World Transactions on Engineering and Technology Education
Vol.11, No.4, 2013

Engineering education knowledge management based on Topic Maps

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ABSTRACT: The Internet and other information technologies have now become integrated into learning. However, some problems have emerged when the information used in the Web environment, such as knowledge representation, knowledge reorganisation, knowledge clustering and knowledge retrieval have been used. With changes in the external environment and the emergence of new demands, engineering and technology education is undergoing a paradigm shift. In this study, a Topic Maps technique is proposed, to reform the organisation of information relating to engineering and technology education knowledge. An example course and thesaurus are used to illustrate the technique. The technique organises the information into a hierarchical and multi-granular model that includes semantic associations and intelligent classification course content and support for different learning styles. The results have shown that the technique engages students who find it enjoyable.

INTRODUCTION

Considerable growth in the use of educational materials over the World Wide Web has taken place in recent years. Information technologies have become thoroughly integrated into the field of learning [1]. Technology plays an important role in almost every aspect of human life, such as industry, commerce and education; the Internet and other information technologies also have become integrated into the lives of today's college students. Learning management systems based on the Web, such as Blackboard, Moodle or Sakai are commonly used in colleges and universities.

All of these, to a large extent, have changed the way students learn [2]. Engineering and technology education requires a widespread and up-to-date access to various information sources, for instance, textbooks, journals, operating guidelines, selected Internet sites and expert colleagues. However, an efficient use of these information resources in learning is hampered by the heterogeneity and spatial distribution of the data, implying the necessity to make use of different retrieval techniques.

Traditional knowledge systems (such as classification systems, thesauri subject headings) are an important part of the organisation of traditional literature. When they are used in the Web environment, some disadvantages emerge, such as retrieval results that are not understandable, requests that cannot be processed or the retrieval function that may be slow. The explosive growth of the Internet requires a new generation of technologies for managing the *big data*. It is necessary for these to transform content and structure, such that they reconstruct networked knowledge systems to support organisation knowledge and content-based information retrieval.

In current research about on-line collaborative learning and knowledge building, there are two categories of thought: theories on how to customise a personal learning environment and research focused on collective learning processes. The main limitations with these studies lie in the management and interpretation of the knowledge. As the time of big data is coming, so is the need for a new generation of technologies for managing information flow, data and knowledge. To reiterate, it is necessary for these technologies to support organisational knowledge and content-based information retrieval.

The International Organization for Standardization (ISO) provides a syntax for the structure of information resources, which is used to define topics, associations, occurrences and relationships. Topic Maps is an ISO standard for knowledge representation and interchange, with an emphasis on navigation and retrieval of information. As defined by the standard, Topic Maps can represent data contained in knowledge objects, e.g. as topics, associations and occurrences enabling the creation of navigational tools, linking these topics together to enable management of the knowledge objects and data retrieval by creating user and purpose-specific views [3]. Thus, Topic Maps are used to manage knowledge, knowledge representation and information retrieval.

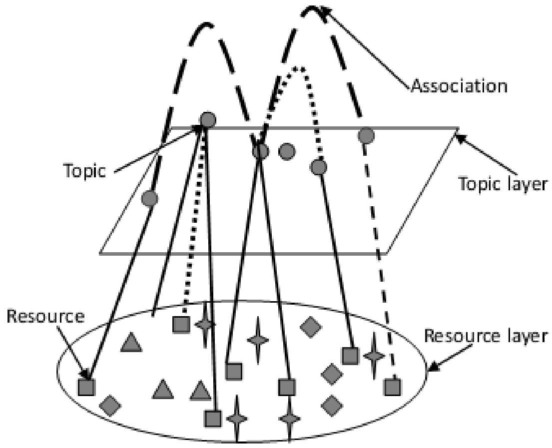

Figure 1: Structural model of Topic Maps.

Figure 1 shows the structural model of Topic Maps. Topics are the main building blocks. The word *topic* comes from the Greek word *tops*, which means both location and subject. A topic is a computer representation of a subject and may be applied to a set of locations. Each of these locations is a resource, called a topic occurrence. The subject of a topic is the primary characteristic and the secondary characteristic resides in the occurrences [4]. That subject can be expressed by pointing to a resource. Two cases are possible: either the resource itself constitutes the subject of the topic or the resource merely indicates the subject.

Topics are connected to each other through associations. The definition of the association semantics is left to the designers of the Topic Map instance. Associations can be used to represent usual relations in thesauri (for example, narrower term, broader term or related term). They can express the relations used in relational database tables, as well [5]. Associations also can be used to overlay hierarchical structure upon existing information resources and, therefore, associations are useful for building virtual tables of contents that serve to present information objects in a given order, regardless of the way they are actually stored.

With open source software, many organisations provide opportunity for anyone to download from the Web, and also to have accompanying licences for those who do not have to pay. Open source licences also allow those who pay to use the software in commercial projects. Combining Topic Maps and XML technology opens fascinating new ways of using Topic Maps for the Web to facilitate the structuring of information and provide a consistent look and feel throughout entire Web sites. The Web design and implementation framework discussed here mandates consistency in representing and accessing knowledge.

Topic Map technology is based on the idea of ontology and metadata; it not only inherited the traditional knowledge organisation methods, such as classification, indexing, vocabulary, but has also adopted advanced ideas from the semantic Web and ontology. Topic Map technology integrates and correlates subject and theme, and also separates topics and resources. This is presented as a graphical network to the user. In this way, users can fully grasp the explicit knowledge and the theme linking tacit knowledge and the diversified information resources.

The development of engineering and technology, and engineering and technology education calls for new methods of knowledge management to enhance the core knowledge of the engineering and technology disciplines and to cultivate innovation. In this study, the methods of literature analysis, case studies, expert interviews and questionnaire investigation, were adopted, to analyse the mechanism and approach to knowledge management in engineering education. The study presented here is about the Topic Maps technique used to reform a course based on the information from the course and a thesaurus that organises the information in a hierarchical and multi-granular way. The reform involved developing a semantic association and classification of the course information that supports different learning styles. Students have reacted positively to the reformed course.

METHODOLOGY

The Topic Map technique requires the determination of topics and the relations between them [6]. To do this, it is necessary to first identify the course thesaurus and describe the relationship between the topics; then, standardise the descriptions using the theme graph grammar of the Ontopia engine as a thematic map processor; hence, linking and organising resources to provide navigation-type access.

There are various definitions of knowledge management. In the field of information management and computing, knowledge management is the creation of an integrated knowledge system, allowing shared access and updating. Users in an organisation can quickly obtain key knowledge. Knowledge management systems structure knowledge for fast and shared access [7].

Determine the Thesaurus

A thesaurus is an expanded index that interconnects terms in a particular area, and contains information, such as definition and application. Given a specific word, a thesaurus will, for example, indicate which other words mean the same, which terms represent a broader category or a narrower category.

As an example, a course covers a specific topic. This topic will be at the centre (captioned with keywords). Eight relevant keywords and alternative words can be selected for the correlation analysis and to sum up the relationship between the words.

In this study, four types of relationship were defined as: definition, broader term, narrower term and related term. This is important, because it makes it easy to know that not only are two terms related, but also how or why they are related.

XTM (XML Topic Maps Specification) Grammar Used to Write Code

XML (eXtensible Markup Language), was produced by the World Wide Web consortium (W3C). It is a structured markup language, describing data and data types. The XML tags are customised to provide an extensible language. The XTM is a Topic Map customisation of XML. The XML code can describe complex data relationships, and applications based on XML can search data. The Topic Map technique describes the information in documents and databases by linking them using URIs (Uniform Resource Identifiers) - see Appendix A for an example. The Topic Map used in this work and coded in XTM 2.0, contains eight topic types, four association types, 16 role types and 13 occurrence types.

Topic Maps Release and Display

Omnigator, a free downloadable topic map navigator, powered by Ontopia, is used with Java Server/Servlets to develop a free Topic Map browser [8]. Omnigator can access information quickly. It uses a client/server architecture based on the HTTP protocol and, with Tomcat as the server, can read databases and generate dynamic HTML pages on the client side. The browser receives the HTML, to display the Topic Map visualisation. Omnigator implements Topic Map management functions, such as loading, overloading and deleting. It can validate Topic Maps syntax. It also provides full-text indexing of plug-ins, statistics, filter plug-ins, merge plug-ins, export plug-ins, etc.

Vizigator is the Ontopia visual component - a desktop visualisation module consisting of the visualisation application and a visualisation plug-in. Unlike Omnigator, which uses text to display the Topic Maps, Vizigator navigation has a graphical user interface to visually display the theme, correlation and resources, in different colours and different shapes for different parts of the Topic Map. The size of the graphics can be adjusted to effectively display the knowledge structure of information resources.

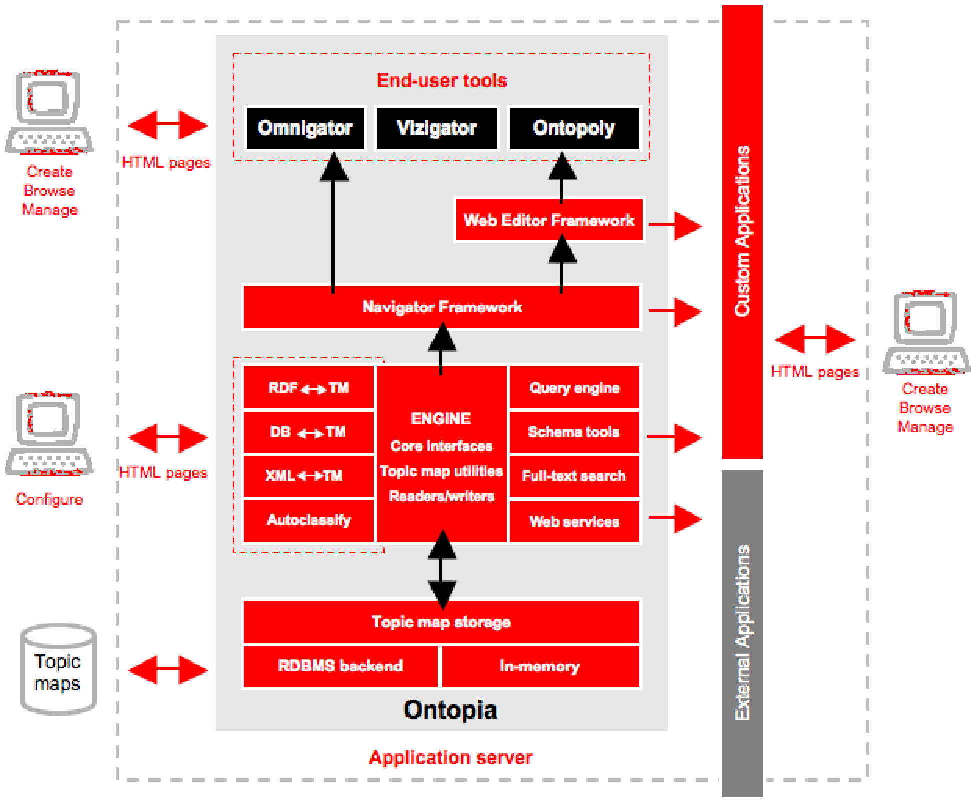

Figure 2: Functional unit and processing of Ontopia.

The study of Topic Maps included reviewing the periodical literature related to Topic Maps. Current research on Topic Maps technology and knowledge navigation was summarised to determine methods, objectives and content. The objective in constructing Topic Maps is to help teacher and learner and to promote the exchange of existing learning resources. Figure 2 shows the functional unit and processing of Ontopia.

The Vizigator's graphical visualisations of the relations of a Topic Map clearly display data, and is a visually attractive and useful way to display a Topic Map. Vizigator allows the user to create the structure of Topic Maps. Nodes are connected by lines to represent the relationships between subjects. The graph, consisting of nodes and the relations between them, facilitates locating knowledge and to understand the relationship between different points of knowledge. Also, the graph can *recommend* to a learner their own personalised learning path.

Figure 3 shows an integrated Topic Map for a *partial ordering* process, which takes the subject of learning science as an example. It also shows the topic vocabulary of the education information processing network course, the subject of relevance, relevance between, i.e. in the role of guidance and resources of the category. When the user searches with key words shown at the centre of the knowledge structure, the system provides solutions for knowledge organised for individual learning. Based on the principle of multi-representation, an individualised and convenient knowledge system was developed in this study for students with special learning needs and for teachers.

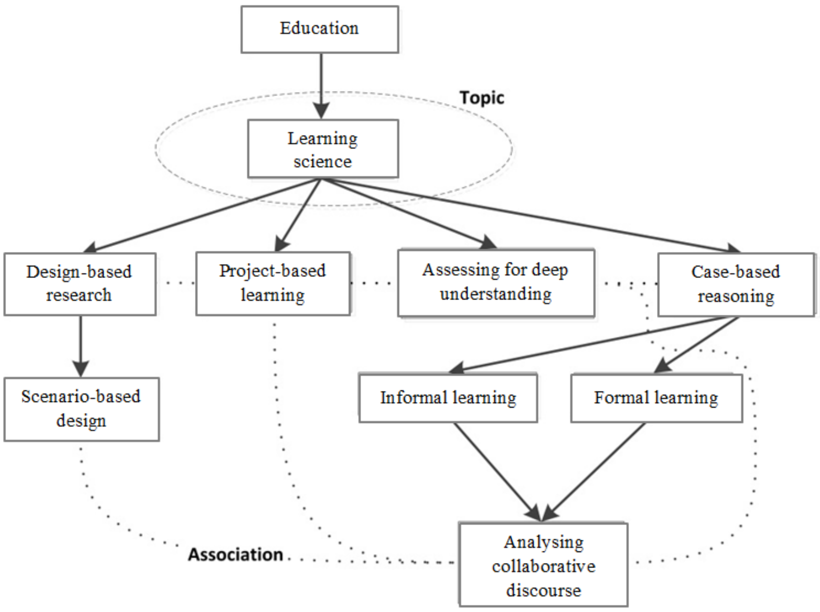

Figure 3: An integrated Topic Map for the partial ordering process.

PERCEPTION SURVEY RESULTS

Evaluation of the results focused on students' perceptions of using topic map technology and are shown in Table 1. The five-question perception survey, which used a scale from 1 (strongly disagree) to 5 (strongly agree), was completed by all 122 participants. Although no statistically significant differences occurred, the mean scores were consistently higher for students who had used the author's approach.

Table 1: Perception survey results.

Survey question	Topic Map used (n = 70), Mean	Traditional technology used (n = 52), Mean
Used Topic Map; improved my grade in the course.	3.8	3.2
Used Topic Map; improved my understanding of the subject content.	4.1	3.8
Used Topic Map; increased my feeling of belonging in the course.	4.5	3.7
I would recommend using Topic Map again in the course.	4.3	4.0

Note: Strongly disagree = 1; Disagree = 2; Unsure = 3; Agree = 4; Strongly Agree = 5

CONCLUSIONS

In this article it has been demonstrated how course knowledge may be built into Topic Maps, which are useful for flexible knowledge management. In a Web-based learning environment, the Topic Map provides learners with individualised support. It also promises a convenient and simple interface for course material developers to prepare material and for instructors to set up an individualised reading environment for their students. The usability evaluation indicated all interfaces were easy to use; the efficiency of the system gained the highest score. The evaluators agreed that Topic Maps could increase efficiency for all groups.

After describing in this article the mastering of basic theory and relevant technical aspects of Topic Map, it shows how to implement the application of knowledge navigation in the course, Learning Science, based on Topic Maps. Some comparative analyses of typical applications based on Topic Maps were determined using the components of OKS (Ontopia Knowledge Suite) to build the Topic Maps. First, a theoretical model of knowledge navigation in the network course was proposed based on the Topic Maps, including resource layer, topic layer, the Topic Maps layer and user layer. Then, the topic and ontology were built. Finally, the installation and configuration of OKS and the steps for building the Topic Maps were produced, and a visualisation of the Maps developed using the Vizigator plug-in within OKS. The following concluding comments are:

- As a knowledge organisation technology, Topic Map technology builds on traditional knowledge organisation technology. Literature resource organisations can use this technology to build a theme-structured layer; and to establish the link between literature resources and semantic structure, enabling flexible relationships between literature resources.
- As a knowledge representation language, Topic Map technology uses semantic markup to represent knowledge structures and it uses semantic tags to define the subject, relevance and resources. The advantage is that it is easy to understand and has a simple data structure. At present, Topic Map has a relatively simple ontological language, but the aim is to improve both the form of expression and reasoning.
- Topic Maps technology can be used for knowledge navigation by adopting the idea of ontology and the semantic Web, and various Topic Map technologies. Topic Maps feature reusability and extensibility along with semantic interoperability between different Topic Maps and the semantic relation with data mining.

There are still several aspects of Topic Maps that need further study and exploration. In the future, the focus will be on co-operative methods involving different domains of learning materials.

ACKNOWLEDGEMENT

This work is supported by the soft-scientific project of Henan Province (No. 132400410982), and Research of Education Sciences of Henan Normal University (No. 01026400303, No. 01016400301).

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APPENDIX A: THE XTM CODE

```
<?xml version="1.0"?>
<!DOCTYPE topicMap SYSTEM "xtm1.dtd">
<!-- Topics -->
<topicMap xmlns="http://www.topicmaps.org/xtm/1.0/"
xmlns:xlink="http://www.w3.org/1999/xlink"id="NeferTree">
<topic id="learning science">
        <baseName>
                <baseNameString> learning science </baseNameString>
        </baseName>
</topic>
<topic id=" education ">
        <baseName>
                <baseNameString> education </baseNameString>
        </baseName>
</topic>
<topic id="bt">
        <baseName>
                <baseNameString> Broader Terms </baseNameString>
        </baseName>
</topic>
<association id="association">
        <instanceOf>
                <topicRef xlink:href="# hierarchy relation "/>
        </instanceOf>
                <member>
                        <roleSpec>
                                <topicRef xlink:href="#bt"/>
                        </roleSpec>
                        <topicRef xlink:href=# "learning science"/>
                </member>
                <member>
                        <roleSpec>
                                <topicRef xlink:href="#nt"/>
                        </roleSpec>
                                <topicRef xlink:href="#education"/>
                </member>
 </association>
```