

LESSONS LEARNED FROM UNSTRUCTURED CONCEPT MAPPING TASKS

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Abstract: Two college of education faculty incorporated online concept mapping assessments in their fall 2005 distance education courses, varying in terms of content depth and participation. Students expressed great interest in mapping as an alternative form of assessment for distance courses, and performed adequately on assigned tasks. Attempts to involve students in collaborative pre-mapping and mapping were not entirely successful, as most students expressed more interest in developing individual maps, at least for purposes of assessment. For assessment purposes, recommendations include focusing student maps on concise content segments and using pre-selected terms to reduce the subjectivity of map scoring. For higher-order learning purposes, recommendations include gradually bridging to more open-ended maps, with increased content complexity scaffolded by mapping in small groups.

1 Introduction

Concept mapping serves multiple purposes in providing instructors with an assessment tool to determine what students know about a subject and how that knowledge is structured, and in providing students with an active learning tool to build and revise their own model of understanding. A concept mapping task begins with the instructor selecting a limited domain of knowledge to be mapped by the student (Novak & Gowin, 1984). This knowledge domain should be tied to course material such as required readings, a lab experiment, or an applied problem. The student lists key concepts in the domain and arranges them from inclusive to general and by type. The student completes a concept map by drawing lines between concepts to illustrate relationships and by writing proposition statements on these connecting lines to describe the nature of the relationship. For maps that depict multiple knowledge domains, students may also include cross-links to show how concepts that are not directly connected relate to one another on some higher level.

To use concept maps for assessment, at least three things must be accounted for: a task with directions for creating a map, some format for the student's response, and a scoring system (Ruiz-Primo & Shavelson, 1996). Tasks vary by constraints, with some providing pre-selected terms or propositions to students for mapping, and others asking students to generate their own list of terms or propositions. Response formats vary by mode, including paper and pencil, computer-generated, and interview whereby someone other than the student may generate a map to represent the student's oral responses. Response formats also vary by characteristics and difficulty, with some providing an easier fill-in-the-blank map structure for students on a partially-created map, others providing computer pull-down menus with relationship statements already defined, and some providing no map elements ahead of time.

A variety of methods are available for scoring concept maps. 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 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). A great need still exists for authentic maps that require learners to integrate external resources.

Following constructivist pedagogy, mapping should involve merging one's existing knowledge about a subject with new, external information through recursive cycles of building and revising. In the information age, more than ever students need to make use of tools that allow them to integrate extensive online resources with their own personal knowledge maps, as they constantly update their understanding with new information to solve real problems. Those interested in mapping as a constructivist learning activity and not just a lower-order assessment, can't simply limit the student task to a few terms that fit neatly into a template. A compromise is needed, however, between overly-simplistic maps that are easy to score but tell us little about student knowledge structures, and more complex maps that are valuable learning tools but very difficult to score. Or, can we have our concept map cake (higher-order learning), and assess it too? The cases presented here describe lessons learned by two instructors as they sought to balance student learning through unstructured mapping tasks with the realities of scoring.

2 Procedures

During the fall semester 2005, two university faculty implemented online concept mapping in their graduate education classes. Both classes were taught at a distance using the university's WebCT Vista course management system. The difficulty in delivering and securing traditional tests at a distance is well known (Shyles, 2002). Online concept mapping provided the investigators with an alternative assessment to gauge their students' understanding of course topics. Two small classes participated in the study during fall 2005: Computer Applications and Curriculum Integration (ECI 511), and Classroom Assessment and Evaluation (EAC 595). Both classes were taught completely online with 10 and 13 students completing each course and all embedded mapping assignments respectively.

Course management systems rarely if ever include concept mapping capabilities, thus we selected a third-party tool to meet our needs--Cmap (IHMC, 2006). The freeware Cmap tool enabled our students to develop individual online concept maps and attach a multitude of resources to developed concepts (e.g., Web links, image files, word processed notes, video clips, etc.). Further, Cmap supported collaboration among students with co-edit features and built-in discussion boards and chats. The ability to attach notes to student maps was desirable for feedback and critiques. We utilized the public Cmap servers provided through IHMC to establish student mapping spaces online. These electronic folders were password-protected with access granted only to the instructor and individual students.

In ECI 511, students completed three mapping tasks during the semester: a comprehensive map covering eight class sessions on different technology integration topics (e.g., hardware and software, standards, theoretical foundations); a more focused map covering two class sessions on uses of the internet in the classroom; and a final map covering one class session on factors influencing technology integration. Students were provided with no terms in advance; their maps were completely unstructured and built from self-selected terms. Students were required to integrate electronic copies of assigned readings in their maps to illustrate where they found depicted relationships. Students worked entirely alone on their first map. For their second and third maps, a discussion board was employed to assist students in collaborative pre-mapping by identifying relevant concepts from the readings as a group, before they created maps as individuals. Students were given the option of collaboratively developing their third map with another classmate.

In EAC 595, students completed two mapping tasks as individuals during the semester, covering concepts associated with assessment and evaluation. The first map was optional (non-graded), and completed at mid-semester covering nine weeks of course content. Students opting to turn-in a map at mid-semester received detailed individual feedback. These initial maps were then used as the basis for a second map submitted at the end of the semester covering all course work. An asynchronous communication tool was employed in this class as well, with students developing a list of terms throughout the semester on a group-edited wiki, then choosing their concept map terms from the wiki. Students were required to include at least 50 terms from the wiki on their second concept map. Additional terms not on the wiki could be included if students so wished.

3 Data Sources and Analysis

Through our case studies, we sought to answer the following questions regarding online concept mapping in distance teacher education courses:

1. How does the relative amount of content to map influence student mapping performance? We hypothesized that student map scores might be higher for short-term maps covering only 1-2 weeks of readings with less intrinsic cognitive load related to focused content sets, but that the level of detail included on longer-term, 8-week maps would be greater.
2. What are student preferences for participation in mapping activities, and is student mapping performance enhanced by a certain type of participation? We hypothesized student map scores might increase for mapping activities that included collaborative components--either group work to pre-select terms for mapping or actually co-editing a map with another student.
3. What are student preferences for assessment in online teacher education courses, and how is concept mapping received as an element of distance education assessment? We had no pre-conception for how students would react to concept mapping assessments in our distance classes.

We collected three student data sources to inform the questions: post-survey responses, a log of student questions posed regarding assigned mapping tasks, and the concept maps themselves. Student survey responses were summarized using descriptive statistics, and open-ended comments received by the 23 students were limited and concise enough to summarize thematically.

We initially pre-selected the relational method for our class maps to assign points for correctly identified propositions from course readings. Great variation was apparent across student maps in terms of propositions and other details, however. 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 20 correct propositions and considerable map detail, the relational method was replaced. Variance in scoring widely divergent map elements on open-ended map assignments is known to be an issue, as it was for our classes (Shaka & Bitner, 1996). And as noted earlier, rather than limiting this divergence and student conceptualizations, we were interested in fostering and scoring it.

The relational method was replaced in ECI 511 with a holistic method, looking for evidence that students correctly identified key concepts from the readings, appropriate proposition statements, and attached at least some of the core readings or personal notes to appropriate concepts. Students received written feedback detailing any point deductions for leaving core concepts off their maps, for failing to detail concept relationships through proposition statements, or for failing to attach relevant resources. In EAC 595, the relational method was similarly replaced with a holistic rubric that included as criteria the quantity of words included (50 required from the class wiki), the inclusion of main course themes, and the accuracy of propositions. Admittedly subjective, both instructors found a holistic appraisal to be the single scoring method applicable to their students' open-ended or unstructured maps.

4 Findings

4.1 *How does the relative amount of content to map influence student mapping performance?*

The mean student grades on three mapping tasks in ECI 511 were: 16.6 out of 20 points (83%) (map 1 covering 8 weeks), 47.2 out of 50 points (94.4%) (map 2 covering 2 weeks), and 48.8 out of 50 points (97.6%) (map 3 covering 1 week). Student scores were the lowest for their first map, and near mastery for their other maps. In EAC 595, students only received a grade for their end-of-semester map (a possible 30 out of 1000 semester points). Using the rubric, the mean grade was 27.7 out of 30 points or 92.3%, which excludes zero grades given to two students who did not turn in the assignment. Three students did not turn in their optional concept map at mid-semester, and their grades were on the lower end of the scale (26.33 or 87.78%).

For ECI 511, the mean number of concepts identified on each of three student maps was computed, as well as the mean number of resources attached and proposition statements written, to provide a general picture of the detail students put into their maps. It was expected that students might identify more concepts, attach more resources, and develop more proposition/relationship statements, for their first map covering eight weeks of content than for subsequent maps covering smaller content segments. T-tests revealed no significant differences, however, in the

mean number of concepts identified, resources attached, or proposition statements written, between the divergent map 1 and the more focused maps 2 and 3. Mean values and standard deviations are provided in Table 1.

	<i># of concepts identified</i>		<i># of resources attached</i>		<i># of proposition statements</i>	
	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>
<i>Map 1 (covering 8 weeks)</i>	38.5	19.6	21.4	15.3	28.8	21.0
<i>Map 2 (covering 2 weeks)</i>	34.7	21.8	20.5	11.6	28.4	13.4
<i>Map 3 (covering 1 week)</i>	37.3	23.4	16.6	11.3	34.1	18.8

Table 1: Level of detail provided in ECI 511 concept maps covering different time periods.

On a Likert scale of 5 (strongly agree) to 1 (strongly disagree), students were asked to rate their agreement with the post-survey statements shown in Table 2. The percentage of students who agreed or strongly agreed is reported for each class, as well as the combined percentage across classes. Students in both classes generally agreed or were neutral that mapping 1-2 weeks of content, 1-9 weeks of content, and the whole semester week-by-week, could be useful mapping strategies. Students in ECI 511 who had experienced both short-term and long-term maps indicated a strong preference for mapping more focused content segments of 1-2 weeks. Students in both classes rejected mapping content from an entire semester at the end of the semester, suggesting that strategy would be less useful.

		ECI 511 n=10	EAC 595 n=13	Both n=23
% of students who agree or strongly agree with different applications of concept mapping:	Doing the first draft of the Cmap at mid-semester helped me with the final product.	not asked	4.5	n/a
	Do you agree/disagree that developing a Cmap that covers only 1-2 weeks' content could be useful?	100%	53.8%	73.9%
	Do you agree/disagree that developing a general Cmap that covers several weeks' content (e.g. weeks 1-9) could be useful?	40%	61.5%	52.2%
	Do you agree/disagree that building the Cmap week by week over the semester could be useful?	57.1%*	61.5%	60%*
	Do you agree/disagree that developing a Cmap for the whole semester, but only at the end of semester, could be useful?	0%*	15.4%	10%*

*for these questions, n=7 and 20 respectively

Table 2: Percentage of students who agree or strongly agree with different applications of concept mapping.

4.2 What are student preferences for participation in mapping activities, and is student mapping performance enhanced by a certain type of participation?

As shown in Table 3, survey data illustrates that students generally agreed or were neutral regarding two suggested participation strategies: developing Cmaps by themselves versus co-developing Cmaps with another student. A strong preference for one mode over the other was not illustrated by the data, however students in ECI 511 were given the option of co-developing their final Cmap with another student and only two students chose to work collaboratively. In EAC 595, students were not given the option of working collaboratively on concept maps because of problems experienced earlier in the semester on group assignments. Students complained about different work schedules and the times they were available to work on projects. Most preferred to work as individuals.

		ECI 511 n=10	EAC 595 n=13	Both n=23
% of students who agree or strongly agree with different participation modes:	Do you agree/disagree that developing a Cmap by yourself could be useful?	100%	53.8%	73.9%
	Do you agree/disagree that co-developing a Cmap with another classmate could be useful?	40%	61.5%	52.2%

Table 3: Percentage of students who agree or strongly agree with the usefulness of different participation modes for concept mapping.

One participation strategy employed by both instructors was to provide students with collaboration tools (i.e., wikis or discussion boards) to discuss major course concepts, prior to their individual mapping. This strategy was assumed to help students extract and come to consensus on major and minor course concepts to be mapped, given

the open-ended nature of the task. Student actions did not illustrate useful collaborations, however. In ECI 511, students were given an optional (non-graded) discussion board to discuss major concepts that should be included in their second map, but only one-third of students took part in the discussion. Nearly every student participated in a separate graded discussion board to discuss concepts that should be included in their third map, but only one original post was recorded per student, and only three students posted replies to other students. To no surprise, the maps created by students following these limited discussions were not significantly better than the first map created by students without any direct discussion.

4.3 What are student preferences for assessment in online teacher education courses, and how is concept mapping received as an element of distance education assessment?

When asked to choose between a traditional exam and a Cmap assessment on their post-survey, a majority of students in both classes chose Cmap as shown in Table 4. When given more choices between a traditional exam, Cmap, applied projects, or a combination, a majority of students in both classes still chose Cmap, although applied projects and a combination of assessment methods were preferred by roughly a quarter of students in both classes.

		ECI 511 n=10	EAC 595 n=13	Both n=23
If you could choose between a Cmap assessment or a regular exam, which would you select?	Cmap	90%	69.2%	78.3%
	Regular Exam	10%	30.8%	21.7%
If you could choose between Cmaps, regular exams, or applied projects, which form of assessment would you select?	Cmap	40%	38.5%	39.1%
	Regular Exam	0%	15.4%	8.7%
	Applied Projects	30%	23.1%	26.1%
	Combination of Each	30%	23.1%	26.1%

Table 4: Percentage of students preferring different methods of assessment in distance teacher education courses.

As further evidence of student satisfaction with Cmap assessments, students in ECI 511 were queried on their post-survey as to the one thing they enjoyed most about the course. Five of ten students provided unsolicited comments suggesting Cmap activities were their favorite course element. When queried as to the one thing they enjoyed least about the course, no students disparaged Cmap. Similarly, three students in EAC 595 sent unsolicited email comments to the instructor about the value of Cmap to pull together various course concepts, even though one also noted that it was the hardest thing he had to do all semester.

As shown in Table 5, students in both classes generally agreed or strongly agreed that Cmap helped them to make connections within course sub-topics and between major course topics. Further, students were asked on their post-survey to describe what was most beneficial about Cmap activities. Nearly every student provided written comments that could be sorted in one of two categories--Cmap helped them synthesize and put together course material (e.g., "helped me to focus course concepts into a single picture," "putting what I had learned into an organized format"), or Cmap helped them make connections between course materials (e.g., "having to think about the terms and make connections," "forcing you to relate the topics"). Two students suggested the activities helped them to "remember" or "retain" course information better.

		ECI 511 n=10	EAC 595 n=13	Both n=23
% of students who agree or strongly agree on different values of concept mapping:	The Cmap activity helped me to make connections within a sub-topic of the course (e.g. classroom assessment techniques).	100%*	76.9%	85%*
	The Cmap activity helped me to make connections between major topics of the course (e.g. assessment and evaluation).	100%*	84.6%	90%*
	The Cmap activity was worth enough points in the course.	100%*	53.8%	70%*
	Please rate whether you agree/disagree the following course assignments were useful: Cmap assignments.	90%	not asked	n/a

*for these questions, n=7 and 20 respectively

Table 5: Percentage of students who agree or strongly agree with different values of concept mapping activities.

Students were also asked on their post-survey to describe what was least beneficial about Cmap activities. About one quarter of students surveyed describe technical difficulties learning to use the software (e.g., "...it was difficult to figure out how to use the Cmap software"). At least three students expressed concern over the amount of time it took to create their concept maps, suggesting the hours involved were not worth the number of points awarded for the task (e.g., "...very costly timewise for only 30 points"). Only one student mentioned concern over mapping large chunks of content (i.e., "...having to do it on a huge amount of information").

5 Discussion

5.1 *How does the relative amount of content to map influence student mapping performance?*

Students in ECI 511 passed all three of their mapping assessments, with the lowest scores recorded for their first map. Further, the number of concepts identified, resources attached, and proposition statements written, remained similar between map one that involved considerably more content and maps two and three that involved less overall. The lower overall score and surprisingly similar level of map detail for map one may have reflected a combination of both intrinsic and extrinsic cognitive load factors. In terms of intrinsic cognitive load related to the content itself, for map one students were new to the course content and also mapping the most content of any of their assigned maps (eight weeks). In terms of extrinsic cognitive load or those variables outside of the content, for map one, students were simultaneously learning the process of concept mapping and the new Cmap tool. In fact, 12 out of 15 students originally enrolled in ECI 511 reported they had never created a concept map on a course pre-survey, thus these students were indeed novices who may have benefited from practice mapping before more demanding tasks were assigned. Managing a new strategy and tool as well as a large amount of content simultaneously may have impeded the students' ability to extract and structure all relevant concepts.

In retrospect, students should not have been assigned their most complex map first, but rather more conceptually manageable maps covering only 1-2 weeks of content. Students unfamiliar with the concept mapping strategy or a new mapping tool are likely to have a high external cognitive load, which should be offset by more manageable content chunks with lower overall intrinsic cognitive load. Conversely, students who have some familiarity with the mapping strategy and mapping tools are likely to have lower extrinsic cognitive load and should be ready to handle more intrinsic cognitive load associated with more difficult or more detailed content. Instructors should bridge to more cognitively challenging content chunks after students have mastered mapping basics.

In EAC 595, students who only submitted one final concept map had lower scores than those who had turned in optional maps at midterm and received instructor feedback. Iterative maps are one strategy that may be employed for managing large content chunks, as was the case in EAC 595. A map covering major topics from eight weeks of course content at midterm is no small map, thus the iterative nature of creating, receiving feedback, and revising a map in cycles, appears to have some benefit for at least some students. If instructors plan to use iterative maps that are revisited and revised over time, they may want to allocate at least some grade for preliminary maps to encourage all students to submit them. As with ECI 511, early and smaller concept mapping assignments may also help those students who are new to concept mapping or even resistant to the idea.

5.2 *What are student preferences for participation in mapping activities, and is student mapping performance enhanced by a certain type of participation?*

When concept maps are used as a learning tool in addition to an assessment tool, one must consider the potential benefits of grouping students together for work on a common map. As with the problem-based learning model, students may be able to manage more intrinsic cognitive load tied to ill-defined problems, if they divide their significant research requirements and collaboratively work to define and understand a complex issue. Benefits may ensue as collaborating students discuss and negotiate proper connections between concepts, and collaborating may serve a second purpose in helping students adjust to a new tool and support one another technically on their initial maps, managing extrinsic cognitive load as well.

Student actions in our classes, however, would indicate a preference for individual mapping over group mapping (i.e., choosing to work alone when given the chance to work collaboratively, limited collaboration with others on pre-mapping discussion boards and wikis). This preference may be related to our use of concept maps

primarily as an assessment tool. If learners perceived the task as one of individual assessment, which it was, they may have been less willing to contribute to group-edited discussion boards and wikis during pre-mapping, for fear of "giving away" all of their answers to other competing students. This preference may also be related to our distance learners who predominantly work full-time while taking our courses, and who might perceive scheduling a common time for synchronous group mapping to be a challenge in their busy daily schedule.

Fortunately, both issues are easily managed. Regarding the perception of competition from classmates on assessment tasks, convert the task into an authentic group project for a group grade. For pre-mapping activities, an improved structure would involve grouping 2-4 students into a team that would identify major concepts from readings to include in a group-edited map. Whole group identification of terms followed by individual mapping may be less effective than small group identification of terms followed by that same small group using their own terms on their own map. Regarding distance learners with different time schedules, it is possible for students to build maps asynchronously with Cmap, using built-in discussion boards to support group talk about map content.

5.3 What are student preferences for assessment in online teacher education courses, and how is concept mapping received as an element of distance education assessment?

Concept mapping assessments were well received by a majority of students in both classes, with survey data illustrating a strong student preference for mapping assessments over regular exams. Even when asked to select their preferred method of assessment between maps, exams, and projects, a majority of students chose maps, with about a quarter interested in projects or a combination of methods. In addition, students generally agreed or strongly agreed that Cmap activities helped them make connections between major topics and sub-topics of the courses. Further, most students provided written comments on their post-survey that would suggest the activities helped them to either piece together and organize course information or to understand how course materials were connected or related.

6 Future Directions

A number of task structures are possible in concept mapping. The simplest tasks involve students filling-in concepts on map templates, essentially classifying provided terms amongst others like it on the template (i.e., place these three provided concepts in the proper blanks on the template that already has 15 terms in it). A slight variation with more challenge involves filling-in the propositions on a template, which may or may not be provided to the learner. As noted, finding relationships between concepts is one of the more important aspects of connected understanding (Novak & Gowin, 1984; Schau et al., 2001). More challenging still are pre-selected term maps that require the learner to generate the basic structure, classify the terms, and find the relationships. These vary in difficulty by providing all the terms around some topic or seeding a partial set of terms around some topic that the learner must supplement with additional terms from their own memory. Finally, the most challenging maps of all involve open-ended mapping with little to no guidance provided other than a major topic. These maps require the learner to qualify or extract the most important concept units, generate a structure, classify the terms, and find relationships. The potential for learning is high, but so is intrinsic cognitive load, and this load only increases for online *content* maps that allow a student to justify or prove their map with evidence from external resources.

As shown in Figure 1, a tradeoff exists between structured and unstructured mapping tasks. For fill-in maps, students basically classify information--one thinking skill (Presseisen, 2001). For open-ended maps, students qualify terms, classify terms, generate a structure, find relationships, and perhaps, justify their map with evidence from external sources and draw conclusions on the basis of the map--multiple thinking skills. In our graduate classes, we are interested in fostering multiple skills and tasked individual students with developing complex, open-ended, content maps. Our graduate students were successful and capable of managing this task, and for the most part enjoyed the task, despite some evidence of both intrinsic cognitive load related to longer-term maps and extrinsic cognitive load related to their lack of familiarity with concept mapping and the Cmap tool. The tradeoff was our student maps were very difficult to assess with great variability among them. The relational scoring method was replaced in lieu of a holistic assessment that was admittedly subjective at best.

To maximize student learning while managing our own assessment challenges, in our future classes we plan to employ both pre-selected term mapping for assessments and open-ended mapping for learning activities. Pre-selected term mapping still allows students to practice several important thinking skills in classifying terms, finding

relationships, and generating an original map structure. At the same time, it restricts the students to work with the same concept set, so our assessment can remain much more focused on how these twenty or so terms are related by the students. Since propositions are a critical map element to assess, pre-selected term mapping will allow us to analyze relationship statements branching off of the same defined terms more objectively.

One concern with pre-selected term mapping is its ability to stifle student thinking about larger content sets. Student survey comments clearly illustrated the value they placed on "connecting" course concepts, thus we will also include some unguided or open-ended maps in our classes that allow students more freedom to interrelate divergent content domains, but only after students gain some familiarity with the mapping process and tools. Open-ended maps are difficult to use for assessment purposes, but they represent a useful educational strategy to help students reflect on several weeks' content, perhaps in preparation for an exam. Creating open-ended maps remains a challenge for students, thus we recommend leveraging the collaborative capabilities of Cmap, with small groups of students supporting one another as they work to relate extended course materials.

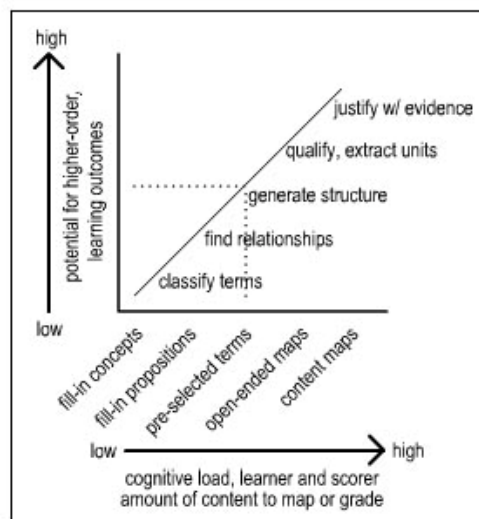


Figure 1: Tradeoffs between structured and unstructured mapping tasks.

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