USING CONCEPT MAPPING AS AN INSTRUCTIONAL STRATEGY TO SUPPORT LOGIC DESIGN LEARNING

Hsiu-Mei Lin [1]

Abstract — *For learning purpose, the learning materials used in teaching should be understandable. Moreover, learners have to construct the concepts and relations of the learning materials. Concept mapping, a technique for representiing knowledge in graphs, has been widely applied as a vehicle to support teaching and learning. Especially, the advancement of the Internet and the WWW could provide an ideal vehicle for interconnecting the concept networks to assist learning. Taking the benefits of the WWW, this paper proposes a framework of concept mapping environment via the WWW for learning logic design. This learning environment intends to guide learners toward general understandings of the materials they have to learn in regard to logic design.*

Index Terms ¾ *Concept mapping, web-based concept maps, logic design, hypermedia.*

INTRODUCTION

Teaching and learning at Chinese Military Academy are typically centered on the conventional modes: teacher-centered orientation. That is, in most disciplines, teaching is purely a transfer of information. The instructor uses the lecturing method, relying on notes prepared in advance. The cadets mostly ignore in this vision of teaching and are perceived as a vessel into which knowledge is poured. How does this kind of instructors' approach influence cadets' learning? As the result, many cadets are accustomed to learn from teacher's lecture; then, memorize textbook's materials to pass examinations. In the minds of these cadets, learning means memorizing the test materials by rote. They seldom think about 'why to learn' and 'how to learn', and care less about knowledge construction and application. However, there are still a few cadets, whose concerns are academic, want to be challenged intellectually, and to be encouraged to learn widely to supplement lecture. In this case, how to provide an instructional approach to encourage cadets recognizing the conception of learning and learning meaningfully is a critical challenge for instructors.

The author, as the instructor of logic design, has been trying to adopt different teaching methods and diverse classroom activities to encourage learning. This paper suggests another approach, web-based concept mapping, to establish a learning environment that promotes meaningful learning. The learning environment provides a flexible learning context for different kinds of students regardless of their background, experiences, learning styles, and learning pace. It allows an interactive, systematic construction of logic design skills for a variety of combinational and sequential circuits. In this learning environment, learners have considerably freedom to: (a) navigate the wide knowledge domains of logic design and the application, (b) choose the direction of the materials they need, and (c) collaborate with their peers in the classroom or outside the classroom.

THEORETICAL PERSPECTIVES ON LEARNING

Definitions of learning are numerous and varied. This section reviews the theoretical perspectives on learning.

Behavioral and Cognitive Theories

A basic issue in the study of learning concerns the process whereby learning occurs. Behavioral theories explain learning in terms of observable phenomena and ignore thoughts and feelings of learners. In contrast, cognitive theories stress the acquisition of knowledge and mental structures and the processing of information and beliefs. Cognitive theories view learning as an internal mental phenomenon inferred fom what learners say and do [1]. Therefore, cognitive theorists focus on how to engage learners' cognitive processes during learning.

These two main conceptualizations of learning have important implications for educational practice. Behavioral theories imply that teachers should arrange the environment so that students can respond properly to stimuli. Cognitive theories emphasize making knowledge meaningful and taking into account learners' perceptions of themselves and their learning environments. Therefore, teachers need to consider how such mental processes might manifest learners during learning. In other words, teachers have to concern not only how information should be structured and presented but also what activities are best for students.

Constructive Learning

Constructivists view that knowledge is a construction of reality, that learners are active and proactive in the process of learning. The concepts or ideas should be related to another as parts of a system [2]. In this sense, learning should involve many interconnected pieces of information. New pieces of information are added to this connected set of

Hsiu-Mei Lin, Dept. of Electrical Engineering, Chinese Military Academy, Fengshan, Kaoshiung 830, Taiwan, hmlin@cc.cma.edu.tw

ideas and become interrelated to the information that is already there. This forms a massive web of ideas and leads the learner to related information that becomes integrated as personal knowledge ([3], [4]). That is, the learner has to make the assimilation of new concepts into existing cognitive structures in order for learning meaningfully. Therefore, to acquire meaningful learning, the learner requires a deliberate effort to relate new knowledge to relevant concepts he already possesses.

Based on the learning perspectives as described above, one of the instructional approaches, concept mapping, could offer as a means for course design, which promotes the development of a structured course within a good pedagogical framework ([4], [5]). By means of concept maps, learners would foster meaningful learning.

THE USE OF CONCEPT MAPPING

Concept mapping have been widely used for educational purposes. It can be used as a means for displaying and communicating information for research, and as a tool to support the design of instructional materials. Moreover, a great number of educators have focus on concept map construction as a learning activity, and as an assessment tool ([4], [6]). For instructional design, concept mapping could be a pedagogical strategy to improve teaching and learning. It could be used for organizing concept maps either for an entire educational program or for part of a simple lesson.

Concept Mapping as an Instructional Tool

Concept mapping is a technique for representing knowledge in graphs. Knowledge graphs are networks of concepts. Networks consist of nodes and links. Nodes represent concepts and links represent the relations between concepts ([4], [6], [7]). In a concept map, it might include a variety of levels of concept whereas more specific, less inclusive concepts serve as guidelines for selecting specific instructional materials and activities. Namely, the top of a disciplinary concept map guides major curriculum planning activities, whereas the lower portion implies specific instructional activities, including the specific objects or events to be learned. Instructional planning have to involve slicing vertically through the curriculum map to achieve meaningful linkages between more general, inclusive concepts and concepts that are more specific [4]. As instruction proceeds, conceptual cross-links will be needed, and these would be represented horizontally across the curriculum conceptual hierarchy.

A good concept map shows key concepts and propositions in explicit and concise words and the superordinate-subordinate relationship between key concepts and propositions. In the concept map, one dominant concept is defined in terms of subordinate concepts, then clarified and illustrated with concrete evidence or instance. Thus, the complete concept map is woven together with explanatory crosslinks [5]. In this sense, concept maps might help us teachers. While we develop a concept map for a lesson or a curriculum, the organizational scheme of that lesson or curriculum becomes clear, and we have a better idea about how to sequence the presentation materials.

In this paper, the author addresses web-based mapping, which intends to guide learners toward general understandings of the materials they have to learn in regard to logic design. Moreover, the concept maps may provide learners with methods and skills of researching, analyzing, synthesizing, and evaluating relevant information in any learning fields.

Web-Based Concept Maps

Traditionally, a concept map used in teaching is regard as a tool to decribe a set of subject concepts by paper and pencils. The paper-and-pencil has some restrictions to track all possible relationships between the nodes of a big map. However, while a concept map developed through the conputer, especially on the WWW, can be implemented as a hypergraph, where a node may lead to a more detailed subpage. The learners could use the chracteristics of hyperlinks to navigate the nonlinear connections and search for different paths between the nodes to explore the contents in whatever order desired ([8], [9], [10]). In brief, the concept map can assist learners in seeking out the "big picture" of the domain of the subject. Kommers & Lanzing [8] proposed that concept mapping through interactive multimedia is an effective mental learning strategy to empower learning. Especially, the wide reach of the Internet , coupled with the hypermedia capabilities of the computers it interconnects, has made the WWW as a vehicle for delivering knowledge [11]. Eric [7] and Kommers & Lanzing [8] indicated that the benifits of using concept mapping on the WWW include: (a) ease of recognition, (b) the possibility to quickly scan picture and find differences or keywords, (c) compactness of representation, and (d) the observation capability.

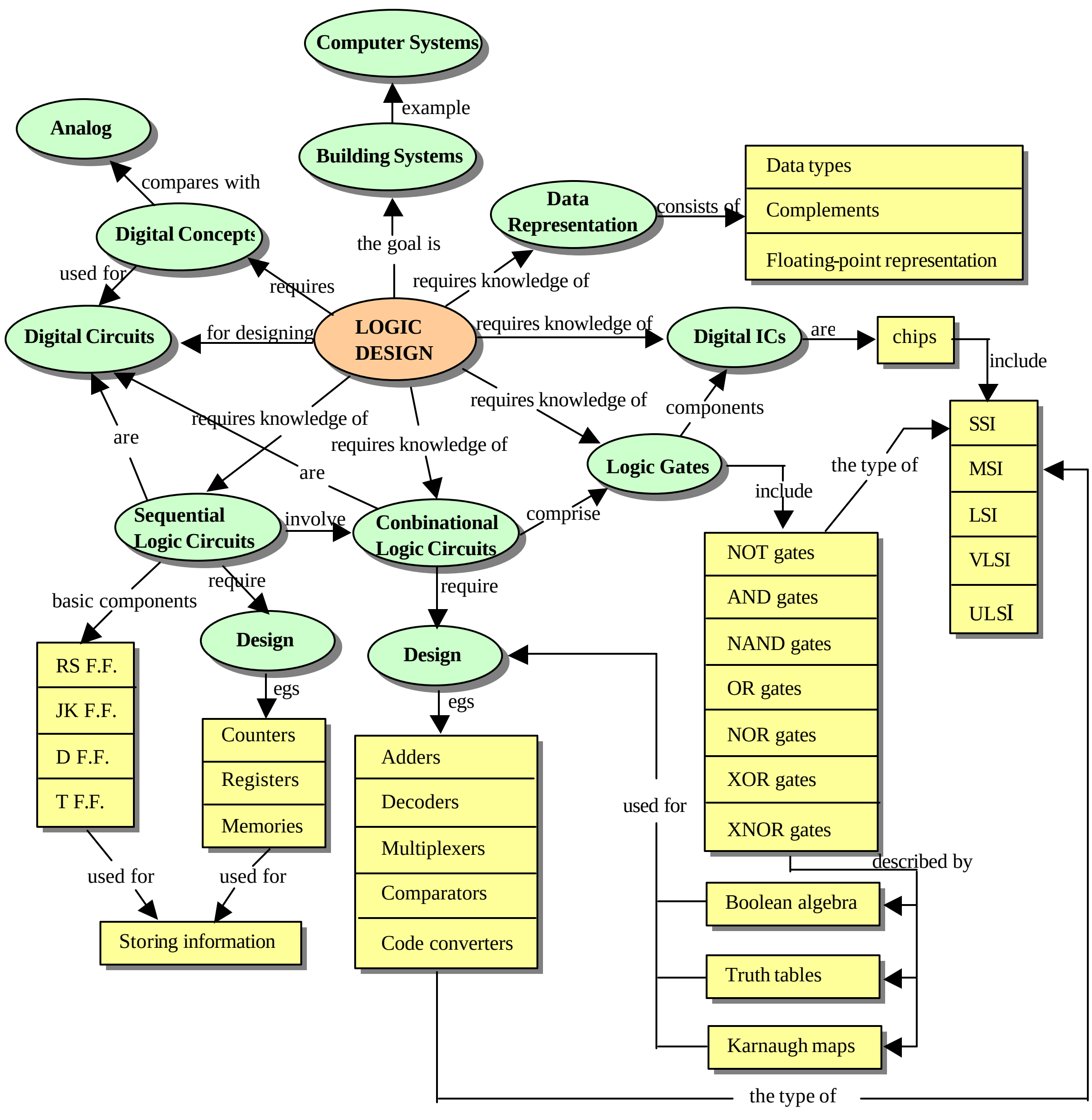
LEARNING ENVIRONMENT FOR LOGIC DESIGN

Instead of passively accepting the information presented by paper, the Internet and the WWW provide an ideal vehicle for interconnecting the concept web to assist learning. The WWW is a rich-structured platform for learners obtaining the information which they need. Moreover, while learners navigate on the WWW, they could flexibly control and decide how and when they study. Research (e.g., [12], [13]) indicated that learners might transform their study from passive to active participants in the learning process. This guides them to related information that becomes integrated as personal knowledge.

Framework of the Learning Environment

Taking the benefits of the WWW, the learning environment for logic design is designed to help instructors integrate the characteristics of hypermedia and the Internet into instruction. The program starts with a map which woven with the most fundamental concepts in the logic design course, as shown in Figure 1. Looking at this concept map, the learner might have a macro view of the concepts to be learned in the logic design course. This map includes five major concepts (data representation, digital IC, logic gates, combinational logic circuits, and sequential logic circuits) covered in the subject matter. In addition to these major topics, the nodes for the goal of this course, and for the description of analog are also shown on the map.

FIGURE 1
THE MACRO VIEW OF LOGIC DESIGN



Then, at the subordinate level of the map, there are a variety of nodes interconnected either 'vertically' or 'horizontally' to the related concept(s). In each concept node, another map is provided that presents the lower level subordinate concepts. These nodes comprise demonstration, tutorials, simulations, and questions to facilitate learners understanding digital logic concepts. The whole concept of logic design knowledge is thus nested and integrated in a hyperlink network. For example, while the learner click the node for multiplexers in Figure 1, the sub-node map about multiplexers will be presented as Figure 2. This map provides the core concepts of multiplexers in order that learners can yield good understanding on the multiplexer topic. Learning from the map, learners can understand the interrelationships among the basic concepts (truth tables, logic diagrams, and logic symbols) for designing multiplexers.

FIGURE 2
THE CONCEPT MAP OF MULTIPLEXERS

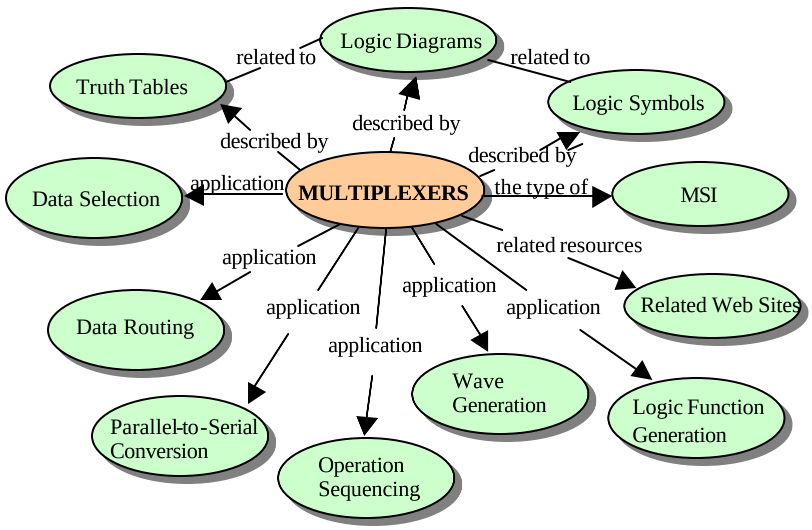
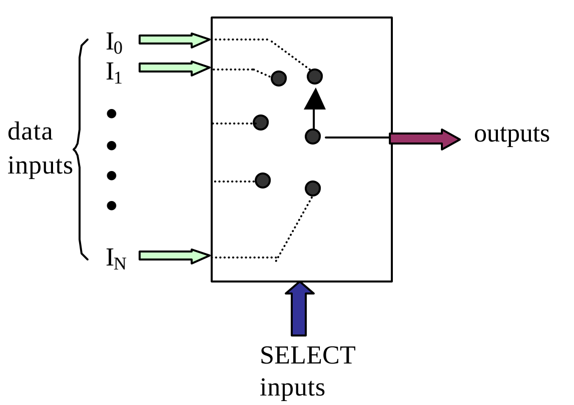


FIGURE 3
THE CONCEPT INSIDE THE 'MULTIPLEXERS' NODE

A ***multiplexer***, also called ***data selector***, is a logic circuit that accepts several digital data inputs and selects one of them at any given time to pass on the output. The routing of the desired data input to the output is controlled by SELECT inputs, as shown below.



For example, the home stereo system may have a switch that selects music from one of four sources: a cassette tape, a compact disc (CD), a video tape, or a radio. The switch selects one of the electronic signals from one of these four sources and sends it to the power amplifier and speakers. A multiplexer does this kind of function.
Note: A multiplexer selects one of several input signals and passes it on to the output.

In this map, while the learner clicks the main node 'MULTIPLEXERS', another map will be provided as Figure 3. This map describes the definition of a multiplexer and its application.

Another feature of the environment is it can be connected to other programs. For example, the flip-flop node can be linked to a simulation program [14]. The program presents the internal operations of the four types of flip-flops (RS, JK, D, T). In the program, learners can select any type of the flip-flops and assign the inputs, then by simulating the dynamic behavior between the internal gate chains to observe the operation of the circuit. Thus, they probably could develop intuition about the phenomenon being simulated.

In summary, this environment offers many equally appropriate paths to the learners. Depending on the learner's interest and available time, he can look at one or many concepts addressing one or more topics. Each concept stands alone, but offers hyperlinks to related topics. A concept map provides easy reference to the concepts that are to be presented in all topics; this makes it possible to better organize the contents for any given module or sub modules. The concept maps are cross-referencing of key ideas, and offer the intrinsic meaning in each module. Thus, learners could acquire vivid mental images.

Characteristics of the Learning Environment

Learning from the program, learners could acquire basic knowledge and synthesize information to build constructive knowledge of logic design.

It is expected that the program will have the following benefits over traditional instructional approaches:

- Presenting material in a clear and organized manner;
- Promoting learners active learning climate;
- Providing learners an interacive environment to manipulate the knowledge and information;
- Guiding learners to navigate the global logic related resources;
- Guiding learners to be inquisitive and explore the domain of digital logic;
- Promoting learners to connect prior knowledge to final knowledge;
- Promoting learners self-regulated learning.

Based on the features of the learning environment, the following pedagogical goals will be achieved:

- Understanding the logical operation of the standard digital components;
- Embedding design skills in practical contexts;
- Integrating the basic logic concept into related applications;
- Encouraging self-awareness of the knowledge construction process;
- Encouraging learner-teacher interaction in the learning process;
- Encouraging collaborated learning between peers.

SUMMARY

In today's classroom, learning emphasis should not be on rote memorization but on the ability to access information in many ways. We cannot assume that the self-directed nature of learning processes by concept mapping will increase learning results. Instead, concept mapping may be viewd as a better approach to complement and supplement the learners' learning process.

It is expected that concept mapping, as described in this paper, is more promising than any other relationship schemes for both teaching and learning. More research is needed on this issue; this paper approaches the issue as stimulation.

REFERENCES

[1] Schunk, D. H., *Learning Theories: An Educational Perspective*, Englewood Cliffs, NJ: Prentice-Hall, Inc., 1996.

[2] Wilson, P., & Coghill, G., "Student learning issues: Factors to consider prior to designing computer-assisted learning for higher education", *Proc. of the International Conference on Computers in Education*, November 2000, pp. 576-584.

[3] Alexander, J. O., "Collaboration design, constructive learning, information technology immersion, & electronic communities: A case study", *Interpersonal Computing and Technology: An Electronic Journal for the 21 Century*, vol. 7, no. 1-2, http://jan.ucc.nay.edu/~ipct-j/1999/n1-2/alexander.html, 1999.

[4] Novak, J. D., & Gowin, D. B., *Learning How to Learn*. New York: Cambridge University Press, 1984.

[5] Clarke, J. H., *Patterns of Thinking*. Needham Heights, MA: Allyn and Bacon, 1990.

[6] Turns. J., & Atman, C., "Concept maps for engineering education: A cognitively motivated tool supporting varied assessment functions", *IEEE Transaction on Education*, vol. 43, no. 2, 2000, pp. 164-173.

[7] Eric, P., "Concept mapping: A graphical system for understanding the relationship between concepts", http://ericir.syr.edu/ithome/digests/mapping.html, 1997.

[8] Kommers, P., & Lanzing, J., "Students' concept mapping for hypermedia design: Navigation through World Wide Web space and self-assessment", *Journal of Interactive Learning Research*, vol. 8, no. 3/4, 1997, pp. 421-455.

[9] Hill, J., & Buerger, B., "Hypermedia as a bridge between education and profession", *Educational Technology Review*, vol. 5, 1996, pp. 21-25.

[10] Rautama, E., Sutinen, E., & Tarhio, J., "Supporting learning process with concept map scripts", *Journal of Interactive Learning Research*, vol. 8, no. 3/4, 1997, pp. 407-420.

[11] Lee, P. M., & Sullivan, W. G., "Developing and implementing interactive multimedia in education", *IEEE Transaction on Education*, vol. 39, no. 3, 1996, pp. 430-435.

[12] Turing, M., Hannemann, J., & Haake, J., "Hypermedia and cognition: Designing for comprehension", *Communications of the ACM*, vol. 38, 1995, pp. 57-66.

[13] Caver, C. A., Howard, R. A., & Lane, W. D., "Enhancing student learning through hypermedia courseware and incorporation of student learning styles", *IEEE Transaction on Education*, vol. 42, no. 1, 1999, pp. 33-38.

[14] Lin, H. M., "A computer simulation program for enhancing the concepts of sequential logic", *Proc. of ED-MEDIA 99*, June 1999, p. 1704.