DOCUMENT RESUME

ED 424 233 TM 027 282

AUTHOR	Herl, Howard E.; O'Neil, Harold F., Jr.; Chung, Gregory K.W.K.; Dennis, Robert A.; Lee, John J.
TITLE	Feasibility of an On-line Concept Mapping Construction and Scoring System.
PUB DATE	1997-03-00
NOTE	27p.; Paper presented at the Annual Meeting of the American Educational Research Association (Chicago, IL, March 24-28, 1997).
PUB TYPE	Reports - Evaluative (142) -- Speeches/Meeting Papers (150)
EDRS PRICE	MF01/PC02 Plus Postage.
DESCRIPTORS	Cognitive Processes; Comprehension; Computer Oriented Programs; *Concept Mapping; *Cooperation; High School Students; Intermediate Grades; Middle Schools; *Online Systems; *Scoring; Secondary Education
IDENTIFIERS	Experts; *HyperCard; Middle School Students

ABSTRACT

The feasibility of the administration, scoring, and reporting of an on-line concept mapping system has been studied in collective research in which concept map construction systems were designed to allow students individually and collaboratively to construct concept maps on the computer to measure content understanding and collaboration. The study reported an attempt to implement a closed map construction system using expert-constructed concept maps to provide automated scoring and feedback for student-constructed concept maps. Participants were 138 middle school and high school students in 9 classes in 4 schools. Each student completed one of two on-line concept mapping tasks, one a collaborative task for three students and the other an individual problem-solving and search task. Students used the Hyper-Card concept mapping software developed for the study. Descriptive statistics associated with the concept maps were semantic content score, organizational structure score, number of terms used, and number of concept links formed. A total of 22 group concept maps were scored according to expert criteria, and pairwise agreement results for the scoring systems appeared to be good, with exact agreement percentages in the 80% range. (Contains 2 figures, 2 tables, and 14 references.) (SLD)

ED 424 233

Feasiblity of an On-line Concept Mapping Construction and Scoring System

Howard E. Herl, UCLA/CRESST
Harold F. O'Neil. Jr., USC/CRESST
Gregory K.W.K. Chung, UCLA/CRESST
Robert A. Dennis. UCLA/CRESST
John J. Lee, UCLA/CRESST

Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL, March, 1997

UCLA GSE/IS/CRESST
1320 Moore hall/Mailbox 951522
Los Angeles, CA 90095-1522

Purpose

The purpose of this presentation is to provide an overview of and assess the feasibility of the administration, scoring, and reporting of on-line concept mapping systems. In our collective studies, computer-based concept mapping assessments were designed to measure students' environmental science content knowledge by requiring them to construct semantic relationships among important concepts in the content domain. Some students were also asked to search a simulated Internet database for information about these important concepts, so as to measure problem solving. Concept map construction systems were designed to allow students to individually and collaboratively (in groups of three) construct concept maps on the computer, so as to measure both content understanding and collaboration.

Theoretical Framework

The motivating concern behind our study has been the desire to assess students' understanding of relationships utilizing a format that departs from both standardized testing and discourse-dependent tasks (e.g., essays). In our research, conceptual knowledge is represented in the form of concept mapping, (Baker & Niemi, 1991; Baker et al., 1994; Baker et al., 1990; Baker, Niemi, et al., 1992; Dansereau & Holley, 1982; Herl, Baker, & Niemi, 1996; Holley &

Dansereau, 1984; Lambiotte, Dansereau, Cross, & Reynolds. 1989) comprising nodes and links, nodes representing concepts or their attributes, and links expressing the semantic relations among those concepts. Empirical research on the efforts of concept mapping (Collins, Dansereau, Holley, Garland, & McDonald 1981; Dansereau et al., 1979; Holley, Dansereau, McDonald, Garland, & Collins, 1979; Lambiotte & Dansereau, 1991; Rewey, Dansereau, Skaggs, Hall, & Pitre, 1989; Roth & Roychoudhury, 1992) found that students using concept mapping strategies performed significantly better on text processing tasks than students using their own methods. The value of mapping as an instructional tool implies the desirability of having methods for constructing and scoring concept maps as a way to link assessment and instruction.

Concept map construction and scoring systems. A concept mapping construction system contains terms, links, and map construction procedures. A term can represent more tangible things, such as people, places, and things, or less tangible things, such as ideas. Links are used to represent semantic relationships among concepts. Specifications for map construction systems should provide the necessary procedures for users for construct those semantic relationships. The importance of the specifications of the system is independent of the testing format (i.e., on-line or paper-pencil task) used to administer the assessment.

There are two main classifications of map construction systems: 1) open, and 2) closed. An open construction system is defined as one which requires map constructors to provide their own terms and links. A closed system contains finite sets of terms and links, from which constructors must choose in order to construct their maps, and provides the model for the map construction system used for this study.

Concept maps have typically been constructed by individuals using paper-pencil formats, in which the map constructor draws the concept map by hand. Currently, there are two problems with the implementation of paper-pencil concept mapping construction systems: (1) the cost of transcribing student-constructed maps from paper-pencil format to computerized data format is directly proportional to the number of students and is not yet feasible for large-scale assessment, and (2) the percentage of students' missing data might be considered unacceptable to some. Herl et al. (1996) collected over 300 paper-pencil concept maps, and reported that more than 4% of students had to be eliminated from data analyses because their maps contained less than a minimum percentage of valid links (in that study, 80% was considered acceptable) in their concept maps.

In summary, map construction systems based on hierarchical memory models must have scoring systems which are based on criteria reflecting a hierarchical nature of cognitive structure, while no such restrictions on associationist memory-based mapping systems. The selection of memory model and the use of expert performance in the scoring system are independent of the decision to use open or closed construction systems. When open map construction systems are implemented, however, their respective scoring systems must include human raters. Such human-based scoring systems are expensive and prone to error. Our study attempted to implement a closed map construction system using expert-constructed concept maps to provide automated scoring and feedback for student-constructed concept maps.

Methods

Participants

Four middle school and high school teachers' classes were recruited to participate in a study about environmental science. Overall, 138 middle school and high school students were randomly selected from three high schools and one middle school, yielding a total of nine classes. Class sizes ranging from 17 to 28. English was the primary language for all students.

Students were randomly selected in groups of three to participate in collaborative concept mapping tasks or individually to complete problem-solving and search tasks. There were 69 students selected for the group mapping task and 69 students for individual problem-solving and search task.

Equipment and Setup

Each classroom contained at least four Macintosh 8500s, each one containing 24MB RAM and 1GB hard disk storage. An ethernet network was configured with two 10T 8-port hubs, in-classroom MACs, and five additional Power Mac 5300/16MB/1GB portable computers. Both the Macintosh 8500s and 5300s had 17" multiscan color monitors connected to them.

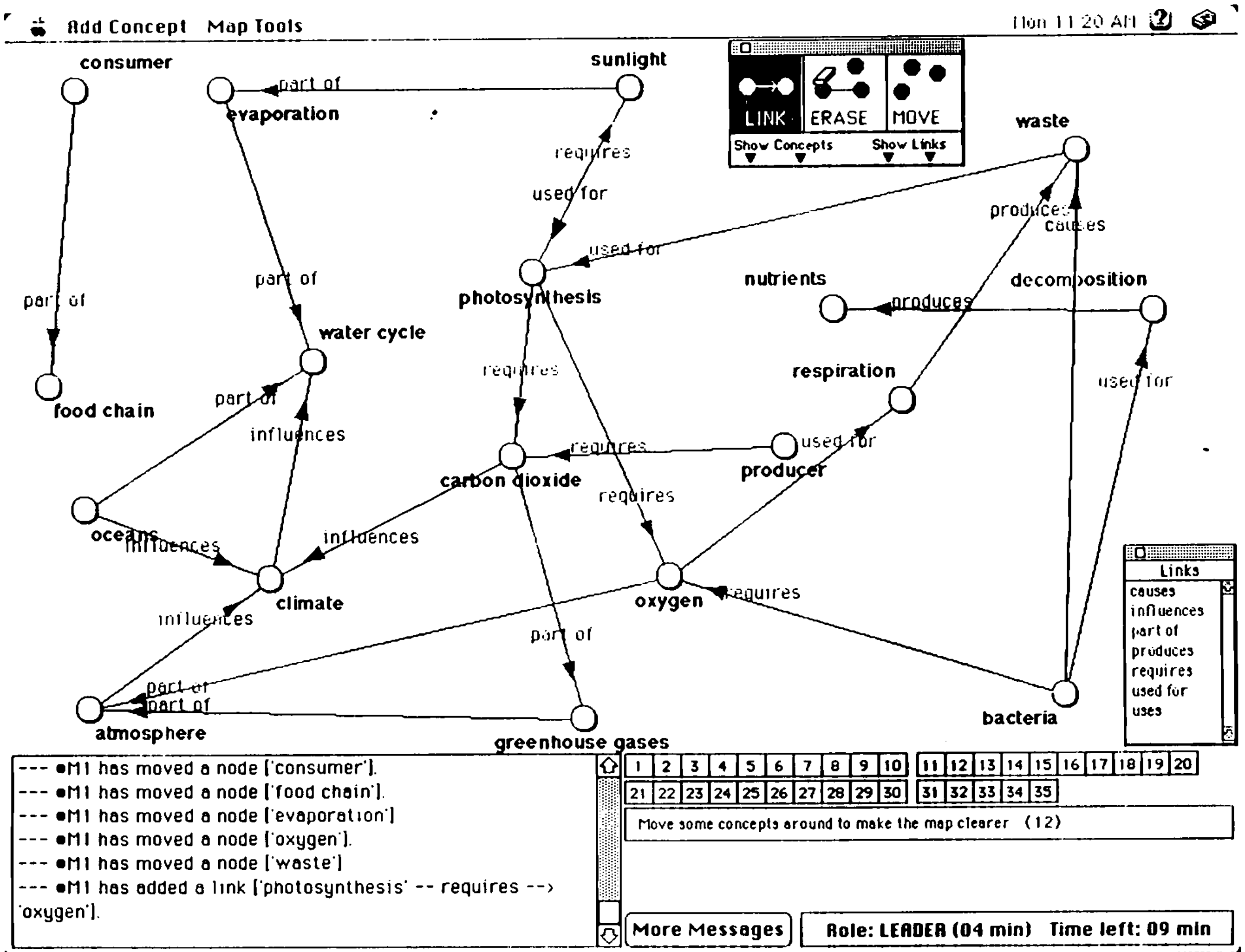
Measures

Each student completed one of two on-line concept mapping tasks. One of the tasks was a collaborative task and the other was defined as the problem-solving and search task.

Collaborative concept mapping task. The collaborative concept mapping task is designed to measure students' content knowledge and collaboration skills by requiring them to construct semantic relationships among important concepts in particular content domains. Students were assigned to three-member teams and asked to collaborate on constructing computer-based concept maps. This task required each student to work on his/her own computer and collaborate with other team members using CRESST-supplied HyperCard® based concept mapping software. Figure 1 displays an example of a concept map constructed using the collaborative mapping system.

Figure 1

Collaborative Concept Mapping Task Screen



9

BEST COPY AVAILABLE

10

A three-member group consisted of two members and a leader. The concept mapping software randomly selects one member from each group to serve as the first leader; however, each member of a group has an opportunity to assume this pivotal role twice during the task. The leader is the only team member to have the ability to make changes to the group concept map; the other two members only have visual access to the map. Any additions or revisions made to the map by the leader are automatically updated on the screens of all group members. On-line collaboration between group members takes place using a pre-defined messaging system. In this data collection effort a pre-defined message system containing 35 different messages was implemented. Each of the three group members served two six-minute terms as leader of the group during the 36-minute task.

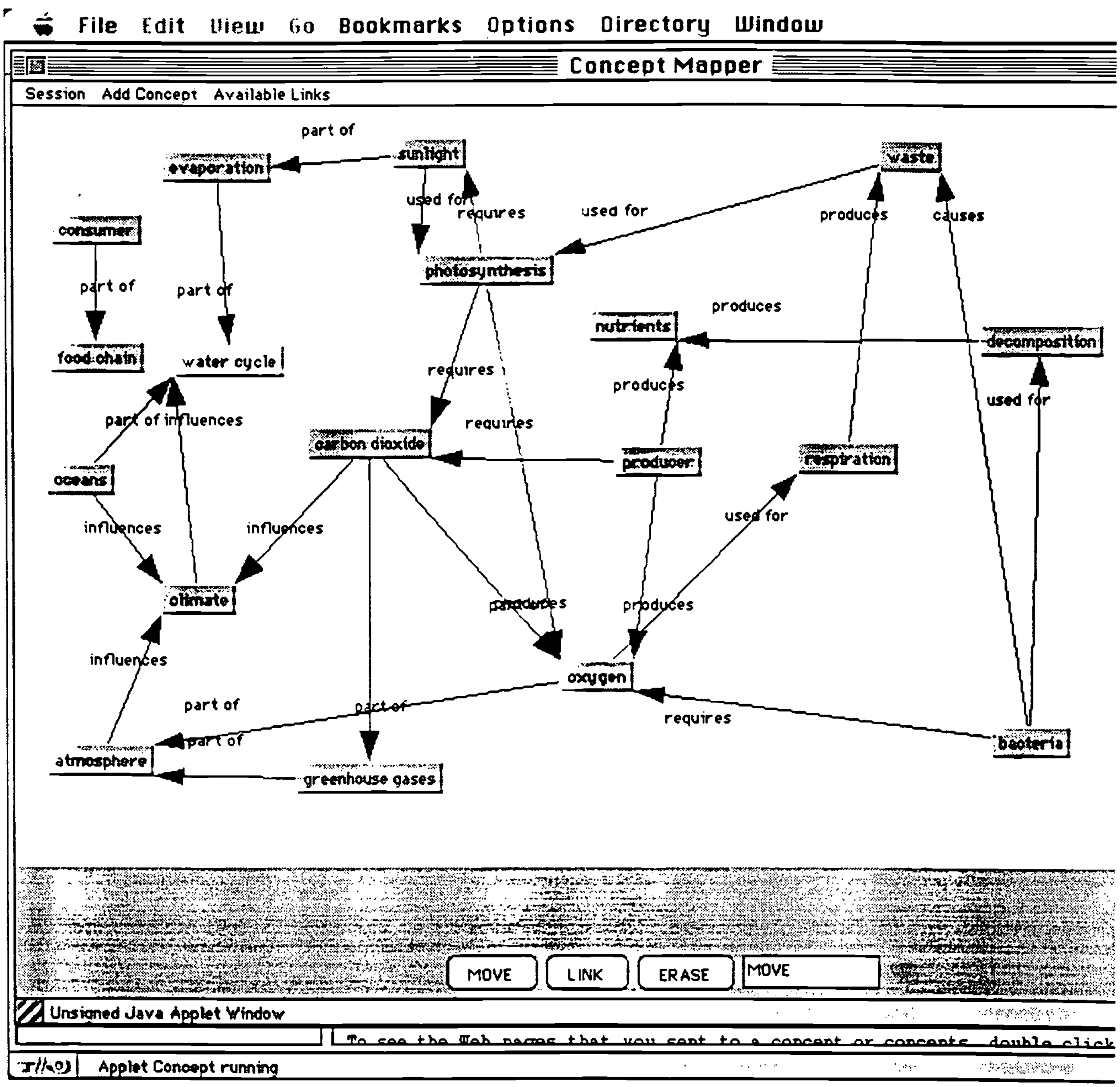
The first step in constructing a concept map was to select a term from the pull-down menu and drag it into place anywhere on the screen. Subsequent steps included selecting other terms from the menu and constructing semantic relationships among pairs of concepts. In this study, sets of environmental science concepts (ATMOSPHERE, BACTERIA, CARBON DIOXIDE, CLIMATE, CONSUMER, DECOMPOSITION, EVAPORATION, FOOD CHAIN, GREENHOUSE GASES, NUTRIENTS, OCEANS, OXYGEN, PHOTOSYNTHESIS, PRODUCER, RESPIRATION, SUNLIGHT, WASTE, WATER CYCLE), link labels (CAUSES, INFLUENCES, PART OF, PRODUCES, REQUIRES, USED FOR. USES), and pre-defined collaborative messages were provided to each student of the group.

Problem-solving and search task. The problem-solving task is also a computer-based task containing two distinct activities. The first activity of the task required students to individually construct concept maps, which serve as pretest measures of content understanding. For this task, environmental science content was assessed for both tasks, and therefore the same sets of concepts and links were used in the collaborative mapping and problem solving and search tasks. Students were allowed 20 minutes to complete their individual maps, after which they were provided with general feedback concerning which concepts needed the most improvement. This feedback was designed to be general in the sense that information was not provided to students specific to their incomplete content understanding

The second part of the task required students to search through a CRESST-developed simulated web space containing information about the set of environmental science concepts. Students were provided with the ability to search the simulated web space via a: 1) searching interface, 2) directory, or 3) glossary. Students were instructed to bookmark any web pages they found to be specifically relevant to particular concepts. They were also instructed to add to or revise their concept maps based upon the information they found resulting from their searches. An additional 40 minutes were provided to students to complete the second activity of the problem-solving and search task. Figure 2 displays a concept map constructed during this task by a 9th grade science student.

Figure 2

Problem Solving and Search Concept Mapping Task Screen



Collaborative concept mapping task. Students participating in the collaborative concept mapping task received 12 minutes of hands-on training using our HyperCard® concept mapping software. One CRESST researcher was assigned to conduct collaborative concept mapping training sessions. The training sessions emphasized the skills necessary for constructing concept maps (adding, linking, moving, and erasing concepts), and sending messages to other group members. The training session was modeled after previous studies (Baker et al., 1990; Baker & Niemi, 1991; Herl, 1995, 1996), but was modified to adapt to the concept mapping construction system designed for this study, which comprised on-line training prompts. Part of the training session was designed to provide definitions for each of the links used in the concept mapping task.

The demo software allowed students to practice constructing, revising, and erasing links, as well as adding, erasing, and moving concepts. It is theorized that very different sets of concepts should be used for concept mapping task training sessions than are used for the task itself. The training set used for the demo included concepts which were not related to the concepts used in the collaborative task, and was considered to comprise a more "general" knowledge content domain. Subsequently, the set of concepts used in the training session consisted of common terms related to birds, including: 1) BIRD, 2) EAGLE, 3) FLIGHT, and 4) WINGS, and the set of training links consisted of: 1) PART OF, 2) TYPE OF, 3) USED FOR, and 4) USES. These sets were contained relatively few concepts and links, serving to provide more manageablity and standardization for the training sessions. Overall, 48 minutes were allotted for the collaborative concept mapping task, including 12 minutes for training and 36 minutes for groups of students to complete their collaborative concept maps.

Problem-solving and search task. For this task, students received eight minutes of hands-on training using CRESST supplied JAVA® concept mapping software. Although there were some JAVA® graphic user-interface differences, the training sessions were similar to those used for the collaborative mapping task. Training procedures were compatible with those used for the collaborative task; however, the problem-solving and search task is completed by individuals, and does not include any collaborative components. After students had completed their 20-minute concept maps, there was an additional 10-minute hands-on training session given to students. The training emphasized each of the three search interfaces provided (search, directory, and glossary). They were also instructed on how to bookmark relevant web pages found during their searches, and how to revisit those pages which had previously been bookmarked. A total of 78 minutes were provided to students for the completion of the problem solving and search task, including 18 minutes for training, and 60 minutes to complete both the individual mapping and searching activities.

Scoring Procedures

Collaborative concept mapping task. Four teachers considered to be knowledgeable in the field of environmental science were recruited to construct concept maps, which were subsequently used as sources of expert criteria to score students' maps. Scores were computed for each group to measure 1) content knowledge contained in the group concept map, and 2) the amount and type of group collaboration.

There are two scores associated with measuring the content knowledge contained in concept maps. The semantic content score of a concept map is based on the semantic links constructed by experts in their concept maps. Two different methods of using expert maps to score student maps for semantic content were tested: (1) stringent, and (2) categorized. These two methods were created to compare the effects of removing subtle differences in the semantic meanings of the links. For each of these two methods, each expert's map was used to compute a total map score for each student, resulting in four scores for each student map. The second method incorporated clustering of similar kinds of links. To compute categorized map scores, some links were first categorized into different sets of link types. For example, CAUSES, INFLUENCES, AND PRODUCES were categorized and labeled as causal links. The second method obviously generates map scores which are greater than or equal to the scores using method one. The number of links constructed in each expert's map represented the maximum possible score for each student map. Since exact agreements and reliabilities using the two methods were similar, categorized map scores were used in the analyses to serve as the semantic content scores because they contained more variance resulting from a greater range of map scores.

The organizational structure score is defined as the similarity between students' and experts' maps. For each student map, organizational structure was calculated using a metric measuring the degree of similarity between neighborhoods of network terms (Herl et al., 1996). The range of the organizational structure score is 0 to 1, where 0 represents no structural similarity at all between the student map and the expert map; and 1 represents a perfect structural match between the student map and the expert map.

Problem-solving and search task. For each student' s map constructed during the problem-solving and search task, two measures were computed related to the content contained in the map, and a list of the URLs for the web pages that were searched and bookmarked were logged. Semantic content and organizational scores were computed for the pretest concept map (after the first 20 minute mapping activity) and posttest map (after the 40 minute searching activity). Each of the 252 web pages in the simulated internet database was scored a priori by two raters. Those raters were trained to score each of the web pages on its relevance to each of the concepts used in the mapping task (Schacter et al., 1997), and averages of the two raters' scores were used to score students' bookmarks.

Analysis

Descriptive statistics

There are four descriptive statistics associated with concept maps presented here. including: (1) semantic content score, (2) organizational structure score. (3) number of terms used, and (4) number of links. The first two statistics were computed using expert concept maps as sources of criteria and the last two were calculated independent of experts' maps. A term was considered to be used in a concept map when there was at least one link connected to it. The number of links is also a countable statistic and is defined as the number of links constructed. There were 22 group concept maps scored according to expert criteria. One group was excluded from the analysis because of problems with one of the computers used in the task.

Table 1 displays the descriptive statistics for the collaborative concept maps, problem solving and search pre- and post- maps, and experts' concept maps. Students' semantic content scores ranged from 0.75 to 15.5 and were slightly positively skewed, while their organizational structure scores ranged from 0.10 to 0.37. Experts' semantic scores ranged from 20.7 to 25.3, while their organizational scores ranged from 0.41 to 0.51. It can readily be inferred from the reported statistics that experts' map scores would be significantly higher than students on each of the first two concept mapping task measures. Obviously, one rationale is that they have higher content knowledge, which allows them to construct more correct links among the set of environmental science concepts.

Table 1
Means and Standard Deviations for Collaborative, Problem Solving and Search Task, and Experts' Concept Mapping Task Measures

Measure	Collaborative[a]	Problem Solving Pretest[b]	Problem Solving Posttest[c]	Experts[d]
Semantic content score				
M	5.17	3.81	4.28	22.50
SD	3.41	2.86	3.98	2.15
Organizational structure score				
M	0.22	0.17	0.18	0.46
SD	0.08	0.09	0.11	0.04
Number of terms used				
M	14.68	12.73	13.02	18.00
SD	3.75	5.07	5.13	0.00
Number of links				
M	18.41	13.77	14.57	44.75
SD	6.50	8.59	9.36	10.31

Note. [a]n=22. [b]n=64. [c]n=63. [d]n=4.

The next speaker will present results and discussion concerning the relationships among the collaborative mapping measures and six teamwork processes, including: 1) adaptability – recognizing problems and responding appropriately, 2) communication – the exchange of clear and accurate information, 3) coordination – organizing team activities to complete a task on time, 4) decision-making – using available information to make decisions,

5) interpersonal – interacting cooperatively with other team members, and 6) leadership – providing structure and direction for the team (Chung et al.,1997). The final speaker will present analysis and discussion of the relationships among pre- and post-test mapping measures, information seeking and retrieval measures (bookmarking), and search processes collected in the problem-solving and search task (Schacter et al., 1997).

Agreement Results for Concept Mapping Tasks

Exact agreement analyses were performed on the pairwise agreement using experts' maps to score students' maps. Each expert's map was used to score each link in students' concept maps. A pair of experts is considered to agree on the correctness or incorrectness of student's links. There are three possibilities for each student-constructed link: 1) both experts construct links, 2) only one expert constructs a link, and 3) neither expert constructs a link. A link was scored as incorrect when it did not match either of the expert's links, or whenever both experts did not construct links. There are two possibilities of how pairs of experts might disagree: 1) experts disagree on whether to score a particular link as correct or incorrect, or 2) only one expert constructs a link between the same two concepts as the student. In this study, agreement is defined as both experts agreeing on the score of a particular link, whether or not both experts constructed links. The number of links in each student's map represents the total number of comparisons made for that particular map. Exact agreement is defined as the number of agreements divided by the total number of comparisons.

The inter-expert agreement results using expert maps as criteria to score student maps are presented in Table 5 for all pairwise combinations of experts. As may be seen in Table 2, the exact agreement percentages are reasonably high (in the 80 percent range). However, it should be noted that if the more strict definition of agreement is used, that is, when experts are considered to disagree when only one of a pair constructs a link between the same concepts (even though the student's score would be scored 0 by both experts), the exact percentage of agreements would range from 75% to 82% for the collaborative mapping task, and 78% to 83% for the problem solving task.

Table 2
Inter-Expert Pairwise Agreement Percentages on Concept Map Scores

			Problem Solving	
		Collaborative[a]	Pretest[b]	Posttest[c]
Rater Pair				
2	1	85	86	88
3	1	88	91	90
3	2	84	87	88
4	1	82	85	87
4	2	89	89	90
4	3	86	89	89

Note. [a]n=22. [b]n=64. [c]n=63.

Discussion

An overview of two different concept mapping construction and scoring systems has been discussed in this paper. Preliminary student achievement results have been presented for two concept mapping measures derived from expert-based map scoring systems. The pairwise agreement results for those scoring systems appear to be very good, however, very few studies have reported these kinds of results for concept mapping tasks. In fact, very few studies have implemented map scoring systems based on expert performance as sources of criteria. The next speaker, Greg Chung, will now present a more detailed discussion of the results of the collaborative mapping task.

References

Baker, E. L., & Niemi, D. (1991). Assessing deep understanding of science and history through hypertext. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Baker, E. L., Niemi, D, & Herl, H. (1994). Using HyperCard technology to measure understanding. In E. L. Baker & H. O'Neil (Eds.), Technology assessment in education and training. Hillsdale, NJ: Erlbaum.

Baker, E., Niemi, D., Gearhart, M., & Herman, J. (1990, April). Validating a hypermedia model of knowledge representation. Paper presented at the annual meeting of the American Educational Research Association, Boston.

Baker, E. L., Niemi, D., Novak, J., & Herl, H. (1992). Hypertext as a strategy for teaching and assessing knowledge representation. In S. Dijkstra (Ed.), Instructional models in computer-based learning environments. Berlin: Springer-Verlag.

Chung, K. W. K., O'Neil, H. F., Herl, H. E., Dennis, R. A., Schacter, J. (1997). Use of Networked Collaborative Concept Mapping to Measure Team Processes.and Team Outcomes. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

Dansereau, D. F., & Holley, C. D. (1982). Development and evaluation of a text mapping strategy. In A. Flammer & W. Kintsch (Eds.), Discourse processing. Amsterdam: North Holland Publishing.

Herl, H. E. (1995). Construct validation of an approach to modeling cognitive structure of experts' and novices' U.S. history knowledge. Unpublished doctoral dissertation.

Herl, H. E., Baker, E. L., & Niemi, D. (1996). Construct validation of an approach to modeling cognitive structure of U.S. history knowledge. Journal of Educational Research, 89, 206-219.

Holley, C. D., & Dansereau, D. F. (Eds.). (1984). Spatial learning strategies: Techniques, applications, and related issues. Orlando: Academic Press.

Lambiotte, J. G., & Dansereau, D. F. (1991). Effects of knowledge maps and prior knowledge on recall of science lecture content. Journal of Experimental Education, 60 (3), 189-201.

Lambiotte, J. G., Dansereau, D. F., Cross, D. R., & Reynolds, S. B. (1989). Multirelational semantic maps. Educational Psychology Review, 1 (4), 331-367.

Rewey, K. L., Dansereau, D. F., Skaggs, L. P., Hall, R. H., & Pitre, U. (1989). Effects of scripted cooperation and knowledge maps on the processing of technical material. Journal of Educational Psychology, 81, 604-609.

Roth, W., & Roychoudhury, A. (1992). The social construction of scientific concepts or the concept map as conscription device and tool for social thinking in high school science. Science Education, 76 (5), 531-557.

Schacter, J., O'Neil, H. F., Chung, K. W. K., and Herl, H. E. (1997). Feasibility of a Web-Based Assessment of Problem Solving. Paper presented at the annual meeting of the American Educational Research Association, Chicago.

NOTICE

REPRODUCTION BASIS

- [x] This document is covered by a signed "Reproduction Release (Blanket)" form (on file within the ERIC system), encompassing all or classes of documents from its source organization and, therefore, does not require a "Specific Document" Release form.

- [ ] This document is Federally-funded, or carries its own permission to reproduce, or is otherwise in the public domain and, therefore, may be reproduced by ERIC without a signed Reproduction Release form (either "Specific Document" or "Blanket").