investigation. Analysis techniques, both quantitative and qualitative, were discussed as well as the sources of data, including the KBE database, the resulting hyperspace and the interviews.

Evaluation and Findings

Introduction

This section shows how the data was analysed to support, or otherwise, the research problem and related questions of group cognition and the enhancing effect of Semantic Web intervention. Findings are recorded and observations are outlined. Positive outcomes are posited as well as some surprising findings.

Activity Analysis Pointing to Knowledge Building

Phase 1 data found that of 14 participants who began the study 3 dropped out at a very early stage. 11 participants initially engaged with the KBE. Two others subsequently withdrew from the study. The other 9 participants engaged with the system to a significant level (i.e. there were a high number of knowledge nodes built and semantic tags were applied to these nodes). These participants constructed knowledge nodes to a somewhat complete level, covering many of the key areas in the sub domains chosen by individual participants (see figure 14 for a visual representation of an individual's application of the KBE). Table 1 gives an overview of the key activity findings for users on completion of implementation time.

Participant Name	Knowledge Domain Topic	Knowledge Nodes Constructed	Semantic Tags Applied (Average per node)	Formalised Links to Other User Nodes	Other people referenced (avg links per node)
S	Renewable resources	10	31 (3.1)	22	10 (3.3)
P	Future for oil companies	6	18 (3.0)	6	5 (2.2)
B	Biomass	5	18 (3.6)	8	3 (2.0)
J	Alternative Energies	11	13 (1.2)	12	3 (2.0)
M	Future Energies	6	3 (0.5)	2	0 (0)
U	Global Crisis	4	14 (3.5)	1	1 (1)
W	Renewable Energy	3	6 (2.0)	4	1 (1)
A	Alternative Energies	5	6 (1.2)	9	1 (2.0)
R	Future Energy	4	10 (2.5)	17	3 (2.0)
Totals		54 nodes constructed	119 semantics	81 formal links	27 nodes linked to
Some interesting values: Median values can be more representative of small sample sizes. Median value for knowledge nodes created per person is 5, for semantics applied is 13, and median for average calculated semantics per node is 2.5. There were 81 formal links chosen, with 27 nodes (out of 54 available)					

Table 1 shows final activity chart from the KBE.

54 nodes were constructed in total (from the 9 identified knowledge builders). There are indicators for various levels of contributions, with a range of created nodes per user from 3 to 11. 9 participants attached a combined 119 semantic tags to 54 created nodes. The range of semantics per user rises from 3 to 31. The median for calculated averages of semantics per node is 2.5. It could be argued that a participant having attached this amount of semantics per node is significant, in either defining further for themselves the knowledge domain

concept or linking with others in order to clarify, organize, knowledge build. Because semantics were used in order to allow the system to search and make matches, it might be suggested that participants engaged with this aspect of knowledge building and that linking with other people or knowledge nodes was important. Such median values would be more representative of the small sample size in this case study.

Three snapshots were taken of the database, one week into the study, three weeks into the study and at the end of the study. These snapshots reveal an organic feel to the growth of the knowledge domain. After week one 36 nodes were created with a total of 34 semantic links. This may indicate a very personal learning curve where users are attempting to build a picture of the domain for themselves. Only three formal links were made at this stage, pointing to early signs of knowledge building. Some of the participants had not engaged with the environment at this stage. At week three the environment had grown a good deal more with 51 of the knowledge nodes completed. Some of the original nodes had been edited since week one, and over 100 semantic tags had been attached to the nodes. Approximately 70 formal links had been made between nodes, showing an exponential growth to the number of connections. It can be seen that the knowledge domain was almost complete from a user perspective. Some users have edited their original nodes, which may suggest learning from other nodes discovered by the semantic agent, but it is not certain whether this could be attributed to normal learning over time.

Findings for *Emergent Group Cognition*

Indicators of *emergent group cognition* include:

- group construction of group meaning (reflexive shared understanding of the domain)
- group strategies
- interpretive perspectives
- and group awareness

The content of knowledge nodes were coded and analysed for themes identified from an initial exploratory study of the domain area: theory (including global warming and economics), explanatory (reasons why, explanations of key problems) and practical (descriptions for actual technologies, such as renewables, nuclear etc). Table 2 describes the participants and node types, and the types of other author nodes linked to, categorising participants into types.

Participant	Node type (no)	Nodes types linked to	Participant Type
S	Practical (6) Theory (2) Explanatory (2)	3 theory, 3 explanatory, 7 practical 1 explanatory, 1 practical 1 explanatory, 2 practical	Mixed topics, mostly practical referencing mainly practical. Some focus on theory, especially from practical nodes.
P	Practical (4) Theory (1) Explanatory (1)	3 practical, 1 explanatory 1 practical 1 practical	Strong practical focus, referencing mainly other practical nodes.
B	Practical (2) Theory (2) Explanatory (1)	1 practical, 1 explanatory 2 explanatory, 1 theory 1 practical, 2 theory	Strong theoretical and <u>explanatory focus</u> , referencing mainly theory and explanatory nodes.
J	Practical (9) Theory (1) Explanatory (1)	6 practical, 1 explanatory, 2 theory 1 explanatory 2 explanatory	Strong practical focus referencing practical and explanatory nodes.
M	Practical (5) Theory (1)	2 practical	Practical focus referencing practical nodes
U	Theory (4)	1 explanatory	Strong theory base. Only one link to an explanatory node.
W	Practical (3)	3 practical, 1 explanatory	Practical interest with references to other practical nodes.
A	Practical (5)	2 practical, 3 theory, 4 explanatory	Strong practical referencing theory and explanatory
R	Practical (3) Theory (1)	6 practical, 1 theory, 1 explanatory	Practical with theory referencing mostly practical.

Table 2. Node and author types.

From the table it can be observed that for the most practical participants, their practical type nodes link mainly practical type nodes. However, for a theory type or mixed type users, practical nodes tend to link to theory or explanatory based nodes (as in the case for participant S and B). There are indicators of an awareness of group meaning when participants are selective in how and what they link to. This suggests **group construction of group meaning**, contributing new semantically contextual nodes to the hyperspace artifact. A question here arises about motivations of community dynamics and knowledge preferences. Figure 15 shows community relatedness based on node linkage.

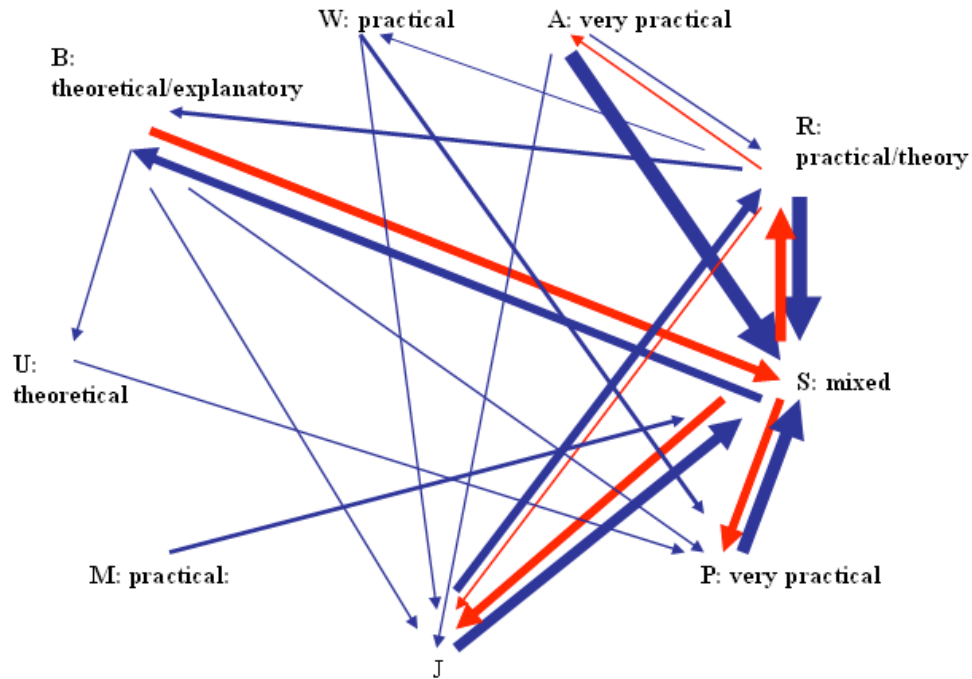


Figure 15. shows user to user relationships. Blue and red arrows show direction of links. The thicker the arrow the more links to this person. For reasons of asymmetric two-way linking, red arrows are introduced.

It can be seen that where a participant is more likely to use a mix of more theory and explanatory, links to those people tend to be stronger from the community. Such participants are also more likely to reciprocate links to referencing individuals. The manner in which there are distributions concentrated around users or nodes suggest individuals are aware of different *interpretations*, which could help to clarify group understanding of a topic. Also 9 of the 27 knowledge nodes were formally linked to 44 times, of a total of 81 links (see table 3).

Participant	High Scoring Node	Number of links to
S	Renewable Resources	11
R	Green Future	7
S	Solar Energy	6
J	Alternative Energy	4
P	Suns Energy	4
B	Biomass	3
J	Nuclear Fuel Cycle	3
S	Peak Oil	3
S	Kyoto Agreement	3

Table 3. Nodes with high number of links to from the community.

Again this shows that the community is centring on certain nodes to explain or clarify. This may also be due to group dynamics and personalities, but in any event it shows that there are significant signs that the community is thinking as a whole (suggesting **group awareness**), and are using certain individuals/nodes to theorise or explain the knowledge domain. This, it could be argued, is an indication of **group strategy**, and the resulting hyperspace (see figure 16) could be said to represent or embody group cognition. In this analysis group cognition seems to have emerged.

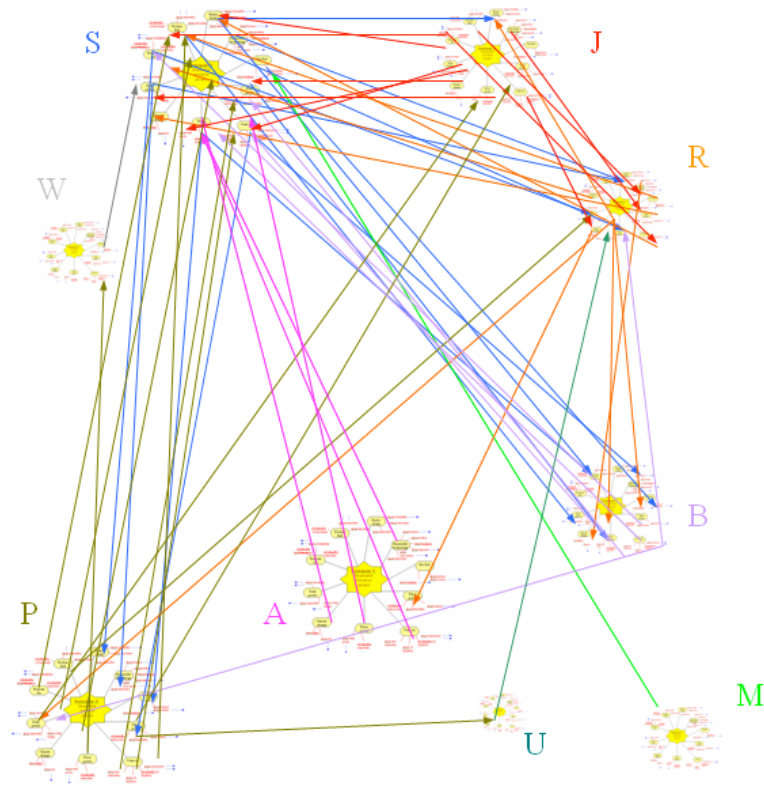


Figure 16. An approximate representation of the resulting hyperspace.

Findings for Semantic Web Technology Intervention

An examination of Semantic Web intervention in knowledge building and group cognition should reveal:

- Attempts to clarify and organise
- Comparative, selective, combinatory, explanatory strategies
- Knowledge relatedness

And importantly:

- Recognition of and preference for knowledge building in this way

Because participants are clearly singling out certain nodes or individuals (indicating **selectivity**) for reasons stated above, this suggests knowledge building strategies of **comparison and explanation**. Taking the example of participant A, who is exclusively practical and strongly tends to link to theory and explanatory nodes, this suggests an attempt to **clarify and objectify** knowledge.

Other analysis of the KBE show that there were 19 classes contributed from which participants could make instance nodes. 9 of these classes were made subclasses of others, suggesting that there was a community dimension to the construction of the KBE ontology. This ontology would be used as the scaffold for building the hyperspace, as it effects how the agent inferences. There were also 48 different types of properties contributed by the community which were used 119 times. Of these there were approximately 10 which were used in the majority of instances to semantically tag and then link nodes. This indicates strategic **group understanding** of how best to create and use the domain ontology and results in awareness of and construction of **knowledge relatedness**.

The KBE environment presented approximately 340 nodes throughout the community, so potentially there might have been this amount of links. However, as in table 1, only 81 links were formalised. Again this points to **selective, comparative and combinatory strategies** being used by the community indicating existence of metacognitive skills.

Finally, the system presented 39 potential 'indirect' links which were inferenced using the advanced ontology building facility. However, only 2 links were chosen by the whole group, which was an unexpected and weak engagement with this facility. This facility could have been used for very strong knowledge building tactics for the domain ontology. It was not clear why weaker than

expected ***knowledge relating*** happened, and was the basis for some of the questions in the interview stage.

From the findings reported here, it could be argued that the *interventions of Semantic Web technologies in KBE enhance* group cognition and knowledge building. Further analysis should find indicators that these effects are due to preferences to using this kind of KBE over other methods of collaborative knowledge building (such as web publishing, Wikis etc.) A quantitative comparative study with other KBEs (such as Knowledge Forum) is beyond the scope of this study. A qualitative analysis of experiential data from interviews is analysed to respond to this question.

Interview Analysis

A sample from the group who were engagers with the KBE were chosen for interview. It was felt that three persons would give a representative experiential account of what happened during the implementation stage. A general activity usage of average semantics applied per node was used to take the sample. The averages were: 0.5, 1.18, 1.2, 2, 2.5, 3, 3.1, 3.5 and 3.6. As some participants engaged minimally it was felt that taking an interquartile range and choosing the median and either ends of this range would give a better representation of the general group. Those participants with an average of 1.2, 2.5 and 3.1 semantics per node were therefore interviewed.

Generally there was a very positive feedback about encounters with the system. Participant responses relate a preference for producing cultural artifacts this way over and above other methods (such as publishing normal web content or using other environments like Wikis). The numerous references to “easy to use” and “enjoyable” feedback indicate an *enhancing effect* over other knowledge building technologies.

“I liked it because you are free to do it the way you want to do it. It’s very straightforward ... It didn’t take long to build all your nodes. You could quickly see where every thing linked to. But with a web site ... you use

your links ... to go to different pages. With this it was completely different. It was categorized as well. If you wanted to find (*something*) you would just look at (*example*) renewable resources and you wouldn't have to worry about the rest."

With reference to a comparison with Wikis, and how retaining identity is important to individuals:

"I liked the way you can view other people's work and that you can link to them. I thought it was great to see how other people were thinking, how I was thinking."

There seemed to have been indications of **group strategy**:

"It's good. It's kind of inclusive. When you type something you're almost thinking, what would they type, how would they answer this, how would they add into it? It would be interesting to see if it did go live what people would say"

This last quote seems to suggest an insight into group cognition, **group awareness**. It's as if the group were thinking metacognitively. There are a number of references to this in other interviews, such as the following:

"It makes you think differently, it makes you think outside the box. This is what someone else has thought on it. And, why are they thinking like this, and why am I thinking like this?"

Another interviewee seems to suggest that the exchange of knowledge was useful:

“It gave me ideas for my nodes. I could go public, and I could see what other people had done. It gave me ideas about doing something similar but not the same.”

There were positive indicators for **knowledge relating** activities. The whole idea of a knowledge building community caught on, and was clearly understood (after initial teething issues). Certainly there was a feel that the environment could be used in a real-world scenario as a useful KBE tool, which demonstrates transferability and understanding of the process of knowledge building:

“It would probably be good for medical research. People share their ideas. Say they’re in different parts of the world, they are doing the same research, having the same thoughts or ideas, and I’d say it would work well with that. They could feed off other people’s ideas.”

Themes of **group strategies** in knowledge building appeared in the interviews. This supports previous findings for emergent group cognition.

“I felt the information expanded what I already had, so I would link it. I was trying to see from the point of view of whoever was looking at my thing, what they would be interested in...”

However, there was some question as to the motivations of some of these links. There was a suggestion that some of the linking was done “just for the sake of it” and that in certain instances it might have become a “game”.

“Immediately you’d see some groups of people who’d be friends would pick whom they possibly thought would be their best friend.”

This is interesting, in that there are inevitably going to be social motivations in any knowledge building exercise. This seems to also have affected the group working of the advanced semantic management facility (influencing **knowledge relatedness**).

“Perhaps people didn’t fully grasp how vast (pause) how the piece of software could go down to that finite level. It’s a proper relationship information piece of software. It’s like people were just seeing the relationship amongst themselves and the other people in the class”

This seems to be the reason why there was not a full engagement with the advanced features that the environment could achieve as found in the quantitative stage. This was also possibly down to the length of the implementation period, and the novelty and learning curves for participants.

The community seemed to be **aware** of the resulting hyperspace and seemed to understand it as a summary of group cognition. However, the experience of using the resulting hyperspace was somewhat mixed.

“You could get lost if you went clicking away happily, and you might find yourself going from one grey area into a different topic. If you follow all the links it could be... it might get you off the topic, because you’d be fed off into a different areas.”

And

“It could draw you away from focusing on your own...but it expands your knowledge though. It definitely expands your knowledge.”

At this stage of using the system, it seems, the process of knowledge building is more important to the community than the actual resulting knowledge itself.

Conclusion

This section showed how the data was analysed. Findings and observations were outlined and positive and unexpected outcomes were put forward.

Discussion, Conclusion and Recommendations

Discussion

In the case study of the KBE it was found that there were indicators of emergent group cognition arising from knowledge building activities. It can be suggested from such a study that the use of Semantic Web technologies in KBE lead to knowledge building and emergent group cognition, and enhance such environments by supporting lasting representations, relatedness, and the principles of sharing knowledge. Indicators include procedures of group awareness and strategy, clarifying, organising and the importance of connecting with proximate knowledge fragments to explain or summarise.

There was a sense of organic growth to the resulting hyperspace, with the number of links between knowledge nodes growing exponentially over the initial stages, and the content of nodes becoming more refined. There were also surprising findings of other motivations within this environment other than knowledge building purposes. There was some element of 'game' going on in the community, where people were trying to link up with people who they may have been friendly with, though it is not possible to identify how much this happened. Such motivations should be considered and harnessed in the design of future KBE, perhaps learning something from peer-to-peer sites such as Bebo. There was also a liking for the ability of the environment to retain a sense of identity for the individual in group knowledge building which may even be a contributory factor in group cognition.

All in all, the environment seemed to be a positive experience for participants, with some mixed usage of the resulting artifact. It seems the experience of the knowledge building process was very enjoyable. The sense was that 'learning is fun'.

Conclusions and Recommendations

To achieve effective knowledge building requires that learners must think together as a group to produce a shared artifact. And using Semantic Web concepts in a knowledge building environment is a way of enabling and enhancing this group cognition. The literature tends to point in that direction and a fusion of the technologies seems possible in achieving these aims.

A case study of a small group activity demonstrates signs of emergent group cognition, signalling an effective and enhanced KBE. It can at least be said that knowledge building success is probable given a comparable setting.

It is recommended that multiple case studies using differing knowledge domain types and communities would be required to further refine and discover new requirements for the KBE. Use of comparative studies would benchmark the use of the environment against others (such as Knowledge Forum).

There are many concepts that could be taken from other KBE, such as advanced support for argumentation, discussion and explicit formulation of new 'rise-above' ideas to make this a full featured KBE.

A Future Vision

Such semantically enabled KBE may become the warp and the weft of the future Internet, with such a facility built into many different applications capable of publishing content. It will enable a global think-tank where communities of knowledge contributors self organise into overlapping neighbourhoods yielding new discoveries and questions from serendipitous interactions. The entire Internet may one day become synonymous with KBE.

Appendix

The following is the outline for the questions asked during the semi-structured interview. It was guided conversational in practice, and interviewees were encouraged to talk on unforeseen issues if pertinent to the study.

How would you rate your general experience of using the artifact?

What strategy did you use in building knowledge nodes in the subject area? How did you go about building knowledge nodes?

Did you place semantics on any knowledge nodes? Why did you place semantics on links? Explain...? How did the processes of building nodes and semanticizing them help you in your understanding of the subject area, if at all?

Did you check to see if the system presented you with potential links? How did you feel about these potential links? Did you formally link to any other nodes? Explain why...?

Are you aware of any learning style preference that you might have? Did the system allow for you to employ these learning styles?

Did you notice other styles, or learning preferences in other nodes you linked to? How did this effect your understanding of the area?

Did you sense there was a community present?

Did anything you read from other people's nodes help you with your understanding of the subject material?

Did you navigate across the environment space? What is your opinion of the resulting flat hypertext space?

Did you feel a sense of individuality within the environment? Did you notice personal characteristics arise? Did you sense you had a place in the community (e.g. contribute to the knowledge building exercise.)

Can you name one or more things you liked about the environment?

Can you name any thing you disliked about the environment?

Do you have other comments or feedback, such as improvements or other uses or ideas for the technology?

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