Oliver, K. (2007, April). Web-based concept maps for alternative assessment in distance teacher education. Paper presented at the Annual Meeting of the American Educational Research Association (AERA), Chicago, IL.

Abstract

Three sections of the same distance education class completed a series of Web-based concept map assessments using one of two methods--open-ended mapping or pre-selected term mapping. Across sections, 41 graduate students expressed great interest in mapping as an alternative form of assessment for distance courses, and performed adequately on assigned tasks. Open-ended maps were applied in the first section and led students to conduct more relational thinking overall, but variance in map items was very high introducing more subjectivity in scoring. In an attempt to reduce subjectivity, pre-selected term mapping was applied with the next two sections. Student pre-selected term maps illustrated moderate similarity to an instructor map used as a standard of comparison with many correctly classified concepts and written propositions. Students in pre-selected mapping sections struggled most with identifying the expected concept sets from the instructor's maps. The high volume of readings associated with the task appeared to further this problem. Students touted different benefits of mapping activities--helping to synthesize and connect course material and to read more intentionally.

Introduction

The difficulty in delivering and securing traditional tests at a distance is well known (Shyles, 2002). Concept mapping provides distance instructors with an alternative assessment tool to determine what students know about a subject. It also provides distance students with an active learning tool to build and revise their own model of understanding as new course materials are revealed. Concept mapping activities involve the instructor selecting a relatively narrow domain of knowledge from course material such as required readings or labs (Novak & Gowin, 1984). The student is either given or extracts key concepts in this domain, groups them in "like" sets, and draws lines between them to illustrate key relationships. A real concept map also includes linking words on the connecting lines to explain relationships (e.g., clear cutting - causes - erosion). Combining concepts and linking words creates a "proposition" that may be evaluated for accuracy (Cardellini, 2004). Flowcharts and mind maps are often mistaken for concept maps, but these techniques usually contain no linking words between concepts and do not capture a student's understanding of important relationships.

Web-based concept map assessments were integrated in three sections of the same graduate class between fall semester 2005 and fall semester 2006. The sections were taught entirely at a distance using the WebCT Vista course management system. The Web-based concept maps provided an alternative assessment to gauge student understanding of course topics. The purposes for the study were to determine if Web-based concept maps could be used to assess student understanding of course readings, to investigate the most appropriate procedures for eliciting and scoring student representations, and to determine how students would react to map activities cognitively and emotionally.

Concept Map Task Structures and Thinking

According to Presseisen's (2001) model of thinking, several lower-level thinking skills are possible ranging from simple classifications to more challenging inductions and evaluations. These skills are used in support of higher-level thinking processes such as decision making and problem solving. Different concept map task structures may elicit different thinking skills as suggested by the study framework presented in Figure 1.

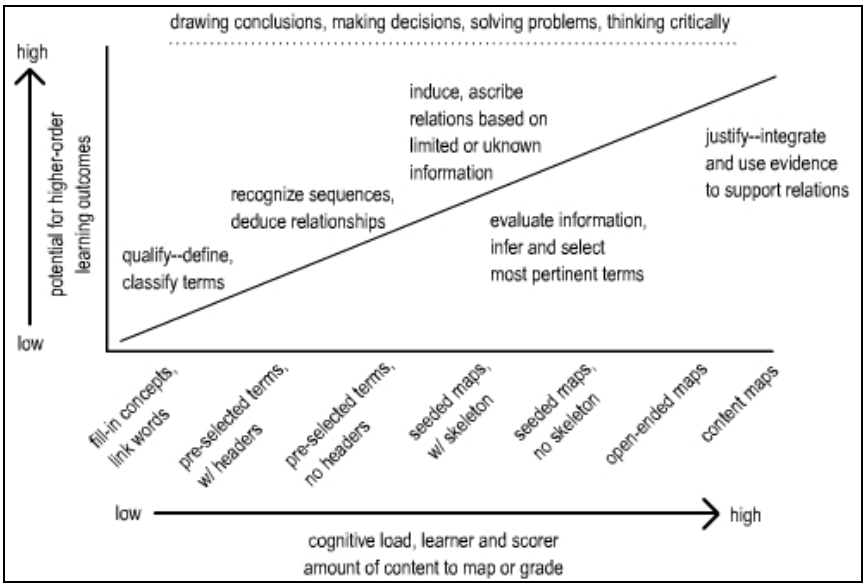

Figure 1: Tradeoffs between structured and unstructured mapping tasks.

Simple concept maps provide students with the general structure and require them to place concepts and propositions in blanks. In some cases, the concepts and/or propositions are even provided, and the student does little more than define and align terms. Moving up the cognitive scale, students may also be given pre-selected terms for mapping, which requires them to recognize sequences and deduce relationships from the context of course materials or readings. Pre-selected term maps may include superordinate headers under which students classify the terms they've been given, or they may require the student to discover higher-level concepts and create a hierarchical structure on their own.

Similar but slightly more challenging are seeded maps, where the student is again given pre-selected terms, but only a small set of 8-10 concepts. In addition to the provided terms, the student must select additional terms from course materials that are related and pertinent to the original set. This task requires the student to evaluate and select the most important information and to induce relationships based on more limited information. As with pre-selected term maps, seeded maps may include a partial structure or "skeleton" onto which new concepts are attached.

The most challenging maps are open-ended maps that provide no terms or structure in advance, just a general topic to be mapped. Students must use all of the thinking skills previously mentioned to create an open-ended map. With new Web-based mapping tools, any of these maps can take on a content dimension with learners connecting external resources such as Web pages

and articles to different items in their maps. If applied correctly, this feature can be used by students to justify or "prove" their map representation citing evidence from others.

While open-ended maps elicit more thinking skills, they also increase the cognitive load for both the learner and scorer (i.e., more to map, more to grade). Concept mapping studies have shown even college students may have difficulty with the highest levels of thinking. DeSimone, Schmid, and McEwen (2001) found students were challenged by creating arguments or inferences and justifying those with evidence collected from readings. Further, Germann and Young (2001) tasked 17 undergraduate students with electronic concept mapping as well as shared journals posted to a listserv and found reflection and changes in map propositions did not occur. Reflection and change in understanding represent a very high level of metacognitive thinking about one's own knowledge structure. Active teacher scaffolding may be required to reach these higher levels of thinking with maps, rather than assuming students will spontaneously apply reasoning (DeSimone et al., 2001).

Using Concept Maps for Assessment

A variety of methods are available for scoring concept maps (Ruiz-Primo & Shavelson, 1996). Scoring systems may include a comparison of the student-created map to an expert or criterion map, a computed score based on map elements, or a combination of both (Ruiz-Primo & Shavelson, 1996). One of the earliest and best-known scoring systems involves a holistic score computed from a sum of correct link-node relationships (1 point), cross-link relationships (2-10 points), structural hierarchies (5 points), and embedded examples (1 point) (Novak & Gowin, 1984). McClure, Sonak, and Suen (1999) outline at least two additional scoring systems: structural, or computing a score from higher-level structures, cross-links, and propositions; and relational, or computing a score from propositions alone.

The relational method is touted for its ease of use, mechanical simplicity, and increased reliability, allowing scores to be easily defended (McClure et al., 1999). Others suggest, however, there is too much data in concept maps to focus on relationship statements alone (Cañas et al., 2004). And the volume of data held in concept maps is increasing through new tools such as Cmap (IHMC, 2006) and the Visual Understanding Environment (Tufts University, 2005). Students can now collaboratively edit concept maps online and attach a multitude of resources to developed concepts (e.g., URLs, images, notes, videos, digital library resources), enhancing the static *concept* map to a more descriptive *content* map with attached external resources.

Scoring maps on the basis of multiple characteristics takes time and increases cognitive load for the scorer, particularly for the new *content* map format with multiple external resource attachments. It is understandable why some would limit the scope of mapping assessments to select-and-fill-in terms on a pre-structured template, and to no surprise such maps correlate closely with standard multiple choice tests (Schau, Mattern, Zeilik, Teague, & Weber, 2001). They should, since students are not creating their own structure, but repeating core knowledge as on a multiple choice test. A problem exists, however, in that restrictive fill-in-the-blank maps limit the knowledge students can represent (Ruiz-Primo & Shavelson, 1996). Better thinking is elicited by more open-ended maps. A compromise is needed between overly-simplistic maps that

are easy to score but tell us little about student knowledge structures, and open-ended maps that are valuable learning tools but very difficult to score.

In this study, three sections of the same course were used to investigate how different task structures may elicit different knowledge representations, and what implications different task structures have for the teacher in terms of assessment.

Method

Participants

Study participants included 41 graduate students enrolled in three sections of the same graduate distance education course over three semesters. The course was based on technology integration topics and issues in K-12 schools and was open-enrollment, thus the student population was derived from program areas across the College of Education and not Instructional Technology specifically. A majority of students enrolled in the course worked full-time off campus in K-12 teaching positions and were enrolled in various Master's degree programs. Table 1 summarizes the students involved in the study, and the map activities they completed.

Semester	Enrolled	Maps Completed and Content Coverage	Task Structure
Fall 05	11	2 individual maps: the internet (2 weeks), influencing factors on tech integration (1 week)	open-ended, no terms provided
Summer 06	15	3 individual maps: hardware (3 weeks), software (4 weeks), the internet (3 weeks)	pre-selected terms provided
Fall 06	15	3 individual maps: hardware (3 weeks), software (4 weeks), the internet (3 weeks)	pre-selected terms provided

Table 1. Summary of Courses, Students, and Mapping Activities

It seems that most of the students enrolled in this course had limited prior knowledge of concept mapping. Students enrolled in the second and third sections were asked on a course pre-survey if they had ever created an electronic concept map before, and 76.9% indicated "No" they had not (n=26).

Materials

The freeware Cmap Tools program enabled students to develop online concept maps and attach external resources to their maps (e.g., Web links, e-copies of assigned articles) (IHMC, 2006). The program was downloaded and installed by each student on their own Internet-connected computer. Cmap is practical for distance courses, since it allows the instructor to create student folders and map templates that the students can access remotely from a server. Each student is given a unique User ID and password to access and edit maps in their folder. IHMC's public Cmap servers were utilized for beta testing with the first class section, and the researcher installed a Cmap server on campus for the second and third sections.

Students used Cmap to restructure concepts from course resources and readings. In the first section, students were required to integrate external resources with their maps, but they were not

told which resources to integrate. They could integrate assigned course readings into their maps as well as other Web links and resources discovered on their own or in electronic discussions with peers. In the second and third section, students were again required to integrate external resources with their maps, but the instructor placed electronic copies of assigned readings in each student's map folder for integration. Table 2 summarizes the maps and related readings that were assigned to each section.

Semester	**1st Map**	**2nd Map**	**3rd Map**
Fall 05	internet (2 weeks): textbook sections, 8 articles	influencing factors on technology integration (1 week): textbook sections, 4 articles	none assigned
Summer 06	hardware (3 weeks): 7 articles	software (4 weeks): 14 articles	internet (3 weeks): 14 articles
Fall 06	hardware (3 weeks): 7 articles	software (4 weeks): 14 articles	internet (3 weeks): 14 articles

Table 2. Maps and Related Readings Assigned.

Also placed in each student's map folder were one or more map templates. For the first section, blank map files were added to the students' map folders to which the students added concepts and began their open-ended mapping (e.g., "Use this blank map to create a concept map about influencing factors on technology integration."). For the second and third sections, map templates were pre-selected term maps based on instructor maps. To create each instructor map, key terms were selected from assigned reading material and organized around a set of superordinate headers (see Figure 2). To create the matching pre-selected term map for students, the links and structure were simply removed from the instructor map (see Figure 3).

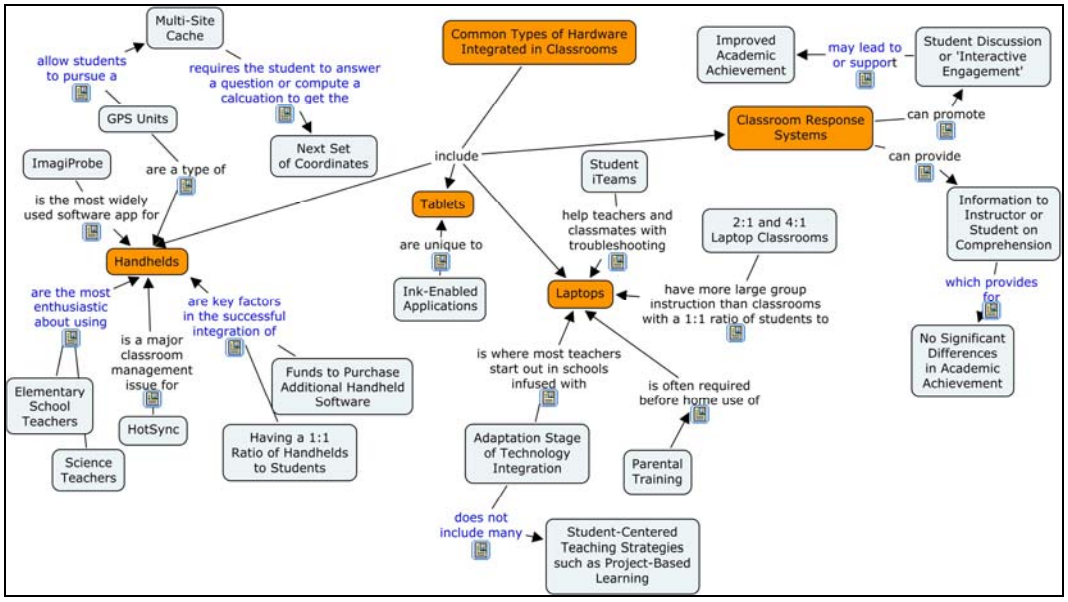

Figure 2. Instructor Map Illustrating Concept Classifications, Sets, and Propositions.

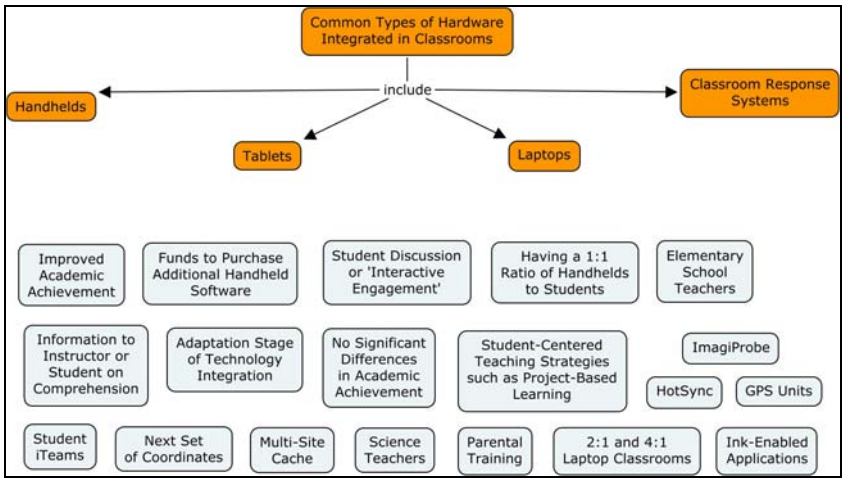

Figure 3. Student Pre-Selected Term Map Created from Instructor Map.

Procedures

Students completed between two and three concept maps related to course resources and assigned readings. In the first section, open-ended maps were employed with no terms provided to students in advance. Students were responsible for extracting relevant concepts from the course resources and readings, organizing and relating them, and integrating external resources to illustrate where they found depicted relationships.

In the second and third sections, pre-selected term maps were employed. Students were provided with approximately 20 unstructured terms in advance of their reading, and they were responsible for organizing and relating those terms on their maps. Three or four superordinate terms were listed at the top of each map onto which students attached their terms.

Students were given no less than one week to complete a map, and typically students were given from three to four weeks to fully develop their maps.

Analysis

A qualitative case study design was employed treating section 1 and sections 2 and 3 as two separate units of analysis, given their differential focus on open-ended versus pre-selected term mapping. Across sections, three student data sources were collected: a log of student questions posed to instructors regarding assigned mapping tasks during the semester, student responses to an online survey distributed at the end of each semester, and the concept map artifacts. The conceptual analysis method of content analysis was applied to questions received by the students as well as open-ended survey comments, identifying frequently used keywords and sorting text by themes. Numerical student survey responses were summarized with descriptive statistics.

Methods for scoring concept maps varied by section and task structure. For the first section with open-ended maps, the number of concepts, correct propositions, and integrated resources were tallied. This method was somewhat holistic, looking for evidence that students correctly identified key concepts from the readings, were capable of verbalizing accurate proposition

statements, and attached at least some external resources or personal notes to appropriate concepts. Great variation was apparent across students' open-ended maps in terms of propositions and other details. Since a student with 36 correct propositions and weak overall details (e.g., attached notes and resources), should not necessarily receive a better score than a student with 25 correct propositions and considerable map detail, the holistic method was deemed insensitive to quality. Variance in scoring widely divergent map elements on open-ended map assignments is known to be an issue, as it was for the first section (Shaka & Bitner, 1996).

In an effort to create a scoring scenario that was less subjective, pre-selected term maps were employed for the second and third sections. These maps allowed the researcher to accurately determine which students understood a concise set of key relationships among a limited set of terms. A combination scoring method was employed, assigning points for items on the students' maps that were similar to items on a comparison instructor's map (Ruiz-Primo & Shavelson, 1996). Specifically, one point was assigned for every concept the student classified under the provided headers similarly to the instructor's map, one point for every set of concepts the student grouped together similarly to the instructor's map, and one point for every correctly written relationship statement.

The examples in Figure 4 illustrate a portion of one student map contrasted with the same portion of the instructor's map. Based on the instructor's map, the student could receive a maximum of five points for correctly classifying the shown terms in any way under the header "Volume of Web Information," and another two points for grouping terms in the sets shown--WebQuests, digital archives, and bookmark managers with volume of Web information, and digital archives with student-centered inquiry projects and digital storytelling activities. Where three or more concepts were co-located in a set, the student had to place all concepts together in the expected grouping or order to receive one point. A half-point was assigned if only some of the concepts were placed together in a set. No correct number of propositions was assumed, since that value would fluctuate depending on how students grouped terms. On the student map shown in Figure 4, the student received five points for classifying all of the expected terms under the header (one extra term, design projects, was incorrectly classified), and one point for identifying the concept set comprised of digital archives with student-centered inquiry projects and digital storytelling activities. The student also received six points for correct propositions. Even though the concept "design projects" was incorrectly classified by comparison to the instructor's map, the student's proposition relating the concept to "WebQuests" was accurate.

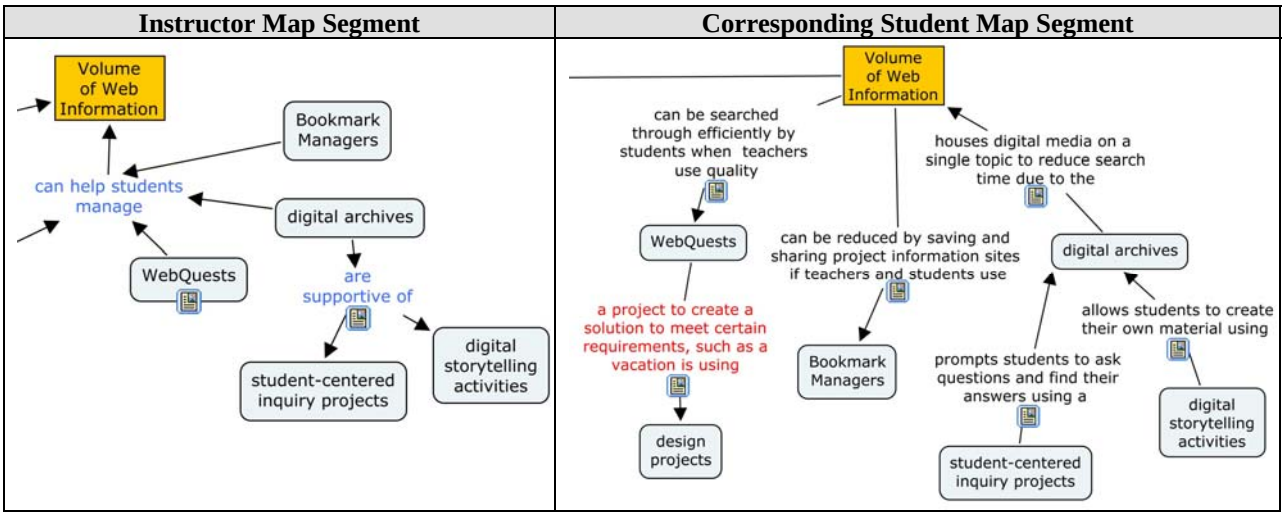

Figure 4. Portion of Instructor Map Compared Against Same Portion of Student Map.

Using the maximum number of points from the instructor's map as a guide, it was possible to calculate a percentage across students (e.g., students correctly classified 81% of the concepts, but only identified 37% of the relevant concept sets). As such, student map scores were analyzed descriptively.

Results

Open-Ended Mapping

In the first section, students placed an average of 34.7 and 37.3 concepts in their two open-ended concept maps with a highly divergent standard deviation of 21.8 and 23.4 respectively (see Table 3). The number of correctly written propositions and unique resources integrated in student maps also had a high overall variance.

	# of maps scored	# of concepts identified		# of resources attached		# of proposition statements	
		Mean	SD	Mean	SD	Mean	SD
internet (2 weeks)	11	34.7	21.8	20.5	11.6	28.4	13.4
factors (1 week)	10	37.3	23.4	16.6	11.3	34.1	18.8

Table 3. Section 1 Concept Map Results.

Using content analysis, the major categories represented on students' open-ended maps were noted (i.e., the higher-level terms on which they placed the most importance). Categories stood out because they were often exemplified with several specific underlying cases. Tables 4 and 5 present the superordinate categories or headers most commonly found on the two open-ended student maps, the number of student maps on which these categories were listed, and some of the underlying concepts students grouped under the superordinates.

Categories on Student Maps	# of Maps Citing	Underlying Concepts Shared by Students
communication tools	11	blogs, bulletin boards, listservs, email, podcasts, chat, messaging, conferencing
copyright	8	acceptable use policies, internet resources, fair use, public domain
collaboration tools	7	wikis, blogs, class Web pages, global learning projects--thinkquest
networks	7	LAN, WAN, wireless, modems, DSL, cable, shared academic tools, servers
internet resources for teachers	7	digital archives, webquests, government sites, online publications, professional organizations, lesson plan sharing
information literacy	4	searching, research, databases
projects and curriculum	3	virtual field trips, treasure hunts, webquests, thinkquests, ask an expert

Table 4. Categories and Underlying Concepts Cited Frequently on Internet Map (n=11).

Categories on Student Maps	# of Maps Citing	Underlying Concepts Shared by Students
funding	9	budget, business and industry, government, NSF, grants, seed money, collection development plans, leasing, fundraising, competing needs, restrictive conditions
professional development	8	on research, on learning theories, on research-based best practice models that are replicable, on teaching/mentoring/coaching skills, for teachers and administrators, collaborative teams, e-learning, in-service
planning	6	school technology plan, school improvement plan, district technology plan, state technology plan, national technology plan, shared decision making, strategic plan, SWOT analysis, goals, strategies, evaluation, STAR Charts, collaborative planning, vision
standards	5	ISTE, 21st Century Skills, No Child Left Behind Act, state technology model, national technology plan
administrative or leadership support	5	hiring risk takers, flexibility with time, provides resources and professional development, mentors, models, advocates, agents of change
technical resources	4	broadband access, data integration, infrastructure, computer labs, one-to-one computing, access to e-learning and virtual tools, up to date hardware and software, connectivity
technical support	2	just-in-time support provided by the school, district, or state, staffing
political influences and legislation	2	superintendents, school boards, commissioners, governor, legislators, federal, state, computer skills testing, No Child Left Behind Act
partnerships and stakeholders	2	business, higher education, community, parents
socioeconomic factors	1	public access to technology, libraries, computers available for take-home, parental technology training

Table 5. Categories and Underlying Concepts Cited Frequently on Influencing Factors Map (n=10).

The categories on open-ended student maps clearly represented topics introduced in course units, thus each student was successful at representing at least some of the major unit topics on their maps. However, since most student maps contained only three or four categories among seven or eight possible, the data further illustrate considerable divergence in the focus of student maps. Students emphasized different topics on their maps and it was possible by content analysis to determine which topics students found most important or relevant on their open-ended maps.

Written feedback was provided to each student, noting the topics they did include on their maps and suggesting specific categories they missed. For example:

> Good job detailing your map with notes, images, and links, particularly the notes. You've hit upon most of the major concept categories in networks, various resources available online (good detail here), and communication tools. One additional category you might have included would be strategies for teaching online (webquests, keypals, ask-the-expert, telecollaborations, data sharing, virtual field trips, etc.).

From an assessment standpoint, it was helpful to analyze student maps as shown in Tables 3-5 before assigning grades, to develop a standard indicator of performance. The decision to deduct points from open-ended student maps was admittedly subjective, however, based on a holistic consideration of several items: number of concepts, propositions, and resources compared to class averages, and any obvious omissions from unit topics commonly cited in student maps.

One procedural advantage noted for open-ended mapping was the ability for students to customize their maps to address personal interests. For the internet map in particular, a few cases were noted where a student who taught a subject such as writing would integrate writing-related concepts and external resources. Personalization of map spaces was discouraged with pre-selected term maps, which a few students in sections 2-3 noted in their post-survey comments:

> The only problem I had was that there is little room for difference of opinion with you. I gathered different ideas and perspectives from some of the articles and thus my concept map varied from yours.

> I would have liked to be able to add other connections that were discussed in the readings.

Pre-Selected Term Mapping

The pre-selected term mapping strategy applied in sections 2-3 was successful in objectively depicting student understanding of specific topics. As shown in Table 6, students correctly classified more than 80% of the pre-selected terms under the superordinate headers provided for each of the three assigned maps. Students also generated between 9 and 14 correct propositions for each map. No correct number of student propositions was assumed, but Table 6 indicates the number of propositions on each instructor map for general comparison.

Map	# of Maps Scored	# of Super. Concepts	Concepts Classified		Sets Identified		Propositions	
			Mean	SD	Mean	SD	Mean	SD
Hardware	30	4	16.6/19 (84.7%)	3.1	2.4/6 (39.4%)	1.8	13.6/17 (80%)	5.6
Software	28	4	16.3/20 (81.4%)	2.6	4.6/9 (51.2%)	2.0	12.7/17 (74.8%)	3.7
Internet	28	3	13.8/16 (85.9%)	1.8	5.2/9 (57.9%)	1.3	9.7/12 (80.7%)	4.2

Table 6. Concept Map Scores for Sections 2-3 Completing Pre-Selected Term Maps.

Students had the most difficulty identifying specific sets of concepts. Compared to the instructor's map, students only identified 39.4% of the expected concept sets on their first map,

and improved slightly to 51.2% and 57.9% for their second and third maps respectively. The difficulty students had identifying the same concept sets as the instructor might be attributed to the depth of each topic, with between 7 and 14 articles assigned for each of the three maps. With so many articles, students would sometimes find alternative groupings for concepts that were different from the instructor's map but still valid. In such cases, students did not receive points for their unique sets, but they did receive points for valid propositions relating the concepts. Four students in sections 2-3 commented on their post-survey that the maps were based on too much content:

> Too many articles to try to find the connections. Smaller Cmaps would have been more useful for me.

> There may have been too many articles to relate.

The author of this paper has conducted similar concept map studies in middle schools where students are given one relatively short reading and approximately 18 pre-selected terms to map. Under these conditions with less reading material, middle school students were more successful at identifying concept sets than the graduate students in this study (Oliver, 2006). Success with proposition writing was lower, however, since younger students struggle to express relationships in writing based on their lack of reading comprehension. The graduate students in this study may not have found the sets predicted by the instructor's map, but with better reading comprehension many were still able to find alternative connections in the readings and correctly integrate terms into their map structure with valid propositions. Five students in sections 2-3 commented on their post-survey that alternate conceptions were possible:

> Sometimes an idea was vague to me to tie it to a particular reading, or I felt it could be tied more than one way.

> I think that sometimes people could make different connections.

Providing pre-selected terms to locate and organize across a selection of readings did encourage better reading among students in sections 2-3. When asked what was most beneficial about Cmap on their post-survey, seven students indicated Cmap helped them to read more thoroughly and to go back and re-read:

> It also forced me to go back and carefully examine all the readings - even though I had read them previously, I always found something I had sort of skimmed over or didn't remember.

> It also gave me a reason to go back to the readings and really internalize the information.

> Required me to REALLY read over the material. A person might could sort of fake their way through some of the discussion, but the Cmap was proof positive that I had thoroughly read the material.

> It made me think about the readings on a deeper level.
>
> By having to dissect the readings in order to do the CMaps, I really digested the information.

The results presented in Table 6 illustrate that students were able to structure and relate specific concepts from their readings in a manner moderately similar to the instructor's map. The class averages were useful to assign points to students, with students falling below the averages receiving fewer points. The standard deviations for concepts classified, sets identified, and propositions were lower overall than the standard deviations for similar points of analysis in open-ended maps, reducing subjectivity in scoring. The most variable skill for pre-selected term maps was proposition writing.

Discussion

Overall, student reactions to Cmap were very positive. Students were asked on their post-survey if they agreed or disagreed Cmap was a useful course assignment. Using a 5-point Likert scale, 86.2% of students from section 1 and 87.2% of students from sections 2-3 agreed or strongly agreed that Cmap was useful. When asked to report the least beneficial thing about Cmap on their post-survey, seven of 29 students across sections 2-3 commented that nothing was wrong with Cmap. For example:

> I find it hard to state something about the Cmap activity that was not beneficial. I really cannot think of why it would not benefit me personally as a learner.

Even among the three students who verbalized a dislike for Cmap, written comments indicate they still found using the tool to be educational:

> Personally I hate doing them, but they are effective tools for learning. Therefore, the least beneficial aspect is my personal dislike; however there is no educational downside.
>
> Not so much useful, but it was a new experience. It challenged beyond memorization.

One of the most positive findings was the number of students in sections 2-3 who indicated they found just learning to use Cmap as a learning tool to be beneficial. A few students even indicated they had adopted or would adopt concept mapping as a strategy with their own students:

> The Cmap activity was immensely useful because it armed us with at least one strategy that we could immediately use in our classrooms.
>
> Since I had never done one, it was beneficial to experience it as a possible tool to use in my own classroom.
>
> I loved them! We will be doing these in my class in 2006-07!

> During this course, I have incorporated concept mapping into my classes. My students now use Inspiration.

Thinking with Cmaps

When asked what was most beneficial about Cmap on their post-survey, 41% of students in sections 2-3 provided written comments to suggest the tool helped them make connections, tie information together, link information, or group information. This ability to explicate relationships was the thinking skill students attributed to Cmap most frequently:

> Making connections among concepts was most beneficial.

> Cmapping helps to tie information together.

> It forced me to understand and make connections between essential course concepts.

> It allowed me to connect all the articles and ideas together for each session.

As shown in Table 7, 100% of students in section 1 and more than 75% of students across sections 2-3 agreed or strongly agreed on a 5-point Likert scale that Cmap helped them to make connections within specific course sessions and between major course sessions. Interestingly, a slightly smaller percentage of students in sections 2-3 agreed that Cmap helped them to make connections between sessions of the course. The opposite effect was predicted, since these students prepared maps from 3-4 weeks of course material compared to students in section 1 who prepared maps from only 1-2 weeks of course material. It may be that the restrictive nature of pre-selected term mapping left students in sections 2-3 with the impression of connecting fewer concepts overall. In fact, they did relate fewer concepts overall (see mean number of written propositions from Tables 3 and 6). One student commented on the post-survey that pre-selected term maps may lead students to read for specific information and miss other general ideas in the process:

> I think since we were given topics ahead of time, it affected how I read the articles. I was reading for specific information, which can be timely and helpful, but I missed some important facts, I discovered upon re-reading.

	Section 1 n=11	Sections 2-3 n=30	All Sections n=41
The Cmap activity helped me to make connections within a specific session of the course.	100%	82.8%	86.1%
The Cmap activity helped me to make connections between sessions of the course.	100%	75.9%	80.5%

Table 7. Percentage of students who agree or strongly agree with different values of concept mapping activities.

Based on written comments from the post-survey, however, many students in sections 2-3 disagreed with the minority opinion that pre-selected term maps may prevent the development of

big picture comprehension. When asked what was most beneficial about Cmap, other students suggested:

> Seeing the terms that the instructor considered important for each session [was beneficial].
>
> It allowed me to see the "big picture" and make connections with all the concepts.
>
> It helped me to sum up what was learned from the articles.
>
> Creating the Cmap clarified or helped to clarify what I had read and learned.

Another thinking skill that concept mapping supported among students was organizing information. As noted in findings, students in sections 2-3 were successful at classifying information and partially successful at grouping concept sets. Many students provided written comments on their post-survey indicating Cmap helped them to organize information visually:

> The visual representation of conceptual meaning--Cmap allows you to organize information in ways that I could understand.
>
> The major benefit of Cmap was the visual representation of our understanding of the readings.
>
> It helped me visualize the connections between subjects and the specifics.

Effects of Content Depth

On a 5-point Likert scale, students were asked on their post-survey if they agreed or disagreed that different concept map strategies which varied by depth of coverage could be useful. The strategy that students in section 1 and in sections 2-3 agreed or strongly agreed would be most useful was developing focused Cmaps covering only 1-2 sessions of the course (see Table 8). Students in section 1 had experienced focused mapping, and a one-way analysis of variance suggests these students found the strategy to be significantly more useful than students in sections 2-3, $F(1, 37) = 5.3$, $p<.03$. However, students across all sections were generally positive about the focused mapping strategy.

A moderate number of students at 57.2% for section 1 and 69% for sections 2-3 agreed or strongly agreed that building a Cmap week by week over an entire semester could be useful. This strategy was not applied with any section. Interestingly, fewer students across sections reported that mapping 3-11 sessions of content could be a useful strategy. The idea of a semester-long, iterative map was deemed more useful than a map covering only two-thirds of the semester, perhaps because students in sections 2-3 had struggled with mapping 3-4 sessions of content or because the notion of a dynamic, ever-developing map was enticing. Students were also asked if developing a non-iterative, semester-long Cmap at the end of the semester could be useful, and most disagreed.

Please rate whether you agree/disagree the following cMap strategies were or could be useful:	Section 1 n=11	Sections 2-3 n=30	Sections 1-3 n=41
developing a focused cMap that covers only 1-2 sessions of content	100%	79.3%	84.6%
developing a general cMap that covers several sessions of content (i.e., sessions 3-11)	40%	24.1%	28.2%
building a cMap week by week over the whole semester	57.2%	69%	66.7%
developing a cMap for the whole semester, but only at the end of semester	0%	13.8%	11.2%

Table 8. Percentage of Students Agreeing or Strongly Agreeing that Different Map Strategies can be Useful.

Proclivity for Independent Work

Students in all three sections worked independently on their maps. In the first section, students were told they could collaborate, but only two students chose to work together on their second map. On their post-survey, students were asked on a 5-point Likert scale if they agreed of disagreed that working alone and working collaboratively could be a useful strategy for developing concept maps. As shown in Table 9, only 37-40% of students agreed or strongly agreed that co-developing Cmaps with other classmates could be useful, so the idea of working collaboratively with others in distance courses was not well received. A one-way analysis of variance revealed the first section had a significantly higher percentage of students who agreed that developing a Cmap by one's self could be useful, $F(1, 36)$, $F = 8.96$, $p = .005$. It's possible that students tasked with pre-selected term mapping in sections 2-3 struggled to restructure pre-selected terms on their own given that terms were drawn from so many articles. These students may have found individual mapping to be less useful than students tasked with open-ended maps who were free to integrate concepts and resources they found to be important.

Please rate whether you agree/disagree the following cMap strategies were or could be useful:	Section 1 n=11	Sections 2-3 n=30	Sections 1-3 n=41
developing a cMap by myself	100%	39.3%	55.2%
co-developing a cMap with another classmate	40%	37.9%	38.4%

Table 9. Percentage of students who agree or strongly agree with the usefulness of individual and collaborative concept mapping.

Conclusions

In this study, two different methods of Web-based concept mapping were investigated as a form of alternative assessment for distance education. Each method was found to have both advantages and disadvantages. For open-ended mapping, students are led to integrate more overall concepts and engage in more relational thinking about those concepts. Open-ended maps are also more flexible in allowing students to customize and integrate their own topics of interest

and external resources. It follows that great variance is evident in the number of concepts and propositions integrated in open-ended maps, and this may present a problem for graders with more divergent information to score. With pre-selected term maps, students are limited to a specific set of concepts and thus engage in directed and more limited relational thinking. Customization of the map is discouraged, which lends itself to lower overall variance in the number of concepts, sets, and propositions. The implications of pre-selected term maps on assessment are less data to score in addition to a criterion map that provides a standard for objectively seeking a one-to-one match in specific classifications, sets, and relations on student maps.

A recommendation is not appropriate for one concept mapping method over the other. Teachers interested in fostering relational thinking about a course topic may opt for open-ended mapping, particularly if the maps are assigned as a project or activity. Open-ended mapping can be used for assessment, but teachers should realize the subjective nature of the scoring task and be comfortable with general content analysis. Teachers concerned with designing an objective assessment may find that pre-selected term mapping carries more precision.

Regardless of method chosen, student reactions to Cmap as a form of assessment were positive for both open-ended and pre-selected term concept maps. When asked to choose between a traditional exam and a Cmap assessment on their post-survey, more than 90% of students in each section chose Cmap (see Table 10). When given more choices, including applied projects and a combination of assessment methods, a majority of students in each section still chose Cmap as the preferred mode.

		Section 1 n=11	Sections 2-3 n=30	All Sections n=41
If you could choose between a Cmap assessment or a regular exam, which would you select?	Cmap	90%	93.1%	92.3%
	Regular Exam	10%	6.9%	7.7%
If you could choose between Cmaps, regular exams, or applied projects, which form of assessment would you select?	Cmap	40%	48.3%	46.2%
	Regular Exam	0%	3.4%	2.6%
	Applied Projects	30%	13.8%	17.9%
	Combination	30%	34.5%	33.3%

Table 10. Percentage of students preferring different methods of assessment in distance teacher education courses.

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