Concept Maps for Teaching Technical Writing to Computer Science Majors: A Case Study in a Japanese Technical Institute

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Abstract: This paper discusses how techniques for representing knowledge, such as concept maps could be effectively used in a technical writing classroom for the conceptual understanding of a problem and as a visualization strategy for complex technical documents. The motivation behind using the knowledge models (concept maps) for an engineering/computer science oriented technical writing class is based on the importance of understanding different knowledge representations in an engineering / Computer Science document and the fact that the ease of solving such a problem is almost completely determined by ways in which problem is conceptualized and represented. In this project, we argue for the importance of using specific kinds of concept maps, such as ladders, in a technical writing class offered for computer science majors. A survey-based study with 25 students from a technical thesis writing class, reported in this article suggested that advanced students in an EFL technical thesis writing course have enough expertise to understand the use and application of specialized concept maps for technical document production activities. Results indicate that students, on most part, understand specific inference-based applications of concept maps in documents, tasks and especially specific sentences in the domain of computer science. Self-reports also indicated that students are reasonably confident about their ability to apply different types of concept maps in logical ways. Teaching evidence suggested that use of concept maps should be effectively integrated both during planning stages and as part of traditional document production techniques. Assignments and activities in a technical writing classroom (e.g., software manual design, quick guides, FAQ, brochures, lab reports etc) should address the use of concept maps for conceptualizing, schematizing and presenting procedural information logically and structurally. Using concept maps efficiently can lead to structural and functional conceptualization, visualization, representation and retention of complex information. The entire English curriculum in this institute designed as "English for computer science" involved students using concept maps from freshman to senior years for conceptualizing and articulating computer science concepts.

Keywords: Concept Maps, Knowledge Models, CMAPTools, Technical Writing, Procedures

Introduction

MOST EFL-BASED UNIVERSITY students in East Asia have studied English for six to seven years upon entering university and they are mostly used to a teacher-driven, deductive, rule-driven grammar-translation instruction methods (Suzuki, 2007). However, with the rising need for English in international business arena, the design of ESP courses started focusing more on professional communication. (Jiajing, 2007). Technical writing, with a balanced focus on both language and communication started adopting an important role in professional communication as university English language programs in EFL context moved more towards content-based instruction. One way to logically structure content-based instruction is to incorporate concept map designs in EFL

The International Journal of Learning
Volume 17, Number 1, 2010, http://www.Learning-Journal.com, ISSN 1447-9494

computer science pedagogy (Roy, 2008). This paper discusses how concept-mapping techniques could be effectively used in an ESL technical writing classroom for the conceptual understanding of a problem and as a visualization strategy for complex technical documents. This paper is focused on the design of such a course with initial reports on how students adopted to the use of concept maps for logical structuring of information in technical documents. This paper discussed various concept maps (e.g., concept ladder, composition ladder, decision ladder, attribute ladder) that could be adopted for representing technical information successfully and with rubric-based guided assistance in a technical writing course.

Technical writing is increasingly seen as an integral part of science, engineering and computer science curricula. Effective technical writing pedagogy emphasizes on audience and task analysis, purpose, careful organization and development of ideas, and a concise and accurate style (Day, 1994). Students can best develop these qualities in a computer science environment when writing assignments are logically discussed and instructions are presented in the realistic context of data interpretation and problem solving. Previous works have supported individual and collaborative thinking and design based on concept maps as efficacious ways to develop students' understanding of the logical structure in the document.

A technical writing course housed in an engineering or computer science school is expected to be production oriented (mostly true of many technical writing course) where students author a technical manual, a technical business proposal, laboratory report etc. However, before moving into direct authorship, it often makes sense to conceptually and logically understand how a document is to be authored and structured, the type of information that is important and how it is to be represented.

The motivation behind using concept maps for an engineering/computer science oriented technical writing class is based on the importance of understanding different knowledge representations in an engineering / Comp. Science document and because the ease of solving such a problem is almost completely determined by the way the in which problem is conceptualized and represented. Concept mapping in general, and sophisticated concept-mapping software in particular, has many benefits to writing and knowledge organization on a large scale (McAleese, 1998).

Design of the Paper

This paper presents a complete schema demonstrating how a technical writing course could be designed with objectives and assignments that have been tailored to achieve various documentation outcomes with logical understanding based on concept mapping techniques. The logical design of this paper is based on (1) an explanation of how assignment, documentation needs and learning outcomes in a technical writing course could be designed with concept mapping tools and logical presentation of the information, (2) an observational study explaining how students initially performed with concept maps in various technical documents and finally (3) an end-of-course experimental survey testing the extent to which students could understand concept mapping techniques and its application in various text and documentation contexts.

Literature Review

Graphic organizers such as concept maps are increasingly becoming a part of EFL curriculum (Unger, 2007), because it focuses on content-based instruction. According to Krashen (1982), in content-based instruction for EFL context, students can acquire the content area of the subject matter with comprehensible input, and simultaneously increase their language skills. To achieve the goal of language skills improvement, Krashen states that the focus of teaching is on the authentic and meaningful input, not on the grammatical form. One such aspect of content-based meaningful input in EFL context is to allow readers to develop schemata through reading because it plays an important role in constructing meaning from text (Taguchi et al, 2004). Concept map is an important tool to help develop such schemata in EFL technical or other context.

Using Concept Maps -A Graphical Model: Graphic models use diagrams and symbols to illustrate simple and complex relationships. Often graphic knowledge models are represented as a set of concept maps and associated resources about a particular domain of knowledge. Concept maps are a result of Novak and Gowin's (1984) research into human learning and knowledge construction. Concept maps are a graphical two-dimensional display of concepts, connected by directed arcs encoding brief relationships between pairs of concepts forming propositions (Canas. et al., 1984). Concept maps can be represented using CmapTools. CmapTools provide a rich collection of features that help users to easily construct Knowledge Models and publish and share them through servers or World Wide Web (Ault, 1985). CmapTools are important applications in the engineering curriculum because it focuses on procedural knowledge and design. Overall patterns in concept maps were found to be indicative of cognitive status. However, there are many other concept-based graphic tools that are conceptually identical but differ in the way it focuses on object identities, relationships between objects and its structural and functional roles.

Concept Maps and their Varying Roles: Concept mapping leads students away from rote learning and toward true understanding of concepts and their relationships (Canas et al., 2003). Concept maps have been used widely in education as pedagogical tools and as assessment devices. In education, teachers often use concept maps as tools to identify those specific areas within the curriculum that should be modified and perhaps re-authored in order to facilitate a better understanding of the subject matter. Human visual/spatial problem solving often requires both global and local information to be processed. But the relationship between those two kinds of information and the way in which they interact with one another during problem solving has not been thoroughly discussed (Kong, 2007). The limitation of the current practice seems to be that concept maps are most often used to focus on declarative knowledge. However, research suggests that procedural knowledge is also structured in a way that can be represented by networks (Sims-Knight et al., 2004). This is how concept map fits in the logical document authoring and information structuring process as should be practiced in technical writing domain.

The use of the type of concept map in technical writing depends on how students understand text and procedures. If students understand the design process as a series of phases, they will adopt a linear pattern in presentation to describe the sequence of events. However, the limitation of such an approach is that students will neither cover the iterative and complex nature of the process; neither will they understand the richness of the association between nodes (Sims-Knight et al., 2004). However, if students understand the richness of the text and the complexity of the process, they will be in a position to judge the nature of concept map to use in order to explain the concepts in a technical document and also structure information accordingly. This is a relatively new area of application in a technical writing class. The range and scope of this discussion on concept map opens up new contexts of application in technical writing genres.

Background to the Technical Writing Course

University of Aizu is an officially bilingual technical university in Japan with an exclusive focus on computer science and engineering. Students at the undergraduate level are required to take 15 credit hours of English language courses and write their graduation thesis in English to graduate. All English courses are taught at the center for language research and the English language content is heavily based on teaching students the production (writing and speaking) and reception (listening and reading) activities related to the different genres in computer science and engineering. English courses range from basic writing and speaking, listening and reading to advanced electives in writing, listening etc. Students need to take the introductory courses before they are able to register for the electives. Students take majority of their computer science courses in Japanese but because around 40% of the faculty members are internationals, they are also exposed to English as a medium of instruction in some of the other computer science courses, besides the 15 credits of English.

The course under discussion here is offered as an elective. The reading topics are exclusively focused on issues that students directly or indirectly encounter as part of other computer science-based courses that they register for simultaneously with this course. The purpose is for them to be able to relate the course content with their subject knowledge. By the time a student enroll for this course, they have taken introductory level courses in writing and speaking wherein they have read and analyzed several introductory articles on computer science in English. This course helps students to bridge the understanding between computer science as a theoretical discipline and the use of concepts maps as a tool for information schematization at any level and for any given context.

Goals and Objectives

The overall aim of the course is to fully prepare computer science junior-level students to analyze a technical situation successfully using logical schemas, represent it successfully using graphic indicators like ladders and also incorporate such schemas in technical documents for end users, who might be able to use the information for multiple purposes. Students design multiple technical documents through audience and task analysis. A major focus of this course is document organization, formatting and logical representation of information for technical and business purposes.

Structure of the Course

The course takes place over 15 weeks and the class meets for 90 minutes per week. Students generally work in a group of four and with special roles assigned to them every week. The target learners are junior students at the department of computer science and engineering.

A major tool in the EFL classroom is continuous assessment where the focus is on developing not judging (Puhl, 1997). Following Carol's model, during the first three weeks of the course, students are explained the different concept mapping techniques and how it could be used for different technical document production. During this time, students are made to explore different introductory computer science articles and they write short explanatory reports on the readings. The focus during this stage is exclusively on analyzing the content and is handled as an individual assignment.

Starting from the fourth week, the structure of the course is designed for continuous assessment in groups. The structure of the assignment is held constant between weeks, but with a change in the reading topic and production context. Every week, student groups read, understand, schematize the overall structure for a published technical article on variety of topics in computer science, using variants of concept maps, and plan and author a technical document successfully, based on the weekly technical article. Based on the weekly reading, students are provided a specific document production context (assignment) and they are asked to follow rubrics and examples that are posted every week in moodle.

Topics/ Schedule	Topic # 1 Internet	Topic # 2 Hardware	Topic # 3 Peripherals	Topic # 4 Design	Topic # 5 Networking	Topic # 6 Security
Week # 1	Synopsis					
Week # 2		E-mails				
Week # 3			Memos			
Week # 4	Interface Analysis Report					
Week # 5				User Manual		
Week # 6			Quick Guides			
Week # 7					Lab Report	
Week # 8						Technical Presentation
Week # 9	Persuasive Report					
Week # 10		Brochures				
Week # 11				Technical Proposal		
Week # 12		Business Proposal				
Week # 13						Demonstrative Presentation
Week # 14					FAQ	

Figure 1: Structure of the Assignments Every Week (Group assignment starts on week # 4)

At each step of this process, concept mapping techniques are used so that the entire process becomes a logical exercise and students learn solid reasoning behind each decision they took. Each week student groups read and post the completed assignment in the learning management system called Moodle. Students, during the document production activities use collaborative editing tools like google docs, chats, wikihow etc. For each weekly assignment, student groups are handed out rubrics that explain sequential steps for completing the assignment successfully. The reading materials chosen for the assignments are mostly procedural in nature, mostly taken from websites such as “How Stuff works”, wikihow or introductory computer science text which explains concepts and procedures. Figure 1 shows the structure of the assignment over the semester.

Group work design: Students worked in a group of four for the before-mentioned assignment. Students used IHMC CMAP software for brainstorming, storyboarding, designing the outline of technical documents like user manual, recommendation and feasibility report etc. They read the technical article and then complete a moodle-based online quiz on the article individually. Following the quiz, they were asked to go back to the article, dissect it conceptually based on the following roles, each person in the group of 4, taking 2 roles each, with the fourth person being the submitter. They were asked to dissect the article so as to extract the concepts and ideas in it, relate it to each other using concept maps and then write a technical document. Students were given adequate and related examples of such technical documents to follow. The individual roles rotate every week.

Person # 1 - Brainstorming

1. Read the content (technical document); highlight sections in article and brainstorm ideas with other group members.
2. Map major concepts and interrelationships between items as a preliminary draft.

Person # 2 - Analyzing the existing article

3. Dissect sentences to understand how different parts of the sentence and major objects/concepts relate to each other
4. Develop separate concept mapping structures as concept graphics to be used for the final document.

Person # 3 - Planner for the Final Document

5. Develop separate concept mapping structures to understand the organization of differrent sections of the final document.
6 For a major sequential procedural task like designing a user manual, identify and relate the assemblies and subassemblies separately and relate them to each other for the final document.

Person # 4 - Submitter in Moodle

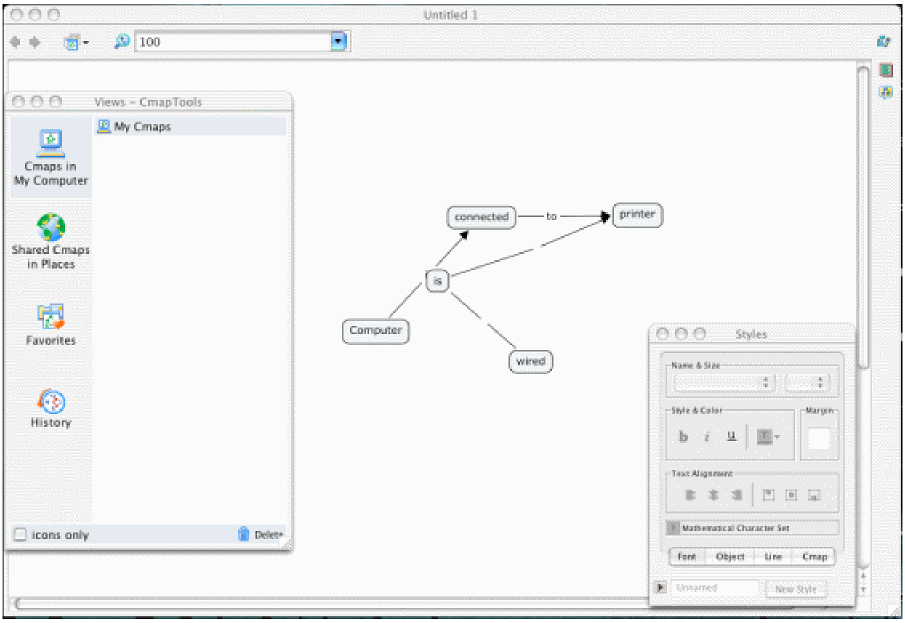

Figure 2: Concept Mapping Software

Figure 2 shows the concept map in IHMC software as students use it during coursework.

Motivation and Reasoning behind the Current Course Structure

English courses at this level and for Japanese students have often shown that they resort to purely grammatical exercises when they are asked to handle an assignment in English. Class observations have shown more often that students start with the production activities even before they try and grasp the context of the text holistically, and tend to focus on meta-cognitive strategies like skimming and scanning. Mostly, the focus is on delivering the output, but not on analyzing the situation. Such an approach will probably work when the intended unit of analysis is at the sentence level only. However, a technical writing course needs a thorough understanding of the audience, purpose, task orientation, specificity of the application context, information organizational ideas and the author might need to make recommendations, study feasibility, or organize ideas based on his/her understanding of the uniqueness of the situation. Context analysis becomes tremendously important in such context and a graphic organizer like concept map plays a very vital role for schematizing both the organization of ideas and the document. This concept mapping technique, the way it is used here in this course (1) more accurately reflects differences of students' knowledge structures; (2) provides greater flexibility for demonstrating students' partial understanding and misconceptions; (3) supply students with more opportunities to reveal their conceptual understanding; and (4) elicit more high-order cognitive processes, such as explaining and planning (Yin et al., 2005).

Students in EFL context, especially in Japan often shows the tendency to first write the output text in Japanese and then translate using online translation services. However, when the focus shifts to the graphic organizers and global content and context analysis, sentence constructions using translation services will then be a sub-conscious and secondary practice and iterative (draft-based) and logical document production and group work leads them to the communicative issues in document production.

Concept Mapping-based Learning Outcomes

There are several learning outcomes that follow directly from the type of assignments, the lecture materials and classroom instructions.

As part of the lecture notes, students are taught to approach each documentation task in the following ways with various factors and planning steps involved in it. Also, students are taught to think about each major objective, not only from a documentation perspective but also with a logical goal attached to it at every stage. The design of such practice is demonstrated in figure 3.

Documentation Outcomes: The chart shows a detailed outline of the documentation outcomes.

Outcome Factors / Outcome Focus	Overall Document Specific Outcome	Concept-map Focused Outcome
1 - Organization	The ability to organize the content in short technical and business documents in English	The ability to prepare the relationship between different concepts and structures for the technical and business documents using concept maps
2 - Logical Structure	Being able to write logically and sequentially in any instructional context.	Design concept maps to show sequential steps and phases for any instructional context (tree diagram).
3 - Design	Specifically, learning to input structural graphics in brochures, manuals, business reports, and proposals such that the content is logically understood.	Ability to use and create specific type of concept map to be used in brochures, manuals, business reports and proposals.
4 - Planning	Developing and understanding various strategies for planning (researching, drafting, revising, and editing documents) that respond effectively and ethically to instructional situations.	Use various concept-mapping structures to formulate strategies for planning (drafting, revising, editing) documents. Students might need to improvise the different concept mapping structures based on the specificity of the situation.

Figure 3: Documentation Features and Outcomes

Communication Outcomes

1. The ability to communicate and collaborate with students and professionals on multiple issues of technical documentation. The collaboration is designed to be focused on exchanging drafts of brainstorming and storyboarding concept maps based on the rubrics.
2. Learning and applying strategies for effective group collaboration and project management.
3. Developing strategies to use and adapt various communication technologies (chat, google docs, moodle forum etc) for document production.

Research/Usability/Technical Design Outcomes

1. Understanding and using various research methods for document testing and delivery. Student rubrics are designed to guide in the development and testing of documents designs. However, any extensive information modeling is beyond the scope of this course.
2. Learning to argue with visual data; understanding and implementing principles of document design.

Assessment Techniques as used for the Course

This technical writing course used concept maps for formative assessment. Learners were asked to make concept maps at various stages of learning during the course and the assignment content and instructions were updated accordingly. Summative assessment was used at the end of the course to determine a learner's understanding of the content, and to assign grades.

Concept-map assessment is composed of a task, a response format, and a scoring system and hundreds of concept-map assessment permutations are possible (Ruiz-Primo & Shavelson, 1996). Since this is a technical writing course, the primary focus was on the assessment of technical documents and concept map as an instrument for document production. An end-of-course survey-based assessment was organized to test students' ability to understand concept maps accurately in varying contexts. The survey and its results have been reported later in this article.

Technical Document Assessment: Students were handed out rubrics (guidelines), which acted as benchmarks for analyzing instructional and business documents.

1. Document-specific expectations (Rubric-based) –
   a. If the content is demonstrated using correct documentation techniques like formatting, layout, typography, use of color, fonts etc?
   b. Has the correct form of business document being chosen to represent the information?
2. Content-specific expectations (Rubric-based) –
   a. How was concept mapping used to represent the content?
   b. Was it correctly used?
   c. Are there alternative ways to represent the information visually?
   d. Does concept maps; the way it was used helped to demonstrate the most important information in logical ways.
   e. The extent to which unnecessary information was represented in concept maps.
3. Moodle-based quiz on content – These quizzes test whether students have understood the content of the weekly articles.

Instructional Prompts for Student Planning

Students were provided specific guidelines with the hope that they follow it closely for completing the weekly exercise.

1. Actual examples of the concept map shown.
2. Micro level text analysis technique shown.

3. Examples shown on how to extract the most important information from the sentence.
4. Very specialized use of concept maps shown as examples.

Students are handed out two separate schemas each week, one for understanding and conceptualizing the information in the article and the other for technical document production. Further, students were provided with more document-specific feedback on a case-by-case basis. Figure 4 shows the schema that students are handed out every week for conceptualizing the information in the article and authoring the technical document. Based on the specificity of the assignment, students are often provided with additional instructions and document-level cues on the following:

1. Identifying the action verbs
2. The global and local concepts
3. Identifying text describing structural versus functional features.
4. Text asking for a decision-making versus comprehension act.
5. How many ideas are communicated in a single text or paragraph?
6. General interest in the topic.

Steps	Schema for Concept Map	Schema for Document Production
1	Read the title to check the scope of the discussion in the article.	Draw a paper-pencil sketch of the different sections of the projected document as you see it.
2	Read the introduction / abstract	Relate the different sections in the paper-pencil sketch as a concept map. This concept map is focused on the organization of the projected document.
3	Design a simple and short concept map based on the overall surface-level idea of the article.	Name the different sections and the document as headings and sub-headings.
4	Read each heading / sub-heading and draw a concept map to suggest how they are related to each other.	Relate the different sections (headings and sub-headings) conceptually on a concept map. You might choose any specialized type of concept map if it fits the schema of the document. This concept mapping is focused on the logical structure of the document.
5	Based on the idea/text under each heading, use specialized types of concept mapping techniques as discussed in class.	Study the projected outline and organization of the document against the example document that you are using. See if the overall structure matches the example document.
6	Based on all headings and sub-headings, you might use a combination of general to specific concept mapping techniques, depending on type and complexity of content.	Start writing the text under each heading elaborately.

'* More feedback will be provided on a case-by-case basis

Figure 4: Rubric for Concept Mapping and Document Production

Besides the rubric as shown above, students have been strongly advised to use the specific concept map types as described below. A few assignments, specific to the concept-mapping type have been mentioned below, as is used during the course.

Specific Concept Map Types and Assignments

In educational setting, concept maps could be used to organize instructional materials for individual courses or entire curricula. For introductory language-focused analysis in this context, we focused on ladders, which are hierarchical (tree-like) diagrams. Some important types of ladders are concept ladder, composition ladder, decision ladder and attribute ladder (Rhem, 2005). These ladder types explain and dissect the introductory concepts successfully and focus on specific patterns for information analysis. During the first 3 weeks of the course, students were explained the concepts of the ladder types and examples from technical text, which maps into ladder types, were introduced. Students also handled short assignments as in-class discussion activities, related to each concept map type, to be posted in Moodle, during the first three weeks, just so they are able to acclimatize with few examples of relatively complex content and task situation. These are handled as individual activities. Students were also encouraged to use unrestricted hierarchical structures in concept maps for any assignment, as they deem appropriate.

Concept Ladder: This shows classes of concepts and their sub-types. All relationships in the ladder are designed to be "*is a*" and *"is"* relationship, e.g., *car is a vehicle* or *BMW is expensive*.

Application: Use concept ladder to explain definitions in the field of technical writing or use it for definitions from any engineering or computer science text. It could also be used to define an attribute of an object. For a basic technical writing class, assign short articles that ask them to focus on the parts that are more declarative (definitional) in nature than process oriented. Ask students to use concept ladder in an attempt to comprehend and represent relationships between objects. More complex articles, demonstrating multiple relationships between objects are more suitable for advanced technical writing classes.

Example Assignment: Design a concept ladder in a quick guide identifying the different major parts of a computer (hard-drive, monitor, memory, keyboard etc) and show the different types (based on brands, speed variety etc) of those parts.

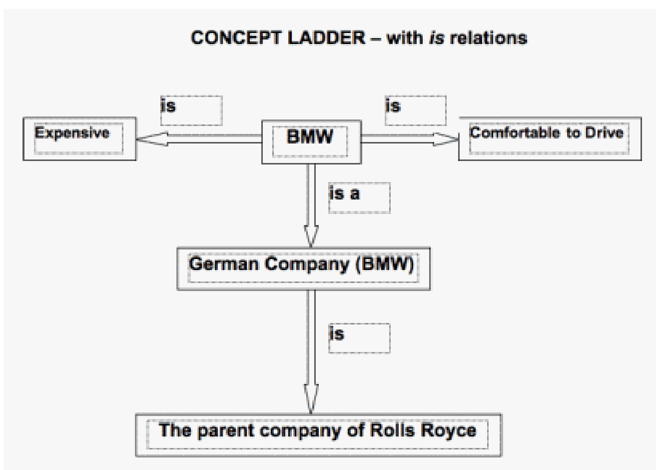

Figure 5: Concept Ladder

Composition Ladder: A composition ladder shows the way a knowledge object is composed of its constituent parts. All relationships in the ladder are the *has* part or part-of relationship, e.g., wheel is part of car.

Application: Use composition ladder to explain the constituent parts of an object for structural identification purposes. Identifying major components and structures in physical objects, software program etc are essential for conducting an experiment, writing about a product in a software manual, to propose idea about a product and so on. Thus, structural identification and relationships within and between objects are crucial for both understanding and describing the functionality.

Example Assignment: Design a composition ladder in a user manual identifying the different major components and sub-parts of the machine (e.g., a printer, fax machine, circuit, chip design etc).

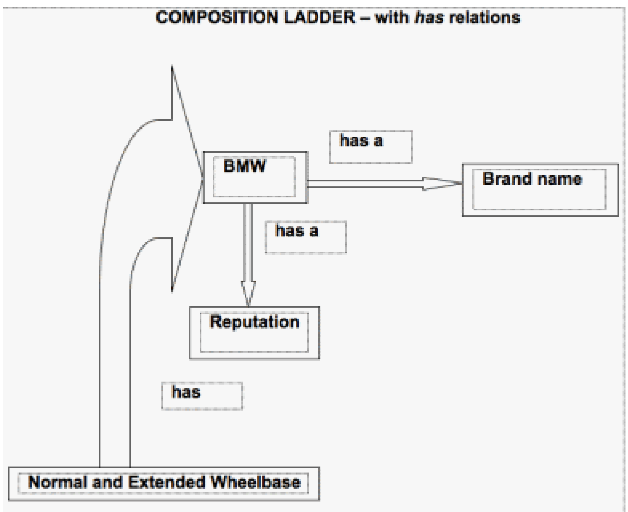

Figure 6: Composition Ladder

Decision Ladder: A decision ladder shows the alternative course of action for a particular decision. It also shows the pros and cons for each course of action, and possibly the assumptions for each pro and con.

Application: Use decision ladder to author something like a recommendation or feasibility report. Since a recommendation report or a feasibility report weighs different options, decision ladder can be a great tool to analyze and logically structure the argument behind each recommendation and weigh one option against the other. However, decision ladder can also be used in highly structured user manuals as well. Depending on the context of application, decision ladders could be used as a planning tool, if not as a direct visualization instrument in the document. Contrarily, decision ladders could also be used directly in a recommendation or feasibility report for concept representation purposes.

Example Assignment: Your University wants to install new computers at the computer lab. You have been asked to develop a detailed report on the specifications regarding the choices and options for the university. For each major issue like brand name, memory, hard-drive, operating systems etc, develop a decision tree (technical report / business proposal) outlining the options that the university has and pros and cons associated with the decision. Figure 7 shows an example of a decision ladder.

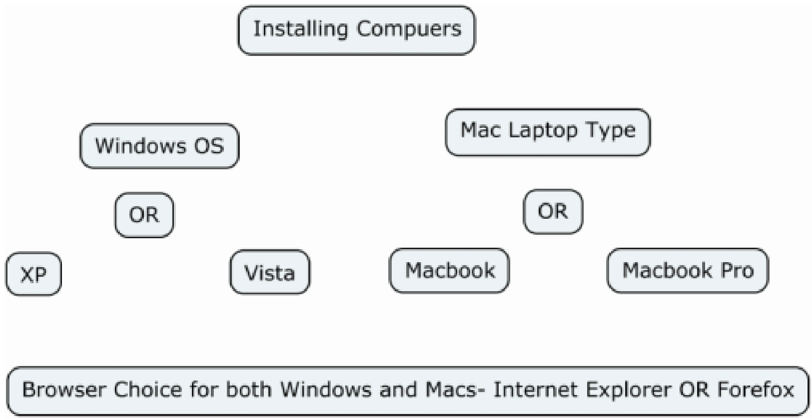

Figure 7: Decision Ladder

Attribute Ladder: An attribute ladder shows attributes and values.

Application: This type of attribute ladder can often be used in identifying the factors associated with a specific object, an event, experiment etc. For example, when learning about an exercise titled "How a Web Browser Works", we might identify attributes as graphics download, multimedia files download, need plug-in applications, download speed. For graphics and multimedia download, the values might be very fast, fast, slow and very slow. For plug-ins, the more detailed attributes might be, depends on the multimedia files, depends on the browser, and depends on both. Another example might involve writing a feasibility report about the type of computer to install in the laboratory. One crucial factor in making the computer installation decision can be computer memory.

Example Assignment: Design a feasibility report that identifies the attributes involved with buying external storage (flash drive, key drive, floppy etc) and identify the values for each. Then, use the attribute ladder to make recommendations and argue the feasibility for each recommendation.

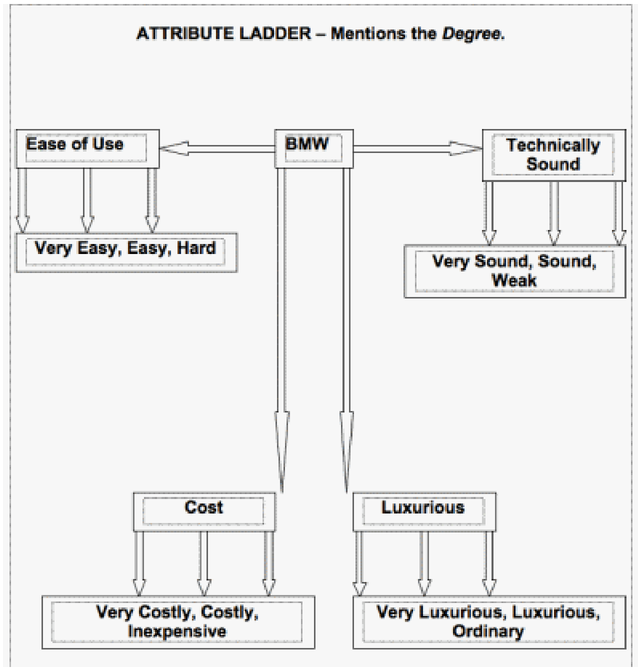

Figure 8: Attribute Ladder

Concept Map Assessment and Results – Observational and Interview-based Findings

Most students reported (in a moodle-based survey and personal interview) having found the concept mapping technique as useful and serve the special context for this course. However, since the entire explanation for the course and the assignments in specific were done in English with little or no Japanese translation, most students took about two class periods on an average to understand the nature of the assignment, the scope of the concept maps, the broad nature of its applications and also what they needed to do, in terms of the assignment guidelines and rubrics. Some students took a while to get adapted to reading and participating in a moodle-based system for the course.

Few students reported that the rubrics were a bit confusing. After talking to them, it appeared that they wanted more specific guidelines as to what needs to be done and the manner in which it should be done. Students took a while to understand that the guidelines/rubrics are designed to help channalize the general thought process when handling the assignments and the specific sequence for task completion is for the student to explore and develop. However, around 80% students reported that their performance became more automatic and streamlined over the course of the semester.

Samples of Student Deliverables

The figures below demonstrate few examples of concept maps which students completed based on text comprehension. The example below is shown from a weekly assignment on how Amazon business works.

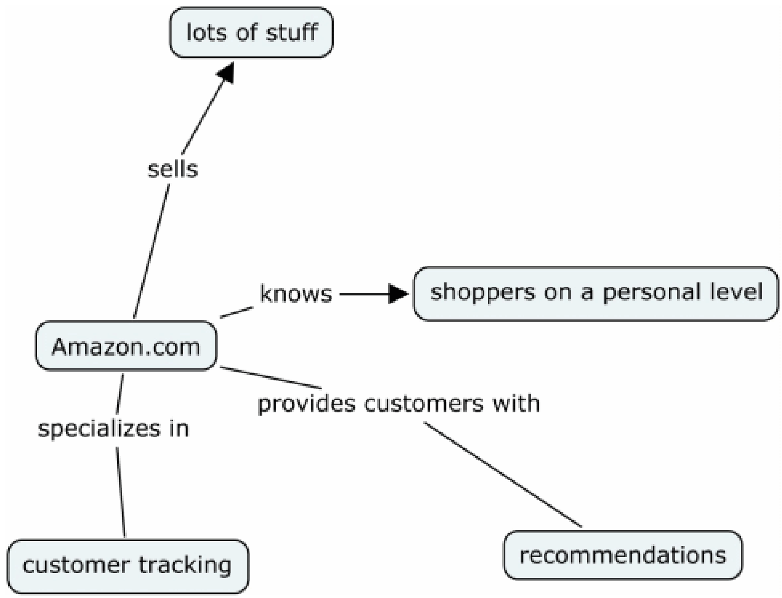

Figure 9: Concept Map Demonstrating a Summary of what Amazon is all about (Introduction)

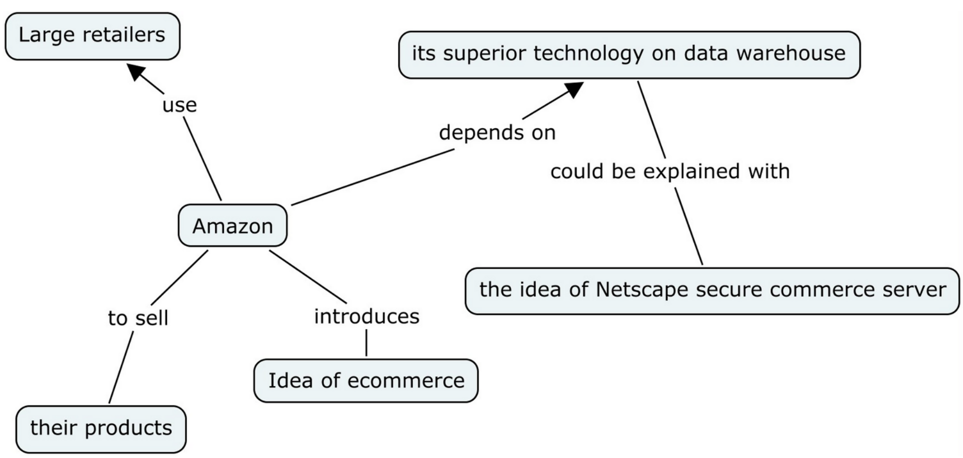

Figure 10: Concept Map Demonstrating Major Concepts Related to Amazon Business (summarizing entire text)

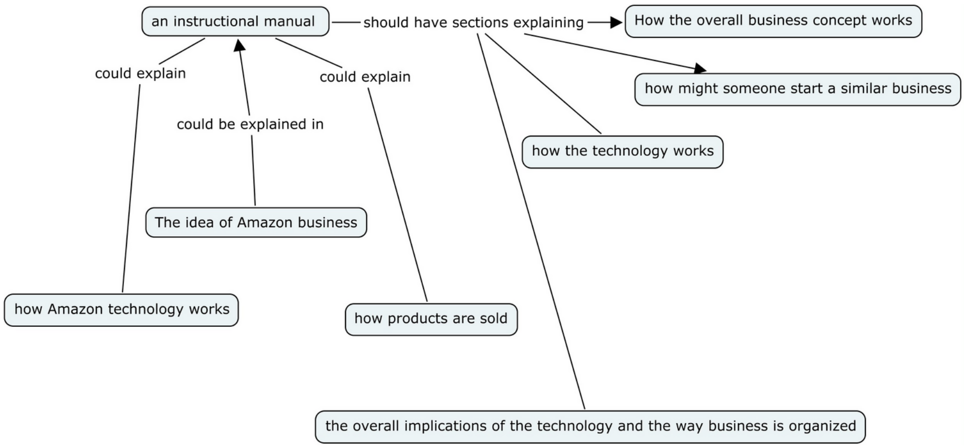

Figure 11: Concept Map Demonstrating the Entire Layout and Planning for Writing an Instructional Manual on How Amazon does Business

All these above examples of concept map designs were executed based on instructions on the rubrics and instructional prompts as explained in the previous sections. The above examples suggest that students were required to analyze the local text, the global text and demonstrate an overall understanding of the plan for the projected document (e.g., instructional guide, recommendation report etc). The following survey tests students' ability to analyze the text and projected document in various independent contexts.

End-of-Course Survey

At the end of the course, a post-task questionnaire tested 25 participants from the class. The survey was designed as a structure, separate from course assignments to test students' understanding of the concept mapping applications with various text and document types in varying contexts. However the application text and document types used words and examples that were adopted indirectly from the weekly assignments which students completed over the semester. The survey tested students' ability to understand the following (based on the suggestions in the rubric as to what they were expected to perform with the weekly assignments):

A. Organization B. Logical Structure C. Design D. Planning E. Execution

Methods and Procedure

Every participant in the survey had adequate experience of using concept map types during the semester. Result also suggested that they successfully completed the concept mapping assignments during various stages of planning and implementation, text analysis etc. Moreover, the participants in the survey worked in a group for most or all concept mapping assignments and they could take decisions through a shared understanding of the process.

The survey was posted electronically in Moodle as four independent sections; concept ladders, composition ladders, decision ladders and attribute ladders. The test instructions clearly mentioned that they take the survey in the prescribed order from section 1- 4. Each section of the survey had three multiple-choice question types on *text-type understanding*, *text-in-document type sentence* and *general sentences* and also asked participants to self-rate their confidence level with each of the three types. In total each section had 6 questions. Two options for each question were designed to be an accurate response (except for questions on confidence levels). Each question had 5 options. The options are parallel in structure and are written for students to understand the information with similar levels of difficulty. The questions on self-rated confidence levels were presented as a likert scale.

Students were asked to choose all that applies for each question. Each section in the survey had a visual representation of the ladder (the same examples as shown above from Fig 5-8), and an explanation as to how it could be used for information schematization.

Logic behind the test design: The primary purpose behind this survey design was to explore whether students have developed the ability to comprehend the textual context beyond a sentence-level analysis, thereby understanding both the text organization strategies and use concept maps for document planning.

Findings

"Ladders-for-specific-applications" type sentences: (Example of option: *Concept ladders are used to explain procedure in technical articles* - 4 such options for each ladder type) - Results showed that students performed fairly and could identify the correct options for concept ladder and composition ladder but the performance dipped for decision ladder and then picked up for attribute ladder. However, a noticeable aspect of their decision-making was that some students were primarily dissecting the text as noun-verb-object even when classifying the text exclusively for concept or attribute ladder. 45% readers could correctly identify the correct ways to use composition ladder, 38% for decision ladder and 78% for attribute ladder. The percentage of accurate responses show some learning effect between ladder types, but overall, such learning effect might not be substantial or consistent. Varying content complexity across sections might have lead to random accuracy scores. However, the overall performance jumped from 40% to 78% (from concept ladder to attribute ladder).

"Text-in-document" type sentences: (Example of option: *Pages in user manuals that shows definitions of components* - 4 such options for each ladder type) - In this case, percentage of accurate clicks show reasonably poor ability to identify the task and the document accurately for concept ladder and composition ladder (when compared to task-specific sentences), when examples of text application type and document type are presented as part of the same option in a sentence. The performance improved for decision and attribute ladder. The overall performance jumped from 30% to 58% (from concept ladder to attribute ladder). Figure 12 supports the above findings.

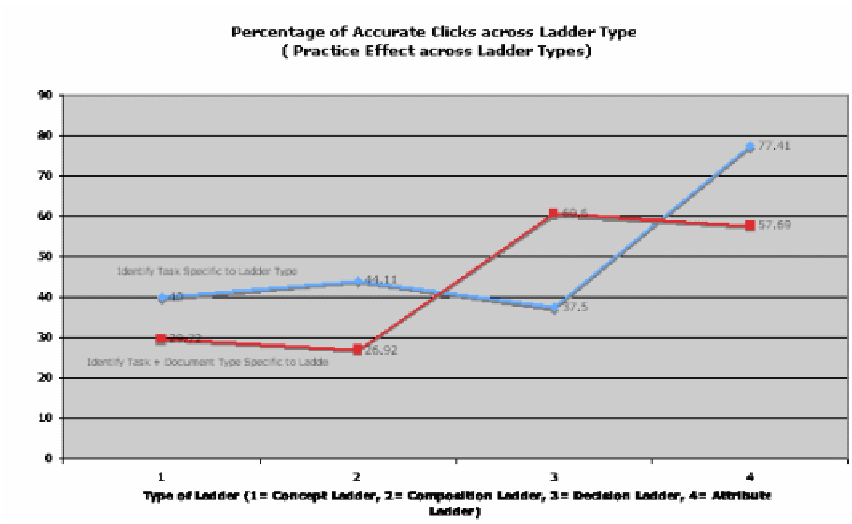

Figure 12: Percentage of Accurate Clicks Across Ladder Types – A Comparative Analysis

General technical sentences: - Results show the percentage of accurate responses for each ladder type. It is important to keep in mind that this percentage value considers all the correct options that readers have clicked for any particular ladder type. The percentages of accurate responses show some practice effect between ladder types, but overall, that practice effect might not be significant for varying content complexity. Results show that overall readers made improvement from concept ladder to decision ladder, but the performance slipped from 93.54% to 85.18% when readers move from decision ladder to attribute ladder. Figure 13 supports the above findings.

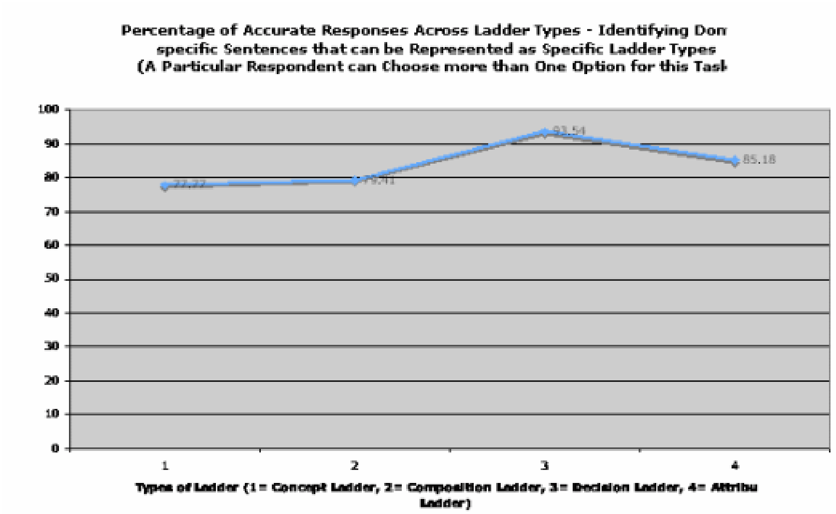

Figure 13: Percentage of Accurate Clicks across Ladder Types (domain-specific sentences)

Discussion and Reflections

Student self-reports and accuracy scores have confirmed some level of efficiency and understanding with various types of concept ladders. However, the results are inconsistent and improvements (practice effect) might not suggest overall statistical significance. It is hard to understand whether varying complexity of the ladder type is an issue, because the performance difference between few ladder types mutually (e.g., the difference in accuracy results between concept and attribute ladder for *ladders for specific type applications*) are significantly different to make a conclusive claim.

Interestingly, some respondents thought that concept ladders might be used for writing abstracts as well, indicating that thought patterns and ideas for application are subjectively based. However, a very small percentage thought that it might be used for writing introduction sections. This is interesting, because although the use of the concept ladder is not explicitly mentioned in the options, other than the use of the word "definitions" in one of the options, readers thought that abstract might be used in a better way to introduce software, hardware definitions, etc rather than the introduction section.

The above findings point towards specific recommendation for teachers using concept maps.

Recommendation # 1: Explain the scope of a document or a document section, when introducing the ways a specific ladder type could be used. (Based on the finding that students took and reported on an average 3 weeks, to understand the scope of concept mapping applications).

Recommendation # 2: Teachers in a Technical Writing course should clearly identify the structural and functional nature of the ladder types and also show example texts in specific documents to help them realize how specific concept ladder ties in with specific nature of text. Further, this will also help readers understand the specific nature of documents. (Based on the finding that few students reported the rubrics as being confusing and asked for more help and clarity with content and instructions explanation).

Recommendation # 3: Teachers of technical writing should have short class exercises that help students streamline the process of thinking in more structured ways. (Based on the finding that few students wanted help to channalize the general thought process when handling the assignments and the specific sequence for task completion).

Recommendation # 4: There should be regular writing assignments during the course, asking students to provide feedback on how they used concept maps for varying contexts. (Based on the findings that students demonstrated some practice effect between concept maps suggesting improved understanding, although results were somewhat random with no clear way to understand what and how students adopted to the varying information types related to text, document and concept map types.

Recommendation # 5: It is important that assignments are structured so as to focus on production, reception and reflection-based activities. (Based on the findings that performance fluctuated randomly with varying content types. In such a context, it is important to understand how readers read the content and interpreted it in association with the concept map type).

Recommendation #6: Instructors teaching a technical writing class for Computer Science majors should categorically identify sentences and paragraphs in textbook/articles that help readers see the difference between a local and global context. (It is possible that the overall class performance might have been random due to the fact students could not comprehend and differentiated within and between the ranges of information that they confronted in any given context. For example, they failed to differentiate between concept maps, which shows a global idea, and one, which shows a local and more specific point. There might be varying levels of such examples).

Conclusion

Technical writing is a very important course in computer science genre because it focuses on systematic thinking, logical reasoning and user-friendly document production. A concept-map based approach needs adequate planning and schematization on the part of the student and ability to administer the process and assessment criteria successfully on the part of the course instructor. Proper understanding of information and ability to select a proper context-specific application of the information needs detailed analysis of the information and a thorough understanding of how information could be represented successfully. As part of the course design, as is mentioned in previous sections, a detailed overall plan for course design, assessment and student objectives are mentioned in a way that could be adopted even as a plan for information schematization in any given technical context. This is more important in computer science because both technical writing and programming are multi-step processes involving planning, drafting, and revising. Moreover, six key aspects of computer programming (modularity, modifiability, user interface, failsafe presentation, style, and debugging) have parallels with technical writing principles and practices as report sectioning, audience analysis and adaptation, and editing (Kaufman, 1988). A technical writing course with such specialized focus needs proper assessment and evaluation mechanisms in place so that students are able to handle the projects as logical steps, use iterative approaches and are involved with multiple communication channels towards proper planning and superior document production. The end-of-course survey has suggested that quite a few students have performed reasonably well with various concept maps and there was some amount of practice effect visible. However, more systematic course plan as suggested, should be executed more carefully so that student performance and improvement could be recorded and analyzed more systematically. The research as executed above is important for the following reasons:

1. It demonstrates how students perceive different kinds of concept maps with different focus.
2. It demonstrates how readers perceive global and local text and comprehend it systematically.
3. It demonstrates how readers perceive the use of concept maps to plan a projected document.
4. It will help develop instructions for rubrics suggesting how various types of text and projected document should be analyzed with different types of concept map types.

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