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A CASE STUDY IN ORGANIZING AND PRESENTING A COURSE WITH CONCEPT MAPS AND KNOWLEDGE MODELS

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Abstract. This work contains a description of a case study in the creation and delivery of a course entitled Web-Enabled Applications that utilized concept mapping and knowledge modeling as the framework for material organization and presentation. While the knowledge modeling approach described here has been in existence for some time, few empirical studies in its use for course development and delivery are to be found. The current work reports methods and statistics pertaining to the development of the knowledge model, how it evolved during use in the course, and student attitudes toward this mode of course presentation.

1 Introduction

Work at the Institute for Human and Machine Cognition has given rise to the notion of a knowledge model (Ford et al. 1991; Ford, Cañas & Coffey 1993) as a linked aggregation of concept maps (Novak & Gowin, 1984) and other electronic resources that elucidate the concepts in the maps. Although the idea of knowledge modeling has been with us for some time, their use in course delivery has not been extensively studied or documented. Some interesting barriers have existed to the assessment of such use. Several of the larger knowledge models created at IHMC have undergone relatively little evaluation because of educational material format. For instance, use of knowledge models in military training is somewhat problematic because of the long tradition of very structured, lockstep training regimens and tightly proscribed types and organization of instructional materials. Similar difficulties were encountered in the nuclear power industry where training materials and protocols are strikingly similar to those utilized by the military.

This paper reports results of work on the development and use of a knowledge model as the framework for the organization of materials and the presentation of a university-level course. The CmapTools (Cañas et al. 2004) software was used to build a knowledge model for a course entitled “Web-Enabled Applications” that pertains to various technologies such as XML, XHTML, XSLT, Javascript, AJAX, and PHP. The knowledge model was then used as the learning environment through which the course was delivered and as the organizing factor for all resources associated with the course. No standard course delivery software (such as PowerPoint™) was used in the course.

After a brief review of the literature pertaining to course delivery with concept maps and knowledge models, the remainder of this article will briefly describe the creation of a knowledge model of the course content and then elaborate a case study in the use of the materials to deliver the course. The case study includes some statistics pertaining to the size of the knowledge model, details of how the knowledge model was used and modified during the semester, and results of surveys pertaining to student attitudes to this mode of presentation. The next section contains a review of literature that is relevant to the current work.

2 Relevant Literature

Advance Organizers are devices that are used to present global summarizations of content to be learned by the student. Ausubel et al. (1968, 1978) state that advance organizers improve the ability of students to incorporate new knowledge into existing knowledge, a key factor in meaningful learning and the retention of knowledge. Several studies have been described that utilized "expert maps" as advance organizers for students in a variety of knowledge domains. Novak (1998) suggested that, if created at a level of generality that is appropriate relative to the learner's current understandings, concept maps can serve as powerful advance organizers. In their new model of education based upon concept mapping and CmapTools, Novak & Cañas (2004) describe the use of expert skeleton maps. Others have described the use of expert maps as advance organizers in the teaching of undergraduate science courses (Heinze-Fry, 2004), in preservice teacher training in pedagogy and subject area content (Colli et al. 2004), in secondary school Physics teaching (Alias, 2006), and in mathematics teacher training (Caldwell et al. 2006).

With regard to the use of full-fledged knowledge models as educational vehicles, results are more difficult to find. Some studies have described the use of knowledge models in informal education. Briggs et al. (2004)

from the Center for Mars Exploration at NASA Ames described the use of this approach to knowledge modeling to organize a large number of electronic resources. Arbea et al. (2004) described the Comenius Project, which utilized the concept of a knowledge model to organize materials pertinent to traditional Spanish festivities.

A few studies of the use of Knowledge models as organizing factors in more formal educational settings have been described as well. Fernandez et al. (2004) described a knowledge model that was used to teach movie (film) analysis and production. Coffey (2005) described the use of a knowledge model in a computer science course on data structures, and Basso & Margarita (2004) described the use of a knowledge model that actually integrated with the Plone open source Content Management System, which was also the topic being taught. The results presented in these studies were all preliminary. The next sections elaborate the idea of a knowledge model in the context of the one used in this study, followed by a description of the current work.

3 Knowledge Modeling

This section contains a description of a knowledge model (Ford et al. 1991; Ford, Cañas & Coffey 1993) as the term is used at the Institute for Human and Machine Cognition. This section describes the structuring of a Knowledge Model to present a visual representation of the structure of course content to students. *CmapTools* (Cañas et al. 2004) was used to create and deploy the knowledge model that is the topic of this article. The section concludes with a description of resources that are typical of those that were used in the current work.

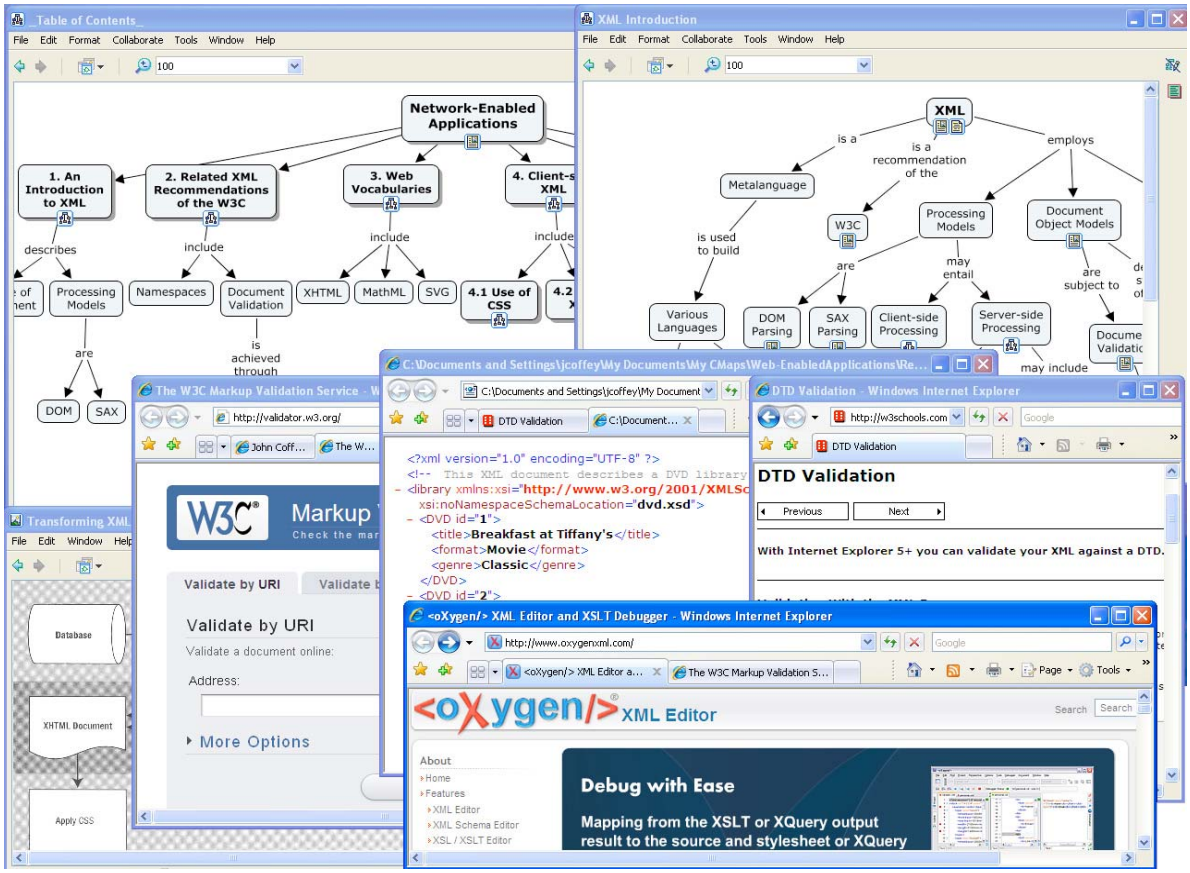

Figure 1. Representative components in a Knowledge model used in the course on Web-Enabled Applications.

Knowledge Models are hypermedia representations structured by Concept Maps, with a general, top-level map as the starting point and more detailed maps pertaining to the central concepts in the Top Level Map (Ford Cañas & Coffey 1993). Documents in any electronic medium might be associated with the concepts in the Concept Maps. *CmapTools* provide support for the creation and representation of knowledge models pertaining to a knowledge domain. Knowledge models created with *CmapTools* may be developed and accessed over a network. Such knowledge models can serve as pedagogical adjuncts to courses or as the main organizing and presentation factor, as was the case in the current work.

Figure 1 contains a graphic of representative components of the Knowledge Model pertaining to the Web-Enabled Applications course. The scenario depicted in Figure 1 has the student opening a global view of the course which is contained in the window entitled "Table of Contents." This representation is not an actual concept map, but rather a modified version of what has been termed a “map of maps” (Coffey, 2006), a structure that represents the hierarchical organization of the concept maps in the system. In this scenario, a Concept Map pertaining to XML was accessed from the course organizer map. The window containing that Concept Map is visible in the top right. From there, the student selected other information pertaining to the topic including a validation website for XML, a sample XML document that might be validated, a link to a tutorial resource on validation from Document Type Definitions, and a link to a website where an XML editor is available. The elements depicted in Figure 1 are typical of those that were included in the knowledge model used in the current study. This Study is described in the next section.

4 A Pilot Study Using a Knowledge Model to Organize and Present Course Materials

This section contains a case study in the use of the knowledge modeling scheme to develop and deliver a semester-long (4 month) course based upon a knowledge model. It starts with a description of the development process for building the model, and then elaborates research questions, methods used to deliver the course and to answer the research questions, and results of the study.

4.1 Developing and Using the Knowledge Model for the course

The initial model was created during the 5-week period before the start of the course. It was created by concept mapping chapters in a book and other background conceptual knowledge, and searching on the World Wide Web for resources with which to augment the knowledge model. Some of the accompanying resources that went into the knowledge model were identified in the book, but most were found separately through search. The top level organizer for the course, which is depicted in Figure 2, gradually emerged as a result of this process. It underwent several revisions as the course was developed. The iterative process of concept mapping and modifying the table of contents led to the structure in Figure 2.

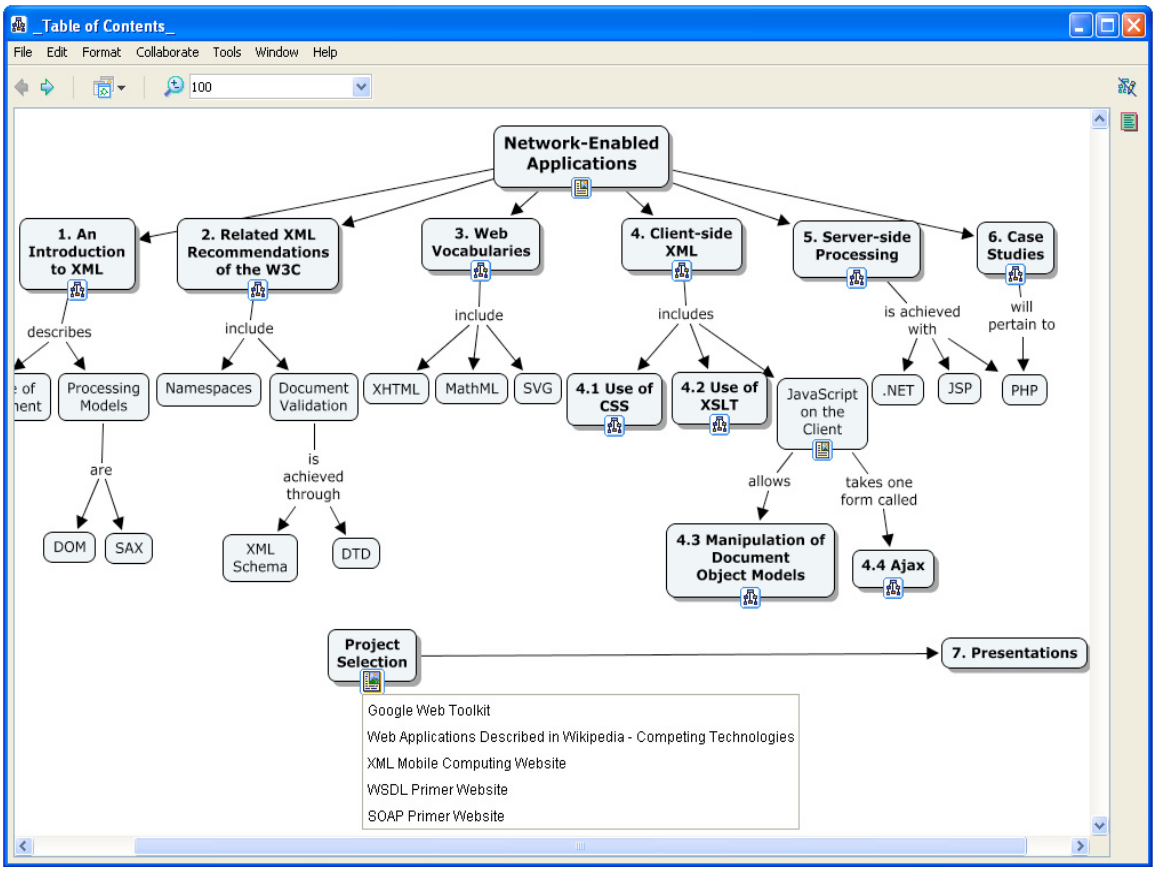

Figure 2. A graphic of the top-level page for the Web-enabled Applications course.

At the start of the semester, the Knowledge Model was placed on a *Public Cmaps* server where it was always available to the students. The instructor presented a brief introduction to Concept Maps, the structure of knowledge models, and the navigation scheme through which students access the concept maps and accompanying resources. Classes were conducted entirely through the use of the knowledge model. At the start of each class, the context of the topic of the day was discussed by viewing its place among the other topics in the organizer map for the course. After this exercise, the particulars for the day's agenda were viewed and discussed by systematically working through the relevant concepts in the concept map that pertained to the topic. This approach created a highly comprehensible broad context for the topic of the day and fostered an understanding of related, more detailed concepts.

Although this course was considered an important one to include in the curriculum, no faculty had any significant experience in these technologies. Consequently, the instructor was attempting to learn about and understand the knowledge domain as he was assembling the course. As suggested by Novak and Gowin (1984), creation of the concept maps played a very positive role in helping the instructor to understand the large amount of background knowledge needed to teach the course.

Interestingly, the process of critically assessing potential accompanying resources also played a salutary role in preparing to teach the course. The evolving knowledge model proved to be a suitable repository for the accompanying resources and it helped the instructor to keep track of them. Among others, the basic categories of resources included client and server-side program code, side-by-side comparisons of program code with the accompanying XML documents that were being processed or created, graphical depictions of software architecture, graphical depictions of processing models, online tutorials on XML, XSLT, DTD, Javascript, PHP and other technologies, and websites offering services such as the Microsoft validation website.

The room where the course was conducted contained computers for each of the students. Students typically accessed the knowledge model either from the provided computers or from their own laptops during the conduct of the class. They could modify and execute programs as the instructor did the same, visit websites linked to the materials to perform group-related active learning exercises, and perform other sorts of interactions with the course materials.

4.2 Research Questions

Four research questions were identified before the course began.

1. Would students find visual knowledge representations to be useful and/or intuitive, compared with other familiar representations of course materials?
2. How would students utilize the knowledge model?
3. Would there be any correlation between learning style and attitudes toward the knowledge modeling scheme?
4. Would the knowledge model evolve during the term, and if so, how?

4.3 Methods

A variety of methods were used to answer the research questions. Students took two surveys during the semester, one that helped to analyze their approach to learning, and a second that captured opinions regarding the use of the knowledge model as the underlying factor in material organization and course delivery. Additionally, the instructor invited students to help refine the concept maps and accompanying resources and tracked statistics on the changes that were made. The most significant changes tended to be "wordsmithing" modifications to the concepts. Changes to the knowledge model were typically based upon consensus that the change would make the model more easily understood or more easily navigable. Finally, students were invited to submit Web sites and other materials to be considered for inclusion in the knowledge model. Statistics relative to this activity were tracked.

With regard to the surveys, a 21 question, five-point Likert Scale learning style inventory that measured one basic bi-polar distinction, a predisposition to adopt either rote or meaningful learning strategies, was administered at the start of the course. Near the end of the course, a 17 question, five-point Likert Scale survey addressing the issues represented in the research questions was administered. The instructor was not involved in tallying the statistics to reassure students that they could be honest in their responses.

4.4 Study Results

The survey pertaining to the research questions included some elements to define how students used the knowledge model. A total of 92% of the students downloaded the CmapTools software to their own machines. The same percentage of students accessed the knowledge model outside class. Students had access to the book and to all code examples separately from the knowledge model, and they could easily bookmark websites that they considered useful. Accordingly, it would not have been difficult to avoid using the knowledge model at all if a student were so inclined. Statistics were also culled pertaining to accesses to documents in the model when students went in. Eight percent indicated they would typically access one document at a time, 73% stated 2-5 documents, and 19% accessed more than 5 documents at a time during an interaction with the model.

Survey Item	Agree	Disagree
The knowledge model is confusing because there are so many documents in it.	17%	67%
The main value of the concepts maps is as an organizing scheme for the other materials, rather than for the information they contain themselves.	33%	42%
I view the concept maps for the information they contain.	83%	17%
I used the concept maps to study for the exam.	58%	42%
I find it easy to find the information I want in a concept map-based knowledge model of the type used in this course	75%	8%
I prefer the organization of materials in a book to the way that they are organized in the knowledge model.	25%	25%
I would prefer to have presentations from PowerPoint than from a concept map	25%	67%

Table 1. Selected survey response rates. The scale used was (strongly agree, agree, neutral, disagree, strongly disagree). Agree is the combined number of agree, strongly agree.

Table 1 contains the most significant results of the survey. Some results are aggregated when multiple questions pertained to an issue. Percentages do not always sum to 100% because the 5 point scale allowed neutral responses. As is evident from the percentages, students did not find the knowledge model of more than 400 resources difficult to navigate. While they had somewhat mixed opinions regarding whether the concept maps were more useful for the knowledge they contained or simply as an organizing scheme, a large majority thought the concept maps conveyed knowledge even if not as large a majority used them to study for the exams. In an absolute sense, students thought the knowledge model arrangement was an effective way to organize materials. However, when compared to more traditional course organization and presentation schemes, students did not express a clear preference either for the knowledge model or the traditional approach. They did show a clear preference for presentations based upon concept maps when compared specifically to PowerPoint presentations.

Category	Count
Concept Maps	10
Total Unique Concepts	308
Average Concepts per Map	30.8
Total Propositions	357
Total Resources	397
Graphics	22
Code	285
Web Links	75
Texts	15

Table 2. Statistics pertaining to the initial knowledge model

Table 2 contains statistics pertaining to the initial knowledge model. There were a total of nine other concept maps and the course organizer map depicted in Figure 2. The concept maps contained 308 unique concepts, and almost 400 total accompanying resources, a significant majority of which were code examples. The second most commonly occurring resource type was links to other websites, not surprising with the many good tutorials, relevant standards documents, services, etc. that were pertinent to the course.

Table 3 summarizes changes to the knowledge model over the course of the semester. A total of 38 concepts were added, changed or deleted, representing 12% of the total unique concepts in the initial knowledge model. Interestingly, linking phrases, which are typically the most difficult part of a concept map to get just right, did not change at all over the course of the semester. No accompanying resources were removed from the model, and a total of 43 resources were added, increasing the number by 11%. These relatively small adjustments would suggest that, even in a relatively unfamiliar domain, knowledge modeling techniques can foster relatively rapid creation of comprehensive, well-organized course materials.

Object	Action	Occurrences	Percentage
Concepts			12%
	Add	14	
	Change	23	
	Delete	1	
Linking Phrases			0%
	Add	0	
	Change	0	
	Delete	0	
Resources			+10.5%
	Add Text	9	
	Add Graphic	7	
	Add Web Link	26	

Table 3. Statistics pertaining to changes in the knowledge model made during the course of the semester.

4.5 Student Learning Outcomes in the Course

The current study had no control group for comparison purposes. Accordingly, no statistical analyses or detailed conclusions regarding relative advantages or disadvantages of this mode of course delivery can be drawn. Nevertheless, some comments might be made regarding student learning outcomes in absolute terms using this approach. Most generally, it can be stated that student learning outcomes were not harmed by this approach. The overall grade point average (GPA) for the class, based upon the average of the final grades for the section, was 3.03 on a 4.0 point system, slightly on the high side compared with the instructor's experience in upper level elective courses. The overall average grade for three exams was 84.5%, slightly higher than for similar courses.

The examinations emphasized both high-level, integrative, conceptual knowledge (for example, compare and contrast the relative benefits of client-side versus server-side XML transformations) and more detailed programmatic problems (e.g.: analyzing a piece of computer program code to state what happens when it executes). Additionally, students performed at typical levels on programming assignments that relied both on conceptual knowledge and the ability to retrieve appropriate code examples from the model that were relevant to the problem. This course was so different from others being offered, that students could not rely on colleagues outside class to have applicable skill in debugging or useful code examples to assist them with the programs. Still, student performance was quite satisfactory on the programming component of the course.

5 Summary, Discussion, and Future Work

This article contains a description of a pilot study in the development and delivery of a course entitled "Web-Enabled Applications" using a concept map-based knowledge modeling approach as defined at IHMC. The course was a senior-level elective involving technology that was new for the instructor and students. A fundamental idea behind the organization of the course discussed in this work was to provide concept maps as advance organizers for each of the major topics in the course.

This study sheds light on the use of this approach in course development where the creation of concept maps and the knowledge model helped the instructor understand the domain and keep track of course materials. The study identified strong acceptance of this mode of course delivery including the use of concept maps in place of more traditional course presentation materials such as PowerPoint. The study suggests that, despite the students' general lack of familiarity with the organization/presentation scheme, they quickly learned to employ the representation effectively.

Future work will further the current study by exploring larger groups of students and expanded uses of the approach. A system of peer review regarding changes to the knowledge model will provide vetting of additions and modifications or materials. It is anticipated that greater participation of students in creating/enhancing knowledge models and in refining the concept maps and accompanying resources will lead to more active learning for the students and a deeper understanding of the course materials.

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